UNITED STATES OF AMERICA
DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

In re:	) Administrative Law Judge
	) Hon. George J. Jordan
Proposed Waiver and Regulations Governing the Taking of Eastern North Pacific Gray Whales by the Makah Indian Tribe	) Docket No. 19-NMFS-0001
	)
	) RINs: 0648-BI58; 0648-XG584
	)

DECLARATION OF JOHN R. BRANDON

I, John R. Brandon, Ph.D., declare as follows:

1. I am a biometrician specializing in population dynamics modeling, statistical analysis, management strategy evaluation, and survey design and am employed by ICF International, Inc. I am under contract with the Tribe's legal counsel to provide expert testimony and testimony based on my personal knowledge of the International Whaling Commission's review of aboriginal subsistence whale hunts and the Tribe's proposed hunt. My work address is ICF International, 201 Mission Street, Suite 1500, San Francisco, CA 94105.

2. For purposes of this hearing, I prepared and hereby incorporate the attached report and supporting exhibits as my written direct testimony.

3. The attached report includes: (1) expert opinions developed through my education, experience, research, and knowledge of population dynamics modeling and management strategy evaluation involving marine mammal populations; and (2) testimony based on my personal knowledge of the proceedings of the International Whaling Commission regarding aboriginal subsistence hunts in general and the Tribe's proposed hunt in particular. My qualifications to testify as an expert are described in further detail at the beginning of the attached report.

4. The attached report provides factual and scientific information supporting

NMFS's proposed waiver and regulations that would, in addition to tribal management measures, govern a ceremonial and subsistence hunt of gray whales from the Eastern North Pacific stock under the Tribe's treaty-reserved right.

5. I have reviewed NMFS's published issues for the hearing, *i.e.*, the "Issues that May be Involved in the Hearing," 84 Fed. Reg. 13639, 13641-43 (Apr. 5, 2019). As I describe in the attached report, I believe there is additional scientific information available that supports the proposed waiver and regulations. In general, as NMFS's proposed issues of fact relate to my testimony, I agree with the issues presented and support the waiver and regulations NMFS has proposed. The Makah Tribe has prepared and is submitting today a document entitled Makah Tribe's Position Regarding NMFS's Proposed Issues of Fact. The document identifies my position as to the issues presented by NMFS (or in some cases, that I have no comment) and I hereby adopt and incorporate those positions as a part of my written direct testimony.

6. The attached report provides support for additional issues of fact for the hearing. The Makah Tribe has prepared and is submitting today a document entitled Makah Tribe's Proposed Issues of Fact. The document identifies additional issues of fact for the hearing based on my attached report and I hereby adopt and incorporate those issues as part of my written direct testimony.

I declare, under penalty of perjury under the laws of the United States, that the foregoing (and the attached report) is true and correct to the best of my knowledge, information and belief.

John R. Brandon, Ph.D.

Dated: May 16, 2019

Testimony of John R. Brandon, PhD

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Bio:

I earned my PhD at the University of Washington, School of Aquatic and Fisheries Sciences. My dissertation was completed under the tutelage of my major professor, Dr. André E. Punt. Our research developed a mathematical modeling framework for population dynamics of large whales given future uncertainties linked to climate change and environmental variability in critical habitat. This allowed us to evaluate the performance of catch control limits relative to management objectives for aboriginal subsistence whaling of bowhead and gray whales, taking into account scientific uncertainties through the use of computational statistics (e.g. Brandon 2009 (Ex. M-0504); Brandon and Punt 2013 (Ex. M-0505)). The methods we employed are also known in fisheries science as Management Strategy Evaluation (see Section 1.2 for an overview of this approach).

I have been an Invited Participant to the Scientific Committee of the International Whaling Commission (IWC or Commission) since 2006. Much of my research in that capacity has involved serving on the working groups and subcommittees that provide management recommendations for catch limits of aboriginal subsistence whaling both in and outside the United States.

In 2010, I was contracted as a Population Dynamics and Statistical Consultant for the Makah Tribe. I have worked in this capacity periodically since then, on projects related to aboriginal subsistence catch quotas for gray whales as they pertain to the Makah Tribe, including research relevant to the IWC and as an expert witness in these proceedings.

At the 2018 IWC Scientific Committee meeting, I served as the Co-Chair of the Standing Working Group on the Aboriginal Whaling Management Procedure. This working group is responsible for: (1) designing and evaluating catch limit control rules relative to the conservation management objectives of the IWC for aboriginal subsistence whaling; and (2) providing scientific recommendations to the Commission based on such evaluations. Since the working group was established two decades ago by the Commission, it has developed rigorous scientific frameworks for quantitatively evaluating aboriginal subsistence whaling hunt management plans as requested by signatory nations of the IWC, including the United States.

My recent marine mammal research has focused on computer simulation performance testing of algorithms that extend the current status quo approach adopted for the Potential Biological Removal (PBR) management scheme under the Marine Mammal Protection Act (MMPA), while still satisfying the

MMPA’s statutory requirements and conservation management objectives (Ex. M-0506 (Brandon et al. 2017); Ex. M-0553 (Punt et al. 2018)).

I am currently a staff biometrician for the Fish and Aquatics Science Team at ICF International, Inc. My research for ICF involves quantitative survey design work, population dynamics modeling, and statistical data analyses for studies of state and federally listed species of fish in California.

List of Acronyms

(DEIS) Draft Environmental Impact Statement

(ENP) Eastern North Pacific stock of gray whales

(ESA) Endangered Species Act

(IWC) International Whaling Commission

(MMPA) Marine Mammal Protection Act

(MNPL) Maximum Net Productivity Level

(MSE) Management Strategy Evaluation

(NMFS) National Marine Fisheries Service

(OSP) Optimum Sustainable Population

(PBR) Potential Biological Removal

(PCFG) Pacific Coast Feeding Group

(SLA) Strike Limit Algorithm

(WNP) Western North Pacific stock of gray whales

Introduction and Outline:

Legal counsel for the Makah Indian Tribe asked me to provide expert witness testimony in this proceeding, and my written testimony is divided into five sections.

The first three sections address the three currently identified gray whale management units in the North Pacific Ocean: (1) the Eastern North Pacific (ENP) stock; (2) the Pacific Coast Feeding Group (PCFG) and; (3) the Western North Pacific (WNP) stock. These sections provide a review of approaches taken to date regarding population dynamics modeling and assessments of conservation risk with respect to human caused mortality of whales within each management unit. Additionally, these sections provide background information and a comparison of the conservation management objectives of the IWC and the MMPA and how they overlap. They also include a comparison of the IWC's scientific approach to evaluating proposed aboriginal subsistence whaling hunt plans and the PBR management strategy under the MMPA.

The fourth section addresses the current hunt plan proposed by the National Marine Fisheries Service (NMFS) for Makah whaling. The IWC Scientific Committee evaluated NMFS's proposed hunt plan at its 2018 meeting (Ex. M-0532 (IWC 2018b)). The results of that evaluation demonstrate that the NMFS hunt plan, which is more restrictive than the previous Makah hunt plan in several respects (including additional provisions aimed at minimizing the conservation risk to WNP gray whales), meets the IWC's conservation management objectives for ENP, PCFG and WNP gray whales. This is an important result because, as I explain in the first three sections, a hunt plan that meets the IWC's management objectives will also meet the MMPA's conservation objective of maintaining a stock at its optimum sustainable population (OSP) or reaching that abundance level if the stock is below it.

The fifth and final section addresses several public comments that were submitted in response to NMFS's 2015 Draft Environmental Impact Statement (DEIS) on Makah whaling (NMFS 2015).

1. Eastern North Pacific Gray Whales

1.1. MMPA Management Objectives; ENP Abundance Relative to the Optimum Sustainable Population Level; Potential Biological Removal Level

The MMPA, 16 U.S.C. § 1361(6), states the primary objective of management of marine mammals should be to maintain the health and stability of the marine ecosystem and that, whenever consistent with that objective, it should be the goal to obtain an optimum sustainable population (OSP) keeping in mind the carrying capacity of the environment. As defined by the MMPA, 16 U.S.C. § 1362(9):

> *The term "optimum sustainable population" means, with respect to any population stock, the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element.*

Because the definition of optimum sustainable population incorporates consideration of the carrying capacity of the habitat and the health of the ecosystem, it seems apparent that a management strategy that is designed to obtain an optimum sustainable population will satisfy the MMPA's primary objective of maintaining the health and stability of the marine ecosystem. Thus, it is not surprising the MMPA management strategies (e.g. PBR, as discussed in more detail below) focus on obtaining an optimum sustainable population.

The definition of OSP relies on the concept of the "… maximum productivity of the population or species…." This concept also draws on the definition of the net productivity rate under the MMPA, 16 U.S.C. § 1362(26):

> *The term "net productivity rate" means the annual per capita rate of increase in a stock resulting from additions due to reproduction, less losses due to mortality.*

The maximum net productivity of a population will occur when its abundance is below the carrying capacity of the ecosystem; as the population increases in abundance and approaches its carrying capacity, its net productivity will decline. Thus, for regulatory purposes, NMFS has defined OSP as a range of population sizes between the population level resulting in the maximum net productivity at the lower bound and carrying capacity at the upper bound (50 CFR 216.3):

> *Optimum Sustainable Population is a population size which falls within a range from the population level of a given species or stock which is the largest supportable within the ecosystem to the*

population level that results in maximum net productivity. Maximum net productivity is the greatest net annual increment in population numbers or biomass resulting from additions to the population due to reproduction and/or growth less losses due to natural mortality.

The "population level" of a species or stock, relative to the carrying capacity of its environment, at which the maximum net productivity rate is assumed to occur, is also referred to as the "maximum net productivity level" or MNPL (Ex. M-0559 (Wade 1998); Ex. M-0551 (Punt and Wade 2010)). There is no statutory definition of carrying capacity in the MMPA. Stock assessment models of ENP gray whales assume that, carrying capacity is the largest population size that the ecosystem can support, on average, through time (e.g. Punt and Wade 2010). This assumption is consistent with the regulatory definition for the upper bound of OSP (50 CFR 216.3).

MNPL is generally thought to occur between 50% and 85% of carrying capacity, but it is difficult to estimate, given the limited data typically available for marine mammal stocks (e.g. Taylor and DeMaster, 1993 (Ex. M-0558)). Stocks for which an estimate of status, relative to MNPL, has been developed tend to have long time series of abundance and human caused mortality estimates available[1]. For ENP gray whales, data are available in sufficient quantity and quality to estimate with confidence that their abundance, following recovery from historical whaling, is above MNPL (Ex. M-0551 (Punt and Wade 2010)).

Available information for the ENP stock of gray whales includes the time series of abundance estimates from the southbound migration off Central California, which spans the last 50 years (Ex. M-0537 (Laake et al. 2012); Durban et al. 2015 (Ex. M-0516), 2017 (Ex. M-0517). Additionally, annual estimates of human caused mortalities are available, including decades of catch estimates from historical commercial whaling (e.g. Reeves et al. 2010 (Ex. M-0554)). The magnitude of historical catches provides information on the population level, relative to carrying capacity, at the nadir of abundance in the early 1900s following commercial whaling. Given these sources of

[1] The ability to estimate stock status relative to MNPL is not solely a function of the number of abundance and mortality estimates available. It also depends on such factors as the precision of abundance estimates – and in the case of recovering stocks, how far below carrying capacity a stock has been depleted prior to monitoring, the rate of recovery from depletion, *etc*. The exact number of years of monitoring data necessary to estimate stock status relative to MNPL is therefore case specific. In general, however, an estimate of a recovering marine mammal stock's status relative to MNPL requires monitoring data spanning multiple decades.

information, including the lengthy time series of abundance estimates, it is possible to model the population dynamics of ENP gray whales during recovery from commercial whaling (i.e. from the early 1900's to present), and hence assess this stock's status relative to OSP. In the most recent assessment that addresses OSP directly, Punt and Wade (2010) (Ex. M-0551) estimate there is an 88% probability that the ENP stock is at its OSP level, and that the population size is near the carrying capacity of its environment.

Further, the two most recent estimates of abundance, from southbound migrations, indicate the size of the population has increased by approximately 22% since 2010 (Ex. M-0517 (Durban et al. 2017)). The recent increase in abundance is consistent with recruitment from a sustained period of high calf production that has been ongoing since 2011 (Ex. M-0545 (Perryman et al. 2017)).

Given the difficulty in determining OSP for most marine mammal stocks — because of the lack of data such as that available for ENP gray whales — PBR was introduced in the 1994 amendments to the MMPA. Although this section of my testimony does not focus on PBR in detail, a brief introduction at this stage is nevertheless relevant in the broader context of the OSP management objective under the MMPA.

PBR was developed as a reference level for NMFS to assess whether the OSP conservation management objective would be expected to be achieved given estimates of incidental mortality in commercial fisheries. The PBR level is defined in the MMPA, 16 U.S.C. § 1362(20), as:

> *the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. The potential biological removal level is the product of the following factors:*
>
> > *(A) The minimum population estimate of the stock.*
> >
> > *(B) One-half the maximum theoretical or estimated net productivity rate of the stock at a small population size.*
> >
> > *(C) A recovery factor of between 0.1 and 1.0.*

It is worth noting that PBR was established to determine the number of animals that could be removed from a stock while allowing the stock "to reach or maintain" its OSP level. Thus, PBR is a management tool that is designed to achieve the MMPA's statutory objective of obtaining OSP, whether or not a stock's current status relative to OSP can be calculated based on current information. For ENP gray whales, a recent value of PBR was calculated to be 624 whales (Ex. M-0514 (Carretta et al. 2017)).

Sections 1.2.1 and 2.2 of my testimony provide a more detailed discussion of how PBR has been applied in practice. Specifically, I will discuss how that application compares to the approach used to evaluate catch limits for aboriginal subsistence whaling by the IWC. And more generally, I will discuss how the conservation management objectives of the IWC mirror the OSP management objective of the MMPA.

1.2. Management of Aboriginal Subsistence Whaling for ENP Gray Whales

1.2.1. IWC Management objectives; Comparison to OSP and PBR

The IWC establishes aboriginal subsistence whaling catch limits for whale stocks under its jurisdiction, including the ENP gray whale stock (Ex. M-0530 (IWC 2016)). In 2012, the IWC approved a 6-year block catch limit covering 2013 through 2018 for ENP gray whales based on information submitted by the United States and Russian Federation regarding the needs of aboriginal subsistence whaling communities in those countries (the Makah in the United States and Chukotka Natives in Russia; Ex. M-0526 (IWC 2013a)). In 2018, the IWC approved a 7-year block catch limit covering 2019 through 2025.

The IWC Scientific Committee has interpreted the management objectives for aboriginal subsistence whaling, as established by the Commission, into three principles in order to provide management advice (Ex. M-0521 (IWC 1995)):

> *(1) Ensure that the risks of extinction to individual stocks are not seriously increased by subsistence whaling;*
>
> *(2) Enable aboriginal people to harvest whales in perpetuity at levels appropriate to their cultural and nutritional requirements, subject to the other objectives; and*
>
> *(3) Maintain the status of stocks at or above the level giving the highest net recruitment and to ensure that stocks below that level are moved towards it, so far as the environment permits.*

Highest priority is given to the first objective: to ensure that aboriginal subsistence whaling does not increase the risk of extinction to individual stocks (*id.*). However, under the third objective, the abundance level resulting in the "highest" or "maximum" net recruitment is a key reference population level for management of aboriginal subsistence whaling under the IWC's conservation management objectives and can be compared to MNPL (the maximum net productivity level) under the MMPA. The IWC uses a different term than the MMPA for this population level. Instead of MNPL, the IWC refers to it as the "maximum sustainable yield level" or MSYL (e.g., Punt 1999 (Ex. M-0546); Punt and Wade 2012 (Ex. M-0552).

Under identical assumptions regarding the mathematics of population dynamics, MNPL and MSYL are equivalent. As an illustrative example, in the most recent assessment of the population status of the ENP gray whale stock under the MMPA, Punt and Wade (2010) (Ex. M-0551) present estimates of abundance relative to MNPL. Based on the same analyses, Punt and Wade (2012) (Ex. M-0552) present these numerical estimates in the peer-reviewed scientific publication of the IWC. For the IWC audience, the numbers are presented in terms relative to MSYL, rather than MNPL. The numbers are identical in both reports — only the nomenclature differs. For consistency, I will refer to this reference level, shared by MMPA and IWC conservation management objectives, in terms of MNPL.

MNPL serves as the reference population level for the third IWC conservation management objective for aboriginal subsistence whaling, as well as for the OSP management objective under the MMPA. As noted above, under Section 1.1, in the MMPA, OSP is defined in terms of the number of animals that will result in the "maximum productivity" of a population. And, in NMFS's regulations, MNPL is the abundance level at the lower bound of the range considered to satisfy the OSP management objective of the MMPA (50 CFR 216.3). Therefore, the MMPA and IWC conservation management objectives are effectively identical in this respect and can be jointly summarized as: limiting the extent of human caused mortality such that the goal of maintaining or recovering stocks to population levels at or above MNPL will be achieved.

Under the MMPA, this shared conservation management objective is expressed in the statutory definition of Potential Biological Removal (provided in Section 1.1 above) as well as in the statutory and regulatory definitions of OSP. As explained above, PBR was developed to assess whether or not incidental mortality levels (e.g. bycatch) in commercial fisheries are sufficiently small to allow a "stock to reach or maintain its optimum sustainable population" level [MMPA, 16 U.S.C. § 1362(20)[2]].

As also explained above, PBR is defined in the MMPA as the product of three terms: (1) The minimum population estimate of the stock (N_{MIN}); (2) One-half the maximum theoretical or estimated net productivity (growth) rate of the stock at small population size ($0.5 * R_{MAX}$); and (3) A recovery factor (F_R) of between 0.1 and 1.0. Although the MMPA prescribes the general formula for

[2] In other words, if a stock is below MNPL (below OSP), mortality from commercial fisheries bycatch or other human activity that is at or below the PBR level should not prevent the stock from recovering to a population level that is at or above MNPL (*i.e.*, OSP). Likewise, if a stock is above MNPL (at OSP), mortality at or below the PBR should not result in a decline below MNPL (below OSP).

calculating PBR,[3] it does not specify detailed quantitative definitions of the terms used in the formula (Ex. M-0559 (Wade 1998)). For example, the term "minimum population estimate" (N_{MIN}), is only qualitatively defined under the MMPA, 16 U.S.C. § 1362(27):

> *The term 'minimum population estimate' means an estimate of the number of animals in a stock that – (A) is based on the best available scientific information on abundance, incorporating the precision and variability associated with such information; and (B) provides reasonable assurance that the stock size is equal to or greater than the estimate.*

Wade (1998) (Ex. M-0559) used computer simulations to provide quantitative specifications for the constituent terms of PBR. For example, the simulations were used to "tune" the N_{MIN} parameter as a function of an abundance estimate and its precision, such that the resulting PBR value would be sufficiently precautionary to meet the OSP management objective with 95% confidence. Through these simulations, Wade (1998) found that using the 20th percentile (the lower 60% log-normal confidence limit) of abundance estimates provided a sufficiently precautionary quantitative specification for N_{MIN}. The values currently in use for R_{MAX} and F_R were also evaluated through the simulations, and the simulations were designed to be generic enough that the resulting quantitative specifications for PBR could be applied across a range of stocks with confidence that the OSP management objective would be met.

The IWC also uses computer simulations to evaluate proposed hunt plans and catch limits for aboriginal subsistence whaling (e.g. Punt and Donovan 2007 (Ex. M-0549)). Those evaluations, including proposed hunt plans and catch limits for gray whales, follow the same general approach used to determine the quantitative specifications currently adopted for PBR. The technical details of these two approaches are not identical, however, and I discuss the differences between simulation testing of PBR and aboriginal subsistence whaling catch limits in more detail under Section 2. Nevertheless, like the simulations used to derive the quantitative specifications for PBR, the IWC evaluations are also based on simulating the performance of proposed catch limits and management strategies relative to their ability to allow stocks to reach or maintain a population level at or above MNPL (i.e. OSP). In other words, the IWC evaluations of aboriginal subsistence whaling catch limits are both consistent with meeting the OSP conservation management objective under the MMPA and, likewise, they employ the same general scientific methods used to develop the quantitative specifications for the current PBR formula. In the next section, I provide background on the computer simulation

[3] $PBR = N_{MIN} * 0.5 * R_{MAX} * F_R$

approach used to evaluate PBR under the MMPA, and aboriginal subsistence whaling catch limits under the IWC.

1.2.2. IWC Management Strategy Evaluation of Aboriginal Subsistence Hunt Plans

IWC catch limits for aboriginal subsistence whale hunts, including those for gray whales, follow the recommendations of the IWC's Scientific Committee. The Scientific Committee's recommendations for ENP gray whale catch limits are based on the approach known in fisheries science as "Management Strategy Evaluation" (MSE). The MSE approach was also used when evaluating the PBR management scheme as currently implemented and its ability to meet the OSP management objective of the MMPA (Ex. M-0559 (Wade 1998)).[4] MSE is also regularly employed to provide management advice for commercial finfish and shellfish fisheries in the United States and abroad (Ex. M-0548 (Punt et al. 2016)).

A management strategy in this context relates to specifications for the data to be collected and how those data are used to inform a set of rules for calculating limits on human caused mortality. MSE provides a scientific means to assess the expected performance of management strategies relative to management objectives, like maintaining stocks at or above MNPL (Ex. M-0549 (Punt and Donovan 2007); Ex. M-0548 (Punt et al. 2016)). Computer simulation is used to perform experimental stress tests to determine if a management strategy can be expected to satisfy management objectives, even if the current assessment of a stock's status is not accurate (e.g. under a scenario where data are subject to bias). In this regard, MSE is consistent with the "precautionary principle" (Holt and Talbot 1978) (Ex. M-0520), in that management strategies are evaluated relative to whether they are robust to scientific uncertainties (Ex. M-0509 (Butterworth 2007)).

MSE involves several steps: (i) developing a model of the system, which represents the "truth" for the purposes of simulation (the "operating model"); (ii) specifying the range of uncertainties to be considered and thereby which "trials" will be undertaken to test a candidate management strategy; (iii) defining performance metrics that quantify the management objectives; (iv) conducting projections of each candidate management strategy across the set of trials to evaluate performance relative to management objectives; and (v) providing the results in the form of scientific recommendations to decision makers (Ex. M-0548 (Punt et al. 2016)).

MSE has been used extensively to evaluate the ability of proposed management strategies related to commercial and aboriginal subsistence whaling in terms of their abilities to satisfy the management objectives of the IWC for these two separate categories of whaling (Ex. M-0549 (Punt and

[4] A comparison of the MSE approaches used for PBR and ASW is discussed in more detail under Section 2.

Donovan 2007)). In addition to ENP gray whales, MSE has also been used to evaluate aboriginal subsistence whaling catch limits for the Bering-Chukchi-Beaufort seas (BCB) stock of bowhead whales in Alaska and Russia (e.g. IWC 2002) (Ex. M-0522), as well as for aboriginal subsistence hunts of humpback, fin, minke, and bowhead whales off Greenland (Ex. M-0532 (IWC 2018b)). Although the Scientific Committee of the IWC only just recently completed MSEs for the Greenlandic aboriginal subsistence hunts, the catch limits that have been implemented for ENP gray whales and the BCB bowhead whales have a long track record of sustainability. The first MSEs for BCB bowhead and ENP gray whales were completed in 2002 and 2004, respectively. Since their implementation nearly two decades ago, the resulting catch limits for these stocks have proven to meet conservation management objectives for population growth and recovery while also satisfying aboriginal subsistence need (e.g., Carretta et al. 2017 (Ex. M-0514); Muto et al. 2017 (Ex. M-0543)).

An important component of the MSE process in the IWC is known as an "Implementation Review". After the initial MSE and "Implementation" of a catch limit for an aboriginal subsistence hunt, the IWC requires regular Implementation Reviews. The purpose of these reviews is to consider any new information that has become available since the previous Implementation Review (or the initial MSE). As such, regular Implementation Reviews provide the Scientific Committee the opportunity to review any new information on the relevant stock and evaluate whether it warrants a change in the management advice to the IWC. The goal of an Implementation Review is to determine if any of the new information indicates that the current state of nature[5] is outside the bounds of plausibility considered to date (Ex. M-0549 (Punt and Donovan 2007); IWC 2013b, p. 170-171 (Ex. M-0527)).

These reviews are scheduled on a regular basis, often coinciding with IWC's consideration of a request to renew a block catch limit. Currently the default interval is every six years, but Implementation Reviews may be called at any time if new information is presented that warrants a re-evaluation of the current management strategy (e.g. introducing additional trials and simulation testing for existing catch control rules to take into account previously unevaluated scenarios). This is a form of adaptive management and serves a similar purpose as the regular updating and review of Stock Assessment Reports (SARs) under the MMPA, including updating the comparison of estimates of human caused mortality relative to PBR. An

[5] A "state of nature" represents such factors as natural mortality, reproductive rates, and stock structure. MSE involves developing multiple versions of an operating model, which reflect alternative plausible hypotheses about the 'true' state of nature. In particular, new information has become available over the last decade that indicates the state of nature of gray whale stock structure may be more complicated than previously hypothesized. This is discussed below in terms of the Implementation Review with a focus on the PCFG, as well as the recent evaluation based on the Rangewide modeling, which incorporated new information on WNP gray whales,

Implementation Review, however, is typically a much more data- and modeling-intensive review than the domestic SAR process.

Catch control rules for aboriginal subsistence whaling under the IWC, in combination with data collection schemes, are known as "Strike[6] Limit Algorithms" (SLAs). The *Gray Whale SLA*, which has been used to set aboriginal subsistence whaling catch limits for ENP gray whales, was subject to an MSE under the IWC prior to its initial implementation (Ex. M-0523 (IWC 2005)). During a subsequent Implementation Review, which was completed in 2010[7], there was no change in management recommendations with respect to the *Gray Whale SLA* being the most appropriate tool for calculating catch limits for ENP gray whales (Ex. M-0524 (IWC 2011)). The 2013-2018 IWC catch limit for the ENP stock of gray whales, which was based on the joint request by the Russian Federation on behalf of the Chukotka Natives and the United States on behalf of the Makah Tribe, was set over a six-year block, with a catch limit of 744 whales over the block period and no more than 140 whales in any given year. In 2018, the IWC approved a catch limit for the ENP stock of gray whales for a seven-year block.[8] The new catch limit was for 980 whales over the block period and no more than 140 whales in any given year. These limits reflect the demonstrated subsistence need of the Chukotkan and Makah communities. For comparison, as noted above, the recent value of PBR for this stock in any given year is 624 whales, more than four times the IWC's annual catch limit (Ex. M-0514 (Carretta et al. 2017)).

The average subsistence harvest of gray whales by Chukotka Natives in the years 2000 – 2015 was 125 whales per year.[9] As discussed above, the most recent assessment of the population's status relative to OSP (Punt and Wade 2010 (Ex. M-0551); 2012 (Ex. M-0552)) and current trends in estimates of abundance (Durban et al. 2017 (Ex. M-0517)) indicate that the IWC catch limits for ENP gray whales have been sufficiently conservative to maintain ENP gray whales above MNPL, i.e., at their OSP level. Furthermore, the Scientific Committee has recently evaluated aboriginal subsistence whaling

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[6] The Scientific Committee's evaluation of a hunt's impact focuses on strikes and typically makes the precautionary assumption that every strike results in a kill, regardless of whether or not the whale is landed, i.e., a "catch." This is another example of how MSE, as applied by the IWC, is consistent with the 'precautionary principle.'

[7] Information was presented during the 2010 ENP gray whale Implementation Review that resulted in the Scientific Committee immediately calling for a subsequent Implementation Review, but only after it reiterated that its management advice on the *Gray Whale SLA* was still appropriate for ENP gray whale catch limits. The subsequent Implementation Review focused on the Makah hunt and the PCFG and is discussed in Section 2 below.

[8] The 7-year length is only for 2019-2025; subsequent catch limit blocks will revert to 6 years (Ex. M-0534 (IWC 2018d (Chair's Report, Annex P)); Ex. M-0535 (IWC 2018e (IWC/67/01 Rev 01) pp. 4, 10)).

[9] Source: https://iwc.int/table_aboriginal

catch limits for ENP gray whales under the assumption that this stock would be subject to combined catches by Makah and Chukotkan whaling; as discussed below, those evaluations indicate that the management of catch limits that have been proposed for Makah whaling pose no concern with respect to maintaining ENP gray whales above MNPL (IWC 2014a (Ex. M-0531); 2018b (Ex. M-0532)).

2. The Pacific Coast Feeding Group Gray Whales

2.1. Lack of Data to Determine Optimum Sustainable Population Level

The second currently identified management unit of gray whales in the North Pacific Ocean is the Pacific Coast Feeding Group (PCFG). However, unlike ENP gray whales, NMFS does not consider the PCFG to be a stock under the MMPA. Rather, NMFS considers the PCFG to be a feeding group of ENP gray whales (Ex. M-0561 (Weller et al. 2013)).

Unlike the available data for the greater ENP stock of gray whales, the available data for the PCFG is not sufficiently informative to determine whether the abundance of this feeding group is above or below MNPL, i.e., to determine whether it is at an OSP level (Ex. M-0550 (Punt and Moore 2013)). As noted by Punt and Moore (2013), because the PCFG is not a 'closed'-population (i.e. immigration and emigration occur), estimates of its status relative to MNPL are confounded by uncertainty in factors like bycatch mortality and annual rates of immigration into the PCFG from the greater ENP stock.

I am not aware of another example where a formal quantitative OSP status determination has been attempted (much less successfully estimated relative to MNPL) for a non-stock feeding group of marine mammals in the United States or elsewhere. I believe this would be unusual, if not unprecedented.

Most large whale stocks, and most marine mammal stocks in general, have an undetermined status relative to MNPL due to insufficient data in this regard. NMFS publishes stock assessment reports (SARs) for three regions: Alaska, the Atlantic and Gulf of Mexico, and the U.S. Pacific (including Hawaii but not Alaska). Of the 87 marine mammal stocks that have been assessed in the U.S. Pacific region, a formal quantitative OSP determination of stock status relative to MNPL has only been attempted for a handful (e.g. Carretta et al. 2017 (Ex. M-0514)). Harbor seals in Oregon (Brown et al. 2005) (Ex. M-0508) and Washington (Jeffries et al. 2003) (Ex. M-0536) previously were assessed to be at OSP but those determinations are considered outdated under NMFS's Guidelines for Assessing Marine Mammal Stocks because the most recent abundance estimates are more than eight years old (Ex. M-0544 (NMFS 2016); Carretta et al. 2017)). The northern California/southern Oregon stock of harbor porpoise has undergone a formal OSP status determination, and it is currently considered to be at OSP (Carretta et al. 2017). And most recently in the U.S. Pacific region, a first OSP status determination has been conducted for California Sea lions (Ex. M-0538 (Laake et al. 2018)). Nevertheless, including ENP gray whales, these examples add up to only five stocks representing only six percent of stocks in the U.S. Pacific region having an available quantitative estimate of stock status relative to MNPL. I am not aware of any stocks in either the Alaska or Atlantic and Gulf of Mexico regions that have an OSP status determination presented in the SARs that is based on a quantitative analysis (e.g. fitting a population dynamics model to available data, in order to estimate the abundance level as a fraction of carrying capacity, as has been done for ENP gray whales).

2.2 Managing Stocks to Achieve OSP Management Objectives: Generic and Case-Specific MSEs

The challenge of assessing stock status relative to MNPL, i.e., of assessing whether a stock is at its OSP level, was one of the motivating factors in developing the PBR management scheme more than two decades ago (Ex. M-0558 (Taylor and DeMaster 1993)). It takes much less data to calculate PBR than it does to estimate a stock's status relative to MNPL. Nevertheless, through the use of MSE, PBR has been shown to be a relatively simple and straightforward approach to calculating levels of human caused mortality that are consistent with the OSP management objective of the MMPA (Ex. M-0559 (Wade 1998)). Similar considerations led the IWC to start evaluating candidate management strategies for whaling based on principles analogous to those that precipitated the development of PBR (Ex. M-0549 (Punt and Donovan 2007)). Although PBR and SLAs for aboriginal subsistence whaling share common underpinnings, there are also some important differences. In this section I explain and compare these approaches.

PBR was developed with the goal of being generically applicable to all marine mammal stocks found in the U.S. Exclusive Economic Zone. As context, after PBR was introduced in the 1994 amendments to the MMPA, the first set of marine mammal SARs included about 165 stocks.[10] At the time of the 2014 SARs, the number of stocks identified had increased to 248 (Ex. M-0557 (Simmons 2016)). The quantity and quality of data available for each stock is also variable (Ex. M-0514 (Carretta et al. 2017); Ex. M-0519 (Hayes et al. 2017); Ex. M-0543 (Muto et al. 2017)). Developing case-specific MSEs for all of these stocks, or even the subset of stocks with frequent interactions with

[10] Source: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessments

commercial fisheries, currently appears to be an unrealistic proposition given the limited available agency resources.

The quantitative implementation of PBR was developed as an approach that is not data intensive compared to the estimation of a stock's status relative to MNPL (i.e. an OSP status determination); PBR only requires a minimally sufficient amount of information necessary to provide an assessment of incidental human caused mortality relative to the OSP management objective of the MMPA. For example, the current default values (e.g. for N_{MIN}) were evaluated based on calculating PBR from only the single most recent abundance estimate (Ex. M-0559 (Wade 1998)). An OSP status determination requires many more years (often decades worth) of abundance estimates.

The development of PBR is consistent with a mortality reference level being applied to stocks with limited time-series abundance estimates and estimates of incidental levels of human caused mortality. As noted above, PBR can be calculated given only a single recent estimate of abundance (Ex. M-0554 (NMFS 2016)). The lowest common denominator for assessment of bycatch relative to the MMPA conservation management objectives under the PBR management scheme is therefore two data points: a single recent estimate of abundance to calculate PBR, and, for comparison, a single recent estimate of human caused mortality (NMFS 2016). However, in order for approaches such as PBR to achieve conservation management objectives across a wide spectrum of data availability scenarios (e.g. including higher degrees of uncertainty common for data-limited stocks), such approaches may need to be more precautionary than case-specific MSEs that have been applied to aboriginal subsistence whaling for more data-rich stocks (Ex. M-0549 (Punt and Donovan 2007)).

Aboriginal subsistence whaling catch limits under the IWC, in contrast to PBR, have been evaluated using case-specific approaches. This allows, for example, the full time-series of available abundance and human caused mortality data (including any information on age- and sex-structure of human caused mortality) to be incorporated when estimating the parameters of the operating model, and forms the quantitative basis to simulate future abundance trajectories in the MSE. Likewise, case-specific approaches allow for underlying spatial and temporal patterns in abundance to be modeled for feeding groups (where stock structure might be uncertain), as has been the case for ENP gray whales and the PCFG.

The approach taken for aboriginal subsistence whaling also allows for case-specific trials to be tailored such that uncertainties for the affected stock (or stocks) can be evaluated. For example, during the 2010 – 2013 IWC

Implementation Review for ENP gray whales with an emphasis on the PCFG, scientific uncertainties in the availability rates of the PCFG to the Makah hunt were evaluated (i.e. the performance of the 2005 hunt plan[11] was evaluated under trials which assumed the availability of PCFG whales to the hunt would be twice that estimated from available photo-identification data). This was shown to be an important consideration in the performance of the hunt plan relative to conservation objectives. Based on the results of the MSE, the IWC Scientific Committee's management recommendations included a research provision for future monitoring of the proportion of PCFG whales in the area of the Makah hunt (Ex. M-0528 (IWC 2014a)). One benefit of the case-specific approach is that an evaluation of the management strategy extends beyond the performance of the rules controlling catch limits. It also allows for a means of assessing whether case-specific data collection strategies are sufficient to meet management objectives and if they are not, to recommend modifications.

Case-specific MSEs, like those used by the IWC in evaluating the effect of proposed catch limits on the PCFG, may result in different mortality limits than PBR. Under certain circumstances, human caused mortality limits can be greater than PBR, while still meeting the MNPL management objective. Brandon et al. (2017) (Ex. M-0506) demonstrate an example along these lines: if multiple imprecise estimates of abundance are averaged to calculate N_{MIN}, a higher value than the 20^{th} percentile for N_{MIN} could be used in calculating PBR. Hence a larger mortality limit could be allowed in such cases, while still meeting the OSP management objective relative to MNPL. The reverse can also be true; for example, if reproductive females are particularly vulnerable to human caused mortality, PBR as evaluated would not be sufficiently conservative, unless an additional adjustment is made to decrease the recovery factor (F_R) value (Ex. M-0544 (NMFS 2016); Brandon et al. 2017)).

Given these and other factors, catch limits evaluated based on case-specific MSEs for aboriginal subsistence whaling might be above or below the corresponding value calculated for PBR. Nevertheless, if a case-specific management strategy for aboriginal subsistence whaling is evaluated to meet the conservation management objectives of the IWC, it will also meet the OSP objective of the MMPA because of the shared MNPL performance criteria. This holds true even if, in combination with estimates of incidental human caused mortality levels, case-specific aboriginal subsistence whaling catch limits exceed PBR to some degree.

[11] The "2005 hunt plan" or "Makah hunt plan" refers to the catch limit rules proposed in the Makah Tribe's 2005 application for a waiver of the MMPA's take moratorium.

2.3. IWC Evaluation of the Impacts of the 2005 Makah Hunt Plan on the PCFG

2.3.1 The 2010-2013 Implementation Review

The main focus of the IWC Scientific Committee's research during the 2010—2013 Implementation Review involved extending the previous case-specific ENP gray whale MSE (i.e. that used to evaluate the *Gray Whale SLA*; IWC 2005 (Ex. M-0523)) to also model the effects of the 2005 Makah hunt plan on PCFG gray whales. Although most ENP gray whales utilize summer feeding grounds in the Bering, Beaufort and Chukchi Seas, some utilize more southerly summer feeding grounds. At the Scientific Committee's 2010 meeting, an analysis of genetics data was presented, which compared samples between gray whales on a southern feeding ground (Clayoquot Sound) off British Columbia, with samples from wintering areas, including nursery lagoons around Baja California, Mexico (Ex. M-0518 (Frasier et al. 2010)). Based on that analysis, which showed a small but statistically significant genetic difference in the samples compared, the Scientific Committee agreed that a precautionary strategy would be to develop an updated operating model that incorporated the hypothesis of stock structure within the ENP population in order to evaluate the impact of aboriginal subsistence whaling catch limits that might be allocated between Russia and the United States on the PCFG. (Ex. M-0524 (IWC 2011, pp. 17–20)). The modeling framework that was developed for this Implementation Review assumed there were two stocks in the greater ENP population: the larger 'Northern' feeding group and the smaller, more southerly PCFG. The PCFG was assumed to be composed of individuals observed to have some defined level of seasonal fidelity to feeding areas between Northern California and Northern British Columbia (Ex. M-0527 (IWC 2013b)).

The Makah hunt plan was incorporated in this MSE based on the specifications of the Makah's 2005 application for a waiver of the MMPA's take moratorium (Ex. M-0527 (IWC 2013b)). Specifically, the IWC gray whale Implementation Review conducted from 2010 to 2013 focused on evaluating whether the proposed Makah hunt plan was sustainable in terms of meeting conservation management objectives for the PCFG, under the assumption that the PCFG was a separate stock (*id.*). The Scientific Committee made no formal statement as to whether the PCFG should be considered a separate stock by the IWC. Rather, the Scientific Committee agreed that the most precautionary strategy would be to proceed by evaluating the catch limits under the assumption that the PCFG was a separate stock.

The Implementation Review process involved multiple meetings of the full Scientific Committee, as well as intersessional meetings of smaller working groups composed of domestic and international scientists with expertise in gray whale ecology, biology, genetics and population dynamics modeling, including applied mathematicians and statisticians. In particular, the Standing Working Group on the Aboriginal Whaling Management Procedure ("AWMP") is responsible for developing case-specific MSEs, which form the basis for Implementation Reviews of aboriginal subsistence whaling. The AWMP Standing Working Group, and the other working groups and subcommittees of the Scientific Committee, convene prior to the annual meeting of the full Scientific Committee. During this annual meeting, the AWMP Standing Working Group considers, among other research, the progress of intersessional working groups tasked with developing MSEs in preparation for an Implementation Review. Any resulting recommendations of the AWMP Standing Working Group are reported to the full Scientific Committee, which convenes after the completion of the working group and subcommittee meetings. If the full Scientific Committee reaches agreement on any of its working group or subcommittee recommendations, including catch limits, these are provided as recommendations to the Commission in the annual report of the Scientific Committee.

Much of the Scientific Committee's deliberations during the 2010-2013 gray whale Implementation Review revolved around how best to model information relevant to the available time series of abundance estimates resulting from photo-identification sampling efforts focused on PCFG whales (Ex. M-0527 (IWC 2013b); Ex. M-0510 (Calambokidis et al. 2010)). At the time, the Implementation Review with a focus on the PCFG involved the most extensive and detailed MSE developed for providing management advice on aboriginal subsistence whaling catch limits for gray whales. The number of data inputs compared to the MSE used during the initial implementation of the *Gray Whale SLA* had doubled. The number of modeling scenarios representing uncertainties had likewise expanded compared to the previous Implementation Review, which had assumed only a single stock. In total, there were 119 trials[12] representing various uncertainties in: available photo-identification data; population demographics, including hypotheses regarding internal and external recruitment rates for the PCFG; availability rates of the PCFG to whaling by the Makah; struck and lost rates; intrinsic rates of population growth; episodic mortality events, and other factors (see Tables 3 and 4 in IWC 2013b, p. 139).

2.3.2 IWC performance criteria

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[12] For comparison, the MSE for PBR considered nine base-case bias trials with respect to the MNPL objective under the MMPA (Ex. M-0559 (Wade 1998, Table 2, p. 11)).

A key MSE performance metric that has formed the basis of the current PBR management scheme, as well as the IWC's MSEs for ENP gray whales (including the 2010-2013 Implementation Review with a focus on the PCFG), is that there should be 95% certainty that abundance will be above MNPL after 100 years. For each trial[13] in these MSEs, a set of simulated population trajectories results in a range of final abundance levels at the end of the projection period. The range of projected final abundance levels results from future uncertainties (abundance estimates, catches, etc.) being modeled probabilistically. The lower 5th percentile of the resulting range of abundance is compared with the MNPL management goal, to determine whether the candidate management strategy is able to satisfy the performance criteria with 95% certainty and meet the conservation management objective, given the assumptions underlying a given trial (Ex. M-0559 (Wade 1998); Ex. M-0527 (IWC 2013b)).

Additional performance metrics have also been considered for aboriginal subsistence whaling under the IWC: metrics for subsistence need satisfaction have been taken into account, as well as trends in abundance at the end of the projection period. These metrics have been used to evaluate the performance of management strategies relative to the first two management objectives of the IWC for aboriginal subsistence whaling (IWC objectives 1 and 2, above). During the 2010-2013 ENP gray whale Implementation Review, all three types of performance metrics were considered. The conservation performance metrics (not increasing extinction risk, and moving to or maintaining stocks above MNPL) were generally given a higher priority than subsistence need satisfaction during that Implementation Review. This is consistent with the priorities of the IWC management objectives for aboriginal subsistence whaling (IWC 1995 (Ex. M-0521); 2013b (Ex. M-0527)).

The following table provides a summary of the conservation performance metrics mentioned in the preceding paragraph. These performance metrics (also called performance statistics) are also described in more detail under Section 4.4:

Table 1.

Performance metrics used by the IWC to evaluate the conservation risks of gray whale aboriginal subsistence hunt plans and catch limits.

Performance Metric	What it shows	Why it was used

[13] Trials are described in further detail under Sections 1.2.2 and 4.1.

Final Depletion	Abundance relative to carrying capacity at the end of the projection period.	Evaluate whether hunt would allow stocks to reach or exceed MNPL, i.e. to reach or maintain OSP.
Relative Depletion	Abundance relative to carrying capacity, with whaling, at end of the projection period divided by the expected abundance relative to carrying capacity, with no whaling, at the end of the projection period.	Evaluate whether hunt plan would increase the risk of extinction by comparing population levels expected with and without whaling.
Relative Increase	Whether abundance will increase or decrease under hunting.	Evaluate whether hunt plan would allow population levels below MNPL to be recovering towards OSP.

2.3.3 Conclusions of the 2010-2013 Implementation Review with a focus on the PCFG

The Implementation Review with a focus on the PCFG eventually spanned three years and was completed when the Scientific Committee was able to reach full agreement on management advice in 2013 (IWC 2013b (Ex. M-0527), 2014a (Ex. M-0528)). The Scientific Committee agreed that the proposed 2005 Makah hunt plan met the conservation management objectives of the IWC for aboriginal subsistence whaling, i.e. the proposed Makah hunt plan would not increase extinction risk or result in a PCFG abundance level below MNPL after 100 years. Because of the overlap between the IWC's conservation management objectives and those of the MMPA, the Scientific Committee's conclusion provides compelling evidence that the 2005 hunt plan also met the MMPA's conservation objectives for the PCFG.

The Scientific Committee's evaluation also demonstrated, however, that the 2005 Makah hunt plan was sensitive to potential bias in the estimates of availability of PCFG whales to the hunt. The Scientific Committee's conclusion was therefore conditioned on a research provision, which requires a continuation of the annual photo-identification surveys in order to monitor the relative probability of the Makah hunt encountering a PCFG whale (IWC 2013a (Ex. M-0526), 2014a (Ex. M-0528)).

A related factor that complicated the IWC evaluation of the 2005 Makah hunt plan stemmed from a proposed catch limit rule regarding whether or not a struck and lost whale would be presumed to be a PCFG whale. The Makah hunt plan, as then proposed, would have allowed whaling to occur during the migratory period: Dec. 1st – May 31st. Acknowledging that PCFG whales are more likely to be encountered closer to the summer feeding season, NMFS proposed that any whale struck and lost during the month of May would have to count towards the PCFG mortality limit in the plan (based on a PBR calculation); however, if a whale was struck and lost during any other month (Dec – Apr) it would not count towards the PCFG limit (i.e. that whale would be assumed to be an individual from the 'Northern' feeding group on migration; IWC 2013b (Ex. M-0527)).

A difficulty with the proposed catch limit rules that were evaluated during the 2010—2013 Implementation Review arose from the fact that there were insufficient data *a priori* to inform when Makah whaling effort might be expected to occur by month. Therefore, it was not possible to predict the proportion of strikes that might occur during the proposed Dec–Apr *vs.* May split (i.e. there was an outstanding question regarding what proportion of struck and lost whales might be assumed to be PCFG and therefore count towards the PBR-based limit under the proposed rule). In order to take this uncertainty into account, the Tribe proposed evaluating two variants of the hunt plan. Each variant represented an extreme case as to when the hunt might occur with respect to the assumption of whether or not struck and lost whales would be assumed to be from the PCFG (Ex. M-0527 (IWC 2013b); Ex. M-0507 (Brandon and Scordino 2013)).

The two variants of the proposed 2005 Makah hunt plan therefore bracketed the range of possible strikes by month. At one end of the extreme, Variant 1 was tantamount to assuming all hunting (up to 7 strikes) would occur during Dec-Apr, when struck and lost whales would not be assumed to be individuals from the PCFG. At the other end of the extreme, Variant 2 assumed all hunting would occur during May, and every struck and lost whale would be assumed to be PCFG. At the 2012 Scientific Committee meeting it was noted that that neither of these variants modeled the Makah hunt exactly as it had been proposed because the plan did not specify month-by-month use of available strikes (Ex. M-0526 (IWC 2013a)). Brandon and Scordino (2013) (Ex. M-0507) demonstrated, and the Scientific Committee subsequently agreed, that the IWC's evaluation of the 2005 Makah hunt plan (as modified to add the struck and lost presumption) is not sensitive to the month-by-month distribution of available strikes; ultimately, this issue did not change the IWC's conclusion that the 2005 hunt plan met the conservation management objectives of the IWC (Ex. M-0528 (IWC 2014a)).

3. Western North Pacific Gray Whales

During the course of the 2010-2013 IWC Gray Whale Implementation Review with a focus on the PCFG, new evidence was presented demonstrating that at least some gray whales considered to be a part of the WNP stock migrate to the eastern North Pacific as far south as the wintering grounds in Mexico (e.g., Mate et al. 2011 (Ex. M-0540)). Although putative WNP gray whales that feed off Sakhalin Island have not been observed to date in the portion of Makah's Usual and Accustomed fishing grounds where the hunt will take place (Makah U&A), they have been observed in the Pacific Northwest off Vancouver Island, Canada (Ex. M-0560 (Weller et al. 2012)). These observations have raised conservation concerns that WNP gray whales, listed as endangered by NMFS under the Endangered Species Act (ESA), could be vulnerable to Makah whaling.

3.1 Estimate of the Probability of a Take in the Makah Hunt

The conservation risk of the Makah hunt plan for WNP gray whales was not evaluated during the 2010-2013 Gray Whale Implementation Review. Instead, given the focus of that Implementation Review on the PCFG, a full evaluation of the conservation risk to WNP gray whales was deferred to a later date, when a set of workshops to review the rangewide population structure and status of North Pacific gray whales would be completed (Ex. M-0529 (IWC 2014b, p. 191)). However, given the available evidence at the time, the Scientific Committee also emphasized the need to estimate the probability of a WNP gray whale being taken by Makah whaling (Ex. M-0525 (IWC 2012, p. 137)).

To address this need and also to inform the analyses for NMFS's DEIS for proposed Makah whaling, Moore and Weller (2013) (Ex. M-0541) developed a modeling framework to estimate the probability of taking a WNP gray whale in the Makah hunt proposed in 2005. They considered multiple models while noting their preference for one model in particular:

> *"We consider Model 2B the most plausible of all models because model set 2 makes use of all available information and 2B contains fewer assumptions than 2A."*
>
> - Moore and Weller (2013, p. ii, also pp. 7, 11)

The resulting estimate was based on several factors, including: (i) the relative abundance of ENP and WNP gray whales (as of 2007 and 2012, respectively); (ii) the proportion of non-PCFG (migrant) whales recorded in the photo-identification catalogue in the Makah U&A during the proposed hunting season; and (iii) the maximum number of non-PCFG gray whales that could be taken, as allowed under the proposed 2005 hunt plan. Additionally, probabilities were estimated for the expected number of unsuccessful strikes (a strike that either misses or fails to penetrate a whale) as well as non-lethal approaches (pursuit, but no attempt to strike a whale). The analyses included a range of uncertainties across these factors and calculated probabilities using Bayesian inference, which allowed for the integration of the various sources of uncertainty in the estimation process. Moore and Weller (2013, p. 11) stated that the "[e]stimates from our analysis are considered precautionary" and the results "offer a conservative initial step in assessing the potential risk of WNP gray whales incurring mortality incidental to the proposed hunt . . . "

Moore and Weller (2013) (Ex. M-0541) presented the results of all models considered, including versions A and B for two of the models (Moore and Weller 2013, pp. 8-10). Based on the results of the preferred model (2B), they estimated that the probability of striking a WNP whale during a given take event was 0.2%.[14] In one season under the 2005 hunt plan, the probability of striking at WNP whale was between 0.7% and 1.2% (based on a range of 3 to 7 strikes). Over a 5-year period, the probability of a strike ranged from 3.6% to 5.8%. The analysis also provided the expected number of struck WNP whales under the various scenarios (*i.e.*, over 1 or 5 years). Here, the results were 0.01 in one year and between 0.04 and 0.06 over five years of hunting. In the 2014 stock assessment report for WNP gray whales, NMFS translated the single-year strike probability (there, reported as a range of 0.006 to 0.012) to a more tangible number, stating that it "corresponds to an expectation of ≥ 1 WNP whale strike in one of every 83 to 167 years (Ex. M-0513 (Carretta et al. 2015, p. 185)). Based on the model results, Moore and Weller (2013, p. 8) concluded that the probability of striking a WNP gray whale over a 5 year period under the 2005 Makah hunt plan was "relatively low but non-trivial."

Moore and Weller (2018) (Ex. M-0542) subsequently presented updated estimates of the probability of a WNP gray whale being struck in a Makah hunt.[15] The reported median probabilities of striking at WNP whale in a single interaction, over one year, and over a 10-year waiver period, are 0.4%, 1.2% and 5.7%, respectively (Moore and Weller 2018, p 5). The point estimate for the expected number of WNP strikes if all 15 available strikes are used in the even year (migration season) hunts over the 10-year waiver period is 0.06 WNP whales. Using the same translation of the single-year strike probability as NMFS's 2014 stock assessment report, the 2018 results would correspond

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[14] All modeling results presented here are median values. Moore and Weller (2013) also reported the upper 95th percentile value. They noted that for model sets 1 and 2, median parameter estimates were higher for version A than B, although upper 95th percentile estimates were similar.

[15] Moore and Weller informally updated their analysis for the 2015 DEIS. There, they took "into account modified assumptions/data values regarding hunt duration and the number of approaches, strikes, and attempted strikes (NMFS 2015, p 3-93). The DEIS indicates that Moore and Weller "rel[ied] on the same [2013] model but reflect the updated data."

to an expectation of ≥ 1 WNP whale strike once in 83 even-year hunts (or once every 166 years given the alternating season structure of the hunt).

These new estimates are based upon updated photo-identification and abundance data. The estimates are also updated to reflect the hunt plan and catch limits proposed by NMFS in 2018. Importantly, instead of being based on the previously preferred 'Model 2B' they are now based on 'Model 2A', which is the more conservative of the two, *i.e.*, it is more precautionary with respect to the probability of encountering a WNP gray whale in the Makah U&A.[16]

The difference between Model 2A and 2B essentially boils down to an assumption regarding the proportion of non-PCFG whales during the migration season that could be WNP gray whales. Model 2A assumes that, on a per-capita basis (i.e. taking into account the different population sizes), non-PCFG whales in the Makah U&A are as likely to be WNP gray whales as they are to be ENP gray whales (in essence, assuming that all WNP gray whales migrate through the Makah U&A). Model 2B does not make that assumption. Instead Model 2B incorporates more uncertainty about the per-capita likelihood by integrating over a range of probabilities for this variable. The difference between the two modeling approaches, and the rationale for presenting updated estimates based on Model 2A, is described by Moore and Weller (2018) (Ex. M-0542):

> *"Moore and Weller (2013) considered four models in their analysis but they based final inferences on what they termed Model 2B. Here, we use Model 2A instead. Models 2A and 2B are similar. The difference is that for Model 2A, the conditional probability of a non-PCFG whale being a WNP (rather than ENP) whale is simply based on the ratio of WNP:ENP population size. This is an intuitive estimator, though it does rely on the assumption that WNP and ENP animals migrating together are using the same migration corridors and behaving similarly. For Model 2B, this assumption is relaxed and we allow for broader uncertainty by stating that the conditional probability varies uniformly from zero (if the WNP whales do not migrate through the Makah area at all) to some maximum value that is based on (but not equivalent to) the ratio of WNP:ENP population size. However, it is difficult to define the maximum value, and allowing a lower probability of zero is not precautionary and arguably should not be considered without supporting evidence."*

[16] Unlike Moore and Weller (2013), Moore and Weller (2018) do not present the results of all models used in their analysis.

- Moore and Weller (2018, p. 4)

Although Moore and Weller's (2018) analysis using a conservative selection of the available models demonstrates there is a very low probability of striking a WNP gray whale, it is important to emphasize that whatever the merits of the probability analysis, this approach cannot assess the central and far more complex issue in evaluating the impacts of the proposed hunt, namely what are the expected population level consequences (for WNP or PCFG whales). In the next section, I detail how the Scientific Committee of the IWC addressed this issue comprehensively and more definitively through a series of annual workshops and related meetings culminating in 2018. In that more comprehensive effort, the Scientific Committee of the IWC found that Makah whaling under the current proposed hunt plan would meet the conservation management objectives of the IWC, and, consequently, the OSP management objective of the MMPA.

3.2 IWC Rangewide Review

As noted above, the 2010—2013 IWC gray whale Implementation Review with a focus on the PCFG did not attempt to evaluate the population level consequences of the proposed 2005 Makah hunt plan on WNP gray whales (Ex. M-0529 (IWC 2014b, p. 191)). Instead, the Scientific Committee requested the probability analysis ultimately performed by Moore and Weller and deferred the population level evaluation until it could complete a rangewide review of relevant information for North Pacific gray whales as a whole (Ex. M-0525 (IWC 2012, p. 137)). To this end, following the 2010 – 2013 Implementation Review with a focus on the PCFG, the Scientific Committee conducted five workshops during 2014–2018 (e.g. IWC 2018a (Ex. M-0531)).

These IWC "rangewide workshops" originated from the need to carefully consider the conservation implications of satellite tagging, genetic, and photo-identification data that demonstrated at least some whales from the putative WNP gray whale stock migrate to the eastern North Pacific (Ex. M-0540 (Mate et al. 2011); Ex. M-0560 (Weller et al. 2012)). The potential conservation risks for WNP gray whales in the eastern North Pacific are not limited to Makah whaling; risk in this context also includes sources of incidental human caused mortality between Alaska and Mexico, e.g. entanglements and ship-strikes (e.g. Scordino et al. 2014 (Ex. M-0555).

A related motivating factor behind the IWC rangewide review was the recognition that the previously established idea that there are two separate populations of gray whales (ENP and WNP) with non-overlapping ranges in the North Pacific was in need of re-evaluation (e.g. Bickham et al. 2013 (Ex. M-0503)). Thus, because it had become evident by 2013 that gray whale stock structure was more complicated and the scientific understanding of such more uncertain than had been realized just a few years earlier, the Scientific Committee undertook the most comprehensive review of North Pacific gray whales to date (e.g. IWC 2018a (Ex. M-0531)).

The annual workshops involved the participation of scientific experts from range states across the North Pacific (e.g. South Korea, Japan, Russia, the United States, Canada and Mexico). They served as an expert review to synthesize available information relevant to stock structure and conservation risks. The information reviewed included (but was not limited to): genetics; population dynamics; and incidental human caused mortality levels, across the entire North Pacific gray whale range.

An important goal of the IWC rangewide review process was to synthesize relevant information in order to develop a set of stock structure hypotheses that include plausible alternative scenarios representing underlying spatial-temporal mixing patterns across stocks. For example, one stock structure hypothesis developed during the IWC rangewide review involves a scenario where gray whales found off Sakhalin Island are a mixed stock feeding aggregation. Under this hypothesis, the feeding aggregation off Sakhalin is composed of members of two stocks: the ENP stock, some of whose members feed off Sakhalin and migrate back to the eastern North Pacific after the feeding season (this hypothetical ENP group has been termed the ‘Western Feeding Group’, or WFG); and a ‘Western Breeding Stock’ (WBS) that migrates south of Japan after the feeding season and interbreeds in the western North Pacific. Other stock structure hypotheses were developed as well, including a scenario where gray whales in the western North Pacific are at present composed solely of WFG whales (i.e., whales from the ENP stock) and the WBS was extirpated at some point in the past (Ex. M-0531 (IWC 2018a)).

The IWC rangewide review is important because the resulting set of stock structure hypotheses for WNP gray whales provide a basis for developing an updated operating model, which can be used for evaluating hunt plans for Makah whaling (along with the hunt in Russia by Chukotka Natives). The stock structure hypotheses also provide a context for evaluation of the risk of a “WNP” strike—for instance, if the whales from Sakhalin Island are actually a feeding group of ENP whales (the WFG), the hunt poses no risk to the western breeding stock of WNP whales. The five-year IWC rangewide review process has culminated in agreement between international experts on the specifications for this rangewide multi-stock modeling framework. The resulting framework represents the best available science in terms of an approach for quantitatively evaluating management plans and mitigating conservation risks for WNP and ENP gray whales, including the PCFG. In the next section I discuss some aspects of the new hunt plan that NMFS proposed in 2018 for Makah whaling, how the IWC rangewide modeling framework was applied to evaluate that hunt plan, and what the results of that evaluation indicate in terms of the hunt plan's expected performance under the statutory OSP objective of the MMPA.

4. Evaluation of the 2018 Proposed Hunt Plan

4.1. Description of the 2018 Proposed Hunt Plan

The hunt plan proposed by NMFS in 2018 differs from the 2005 hunt plan in several important respects: allowable strike and landing limits have been reduced by approximately one-half (see Table 2); an alternating season structure is used; a limit on the number of PCFG females that can be taken in the hunt is introduced; and the confirmed striking of a WNP gray whale will result in a suspension of the hunt. An additional new component of the 2018 hunt plan is a requirement that a mathematical projection based on the time series of PCFG abundance estimates indicate that PCFG abundance is above a threshold limit (i.e. a point estimate of 192 or an N_{MIN} value of 171[17]) for hunting to occur in any year. These threshold limits also apply to the most recently available abundance estimate from photo-identification data, noting abundance estimates are typically not available until a year or two after the end of a survey season. Also, NMFS is seeking to authorize the hunt for only ten years. A comparison of the strike and landing limits for the hunt plans is provided in Table 2 below.

Table 2.

Comparison of 10-year ENP gray whale strike and landing limits for the 2005 and 2018 hunt plans proposed for Makah aboriginal subsistence whaling.

	Hunt Plan	
Limits over 10 years[18]	2005	2018
Strikes	70	25
Struck and Lost	30	25[19]

[17] N_{MIN} is the 20th percentile of the projected or empirically estimated abundance.

[18] No ten-year sunset was proposed in the 2005 hunt plan.

[19] Unlike the hunt plan proposed in 2005, the 2018 hunt plan does not have separate limits for 'strikes' and 'struck and lost' whales; thus, the limit on 'strikes' is, in effect, the limit on 'struck on lost' whales.

Landings	40	20
PCFG Strikes	Determined by PBR[20]	16
PCFG Female Strikes	NA[21]	8
Plan sunsets after 10 years?	No	Yes

The 2005 hunt plan was proposed before WNP gray whales were known to migrate to the eastern North Pacific. In that context, the focus of the 2005 plan was to minimize the conservation risk of Makah whaling to PCFG whales. As such, proposed whaling effort in the 2005 plan was restricted to the migration season (Dec – May). During the migration season, the vulnerability of PCFG whales to the hunt is lower than during the feeding season, because large numbers of whales from the greater ENP stock are available to the whalers. The mixture dilutes the conservation risk to the PCFG during the migration season. The migration around (and potentially through) the Makah hunt area is now known, however, to also include WNP gray whales.

The presence of WNP gray whales in the eastern North Pacific adds a new dimension to any risk assessment for Makah whaling. Further, there is a competing seasonal risk factor between WNP and PCFG whales. All else being equal, whaling during the migration season increases the risk to WNP whales while decreasing the risk to PCFG whales. The conservation risk is reversed for whaling in the summer feeding season, when WNP whales are known to be feeding in the western North Pacific, and PCFG whales are likely to be present in the Makah U&A.

The 2018 hunt plan includes management measures to reduce the likelihood of Makah whalers encountering a WNP gray whale. These measures reduce the overall number of strikes and shift all whaling effort away from the migration season in half of the years to limit the exposure of WNP gray whales. Whaling effort would be required to alternate annually between the feeding and migration seasons. During even numbered years, whaling would be

[20] As proposed and subsequently evaluated by the IWC (2013b) (Ex. M-0527), the 2005 hunt plan uses a PBR calculation to determine the allowable limit on PCFG strikes, where PBR is the product of: (i) $0.5 * R_{MAX} = 0.0235$; (ii) $F_R = 1.0$, and; (iii) N_{MIN} = the lower 20th percentile of a subset of the PCFG abundance estimate from Oregon to Southern Vancouver Island. Only whales struck and lost in May, and those whales struck during Dec—Apr (either lost or landed) that are subsequently matched to an individual in the PCFG photo-identification catalogue, counted against the PCFG limit under the 2005 hunt plan.

[21] "NA" stands for "Not Applicable", i.e. the PCFG strike limit is independent of sex under the hunt plan proposed in 2005.

restricted to the migration period (from the previous December to May). In odd numbered years whaling would be restricted to a subset of the feeding season (from July to October). No hunting would be allowed in June or November to give time for late northbound WNP migrants to pass through the hunt area and for early southbound WNP migrants to enter the hunt area without risk of being struck in a hunt. In effect, the 2018 plan's alternating season framework is a hedge – spreading the whaling effort across seasons – given the competing seasonal risks for WNP and PCFG gray whales. The reduction of annual strikes during the migration season (3 strikes maximum) compared to the 2005 hunt (7 strikes maximum) also serves to reduce the likelihood of whalers encountering or killing a WNP gray whale. The strike limit proposed in the 2018 hunt plan during the summer feeding season is two; however only one strike is allowed if the first whale is landed. As mentioned above, hunting in any year is only allowed if projected PCFG abundance stays at or above recent levels[22] in order to limit the impacts of the hunt on PCFG whales.

4.2. Request for IWC Review of the 2018 Proposed Hunt Plan

The new hunt plan proposal was presented by NMFS at the March 2018 IWC rangewide review workshop (Appendix 1 of IWC 2018a (Ex. M-0531)), and a request was made on behalf of the United States government for the Scientific Committee to evaluate the plan and determine if it would meet the conservation objectives of the IWC. As I described above, the conservation objectives of the IWC mirror the conservation objectives of the MMPA (Section 1.2.1 above).

At the same IWC rangewide workshop, a final set of operating model specifications (e.g. stock structure hypotheses) and trials were agreed upon in order to evaluate the new hunt plan. The specifications for the rangewide operating model, as well as factors identified as key scientific uncertainties in the evaluation trial structure (e.g. levels of cryptic incidental human caused mortality), had been under development and review by the Scientific Committee since the first annual rangewide workshop in 2014 (Ex. M-0531 (IWC 2018a)). In addition to modeling the spatial distribution, population dynamics, and sources of human caused mortality for gray whales across the North Pacific, the rangewide modeling included updated estimates of abundance and human caused mortality for WNP, ENP and PCFG whales (IWC 2018a). In total, 54 trials, incorporating multiple stock structure hypotheses were selected for the evaluation. Additionally, it was agreed a variant of the 2005 hunt plan would also be subject to performance testing using the same

[22] "Recent levels" pertains to the relatively stable period in abundance estimates since 2002.

rangewide operating model and trial structure for comparative purposes.

While the evaluation of the hunt plan using the model developed in the rangewide review was not a formal Implementation Review, the process shared many of the same elements. For example, the modeling and evaluation framework were developed through the course of a multi-year review of available information[23]. Additionally, the steps taken in developing the evaluation process (e.g. alternative stock structure hypotheses) were presented in annual workshop reports to the broader Scientific Committee for feedback during 2014-2018 (e.g. IWC 2018a (Ex. M-0531)). The next Implementation Review for gray whales is scheduled for 2020 (a one year delay from the normal interval). The results of the evaluation based on the rangewide modeling will almost certainly form the basis for providing management advice during the next Implementation Review. In essence the rangewide evaluation had all the technical rigor of an Implementation Review, without the formal title.

4.3. Trial Structure for Evaluating Makah Hunt Plans Under the IWC Rangewide Model

Incorporating WNP gray whales (and alternative plausible stock structure hypotheses) in the IWC rangewide evaluation framework for the proposed hunt was a critical and necessary development accomplished through the last five years of the rangewide review process. That was not, however, the only important revision that has been introduced to the current evaluation framework and trial structure. During the 2010-2013 Implementation Review with a focus on the PCFG, the hunt plan proposed in 2005 was evaluated under the base case assumption that there was no negative bias (or at least that any such bias was negligible) in reported numbers for incidental human caused mortality and prorated serious injuries in the United States and Canada. In other words, incidental human caused mortality levels were assumed to be equal to observed counts of "serious injury and mortality" by NMFS (Ex. M-0527 (IWC 2013b); Ex. M-0514 (Carretta et al. 2017)). Although the previous evaluation did include a trial where 'true' incidental human caused mortality was modeled to be twice as large as recorded numbers (*id.*), new information was published subsequently that indicated the previous assumptions regarding this correction factor may have been optimistic (Ex. M-0552 (Punt and Wade 2012); Ex. M-0512 (Carretta et al. 2016)). In addition, an effort to

[23] Compared to the 2012 – 2013 Implementation Review focused on the PCFG, the rangewide review developed a more sophisticated operating model in order to take into account the complexities of alternative stock structure hypotheses that include WNP gray whales.

compile a record of human caused mortalities in other countries within the gray whale range was completed and peer-reviewed by the Scientific Committee (Ex. M-0556 (Scordino et al. 2017)).

Taking this new information into account, the rangewide evaluation framework assumed a base case multiplicative correction factor of four times the number of reported incidental human caused mortalities throughout the gray whale range (Ex. M-0556 (Scordino et al. 2017); Ex. M-0531 (IWC 2018a)). This updated correction factor is founded on a published analysis of observed versus expected carcass recovery rates for the California coastal population of bottlenose dolphins (Ex. M-0512 (Carretta et al. 2016)). Furthermore, based on a comparison between: (i) an estimate from population dynamics modeling of the number of gray whales that died during the 1999-2000 mortality event; and (ii) the reported number of gray whale carcasses observed stranded between Mexico and Alaska during that event, Punt and Wade (2012) (Ex. M-0552) estimate that only 4 – 13% of gray whales that die each year, over that geographical range, are actually observed as stranded. Therefore, in addition to the base case assumption for incidental mortality (four-times observed), additional trials were introduced in the rangewide evaluation framework that assume incidental human caused mortality levels are 10 and 20 times higher than observed (IWC 2018a).

Another important aspect of available data on incidental human caused mortality includes the nature of fisheries effort as it pertains to uncertainties in historical estimates of mortality due to fisheries bycatch. Certain fisheries are known to have higher rates of gray whale bycatch due to factors like gear type and operational effort overlapping with the gray whale migration. Unfortunately, for some fisheries that are known to have relatively high interaction rates with gray whales, available time series of systematic observer effort are incomplete, e.g. reliable data on gray whale bycatch are unavailable prior to the early 1980s for the set-net fishery targeting halibut off California (Ex. M-0531 (IWC 2018a)).

The IWC rangewide review included a dedicated effort to reconstruct relevant historical fishing effort as it relates to spatial and temporal patterns of gray whale bycatch underlying the trial structure used for evaluation. This research involved the collaboration of scientists with expertise in pertinent fisheries bycatch data and provided a basis for bycatch rates to be extrapolated back in time over years for which observer data are incomplete (Ex. M-0556 (Scordino et al. 2017); Ex. M-0531 (IWC 2018a)). To the best of my knowledge, this research initiative has resulted in the most complete reconstruction to date of incidental human caused mortality of gray whales. Reconstructing historical bycatch rates vis-à-vis trends in fisheries' effort through time is important in the context of the IWC evaluation process because of the magnitude of bycatch multipliers used to develop trials for this factor as discussed above, i.e. if such mortality is not accurately modeled, the results of the evaluation may be biased. To guard against such an outcome, the rangewide model included several sensitivity tests with respect to how the commercial fishing effort data was incorporated in the reconstructed record of incidental human caused mortality (IWC 2018a).

In general, the strategy for developing the IWC rangewide trials involved first identifying a set of factors representing scientific uncertainties relevant to conservation risk (e.g. cryptic mortality). Base-case levels assumed for key factors were then expanded, forming a list of values (i.e. multiple levels may be assumed for each factor). Examples of key factors include, cryptic mortality [levels of 4 (base-case value), 10 or 20 times observed mortality, in addition to a level where zero cryptic mortality was assumed], and annual immigration rates into the PCFG [levels of zero, one, two (base-case value) or four whales immigrating into the PCFG per year, which 'recruit' into the feeding group]. The IWC rangewide evaluation considered a total of 21 factors in the set of trials, including other key factors such as various stock structure hypotheses and values for intrinsic[24] growth rates for each stock (Ex. M-0531 (IWC 2018a, Table 5, p. 16)).

The value for each factor that was considered most plausible in an expert review usually was adopted as the 'base-case' level (*id*.) but in some cases a value that was more conservative than the most plausible value was selected. The majority of base-case values were determined from empirical data. For example, the base-case level for PCFG availability to Makah whalers during the migration season is based on estimates from photo-identification data. Likewise, as mentioned above, the base case value for the level of cryptic mortality assumes that total incidental human caused mortality is four times that observed based on the carcass recovery study of coastal bottlenose dolphins (Ex. M-0512 (Carretta et al. 2016)). And the probability of encountering a WNP gray whale was based on the analyses of Moore and Weller (2013) (Ex. M-0541).

An example where the selected value was less than the most plausible value to ensure the model was conservative was the adoption of the immigration rate of two whales per year into the PCFG, even though simulations of genetic diversity were found to be most consistent with four

[24] "Intrinsic" in this context means the growth rate of a stock, in terms of its life history (birth rates, natural mortality rates, etc.), independent of extrinsic factors that would result in changes of abundance (e.g. incidental human caused mortality, immigration, or aboriginal subsistence whaling)

immigrants per year (Ex. M-0539 (Lang and Martien 2012); Ex. M-0531 (IWC 2018a, Table 5, p. 16)). Multiple levels were often added for key factors for evaluation, until the range of values for each spanned the bounds of agreed plausibility. The probability analyses of Moore and Weller (2013) (Ex. M-0541) was included.

The final set of trials was then developed by “crossing” various levels between factors, resulting in a set of trials that aimed to cover the plausible parameter space, not just for a single factor but across all key factors (Ex. M-0531 (IWC 2018a, Table 6, p. 17)). As a simplified example of crossing levels between factors, consider just two factors, cryptic mortality and the immigration rate into the PCFG; crossing the base case value of PCFG immigration with all four levels of cryptic mortality would result in four potential trials represented by the various combinations across levels (2 immigrants per year with no mortality correction factor; 2 immigrants per year with a mortality correction factor of four, etc.). Each of the factors in this example has four levels (as listed above), hence fully crossing all levels across just these two factors would result in 16 combinations or 16 potential trials if all other factors were held constant. This, in turn, would represent a subset of the global parameter space, which can be thought of as a larger grid containing the full set of potential combinations resulting from crossing all levels across all factors.

The cost of running the entire global set of potential trials would have been exorbitant and ultimately prohibitive in terms of computational time (running a single trial may take many days to complete). Fortunately, there are areas of the global parameter space that, while plausible, are not necessarily informative with respect to evaluating the performance of a hunt plan in terms of its ability to satisfy conservation management objectives. Take for example a single factor like the intrinsic growth rate of the PCFG. This factor included three[25] levels in the IWC rangewide evaluation: 2%, 4.5% (base-case value), and 5.5% growth per year, as measured at MNPL. The majority of trials in the final set involve the base-case value, consistent with the treatment of other factors, with four trials run as “sensitivity tests” under the lower and upper values for intrinsic PCFG growth rate. The bottom end of the range for this parameter-value was determined during the 2010-2013 Implementation Review to have lower plausibility than the base-case value given empirical data and observed rates of increase (Ex. M-0527 (IWC 2013b, p. 142)). The upper value, on the other hand, is not necessarily as informative as the base-

[25] A fourth level was also included, which involved estimating the value of this parameter from available abundance data, but I am ignoring that level here, for the purposes of illustrating a larger point.

case value, because if the performance of a hunt plan satisfies conservation management objectives under scenarios with 4.5% intrinsic growth rate, its performance will be satisfactory under scenarios with a higher level of productivity and resilience (i.e. under a value of 5.5% intrinsic growth rate). Based on considerations such as these, the Scientific Committee agreed on a final set of trials for the rangewide evaluation, such that a balance was struck between covering relevant and plausible parameter space in terms of informing the evaluation of conservation risk while also limiting the extent of redundancy between trials (Ex. M-0531 (IWC 2018a, Table 6, p. 17)).

4.4. Performance Statistics for Evaluating Makah Hunt Plans Under the IWC Rangewide Model

In evaluating NMFS's 2018 proposal for the Makah hunt, several additional performance statistics were considered in addition to the 100-year MNPL management objective. These included the 'relative depletion' and 'relative increase' statistics discussed above (see Table 1).

Depletion is a key element in both of these statistics. In this context depletion refers to abundance as a fraction of carrying capacity, so that a stock that has a depletion level of 40% is at 40% of its carrying capacity, a stock that has a depletion level of 60% is at 60% of its carrying capacity, and so on. Stocks with depletion levels at a high percentage of carrying capacity are less depleted, and vice-versa (depletion levels at lower percentages of carrying capacity are more depleted). Thus, the lower the percentage, the more depleted a stock is said to be. MNPL is commonly assumed to represent a depletion level of 50-60% of carrying capacity (e.g. Punt and Wade 2010 (Ex. M-0551); Wade 1998 (Ex. M-0559)).

Relative depletion provides a comparison of how much whaling contributes to the depletion of stock or feeding group relative to the expected level of depletion without whaling. This performance statistic is informative for trials with high levels of incidental human caused mortality, like those in the IWC rangewide evaluation in which incidental human caused mortality is assumed to be 10 or 20 times the observed value. Under the assumptions of such trials, future abundance could be well below carrying capacity (and other reference levels like MNPL) even in the absence of whaling. Relative depletion is therefore a useful performance statistic because it controls for extrinsic factors, which might otherwise bias the interpretation of simulation results, and allows the effects of whaling and non-whaling factors to be separated during the performance evaluation.

Relative depletion also provides a metric for evaluating a hunt plan's responsiveness under scenarios where the stock has become highly depleted (at a small fraction of carrying capacity) or is declining for some reason in the future. In such cases a hunt plan would be expected to respond by reducing or stopping catches such that the risk of extinction is not being increased. The relative depletion statistic has also been employed in the evaluation of other aboriginal subsistence hunt plans (e.g. West Greenland humpback whales; IWC 2014b (Ex. M-0529)).

It is widely accepted that no hunt plan can be expected to meet conservation objectives under the most difficult of hypotheticals, and the relative depletion statistic ensures that the performance of a hunt plan relative to the first conservation objective of the IWC, i.e. "risks of extinction to individual stocks are not seriously increased by subsistence whaling," is met (Ex. M-0521 (IWC 1995); Section 1.2.1)). That is not to imply that a hunt plan would be considered to have met the IWC's conservation objectives if it satisfies this objective alone. For the remaining IWC conservation objectives, including those that mirror the OSP objective under the MMPA, hunt plans are evaluated by the IWC given the additional performance metrics that I describe below.

The relative increase statistic measures the expected future depletion of a stock with hunting divided by that prior to the implementation of a hunt plan. A value of this statistic equal to 1.0 would indicate the future status of a stock would be unchanged by whaling. Values greater than 1.0 would indicate a population would grow under whaling while values less than 1.0 would indicate it would decline under whaling. This performance statistic is important in evaluating how well a candidate hunt plan is expected to perform relative to a component of the third conservation management objective of the IWC for aboriginal subsistence whaling, *i.e.*, to "…ensure that stocks below that level (*i.e. MNPL*) are moved towards that level, so long as the environment permits" (Ex. M-0521 (IWC 1995); Section 1.2.1; words in italics are mine). In cases where the status of a stock or feeding group may be below MNPL, or where its status is uncertain prior to the onset of aboriginal subsistence whaling (e.g. the PCFG; Punt and Moore 2013 (Ex. M-0550)), this performance statistic is useful in evaluating whether a candidate hunt plan will allow stocks (or feeding aggregations) below MNPL to recover to MNPL in the future with whaling. In terms of the MMPA, relative depletion measures how well a candidate hunt plan is expected to perform under the management objective of "allowing a stock to *reach* or maintain its optimum sustainable population" [MMPA, 16 U.S.C. § 1362 (20), italics added].

4.5. Results of Evaluating Hunt Plans for Makah Whaling Under the IWC Rangewide Model

As noted above, in addition to simulating the performance of the 2018 hunt plan, a variant of the hunt plan proposed in 2005 was also subjected to performance testing under the IWC rangewide model and set of trials. The evaluation results for the older hunt plan did not enter into deliberations during the 2018 Scientific Committee meeting, which instead focused on the 2018 plan, but a preliminary inspection of the results by the AWMP Standing Working Group confirmed that the new hunt plan is more conservative than the 2005 plan[26]. In particular, one illustrative example of the performance of the two hunt plans stands out in comparison. Recall, that the during the 2010-2013 Implementation Review, the performance of the 2005 hunt plan was found to be sensitive to the availability of PCFG whales, which led to the IWC's affirmative management recommendation being provisional on the continuation of photo-identification studies in the future in order to monitor the proportion of PCFG whales available to the hunt. A trial was included during the 5th IWC Rangewide workshop that assumes 100% of whales available to Makah whaling are from the PCFG. The assumption that 100% of all whales taken by the Makah hunt will be removed from the PCFG represents a 'worst-case' scenario, for conservation risk to the PCFG under this factor.

Not surprisingly, given the 2005 hunt plan's demonstrated sensitivity to the availability factor in the 2010-2013 Implementation Review (previously only evaluated at up to 60% PCFG availability), the 2005 hunt plan did not meet the MNPL management objective for the 100% PCFG availability trial under the rangewide evaluation framework. The 2018 hunt plan, on the other hand, was able to satisfy the MNPL management objective under this trial for the PCFG. This is an illustrative example in terms of conservation performance between the two hunt plans. It indicates the 2018 hunt plan is more robust to scientific uncertainties in terms of being expected to meet management objectives over a wider range of hypothetical scenarios, including certain worst-case scenarios. Qualitatively at least, this is not a particularly surprising result given the 2018 plan's more conservative catch limits compared to the 2005 hunt plan (Table 2). Quantitatively, and perhaps more importantly, this result demonstrates that the 2018 hunt plan is not sensitive to a key factor identified in the Scientific Committee's evaluation of the 2005 hunt plan. For completeness, it should also be noted that both hunt plans as evaluated under the IWC rangewide model, met the MNPL/OSP objective for WNP and ENP gray whales under this trial (i.e., 100% PCFG availability).

The evaluation of the 2018 hunt plan was completed under the rangewide

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[26] This is based on my personal observations of the Scientific Committee's discussion while co-chairing the AWMP Standing Working Group meetings during the 2018 Scientific Committee meeting.

modelling framework at the 2018 Scientific Committee meeting (Ex. M-0533 (IWC 2018c)). The evaluation considered the performance of the hunt plan over a set of gray whale stock structure hypotheses and trials developed by international experts during the course of the five years of research, analysis, and modeling at the IWC Rangewide Workshops. This represents the first and only management strategy evaluation to evaluate a gray whale hunt plan for the Makah taking into account population level consequences of expected removal levels on the WNP stock.

In the final analysis of the 2018 hunt plan, there were 106 trials across the alternative stock structure hypotheses. The results across the vast majority of trials were found to meet the MNPL conservation management objective. In other words, across the vast majority of trials, all three management units (ENP, PCFG, and WNP) would be above (or allowed to reach) MNPL under the 2018 hunt plan after 100 years. [27]

For the PCFG and western feeding group (WFG) a total of four trials across stock structure hypotheses did not meet the final depletion (MNPL) or the relative increase conservation management objectives, i.e. the abundance of the affected group of whales was below MNPL (OSP) and was not increasing towards that level at the end of the projection period. These trials assumed levels of cryptic mortality that were 10 or 20 times observed, and/or little to no immigration into the PCFG. Three of the four trials were for the PCFG. For the PCFG trials, the relative depletion statistic ranged from 81 to 92 percent. The WNP trial, which assumed cryptic incidental mortality was 20 times observed, had a relative depletion statistic of 99 percent. As described above, the relative depletion statistic is the projected population size with removals from whaling, divided by the projected population size with no whaling. The high relative depletion statistics for these trials is consistent with scenarios in which aboriginal subsistence whaling is not seriously increasing the risk of extinction (the primary conservation management objective of the IWC for aboriginal subsistence whaling). In other words, the high values for relative depletion indicate that it is not removals from whaling that result in smaller population sizes for these trials, but rather it is the assumptions about little to no immigration into the PCFG and high levels of cryptic mortality. In its final evaluation, the AWMP concluded that these trials "corresponded with scenarios that were considered to have low plausibility (e.g. bycatch mortality of ~20 PCFG whales per year)" (Ex. M-0532 (IWC 2018b)).

[27] 100 years is a standard projection period for evaluating mortality limits in this type of simulation modeling. It was the length of time used for the base case management strategy evaluations of PBR as well (Ex. M-0559 (Wade 1998)).

Ultimately, after reviewing the AWMP's evaluation of the performance metrics (including those that correspond with the OSP management objective under the MMPA), the full Scientific Committee agreed with the AWMP's assessment that the 2018 hunt plan meets the IWC's conservation objectives for all affected gray whales:

> *"the performance of the management plan for Makah whaling was adequate to meet the Commission's conservation objectives for the Pacific Coast Feeding Group, Western Feeding Group and Northern Feeding Group [of] gray whales in the context of the proposed Makah hunt."* (Ex. M-0533 (IWC 2018c, Report of the Scientific Committee, p. 16))

As discussed above (section 2.3.2), the criteria used to evaluate the performance of the 2018 hunt plan were based on quantitative metrics for the conservation management objectives of the IWC. The evaluation framework included a wide range of available information about North Pacific gray whales and took into account important uncertainties (e.g. in stock structure). In taking into account various sources of uncertainty, conservative assumptions for parameter values were made with respect to conservation risk. Further, the Scientific Committee is composed of leading international and domestic scientists in both gray whale ecology and MSE for aboriginal subsistence whaling hunt plans. For these reasons, it is my opinion that the results of the Scientific Committee evaluation represent the best available science with respect to the potential impacts of the 2018 hunt plan on gray whales.

As I also explained above (section 1.2.1), the quantitative metrics and the IWC's conservation management objectives used to evaluative the 2018 hunt plan mirror those under the MMPA (e.g. OSP). However, in important respects the IWC's evaluation was more conservative than what is required under the MMPA. For example, if a waiver were granted under the MMPA, it would cover a ten-year period, whereas the IWC evaluation focused on the conservation risk of the hunt plan over a 100-year timeframe (as was done with PBR). The evaluation of the hunt plan over a longer time period is conservative, because the aggregate removals over 100 years would be larger than for a 10-year waiver period. It is therefore my opinion, based on the Scientific Committee's evaluation and the conclusions of the world's leading experts therein, that if a waiver were granted to implement the current (2018) version of the hunt management plan for Makah whaling, this plan would meet the OSP statutory objective of the MMPA for WNP, ENP and PCFG gray whales.

5. Response to Selected Public Comments

I have also been requested by legal counsel for the Makah Indian Tribe to respond to four public comments that were provided to NMFS regarding the 2015 DEIS.

First, with regard to WNP gray whales, in a public comment letter to Steve Stone of NMFS, the Animal Welfare Institute (July 31, 2015; hereafter "AWI" (Ex. M-0502)) states:

> *… the analysis by Moore and Weller examined only the numerical probability of being affected by the hunt based on the total number of WNP gray whales and the proportion of the population known to have emigrated to the ENP gray whale range. They didn't consider any variable linked to time spent in the ENP range or, more specifically, in the Makah U&A. This is not a trivial concern since the more time a WNP gray whale spends in the hunting area, particularly during the time when a hunt is permitted, the greater the probability of an approach, pursuit, strike attempt, or strike.*
>
> *Even NMFS notes that "Sakhalin whales were seen in an area of the ENP (i.e., Vancouver Island) where some whales tend to linger and feed during the northbound migration," and that "the long distance and potential open water crossing required for transit from the ENP to the WNP may make it more advantageous for whales to spend time feeding in the Pacific Northwest prior to undertaking a westerly passage to Sakhalin." DEIS at 3-89 (citing Darling et al. 1998 and Weller et al. 2012).*
>
> - AWI (2015 p. 61)

As noted by AWI, the amount of time WNP gray whales might spend in the Makah U&A is an important factor in evaluating the conservation risk of the proposed hunt. I also agree that the quotation from the DEIS (citing Darling et al. 1998 (Ex. M-0515) and Weller et al. 2012 (Ex. M-0560)) represents a plausible scenario for WNP gray whale movements through the eastern North Pacific (i.e. WNP gray whales might make a "pit stop" to feed). The fact that the six WNP gray whales sighted off Vancouver Island were in an area where gray whales have been observed feeding (Barkley Sound; *id*.) supports this line of reasoning, but only to a point. When considering this comment, it is important to focus first on available data from the area of the Makah hunt (the ocean portion of the Makah U&A).

Moore and Weller (2018) (Ex. M-0542) present available photo-identification survey effort for gray whales in the Makah U&A during 1996 – 2012. Survey data from the Makah U&A provides the most direct line of evidence (*i.e.*, the best available scientific information) on the availability of WNP gray whales in the hunting area. As noted by Moore and Weller (2018, p. 3), with respect to the available survey data in the Makah U&A, "none of the 181 whale-days[28] observed included WNP gray whales." Moore and Weller (2013) (Ex. M-0541) note that WNP gray whales have a high fidelity to their feeding grounds off Sakhalin Island, and therefore, in their assessment, the absence of WNP sightings in the Makah U&A is likely not due to false negative identification errors (i.e. the absence of WNP whales in the Makah U&A photo-identification catalogue is likely not due to missing a match with the Sakhalin catalogue).

It is possible that the amount of survey effort in the Makah U&A has not been sufficient to detect WNP gray whales there. Some WNP gray whales may have been missed. Nevertheless, the conservation concern stated by AWI rests on the premise that WNP gray whales might spend longer periods of time in the hunt area than is considered by the analyses of Moore and Weller (2013 (Ex. M-0541), 2018 (Ex. M-0542)). Under this scenario, not only would the risk posed by hunting during the migration season be increased, but the likelihood of WNP gray whales having been sighted during the surveys in this area would also be increased. Simply put, there is no evidence from the Makah U&A sightings data to support AWI's hypothesis that WNP gray whales spend a disproportionate amount of time in the Makah U&A, whether feeding or otherwise. Next I will respond to three comments related to the PCFG.

First, regarding the PCFG and the Implementation Review conducted during 2010—2013 (IWC 2013a (Ex. M-0526), 2014a (Ex. M-0528)), AWI notes, with respect to the IWC evaluation of the variants of the hunt plan proposed in 2005 for Makah whaling:

> *Although both variants were deemed acceptable, neither corresponded exactly to the hunt proposal submitted by the Makah Tribe to the IWC; therefore, the Scientific Committee expressed concern that the actual conservation outcome of the proposed hunt was not tested. DEIS at 3-160. More specifically, the "aspect of the proposed hunt that had not been evaluated was the*

[28] "Whale days" represent an individual whale being sighted on a given day, "e.g., multiple sightings of the same individual on the same day count as just 1 whale-day, but the same individual seen the next day would count as a second whale-day" (quoting Moore and Weller, 2013, p 3) (Ex. M-0541).

interaction between the actual number of strikes per month during the hunting season (December through May) and the assumption of whether a struck and lost whale belongs to the PCFG." id.

- AWI (2015 p. 65) (Ex. M-0502)

I will keep my response here brief. My testimony above, under Section 2.5 covers this topic in detail. To summarize, Brandon and Scordino (2013) (Ex. M-0507) responded to the Scientific Committee's concern by demonstrating that the conclusions from the IWC evaluation of the 2005 hunt plan were not sensitive to the specific timing of allowable strikes. The Scientific Committee accepted and agreed with our analysis, and this marked the completion of the Implementation Review with a focus on the PCFG (Ex. M-0528 (IWC 2014a)). Moreover, in light of the fact that a new hunt plan has been proposed and the IWC has recently completed an evaluation of that plan based on the rangewide modeling, this concern is moot.

Second, with respect to the PCFG's status relative to OSP, AWI states:

"… NMFS reports that the PCFG abundance trend appears to be flat at the current rate of recruitment. DEIS at 4-84, 4-100 (See Figure 637). Noting that Punt (2015) ***found*** *that PCFG whales are at 50 percent of K, the long-term stability of this population should be cause for concern, since the population should be increasing in size toward the region's carrying capacity."*

- AWI (2015 p. 75) (Ex. M-0502)

My reply to this comment is two-fold: First, although the trend in PCFG abundance may have appeared (at the time) to be flat given the available estimates when the 2015 DEIS was written, more recent estimates suggest this is no longer the case (Fig. 1 below; data from Calambokidis et al. 2017 (Ex. M-0511)). In particular, over the five most recent abundance estimates available, the number of PCFG whales is estimated to have increased from 205, in 2011, to 243, in 2015 (an 18.5% increase, with an average 4.6% annual rate of increase during those years). Over the longer-term, the abundance of the PCFG is estimated to have approximately doubled between 1998 and 2015 (Calambokidis et al. 2017; Fig. 1).

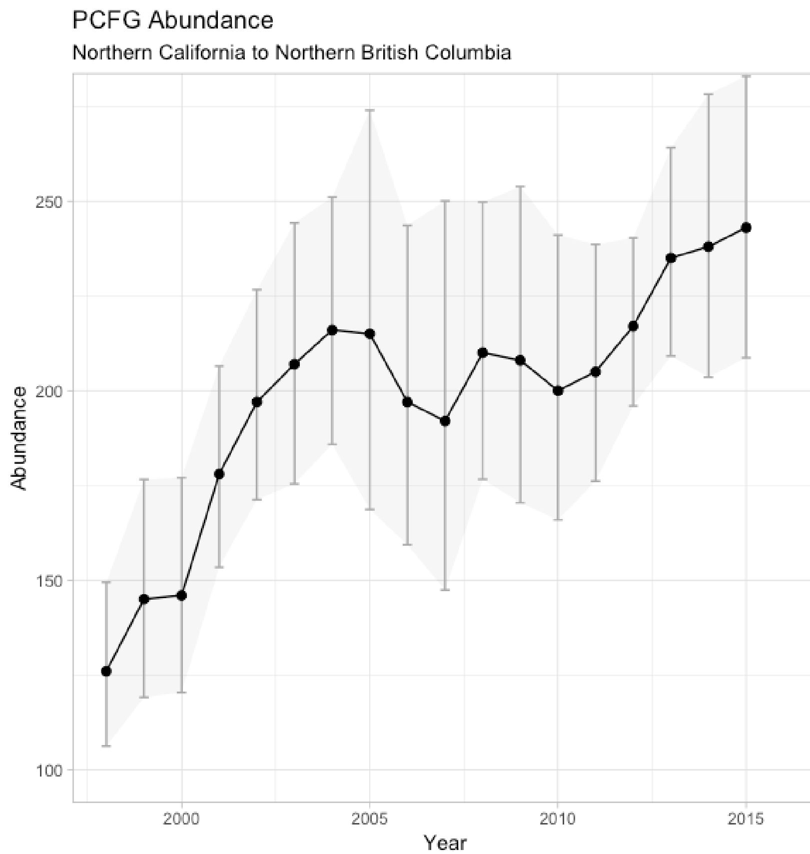

FIG 1. Abundance estimates for the PCFG between Northern California and Northern British Columbia: 1998—2015. Estimates are from Calambokidis et al. (2017) and are shown with point-wise 95% confidence intervals (vertical gray error bars).

Third, AWI cites the results of Punt (2015) (Ex. M-0547) out of context. Punt (2015) did not "find" that PCFG whales were at 50% of carrying capacity. Rather, Punt (2015) discussed various "data inputs" to inform the scientific working group at the IWC rangewide modeling workshops. Punt (2015) simply listed numerous caveats with respect to preliminary data inputs at the time, so that the working group of experts would have this list to consider when providing feedback on the modeling and data inputs:

"Several of the data inputs are preliminary. Specifically, it is necessary to finalize the catch series, update the survey estimates of abundance to include the variance covariance matrices for the abundance estimates for the Sakhalin feeding ground and the recent surveys off California. The mixing proportions should be updated to reflect photo-identification data and other catches of

known stock animals off Asia. The underlying data on mixing should be reanalysed to provide appropriate values for standard errors."

—Punt (2015, p. 7)

AWI also seemingly ignores Punt and Moore (2013) (Ex. M-0550), which adopted the population dynamics modeling framework developed under the IWC during the 2010-2013 Implementation Review with a focus on the PCFG, but focused instead more formally on the question of whether or not the PCFG was above or below MNPL (i.e., whether it was at OSP). After this focused investigation aimed towards a quantitative OSP Status Determination, Punt and Moore (2013) were unable to estimate the status of the PCFG relative to OSP with any statistical confidence, concluding, *"Ultimately it was not possible to draw a definitive conclusion as to whether the PCFG is within OSP"* (Punt and Moore 2013, p. 1).

There has been no subsequent peer-reviewed attempt to quantitatively estimate PCFG abundance relative to OSP, and this question may remain unresolved without substantial new information, including among other things a better understanding of internal vs. external recruitment rates into this feeding group (Ex. M-0550 (Punt and Moore 2013, p. 13)).

Nevertheless, the IWC evaluation frameworks are designed to propagate uncertainty in estimates across many such variables (including, but not limited to uncertainty around present abundance relative to MNPL). These uncertainties are incorporated through the simulations of future projected population dynamics under proposed catch limit rules and data collection schemes and, in the case of the rangewide review, under alternative stock structure hypotheses. The IWC evaluation aims less to answer the question of whether a stock is currently above MNPL (and hence, at OSP), but rather, given a proposed hunt plan (and uncertainties in stock status etc.), whether proposed catch limits would meet the conservation management objective of maintaining stocks above their MNPL (OSP) levels or ensuring that stocks below MNPL are allowed to recover to this management target over a wide range of uncertainties.

As an example, during the 2010—2013 Implementation Review with a focus on the PCFG, the IWC did not attempt to assess whether the PCFG was *currently* above MNPL (*i.e.*, at OSP). Instead, the IWC evaluated whether proposed Makah hunt's catch limits would allow the PCFG to reach or maintain its MNPL (OSP) level in the future. This is precisely the philosophy that went into the simulation testing that resulted in the current PBR management scheme (Ex. M-0559 (Wade 1998)). The PBR management scheme does not require a determination of whether or not a stock is at (or below) OSP. In fact, it was developed in part to provide management guidance without the need to determine a stock's status relative to OSP, which, as noted above, has rarely been accomplished. Instead, PBR is used to determine whether future removals from human caused mortalities would allow the stock to achieve or maintain the OSP management objective 100 years in the future.

It should also be noted that the IWC rangewide evaluation of the 2018 proposed hunt plan for Makah whaling (IWC 2018a) (Ex. M-0531) has since addressed the concerns raised by AWI based on Punt (2015) (Ex. M-0547). Ultimately, that process – through the continuation of IWC Rangewide Workshops in 2014 through 2018 – has resulted in agreement by the Scientific Committee, including experts on evaluating aboriginal subsistence whaling hunt plans, that NMFS's proposed 2018 hunt plan for Makah whaling will meet the IWC's conservation management objectives, including the MNPL (*i.e.*, OSP) goal shared with the MMPA (Ex. M-0533 (IWC 2018c); Section 4.5)).

The last comment I have been requested to respond to involves an argument presented by AWI with respect to the PBR calculation for the PCFG:

> *Interestingly, when the PCFG, OR-SVI, and Makah U&A PBRs are compared to the PBR for the California/Oregon/Washington stock of sperm whales or the ENP stock of blue whales, those populations are much larger than any of the groups of PCFG gray whales, but their PBR is either half (for the sperm whale) or just slightly higher (for the blue whale) compared to the PBR for PCFG whales.*
>
> —AWI (2015, p. 56) (Ex. M-0502)

Under the NMFS Guidelines for Assessing Marine Mammal Stocks (NMFS 2016) (Ex. M-0544), the default recovery factor (F_R) should be 0.1 for stocks that are listed as endangered under the Endangered Species Act (e.g., the aforementioned sperm and blue whale stocks). The PCFG, however, is not considered a stock under the MMPA by NMFS (Weller et al. 2013) (Ex. M-0561), nor is it listed under the ESA. Therefore, as it stands, the notion of PBR for the PCFG is ill-defined at best, and at worst it is illogically suited for comparison to PBR for recognized populations listed under the ESA with well-defined PBR values. Finally, as discussed above (sections 2 and 4), the IWC's case-specific MSEs for the 2005 and 2018 hunt plans proposed for Makah whaling have confirmed that they meet the IWC's conservation objectives for PCFG whales, including the OSP objective shared with the MMPA. For the reasons I discussed in section 2.2, those evaluations are a more reliable assessment of the conservation implications of Makah whaling than a comparison of PBR values between the PCFG and entirely different, ESA-listed stocks.

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AFFIDAVIT OF JOHN BRANDON
EXHIBIT LIST

Exhibit No.	Citation	Document
M-0501	John Brandon	Curriculum Vitae 2019
M-0502	AWI	Public comment letter to Steve Stone of NMFS, from the Animal Welfare Institute (AWI). July 31, 2015.
M-0503	Bickham et al. 2013	Bickham, J.W., Dupont, J.M., Broker, K., 2013. Review of the status of the western North Pacific gray whale; stock structure hypotheses, and recommendations for methods of future genetic studies. Pap. SC/65a/BRG16 presented to the IWC Scientific Committee [Available from: https://iwc.int/sc-documents]
M-0504	Brandon 2009	Brandon, J.R. 2009. Quantifying uncertainty and incorporating environmental stochasticity in stock assessments of marine mammals. PhD thesis, University of Washington, Seattle, Washington. 161pp. [Available from: https://github.com/John-Brandon/phd_dissertation]
M-0505	Brandon and Punt 2013	Brandon, J.R. and Punt, A.E. 2013. Testing the Gray Whale Strike Limit Algorithm (SLA): allowing environmental variability to influence population dynamics. J. Cet. Res. Manage. 13:81—88.
M-0506	Brandon et al. 2017	Brandon, J.R., Punt, A.E., Moreno, P. and Reeves, R.R. 2017. Toward a tier system approach for calculating limits on human-caused mortality of marine mammals. ICES J Mar Sci. 74:877–87.
M-0507	Brandon and Scordino 2013	Brandon, J.R. and Scordino, J. 2013. Additional SLA variants to further evaluate the proposed Makah hunt. Paper SC/65a/AWMP06 presented to the IWC Scientific Committee, 8pp. [Available from: https://iwc.int/sc-documents]
M-0508	Brown et al. 2005	Brown, R. F., B. E. Wright, S. D. Riemer, and J. Laake 2005. Trends in abundance and current status of harbor seals in Oregon: 1977-2003. Mar. Mammal Sci. 21(4):657-670.
M-0509	Butterworth 2007	Butterworth, D.S. 2007. Why a management procedure approach? Some positives and negatives. ICES J Mar Sci. 64: 613–617.
M-0510	Calambokidis et al. 2010	Calambokidis, J., Laake, J., and Klimek, A. 2010. Abundance and population structure of seasonal gray whales in the Pacific Northwest 1978-2008. Paper SC/62/BRG32 presented to the IWC Scientific Committee, June 2010, Agadir, Morocco (unpublished), 50pp. [Available from: https://iwc.int/sc-documents]
M-0511	Calambokidis et al. 2017	Calambokidis, J., Laake, J. and Pérez, A. 2017. Updated analysis of abundance and population structure of seasonal gray whales in the Pacific Northwest, 1996-2015. Paper SC/A17/GW/05 Presented to the Fourth IWC Rangewide Workshop.
M-0512	Carretta et al. 2016	Carretta, J.V., Danil, K., Chivers, S.J., Weller, D.W., Janiger, D.S., Berman-Kowalewski, M., Hernandez, K.M., Harvey, J.T., Dunkin, R.C., Casper, D.R., Stoudt, S., Flannery, M., Wilkinson, K., Huggins, J. and Lambourn, D.M. 2016. Recovery rates of bottlenose dolphin (Tursiops truncatus) carcasses estimated from stranding and survival rate data. Marine Mammal Science 32:349–362

M-0513	Carretta et al. 2015	Carretta, J. V, E. M. Oleson, D. W. Weller, A. R. Lang, A. Karin, M. S. Lowry, J. Barlow, J. E. Moore, and D. Lynch. 2015. Gray whale (Eschrichtius robustus): Western North Pacific population. U.S. Pacific Marine Mammal Stock Assessments: 2014 NOAA-TM-NM:183–188.
M-0514	Carretta et al. 2017	Carretta, J.V., Forney, K.A., Oleson, E.M., Weller, D.W., Lang, A.R., Baker, J., Muto, M.M., Hanson, B., Orr, A.J., Huber, H., Lowry, M.S., Barlow, J., Moore, J.E., Lynch, D., Carswell, L. and Brownell Jr., R. L. 2017. U.S. Pacific Marine Mammal Stock Assessments: 2016. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-SWFSC-577. 414 p.
M-0515	Darling et al. 1998	Darling, J.D., Keogh, K.E. and T.E. Steeves. 1998. Gray whale (Eschrichtius robustus) habitat utilization and prey species off Vancouver Island, B.C. Mar. Mamm. Sci. 14:692—720.
M-0516	Durban et al. 2015	Durban, J.W., D.W. Weller, A.R. Lang, and W.L. Perryman. 2015. Estimating gray whale abundance from shore-based counts using a multilevel Bayesian model. J. Cet. Res. Manag. 15:61–68.
M-0517	Durban et al. 2017	Durban, J.W., D.W. Weller, and W.L. Perryman. 2017. Gray whale abundance estimates from shore-based counts off California in 2014/15 and 2015/2016. Paper SC/A17/GW/06 presented to IWC Scientific Committee. [Available from: https://iwc.int/sc-documents]
M-0518	Frasier et al. 2010	Frasier, T.R., Koroscil, S.M., White, B.N., and Darling, J.D. 2010. Population structure in the eastern North Pacific gray whale: Implications for management of aboriginal whaling. Paper SC/62/AWMP1 presented to the IWC Scientific Committee. 14pp (plus corrections) [Available from: https://iwc.int/sc-documents]
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M-0520	Holt and Talbot 1978	Holt, S. and Talbot, M. 1978. New principles for the conservation of wild living resources. Wildlife Monographs 59.
M-0521	IWC 1995	IWC. 1995. Chairman's Report of the Forty-Sixth Annual Meeting. Appendix 4. IWC Resolution 1994-4. Resolution on a Review of Aboriginal Subsistence Management Procedures. Rep. int. Whal. Commn 45:42–3.
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M-0527	IWC 2013b	IWC. 2013b. Report of the Scientific Committee. Annex E. Report of the Standing Working Group on the Aboriginal Whaling Management Procedure (AWMP). J Cetacean Res. Manage. Suppl (14): 137–171.
M-0528	IWC 2014a	IWC. 2014a. Report of the Scientific Committee. J Cetecean Res. Manage. Suppl (15): 1–75.
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M-0530	IWC 2016	IWC. 2016. International Convention for the Regulation of Whaling, 1946: Schedule. As amended by the Commission at the 66th Meeting, Portoloz, Slovenia, October 2016. [Available from: https://archive.iwc.int/pages/view.php?ref=3606&k=]
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M-0532	IWC 2018b	IWC. 2018b. Report of the Scientific Committee. Annex E. Report of the Standing Working Group on the Aboriginal Whaling Management Procedure (AWMP). Paper IWC/67/Rep01(2018), Annex E 25/05/2018
M-0533	IWC 2018c	IWC. 2018c. Report of the Scientific Committee. Paper IWC/67/Rep01 25/05/2018.
M-0534	IWC 2018d	IWC. 2018d. Chair's Report of the 67th Meeting, Annex P (Amendments to the Schedule Adopted at the 67th Meeting)
M-0535	IWC 2018e	IWC 2018e. PROPOSAL FOR A SCHEDULE AMENDMENT ON ABORIGINAL SUBSISTENCE WHALING. Paper IWC/67/01 Rev 01 (Agenda item 6.1)
M-0536	Jeffries et al. 2003	Jeffries, S., H. Huber, J. Calambokidis, and J. Laake. 2003. Trends and status of harbor seals in Washington State: 1978-1999. J. Wildl. Manage. 67(1):208-219.
M-0537	Laake et al. 2012	Laake, J.L., Punt, A.E., Hobbs, R., Ferguson, M., Rugh, D. and Breiwick, J. 2012. Gray whale southbound migration surveys 1967-2006: An integrated re-analysis. J. Cetacean Res. Manage. 12:287–306.
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		recruitment into the Pacific Coast Feeding Group of gray whales. Paper SC/64/AWMP4 presented to IWC Scientific Committee. [Available from: https://iwc.int/sc-documents]
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M-0541	Moore and Weller 2013	Moore, J.E. and Weller, D.W. 2013. Probability of taking a western North Pacific gray whale during the proposed Makah hunt. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-506, 13 p.
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M-0543	Muto et al. 2017	Muto, M. M., Helker, V. T., Angliss, R. P., Allen, B. A., Boveng, P. L., Breiwick, J. M., Cameron, M. F., Clapham, P. J., Dahle, S. P., Dahlheim, M. E., Fadely, B. S., Ferguson, M. C., Fritz, L. W., Hobbs, R. C., Ivashchenko, Y. V., Kennedy, A. S., London, J. M., Mizroch, S. A., Ream, R. R., Richmond, E. L., Shelden, K. E. W., Towell, R. G., Wade, P. R., Waite, J. M. and Zerbini, A. N. 2017. Alaska marine mammal stock assessments, 2016. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-355, 366 p. doi:10.7289/V5/TM-AFSC-355.
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M-0544	NMFS 2016	National Marine Fisheries Service (NMFS). 2016. Revisions to the guidelines for assessing marine mammal stocks (GAMMS) Available at https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks
M-0545	Perryman et al. 2017	Perryman, W.L, Weller, D.W., and Durban, J.W. 2017. Estimates of eastern North Pacific gray whale calf production 1994-2016. Paper SC/A17/GW/07 presented to the IWC Rangewide Workshop, La Jolla, CA, April, 2017 [Available from: https://iwc.int/sc-documents]
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M-0549	Punt and Donovan 2007	Punt, A. E. and Donovan, G. P. 2007. Developing management procedures that are robust to uncertainty: lessons from the International Whaling Commission. ICES Journal of Marine Science, 64: 603–612.
M-0550	Punt and Moore 2013	Punt, A.E. and Moore. 2013. Seasonal gray whales in the Pacific Northwest: An assessment of optimum sustainable population level for the Pacific Coast Feeding Group. NOAA Tech Memo. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-518
M-0551	Punt and Wade 2010	Punt, A. E. and Wade, P. R. 2010. Population status of the eastern North Pacific stock of gray whales in 2009. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-207, 43 p.
M-0552	Punt and Wade 2012	Punt, A.E. and Wade, P.R. 2012. Population status of the eastern North Pacific stock of gray whales in 2009. J. Cetacean Res. Manage. 12:15–28.
M-0553	Punt et al. 2018	Punt, A.E., Moreno, P., Brandon, J.R. and Mathews, M. 2018. Conserving and recovering vulnerable marine species: a comprehensive evaluation of the US approach for marine mammals. ICES J. Mar. Sci. 75:1813-31
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M-0555	Scordino et al. 2014	Scordino, J.J., Carretta, J., Cottrell, P., 2014. Bycatch and ship strikes of gray whales in U.S. and Canadian waters, 2008-2012. Pap. SC/65b/BRG21 Presented to the Scientific Committee of the IWC.
M-0556	Scordino et al. 2017	Scordino, J. J., M. Gosho, P. J. Gearin, A. Akmajian, J. Calambokidis, and N. Wright. 2017. Individual gray whale use of coastal waters off northwest Washington during the feeding season 1984 – 2011: Implications for management. Journal of Cetacean Research and Management 16:57–69.
M-0557	Simmons 2016	Simmons, S.E. 2016. “Review of the National Marine Fisheries Service’s Marine Mammal Stock Assessment Reports: Range, Abundance and Potential Biological Removal.” Marine Mammal Commission, Bethesda, MD 20814. 16 pages [Available from: https://www.mmc.gov/wp-content/uploads/SARsReport.pdf]
M-0558	Taylor and DeMaster 1993	Taylor, B.L. and DeMaster, D. 1993. Implications for non-linear density dependence. Mar. Mamm. Sci. 9(3): 360–371.
M-0559	Wade 1998	Wade, P.R. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Mar. Mamm. Sci. 14: 1–37.
M-0560	Weller et al. 2012	Weller, D.W., Klimek, A., Bradford, A.L., Calambokidis, J., Lang, A.R., Gisborne, B., Burdin, A.M., Szaniszlo, W., Urbán, J., Gomez-Gallardo Unzueta, A., Swartz, S. and Brownell, R.L., Jr. 2012.

		Movements of gray whales between the western and eastern North Pacific. Endangered Species Research 18:193-199
M-0561	Weller et al. 2013	Weller, D.W., Bettridge, S., Brownell, R.L., Jr., Laake, J.L., Moore, J.E., Rosel, P.E., Taylor, B.L and Wade, P.R. 2013. Report of the National Marine Fisheries Service gray whale stock identification workshop. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-507

John R. Brandon, PhD
Biometrician

John is a staff biometrician at ICF International, Inc., where he provides survey design, population dynamics modeling and statistical support to the Fish and Aquatic Science Team. Prior to joining ICF, he was an independent consultant. His clients from independent consulting include: A National Science Foundation fisheries research center initiative; The International Whaling Commission; and The Makah Tribal Council. His independent consulting work has involved evaluating the performance of alternative management strategies using mathematical modeling, simulation, and computational statistics. Previously, he worked as a staff biostatistician for LGL and Greeneridge Sciences, Inc., leading the development of survey designs based on statistical power analyses, as well as post-survey data analyses and reporting for monitoring and mitigation studies.

Academic Degrees

PhD. School of Aquatic and Fisheries Sciences (SAFS), University of Washington (UW), 2003-2009, Dissertation Title: '*Quantifying Uncertainty and Incorporating Environmental Stochasticity in Stock Assessments of Marine Mammals.*'

B.Sc. Biology, Ecology and Evolution (Provost's Honors), University of California San Diego (UCSD), 1994-1998: Minors in Meteorology and Ocean Sciences (Scripps Institute of Oceanography), and Biological Anthropology.

Professional Positions

Biometrician, ICF International, Inc. Fish and Aquatic Science Team, 2019 – Present

Management Strategy and Software Development Consultant to the International Whaling Commission, 2017 – 2018

Population Dynamics and Statistical Consultant to The Makah Tribe, Neah Bay, WA, 2010 – 2013 and 2015—present

Management Strategy Consultant to the U.S. National Science Foundation's Science Center for Marine Fisheries Initiative, 2014 – Present

Biostatistician/Fisheries Scientist, LGL and Greeneridge Sciences, Inc., 2009 – 2015

Population Dynamics Modeling and Statistical Consultant to the Palumbi Lab, Stanford University, CA, 2011

Invited Participant to the Scientific Committee of the International Whaling Commission and 2018 Co-Chair of the Aboriginal Whaling Management Procedures Sub-Committee, 2006 – Present

PhD Student and Research / Teaching Assistant, SAFS, UW, Seattle, WA, 2003 – 2009

Protected Species Observer (Field Scientist), Various Monitoring and Mitigation Surveys, 1999 – 2012

Research Scientist, National Marine Fisheries Science Service, Seattle, WA and La Jolla, CA 1998 – 2003

Teaching Assistant (Undergrad), UCSD, La Jolla, CA 1997 – 1998

Peer-Reviewed Publications

2018. Punt, A.E., Moreno, P., Brandon, J.R. and Mathews, M. 2018. Conserving and recovering vulnerable marine species: A comprehensive evaluation of the U.S. approach for marine mammals. *ICES J. Mar. Sci.* 75: 1813–31.

2017. Brandon, J.R., Punt, A.E., Moreno, P. and Reeves, R.R. 2017. Toward a tier system approach for calculating limits on human-caused mortality of marine mammals. *ICES J. Mar. Sci.* 74: 877 – 87.

2015. Robertson, F.C., Koski, W.R, Brandon, J.R., Thomas, T.A. and Trites, A.W. 2015. Correction factors account for the availability of bowhead whales exposed to seismic operations in the Beaufort Sea. *J. Cetacean Res. Manage.* 15: 35 – 44.

2013. Brandon, J.R. and Punt, A.E. 2013. Testing the *Gray Whale SLA*: Allowing environmental variability to influence population dynamics. *J. Cetacean Res. Manage.* 13: 81 – 88.

2010. Alter, S.E., Simmonds, M.P and Brandon, J.R. 2010. Forecasting the consequences of climate-driven shifts in human behavior on cetaceans. *Mar. Policy*. 34: 943 – 954.

2008. Li, S., Akamatsu, T., Wang, D., Wang, K., Dong, S., Zhao, X., Wei, Z., Zhang, X., Taylor, B., Barrett, L.A., Turvey, S.T., Reeves, R.R., Stewart, B.S., Richlen, M. and Brandon, J.R. 2008.

Indirect evidence of boat avoidance behaviour of Yangtze finless porpoises. *Bioacoustics*. 17: 174 – 176.

2007. Brandon, J.R., Breiwick, J.M., Punt, A.E., and Wade, P.R. 2007. Constructing a coherent joint prior while respecting biological realism: application to marine mammal stock assessments. *ICES J. Mar. Sci*. 64: 1085 – 1100.

2007. Turvey, S.T., Pitman, R.L., Taylor, B.L., Barlow, J., Tomonari, A., Barret, L.A., Zhao, X., Reeves, R.R., Stewart, B.S., Wang, K., Wei, Z., Zhang, X., Pusser, L.T., Richlen, M.R., Brandon, J.R. and Wang, D. 2007. First human-caused extinction of a cetacean species? *Biology Letters*. 3: 537 – 540.

2006. Brandon, J. R., and Wade, P.R. 2006. Assessment of the Bering-Chukchi-Beaufort Seas stock of bowhead whales using Bayesian model averaging. *J. Cetacean. Res. Manag.* 8: 225 – 239.

Selected Reports

2014. LGL Alaska Research Associates, Inc., JASCO Applied Sciences, Inc., and Greeneridge Sciences, Inc. 2014. Joint Monitoring Program in the Chukchi and Beaufort Seas, 2012. LGL Alaska Final Report P1272-2 for Shell Offshore, Inc. ION Geophysical, Inc., and Other Industry Contributors, National Marine Fisheries Service, and U.S. Fish and Wildlife Service. 320 p. plus Appendices.

2011. Brandon, J.R. and Kitakado, T. 2011. Two alternative approaches to the meta-analysis of environmental variability and auto-correlation in reproductive rates of baleen whales. Paper SC/63/RMP30 presented to IWC Scientific Committee, June 2011, Tromso, Norway. 16pp.

2011. Brandon, J.R. 2011. Incorporating updated estimates of historical commercial catches and recent genetic information in an assessment of eastern North Pacific gray whales. 31pp. Prepared for the Lenfest Oceans Program under the Pew Charitable Trust.

2009. Brandon, J.R. and Punt, A.E. 2009. Assessment of the eastern North Pacific stock of gray whales: incorporating calf production, sea-ice and stranding data. Paper SC/F09/CC5 presented to the second International Whaling Commission (IWC) workshop on climate change and cetaceans, Feb. 2009, Siena, Italy. 30pp.

2009. Kaplan, C.C., G.C. White, T.L. McGuire, J.R. Brandon, S.W. Raborn, M.R. Link, and Blees, M.K. 2009. Application of mark-resight methods to estimate abundance of Cook Inlet Beluga Whales. Chapter 2 *In*: Photo-identification of beluga whales in Upper Cook Inlet, Alaska: Mark analysis, mark-resight estimates, and color analysis from photographs taken in 2008. Report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, for National Fish and Wildlife Foundation, Chevron, and ConocoPhillips Alaska, Inc. 40 p. + Appendix.

2007. Brandon, J.R., Punt, A.E., Wade, P.R., Perryman, W.L., Methot, R.D. and Maunder, M.N. 2007. Incorporating environmental time series into a population dynamics model for eastern North Pacific gray whales. Paper SC/59/BRG26 presented to the IWC Scientific Committee, May 2007, Anchorage, AK. 16pp.

2005. Brandon, J.R., Breiwick, J.M., Punt, A.E. and Wade, P.R. 2005. Alternative resampling schemes for life history parameters used in Bayesian stock assessments of bowhead whales. Paper SC/57/BRG5 presented to the IWC Scientific Committee, June 2005, Ulsan, Republic of Korea.

2005. Brandon, J.R., Blokhin, S.A., Brownell Jr., R.L. and Punt, A.E. 2005. Preliminary summary of catch data for the Soviet aboriginal fishery for the eastern Pacific gray whale: 1980-1991. Paper SC/57/BRG6 presented to the IWC Scientific Committee, June 2005, Ulsan, Republic of Korea.

2002. Brandon, J. Gerrodette, T., Perryman W., and Cramer, K. 2002. Responsive Movement and g(0) for Target Species of Research Vessel Surveys in the Eastern Tropical Pacific. SWFSC, La Jolla, CA: Admin. Rep. LJ-02-02.

2002. Gerrodette, T. and Brandon, J. 2002. TRENDS v3.0: Software for Power Analysis and Monitoring Wildlife Populations. Available for download: http://swfsc.noaa.gov/textblock.aspx?Division=PRD&ParentMenuId=228&id=4740

2001. Gerrodette, T., and Brandon, J. 2001. Designing a Monitoring Program to Detect Trends. In Proceedings of a Workshop on Assessing Abundance and Trends for In-Water Sea Turtle Populations, edited by K. A. Bjorndal and A. B. Bolton. Gainesville, Florida. March 24-26, 2000. p. 36-40.

Field Work

Alaska Arctic Marine Mammal Aerial Surveys (LGL and Greeneridge Sciences)
Position: Aerial Survey Team Lead
2009-2012

Cook Inlet, Alaska Beluga Photo-Identification Small Boat Surveys (LGL, Ltd.)
Position: Photographer and Data Recorder
2010

New Jersey Coastal Waters Line-Transect Surveys, New Jersey (Geo-Marine, Inc.)
Position: Marine Species Observer 2008- 2009

Range-Wide Yangtze River Freshwater Dolphin Expedition, China (baiji.org)
Position: Marine Species Observer
2006, Nov. 19 – Dec. 16

Beaufort-Chukchi Seas Open Water Survey for Marine Mammals (LGL, Ltd.)
Position: Marine Species Observer
2006, Sept. 21 – Oct. 8

US Navy LWAD: Testing Navy Sonar Technology in the East China Sea (Marine Acoustics, Inc.)
Position: Marine Species Observer and Acoustician
2007, October 1-12
2005, April 14 – 27

SPLASH Cruise: Studying Population Structure and Abundance of North Pacific Humpbacks (NMFS).
Position: Marine Species Observer
2004, September 1 – 10

ACE/DART Cruises: Studying Distribution and Abundance of Killer Whales and North Pacific Right Whales in the Aleutian Islands and Bering Sea (NMFS).
Position: Marine Species Observer and Acoustician
2004, July 19 – Aug 28
2003, July 3 – Aug 13

Aerial Survey of Bowhead Whales during their Spring Migration past Pt. Barrow, Alaska (NMFS).
Position: Aerial Photogrammatrist
2003, April 11 – June 7

Shore Based Gray Whale Calf Counts during their Spring Migration past Pt. Piedras Blancas, CA (NMFS).
Position: Marine Species Observer
2001, April 3 – April 17
2000, May 15 – May 31
1999, April 31 – June 5

Aerial Surveys of Pinniped Rookeries along the CA Coast (NMFS).
Position: Aerial Photogrammatrist
2001, July 5 – July 20

Aerial Surveys of Blue Whales in the Channel Islands, CA (NMFS).
Position: Aerial Photogrammatrist
2000, July 2 – July 10

SPAM/STARR: Line Transect Surveys for Depleted Stocks of Dolphins in the Eastern Tropical Pacific (NMFS).
Position: Aerial Photogrammatrist and Oceanography Assistant
2000, July 15 – Aug 30
1999, June 11 – July 28

Animal Welfare Institute
900 Pennsylvania Avenue, SE, Washington, DC 20003 • www.awionline.org
telephone: (202) 337-2332 • facsimile: (202) 446-2131

July 31, 2015

BY ELECTRONIC MAIL

Mr. Steve Stone
National Marine Fisheries Service
West Coast Region,
1201 NE Lloyd Blvd., Suite 1100,
Portland, OR 97232.

Dear Mr. Stone:

On behalf of the Animal Welfare Institute, Cetacean Society International, International Marine Mammal Project of Earth Island Institute, Origami Whales Project, Whale and Dolphin Conservation, and the Whaleman Foundation (hereafter "Coalition"), I submit the following comments on the Draft Environmental Impact Statement (DEIS) on the Makah Tribe Request to Hunt Gray Whales (80 Federal Register 14,912 (March 20, 2015)). The Coalition notes with appreciation the decision by the National Marine Fisheries Service ("NMFS") to extend the deadline for public comments on this important issue (80 Federal Register 30,676 (May 29, 2015)). However, the Coalition concludes that NMFS cannot issue the requested MMPA waiver to the Makah Tribe, for reasons detailed below.

The Animal Welfare Institute (AWI) is one of the nation's oldest animal advocacy organizations. Since its founding in 1951, AWI has sought to alleviate the suffering inflicted on animals by people. AWI and the Society for Animal Protection Legislation (AWI's legislative companion organization until a 2004 merger), played a role in the passage of the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA), among other key environmental and animal protection statutes. AWI staff members attend meetings of the International Whaling Commission (IWC) to preserve the ban on commercial whaling, and we work to protect all marine life against the proliferation of human-generated ocean noise, including that from active sonar and seismic air guns. For decades, AWI has been opposed to the Makah Tribe resuming its hunt of gray whales, and for the reasons stated herein, we remain strongly opposed to this day. Other Coalition organizations have also been engaged in campaigns to protect marine mammals, many regularly attend IWC meetings, and all strongly oppose any resumption of whaling by the Makah Tribe.

It is troubling that, after two lawsuits, several environmental analyses, and decades of controversy that NMFS continues to endeavor to permit the Makah Tribe to resume the hunting of gray whales after a nearly 90-year hiatus in whaling. Indeed, with the exception of a single whale killed "legally" in 1999 and a second illegal kill in 2007, the Makah Tribe has not engaged in whaling since the 1920s. Even that date may not accurately reflect when the Makah largely ceased whaling which, based on evidence provided in past Makah needs statements, started to wane in the middle of the 19th century.

Despite this significant gap in whaling and without any apparent concern for international whaling standards or federal law, NMFS continues to commit valuable time and financial resources to this issue, seemingly because of a treaty right that may have been abrogated and its federal trust responsibility to the Makah Tribe.

Furthermore, other overarching concerns with the proposed hunt include the potential conservation implications to Eastern North Pacific (ENP), including Pacific Coast Feeding Group (PCFG), and Western North Pacific (WNP) gray whales by adding intentional take to the litany of threats to these animals. This is especially true for PCFG and WNP gray whales that, at present, number only a total of approximately 209 and 140 animals, respectively, with even smaller numbers in the PCFG regions considered in the DEIS (e.g., the Oregon-Southern Vancouver Island (OR-SVI) and Makah Usual and Accustomed hunting grounds (Makah U&A)). For the larger ENP population of gray whales, considering the significant changes occurring in the Arctic due to climate change and the unknown consequences of such ecosystem-wide alterations on gray whales, now is not the time to allow the Makah to hunt whales.

Such threats, of course, are not limited to the Arctic, as the gray whale has one of the longest migrations of any species on the globe and, throughout that journey, they face an increasing barrage of both anthropogenic and natural threats. Adding to such threats by authorizing a hunt is biologically reckless and unwise. Combine these threats with the hunt's risk to public safety and the basic fact that the chances of an instantaneous death of a swimming gray whale hunted from a moving boat on a rolling ocean are nil, particularly with the cold harpoon proposed by the Makah Tribe, and the evidence against granting the MMPA waiver and authorizing a hunt is insurmountable.

Based on these and other facts and as explained in detail throughout this comment letter, such efforts, including the current National Environmental Policy Act (NEPA) decision-making process, must end, the Tribe's MMPA waiver application must be denied, the United States must advise the International Whaling Commission (IWC) that its 2012 Aboriginal Subsistence Whaling (ASW) quota for gray whales is no longer valid, and it must cease attempting to secure the IWC's allocation of ASW quotas for the Makah Tribe.

For these and other reasons articulated in this letter, the Coalition strongly supports Alternative 1: the No Action Alternative. This is the only alternative that would comply with both international convention standards and US law. It also represents the most precautionary approach available which, in this case, is mandatory considering the critically endangered status of WNP gray whales, the small numbers of PCFG gray whales, and the myriad (and increasing) threats to ENP gray whales (and to the WNP and PCFG whales) throughout their range. This is not to suggest that the Makah Tribe cannot "use" gray whales, but such use must not involve the intentional lethal take of a single whale. Indeed, as described in this comment letter, there are alternatives NMFS failed to adequately consider in the DEIS that would substantially benefit all Makah tribal members while also facilitating the "use" of gray whales in a humane, non-lethal manner that would create jobs, generate revenue, attract tourists to Neah Bay, and provide a platform for the Makah to promote and celebrate their history, culture, and traditions.

While the Coalition strongly opposes whaling by the Makah Tribe, it does respect the Makah's whaling culture, traditions, and history. Contrary to claims made by the Tribe, however, no compelling evidence has been offered in the DEIS or elsewhere to prove that the Makah Tribe needs to kill whales to sustain its culture, to enhance its efforts at cultural revitalization, or to continue to engage in the ceremonies, rituals, dances, or songs celebrating its whaling heritage. For that matter, the DEIS contains evidence to suggest that such traditions have not been continually practiced as the Makah Tribe or its representatives have consistently claimed. Nevertheless, to the extent the tribe, including individual tribal families, need to engage in such traditions, even if they have only recently been resurrected, the annual Makah Days celebration provides the perfect venue for the Makah Tribe to embrace its cultural and historical links to whaling through dance, song, and ceremonies without any need to kill a whale. Similarly, throughout the year, whether whaling traditions are family-specific, secret, or available to celebrate with the entire tribe and/or non-tribal members, there is no reason why these traditions cannot be practiced at family or community events without requiring the resumption of whaling.

Ultimately, however, the Coalition's overarching concern is for the welfare of the whales – as well as the humans – who would or could be adversely impacted as a result of the proposed hunt. More specifically, it is concerned about: the impact of the hunt on gray whales, including WNP and PCFG gray whales; the hunt's legality; the cruelty inherent to whaling; public safety; the precedent that would be set if the hunt proceeds; and cumulative (and increasing) anthropogenic impacts to gray whales and their habitat.

While the Coalition commends NMFS for its 2008 decision to terminate a previous NEPA decision-making process based on new scientific information relevant to PCFG and WNP whales that became available, the present DEIS is replete with deficiencies. In general, those deficiencies include the failure to:

- Demonstrate how allowing the Makah to hunt whales is consistent with US law and international convention standards relevant to ASW;
- Consider a reasonable and feasible range of alternatives;
- Fully disclose all relevant information and provide a clear, consistent, and accurate analysis of the environmental consequences of the no action alternative and action alternatives on, among other variables, gray whales, tourism, economics, the social environment, and public health;
- Accurately assess the precedential effects of granting an MMPA waiver to the Tribe;
- Define or provide meaningful, quantifiable, and measurable impact thresholds to permit the public to distinguish between the direct and indirect impacts of the no action and action alternatives;
- Adequately evaluate the cumulative impacts of the analyzed alternatives in regard to other past, present, and reasonably foreseeable actions undertaken by federal, state/provincial, municipal, or private parties.

Furthermore, before proceeding with this decision-making process, it is imperative that NMFS render a determination as to whether PCFG whales constitute a population stock under the MMPA. Given the implications of such a determination to gray whales and the Makah Tribe's hunt proposal, continuing to delay this determination is improper. Even if making this determination requires additional scientific study of PCFG whales, this should be undertaken expeditiously so that a stock determination can be made as a prerequisite for the continuation of the present planning process.

There are two fundamental legal arguments that demonstrate why the MMPA waiver cannot be granted. These arguments are addressed below.

<u>NMFS cannot issue a MMPA waiver to the Makah Tribe:</u>

The MMPA sets forth general criteria to use in determining if a waiver to the MMPA's take prohibitions should be granted. Specifically, the Secretary, in consideration of the "distribution, abundance, breeding habits, and times and lines of migratory movements of such marine mammals" is authorized to determine "when, to what extent, if at all, and by what means it is compatible with this chapter to" issue a waiver to allow the taking of a marine mammal. 16 U.S.C. § 1371(a)(3)(A). In addition, the Secretary "must be assured that the taking of such marine mammals is in accord with sound principles of resource protection and conservation as provided in the purposes and policies of this chapter." *Id.* To be compatible with the MMPA and in accord with sound principles of resource protection and conservation, such a finding must ensure, at a minimum, that the marine mammals in question are not "permitted to diminish beyond the point at which they cease to be a significant functioning element in the ecosystem of which they are a part and, consistent with this major objective, they should not be permitted to diminish below their optimum sustainable population."[1] *Id.* at § 1361(2).

If NMFS grants an MMPA waiver, it also must promulgate regulations to govern the number, location, and manner of the permitted take as well as permits to formally authorize the take. In promulgating such regulations, the Secretary is allowed to consider all factors that may affect the extent to which such animals may be taken. This includes existing and future levels of marine mammal species and population stocks, international treaty and agreement obligations, and marine ecosystem and related environmental considerations, 16 U.S.C. § 103(b)(1-3), but does not require it to consider any treaty obligations with Native American tribes.

Based on the best available scientific evidence, including the myriad studies cited in the DEIS, it is not possible for NMFS to make the required determination for ENP gray whales. In this case, however, the decision to be made is not limited to ENP gray whales, despite the fact that the Makah's waiver application covers that particular population of gray whales. Because the MMPA's waiver language is applicable to "marine mammals" and is not limited to species or population stocks, since ENP, PCFG, and WNP gray whales can all share a common range (both geographically and temporally), and given that it is impossible to distinguish between ENP, PCFG, and WNP gray whales by observation alone, any MMPA waiver determination for ENP gray whales also must be made for WNP and PCFG whales. Indeed, it would be illogical and illegal for NMFS to issue an MMPA waiver to the Makah Tribe to allow the take, including lethal take, of ENP gray whales if by doing so it would cause WNP or PCFG gray whales to "cease to be a significant functioning element in the ecosystem of which they are a part" or if it could diminish WNP or PCFG gray whales below their "optimum sustainable population." This dilemma is similar to that addressed in *Kokechik Fishermen's Ass'n v. Secretary of Commerce* (839 F.2d 795 (D.C. Cir. 1988)), where the court ruled the issuance of an incidental take permit by NMFS was deemed to be "contrary to the requirements of the MMPA in that it allowed incidental taking of various species of protected marine mammals without first ascertaining as to each such species whether or not the population of that species was at the OSP level."

For the WNP gray whales, the current population estimate is 140 animals. Although the International Union for Conservation of Nature (IUCN) designates this subpopulation's demographic trend as increasing (Reilly et al. 2008), it remains classified as critically endangered. While our knowledge of this population of gray whales is increasing, much remains

[1] Optimum sustainable population or OSP is defined as "the number of animals which will result in the maximum productivity of the population or species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem in which they form a constituent element." 16 U.S.C. §§ 1362(9) and 3-51/52. NMFS further defines this term in regulations implementing the MMPA to mean "a population size which falls within a range from the population level of a given species or stock which is the largest supportable within the ecosystem to the population level that results in the maximum net productivity level." 50 CFR § 216.3 and DEIS at 3-51/52.

unknown, including a complete understanding of migratory patterns. Based on tagging data, DNA analysis from biopsy samples, and photographic identification, 27 WNP gray whales (19 percent of the entire known population) have migrated from Russia, across the Bering Sea, and to the west coast of the United States and Mexico over the past several years. While all 27 WNP gray whales returned to Russia in the spring/summer, it is not known whether they bred with any ENP gray whales, whether any ENP gray whales have migrated to Russia, the total number of WNP gray whales that have emigrated to the ENP range, and whether any WNP whales have remained with the ENP gray whales in the Arctic or within the PCFG.

More importantly, in regard to the MMPA waiver criteria, the carrying capacity of the WNP habitat has not been determined and, consequently, the population's OSP is unknown. According to Punt (2015) the WNP population (which he separates into an Asian and Sakhalin stocks) is approximately 10 percent of their carrying capacities. Consequently, notwithstanding the ongoing need for more information about the migratory patterns and reproductive habits of WNP gray whales, without knowledge of carrying capacity or OSP, the Secretary cannot ensure that the issuance of a waiver to the Makah Tribe to permit the take of ENP gray whales will not diminish WNP gray whales below their OSP. Indeed, as mentioned repeatedly in the DEIS, while Moore and Weller (2013) report that there is only a seven percent chance for a single WNP gray whale being struck by the Makah over six years (under the Makah Tribe's proposal), it cautions that "loss of a single whale, particularly if it were a reproductive female, would be a conservation concern." Moreover, if Moore and Weller underestimated the risk to WNP gray whales from a Makah whale hunt, then the adverse conservation implications of a Makah hunt would be more severe.

Similarly, for PCFG whales, no one has determined the carrying capacity for these whales within the PCFG region or any of its sub-regions and, therefore, its OSP is also unknown. This was confirmed by Punt and Moore (2013), who determined "it was not possible to draw a definitive conclusion as to whether the PCFG is within OSP." DEIS at 3-156. More recently, Punt (2015) found the PCFG "sub-stock" is approximately at 50 percent of its carrying capacity. Even if NMFS determines that it need not consider PCFG whales in making a waiver decision for ENP whales (since PCFG whales have not yet been designated a stock), since NMFS has itself reported that the PCFG may qualify as a stock in the future and considering the precautionary principle, for the purpose of the waiver determination, NMFS should treat the PCFG gray whales as a stock.

Based on the foregoing analysis, and recognizing that with the exception of a handful of PCFG whales that may be known to Makah tribal biologists or other officials based on easily distinguishable markings, it is impossible to differentiate WNP, ENP, and PCFG gray whales through observation alone within the Makah U&A, NMFS must select the no action alternative. Alternatively, if NMFS does allow this process to proceed, the Secretary must not issue the requested waiver at this time. In the future, after further research begins to elucidate answers to many of the remaining questions about stock structure, demographics, reproductive characteristics, genetics, migratory patterns, and behaviors, this waiver request could be revisited but, at present, the waiver application must be denied.

The current NEPA process is invalid and must be terminated because the Makah Tribe cannot qualify for an ASW quota:

The DEIS designates a purpose and need for action for both the Makah Tribe and NMFS. For the Makah Tribe, its purpose is "to resume its traditional hunting of gray whales under its treaty right" while its need "is to exercise its treaty whaling rights to provide a traditional subsistence resource to the community and to sustain and revitalize the ceremonial, cultural, and social aspects of its whaling traditions." DEIS at 1-27. For NMFS, its purpose is "to implement the laws and treaties that apply to the Tribe's request, including the Treaty of Neah Bay, MMPA, and WCA," while its need is "to implement its federal trust responsibilities to the Makah Tribe with respect to the Tribe's reserved whaling rights under the Treaty of Neah Bay." *Id.*

The Coalition does not dispute that the Treaty of Neah Bay includes language recognizing the Makah Tribe's whaling right, but, as explained below, this treaty language may have been abrogated by the passage of the MMPA and the Makah Tribe cannot qualify for an ASW quota under the Whaling Convention Act (WCA) or IWC standards and, therefore, is not able to engage in whaling.

Given that the United States recognizes the legal authority of the IWC to regulate whaling, including ASW, if the Makah Tribe cannot qualify for an ASW quota (as is made clear below), then the United States should not request a quota, no quota should be approved, and, no quota can be allocated to the Makah. Therefore, as explained previously, since the Makah Tribe cannot satisfy the "continuing traditional dependence on whaling and the use of whales" language in the definition of "aboriginal subsistence whaling" and cannot demonstrate either a subsistence or nutritional need for whales or their products, it does not satisfy the basic criteria to obtain an IWC-approved quota (and any previously approved quotas should not be considered valid).

Since the Makah Tribe not qualify for an ASW quota from the IWC, its purpose and need (and the purpose and need proffered by NMFS) cannot be met without violating US law or an international treaty and are, therefore, invalid. In turn, without a legitimate purpose and need, the DEIS is unnecessary and the current decision-making process should be terminated.

If NMFS must select an alternative that satisfies its own or the Makah Tribe's purpose and need (additional discussion of this issue is below), then the overall outcome of this NEPA process has been predetermined in that the Makah will be granted a waiver and will be allowed to kill whales because that is the only option available given the purpose and need statements. Under this scenario, the only question is when, where, how, and how many whales the Makah Tribe will be allowed to kill. Consequently, any interested stakeholder that supports the no action alternative, regardless of the quality or substantive content of their comments, is wasting its time because NMFS will claim that it cannot select the No Action Alternative since it would not meet its or the Makah Tribe's purpose and need. Not only is there nothing in the NEPA statute or its implementing regulations that support this approach, but this effectively undermines the intent of NEPA and the importance of public participation in the NEPA process.

Consequently, to ensure that the decision-making process is meaningful for everyone, NMFS must eliminate the Makah Tribe's stated purpose and need for action and restate its purpose and need so that the no action alternative is a legally viable option at the conclusion of this process. In regard to the Makah Tribe's purpose and need, it is irrelevant what the Makah want, since this DEIS is being used by NMFS to assist in its decision-making process. Indeed, it is unusual for any DEIS to include dual purposes and needs – one set from the applicant and one set from the agency.

For NMFS, if it were to restate its purpose to be "to determine if the Makah Tribe's interest in resuming whaling under the Treaty of Neah Bay qualifies for a waiver of the moratorium on the take of marine mammals under the Marine Mammal Protection Act and is consistent with other federal laws," and its purpose to be "to determine if the Makah Tribe's whaling proposal is consistent with all federal laws," then the no action alternative is relevant. If this were the purpose and need stated in the DEIS, NMFS could decide that despite the treaty language, whaling by the Makah Tribe is not consistent with the MMPA, WCA, or other relevant federal laws and that, therefore, a waiver would not be granted, and thereby the No Action Alternative would be a legally viable selection.

Additional comments:

The remainder of this comment letter will provide additional evidence and analysis to support the deficiencies identified above, while also documenting other inadequacies in the analysis. The analysis will largely be based on the relevant international conventions and US statutes and regulations that govern ASW.

International Convention for the Regulation of Whaling, IWC Schedule, and Whaling Convention Act

As a result of the overexploitation resulting in the near extinction of the gray whale, "the United States signed in 1946 the International Convention for the Regulation of Whaling (Convention or ICRW) in order 'to provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry....'".[2] The ICRW does not explicitly permit Aboriginal Subsistence Whaling (ASW), but exceptions to restrictions on commercial whaling were incorporated into predecessor treaties to the ICRW and have been a part of the whaling regime since the Convention was approved.

The Convention enacted a schedule of whaling regulations (Schedule) and established the IWC, to be comprised of one member from each signatory country. The ICRW "granted the IWC the power to amend the Schedule by 'adopting regulations with respect to the conservation and utilization of whale resources,' including quotas for the maximum number of whales to be taken in any one season.[3] In 1982, the IWC voted to place a moratorium on commercial whaling, which is still in place today. Even those ASW hunts where the products are actively sold (e.g., Greenland), are not considered to be commercial whaling; although the sale of certain ASW products has been used to question if these hunts qualify as ASW. The Schedule provides regulations with which IWC Contracting Governments must comply in regard to whaling and the conservation of whale stocks. Under the auspices of the ICRW, ASW "is permitted, but such whaling must conform to quotas issued by the IWC for various whale stocks."[4]

The WCA (16 U.S.C. 916 et seq.), enacted in 1949, is the legal instrument in the United States that implements the ICRW domestically. The WCA prohibits whaling in violation of the ICRW, the Schedule, or any whaling regulation adopted by the Secretary of Commerce. *See id.* § 916c. The WCA also tasks the National Oceanic and Atmospheric Administration ("NOAA") and the National Marine Fisheries Service ("NMFS"), within the Department of Commerce, with promulgating regulations to implement the provisions of the WCA. *See id.* § 916 et seq.; 50 C.F.R. § 230.1 (1998). As the DEIS states, under the WCA, NMFS must regulate whaling in accordance with the ICRW and IWC regulations. DEIS at 1-26.

For the purposed of this comment letter, the most relevant portion of the Schedule is paragraph 13 and, specifically, subparagraph (b)(2), which pertains to Eastern North Pacific gray whales. That language defines when, where, and how ENP gray whales can be killed by aboriginal subsistence whalers. The current text provides that:

> 2) The taking of gray whales from the Eastern stock in the North Pacific is permitted, but only by aborigines or a Contracting Government on behalf of aborigines, and <u>then only when the meat and products of such whales are to be used exclusively for local consumption by the aborigines</u>. (emphasis added)

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[2] S*ee Metcalf v. Daley*, 214 F.3d 1135, 1138, 9th Cir. (2000), quoting the International Convention for the Regulation of Whaling, 62 Stat. 1716, 1717 (1946). See also, 161 United Nations Treaty Series 72.
[3] Metcalf v. Daley, Id., citing 62 Stat. 1718-19.
[4] *Anderson v. Evans*, 371 F.3d 475, 483 (2002).

> (i) For the years 2013, 2014, 2015, 2016, 2017 and 2018, the number of gray whales taken in accordance with this sub-paragraph shall not exceed 744, provided that the number of gray whales taken in any one of the years 2013, 2014, 2015, 2016, 2017 and 2018 shall not exceed 140.

The WCA requires the United States to comply with the ICRW and the Schedule. The only time when such compliance is not required is if the United States were to file an objection to a Schedule amendment agreed to by the IWC. In the context of ASW, the WCA prohibits the United States from, for example, self-allocating ASW quotas in the event the IWC does not approve such quotas.[5] Furthermore, as made clear by Wold and Kearney (2015) (Attachment 1), even if the WCA allowed the United States to self-allocate ASW quotas, the historic pattern and practice within the IWC, which the United States has repeatedly endorsed, is for ASW countries to obtain approval from the IWC for their ASW quotas based on their documented need and concurrence from the IWC's Scientific Committee that the quotas are sustainable.

There are a number of definitions relevant to ASW used or agreed to by the IWC, contained in the ICRW or Schedule, historically used by the IWC, or included in the WCA. The most relevant definitions are provided below.

A 1981 Ad Hoc Technical Working Group on Development of Management Principles and Guidelines for Subsistence Catches of Whales by Indigenous People defined "aboriginal subsistence whaling" as "whaling for purposes of local aboriginal consumption carried out by or on behalf of aboriginal, indigenous, or native people who share strong community, familial, social, and cultural ties related to a continuing traditional dependence on whaling and the use of whales." The same Working Group defined "local aboriginal consumption" to mean the "traditional uses of whale products by local aboriginal, indigenous, or native communities in meeting their nutritional, subsistence, and cultural requirements."

While the IWC has never formally adopted these definitions, they have consistently been applied by the IWC since 1981 and consequently, based on historical use, are relevant to this analysis. In addition, the United States recites these definitions in the DEIS (DEIS at 1-23) and has done so in all previous NEPA analyses relevant to both the Makah and Alaska Eskimo Whaling Commission ASW hunts. Taken together, these definitions make clear that, to qualify as ASW, any aboriginal group has to demonstrate a "nutritional, subsistence, <u>and</u> cultural" (emphasis added) need for whale products and that they have a "continuing traditional dependence on whaling and the use of whales."

[5] The United States has wrongly suggested that it has the authority to self-allocate ASW quotas (see e.g., 2013 Bowhead Whale Final EIS, page 7, footnote 9).

The Schedule defines "strike" to mean "to penetrate with a weapon used for whaling" and "take" to mean "to flag, buoy or make fast to a whale catcher." Schedule at 1(C). Neither of these terms are defined in the WCA. Conversely, while the term "whaling" is not defined in the ICRW or Schedule, it is defined in the WCA to mean "the scouting for, hunting, killing, taking, towing, holding onto, and flensing of whales, and the possession, treatment, or processing of whales or of whale products."

Makah whaling is inconsistent with the criteria for ASW contained in the ICRW, its associated Schedule, and the WCA:

When these definitions noted above are considered together, it becomes clear that the Makah Tribe does not and never has qualified for an ASW quota from the IWC. Nevertheless, the United States successfully obtained an ASW quota for gray whales to be allocated to the Makah Tribe in 1997. At that meeting, contrary to the description of the debate in the DEIS, nearly all of the IWC Contracting Government delegates that intervened during the discussion of the gray whale ASW quota opposed any ASW quota for the Makah Tribe, stating the tribe did not qualify. Ultimately, the delegates agreed to allow the quota to be used by aboriginal groups "whose traditional subsistence and cultural needs have been recognized."[6] However, in reality the only reason the quota was secured is because the request was made jointly with the Russian Federation, which was seeking a gray whale quota to allocate to its Chukotkan natives who, unlike the Makah, do qualify for an ASW quota.[7]

The primary concerns with the IWC's approval of a gray whale quota for the United States to allocate to the Makah were that the Makah could not satisfy the "continuing traditional dependence on whaling and the use of whales" and that they did not have a "nutritional need." Regarding the first standard, Contracting Governments and many observers argued that, at that time, the approximately 70-year hiatus in Makah whaling simply could not be squared with the requirement that ASW had to be based on a "continuing traditional dependence on whaling and the use of whales." Even NMFS concedes in the DEIS that the Makah whale hunt is different

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[6] After agreement was reached, the United States declared in a press release that it was able to successfully obtain a quota for the Makah Tribe. Australia, in its own press release, strongly disagreed with the United States, claiming that while a gray whale ASW quota was approved, the needs of the Makah had not been recognized by the IWC, and that the IWC was the only entity that had the authority to recognize such needs even though this was not explicitly identified in the language agreed to by the delegates. At the IWC's 2004 meeting, the "whose traditional subsistence and cultural needs have been recognized" text was removed entirely from the Schedule at the request of the Russian Federation.

[7] Prior to the 1997 IWC meeting, neither the United States nor any other ASW country had ever requested a joint ASW quota for a single stock of whales, revealing that contrary to recent claims of a requirement to bundle quota requests for a single stock, the ICRW and Schedule permit ASW countries to separately seek ASW quotas for the same stock.

than other aboriginal subsistence hunts because of "the Tribe's 70-80 year hiatus in whaling." DEIS at 4-268.

Despite the United States' success in obtaining the 1997 quota for the Makah Tribe and subsequent renewal of the quota in 2002, 2007, and 2012, the Makah Tribe's needs statement never satisfied the IWC criteria for ASW that the United States established through its efforts to secure a bowhead whale quota for Alaskan Natives. The Coalition, therefore, asserts that the IWC never should have approved the quota.

Notwithstanding IWC approval, the quota is inconsistent with the WCA, because the Makah Tribe's reported dependence on "whaling and the use of whales" over that 70-year (now nearly 90-year) period does not constitute "whaling" as defined by the WCA. As indicated above, "whaling" as defined in the WCA, means "the scouting for, hunting, killing, taking, towing, holding onto, and flensing of whales, and the possession, treatment, or processing of whales or of whale products."[8] In its needs statements submitted to the IWC (and in their defense of the quota at past IWC meetings), the Makah (and the US Government) have argued that the tribe satisfies the "continuing traditional dependence" language for ASW based on their traditional rituals, ceremonies, songs, dances, and stories that celebrate whales and whaling and their use of whales as culturally important symbols of their whaling traditions; practices that the Makah claim have continued despite the hiatus in whaling. Regardless of whether this claim is true or not (see page 91 for a discussion of such claims), the celebration of whales and whaling through ceremonies, songs, dances, and other rituals does not satisfy the definition of "whaling" in the WCA.

Furthermore, independent of the definition of "whaling" in the WCA, even under the Makah Tribe's definition of "whaling," the Tribe would not be able to meet the "continuing traditional dependence on whaling …" criteria to qualify for an IWC-approved ASW quota. For example, in both its 2001 Management Plan for Makah Treaty Gray Whale Hunting for the Years 1998-2002 and its 2013 Makah Whaling Ordinance (see Appendices A and B of the DEIS), the Makah define "whaling" to mean "the scouting for, hunting, striking, killing, or landing of a whale." The definition clearly does not encompass traditions, rituals, dances, songs, ceremonies, or other spiritual activities that the Makah have claimed they have continued to practice during the Tribe's hiatus in whaling.

As to the portion of the criteria that refers to the "use of whales," that requirement is in addition to a "continuing traditional dependence on whaling." Hence, even if the Makah Tribe could demonstrate a "continuing traditional dependence on … the use of whales," without

[8] Since "whaling" includes the act of "towing" the whale to shore, when other tribes joined with the Makah to assist it in towing the whale killed in 1999 to shore (see DEIS at 1-38, 3-312) they violated the WCA since only the Makah Tribe was authorized to conduct whaling.

being able to satisfy the whaling standard, the Makah cannot and do not qualify for a gray whale quota. In terms of the Makah Tribe's use of whales, while is it unknown how many drift, stranded, or entangled whales the Makah may have used since the late 1920s (when the Makah Tribe ceased whaling), in the past two decades the available evidence suggests the Makah have only used three gray whales; the one killed in the 1999 hunt, one drift whale, and two gray whales that died after being entangled in fishing nets.

Based on the foregoing discussion, it is astonishing that the United States has engaged in over 20 years of scientific study, environmental planning, international outreach, and decision-making, and has expended considerable time and resources attempting to defend its Makah whaling decisions in court, when the tribe clearly and indisputably cannot meet the basic criteria to secure an ASW quota. This inconsistency with the "continuing traditional dependence" language in the definition of ASW has been raised repeatedly by several members of the Coalition (and other organizations) in response to previous environmental analyses, but has been ignored by NMFS, as it has never offered, and fails to offer in this DEIS, any explanation as to how the Makah satisfy this definition. Instead, by forcing this square peg into the round hole of what qualifies for an ASW quota, the United States has undermined the entire ASW process within the IWC, and in the process created a new category of ASW whaling that is based on alleged cultural needs only.

1. <u>The Makah Tribe does not have a subsistence or nutritional need to whale:</u>

The second standard that must be met in order to qualify for an ASW quota as contained in the definition of "local aboriginal consumption" is that there must be a demonstrable cultural, subsistence, and nutritional need. The use of the conjunction "and" in this definition makes clear that all three needs (i.e., cultural, subsistence, and nutritional) must be met for an ASW quota to be approved. In this case, the Makah cannot demonstrate either a "subsistence" or "nutritional" need for gray whales and, consequently do not satisfy the definition of "local aboriginal consumption" and, therefore, do not quality for an ASW quota.

As an initial matter, the Makah Tribe's request for a waiver of the MMPA and the DEIS both specify that the Makah Tribe seeks to resume whaling to satisfy its ceremonial and subsistence needs (see e.g., DEIS at ES1, 1-1). In neither document is it suggested that the Makah Tribe's interest in killing gray whales is based on any nutritional need. There is information about the alleged nutritional benefit of marine mammal products, including whale meat, blubber, and oil, in the DEIS and in past Makah needs statements, including the 2002 statement appended to the DEIS, but the tribe's request for a waiver is explicitly not based on any claimed nutritional need.

The terms "subsistence" and "nutritional" are not defined in the ICRW, the Schedule, or the WCA. The terms "subsistence" and "subsistence use" are defined in regulations implementing the MMPA (50 CFR § 216.3), with the former definition applicable only to Alaskan natives, while the latter is limited to the use of fur seals. The dictionary definition of "subsistence" and "nutritional" (obtained from http://www.merriam-webster.com/) are:

> Subsistence: a)(1) real being; (2) the condition of remaining in existence; b) an essential characteristic quality of something that exists; and c) the character possessed by whatever is logically conceivable or, if used in the context of a means of subsisting then: a) the minimum (as of food and shelter) necessary to support life; and b) a source or means of obtaining the necessities of life.
>
> Nutrition: the act or process of nourishing or being nourished; *specifically*: the sum of the processes by which an animal or plant takes in and utilizes food substances.

The definition of "subsistence" in the MMPA, suggests that "subsistence" refers to the use of marine mammals to meet food, clothing, shelter, heating, transportation and other needs, while the term "nutrition" is specific to the use of marine mammals as food or for nourishment. Neither term refers to any ritualistic, ceremonial, spiritual, or other uses of whales, as those uses are clearly intended to be encompassed within the term "cultural."

Despite the Makah Tribe's claim that they have a subsistence and nutritional need for whale meat and other products, information from its own needs statements, as well as evidence contained in the DEIS, provide ample evidence that the Makah do not have a legitimate subsistence or nutritional need for whale meat and other products. That evidence is summarized in detail in another section of this letter that critiques the analysis of environmental consequences in the DEIS. Indeed, even without compiling and summarizing this evidence, the fact that the Makah Tribe has largely gone without whale products for nearly 90 years should be ample proof of the lack of a subsistence or nutritional need.

Based on the foregoing evidence and analysis, the Makah Tribe does not have and cannot demonstrate a legitimate subsistence or nutritional need for whales or whale products. Considering the definition of "whaling" under the WCA in the context of the requirement of a "continuing traditional dependence on whaling…," the existing ASW quota that the United States obtained on behalf of the Makah (which extends until 2018) is invalid, illegal, and should not be allocated if the Makah are allowed to whale before 2018. Furthermore, absent an amendment to the WCA, should the United States attempt to seek a renewed gray whale quota at the 2018 IWC meeting, it will be acting in violation of the WCA. Similarly, unless the United States can conclusively demonstrate that the Makah Tribe has a legitimate subsistence and nutritional need, it should not seek a quota renewal at the 2018 IWC meeting.

2. The Makah Tribe, if allowed to whale, has to limit consumption of any edible whale products to tribal members on the reservation:

Should the Makah be allowed to whale in the future, the terms of any waiver issued under the MMPA or any associated regulations or permits must require that any edible portions of any whale taken be "used exclusively for local consumption by the aborigines." IWC Schedule at 13(b)(2), DEIS at 1-22.

The DEIS contains references that indicate that if the Makah Tribe is allowed to whale, NMFS would allow the tribal members to "share whale products from any hunt within the borders of the United States with relatives of participants of the harvest, others in the local community (relatives and non-relatives), (and) persons in locations other than the local community with whom local residents share familial, social, cultural, or economic ties." DEIS at 1-24 (emphasis added). While Makah tribal members would not be allowed to sell any edible whale products, NMFS indicates that the distribution of whale products to qualified people in the United States is consistent with the working definition of "subsistence use." *Id*. That definition, which was created at a 1979 meeting of a Cultural Anthropology Panel convened as part of a larger meeting about the Alaska Eskimo bowhead hunt, specifies that "subsistence use" includes:

- The personal consumption of whale products for food, fuel, shelter, clothing, tools, or transportation by participants in the whale harvest.
- The barter, trade, or sharing of whale products in their harvested form with relatives of the participants in the harvest, with others in the local community, or with persons in locations other than the local community with whom local residents share familial, social, cultural, or economic ties. A generalized currency is involved in this barter and trade, but the predominant portion of the products from each whale are ordinarily directly consumed or utilized in their harvested form within the local community.
- The making and selling of handicraft articles from whale products when the whale is harvested for the purposes defined in (1) and (2) above.

This definition was eventually adopted, by consensus, at the IWC's 2004 annual meeting.

NMFS, however, is ignoring the explicit language in the Schedule relevant to ENP gray whales. That language, which trumps any of the IWC approved or adopted definitions, makes clear that the take of gray whales is allowed "only when the meat and products of such whales are to be used exclusively for local consumption by the aborigines." This same limitation is included in Schedule paragraph (b)(1) pertaining to the take of bowhead whales from the Bering-Chukchi-Beaufort Sea stock. For ASW hunting by Greenlandic natives, the relevant language allows for the use of whale products in Greenland "exclusively for local consumption" (Schedule, paragraph 13(b)(3)) while, for aboriginal whalers in Saint Vincent and the Grenadines, whale products can be used "exclusively for local consumption in St. Vincent and the Grenadines" (Schedule, paragraph 13(b)(4)). Consequently, it is the "by the aborigines" language that requires that any whale products obtained by the Makah Tribe to be used exclusively by them, while "local consumption" has to mean on the reservation, particularly since the Makah's alleged need for whale products is based on what is needed by tribal members living in Neah Bay.

If, despite this analysis, NMFS continues to believe the Makah Tribe, if allowed to whale, can share whale products with tribal and non-tribal members outside the reservation, it must, through regulations or permits, significantly restrict such sharing of edible whale products since the "familial, social, cultural or economic ties" language in the definition of subsistence use is so broad that it could allow sharing of such products with an unlimited number of people throughout the entire United States. Indeed, contrary to NMFS's willingness to allow the Makah Tribe to share whale products throughout the country, the Makah's 2005 waiver application requested that it be allowed to kill five gray whales each calendar year (or 20 in five years). Makah Waiver Application at 1. The selection of five whales was not random but, rather, was based on the number of Makah Tribe's ancestral villages. As noted in the DEIS, "the Tribe anticipated harvesting only one or two whales initially, but included five as the maximum extent of the yearly harvest, if it determined that it could use additional whales effectively and allocate them to each of five ancestral villages. DEIS at 1-30 (citing Makah Tribal Council 1995). This would suggest that the Makah Tribe had no intention of sharing whale products beyond its local area (i.e., the five ancestral villages).

Marine Mammal Protection Act

The MMPA (16 U.S.C. 1361 et seq.) is the nation's preeminent law for the protection of marine mammals. In passing this law, Congress found that "certain species and population stocks of marine mammals are, or may be, in danger of extinction or depletion as a result of man's activities." *Id.* at § 1361(1). In addition, Congress determined that "such species and population stocks should not be permitted to diminish beyond the point at which they cease to be a significant functioning element in the ecosystem of which they are a part, and, consistent with this major objective, they should not be permitted to diminish below their optimum sustainable population." *Id*. at § 1361(2) (see also DEIS at 1-13, 1-18). Congress further found that "marine mammals have proven themselves to be resources of great international significance, esthetic and recreational as well as economic, and … they should be protected and encouraged to develop to the greatest extent feasible commensurate with sound policies of resource management and that the primary objective of their management should be to maintain the health and stability of the marine ecosystem." *Id.* at § 1361(6). The goal is to "obtain an optimum sustainable population ("OSP") keeping in mind the carrying capacity of the habitat." *Id.*

To achieve such conservation objectives, the MMPA established a moratorium on the take of marine mammals. Under the MMPA, a marine mammal is defined as "any mammal which (A) is morphologically adapted to the marine environment (including sea otters and members of the orders Sirenia, Pinnipedia and Cetacea), or (B) primarily inhabits the marine environment (such as the polar bear); and, … includes any part of any such marine mammal, including its raw, dressed, or dyed fur or skin." *Id.* at § 1362(6). The law defines "take" to mean "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." *Id*. at § 1362(13).

Take, under some circumstances, can be allowed under the MMPA if the requisite permits are obtained from the agency. In allowing take, the drafters of the MMPA "endeavored to build… a conservative bias" in favor of marine mammals. H.R. REP. NO. 92-707, at 24 (1971), *reprinted in* U.S.C.C.A.N. 4144, 4148.

> In every case, the burden is placed upon those seeking permits to show that the taking should be allowed and will not work to the disadvantage of the species or stock of animals involved. If that burden is not carried-- and it is by no means a light burden-- the permit may not be issued. The effect of this set of requirements is to insist that the management of the animal populations be carried out with the interests of the animals as the prime consideration.

H.R. REP. NO. 92-707 at 18, *reprinted in* U.S.C.C.A.N. 4144, 4151.

When NMFS issues a permit, it needs to satisfy the criteria of section 104 and be consistent with MMPA purposes, as demonstrated by the applicant. MMPA § 1374(d)(3). A permit must also comply with regulations promulgated under section 103, be "consistent with the purposes and policies" of the MMPA, and "not be to the disadvantage of those species and stocks." Id. § 1373(a). A permit will disadvantage a marine mammal stock and cannot be issued if it causes it to fall below OSP or include takes from a stock already below OSP.[9]

One of the exceptions to the moratorium against the take of marine mammals is for "any Indian, Aleut, or Eskimo who resides in Alaska and who dwells on the coast of the North Pacific Ocean or the Arctic Ocean if such taking … (is) (1) … for subsistence purposes; or (is) (2) … done for purposes of creating and selling authentic native articles of handicrafts and clothing; and (3) in each case, is not accomplished in a wasteful manner. 16 U.S.C. § 1371(b)(1-3).

1. <u>Abrogation of the Makah Tribe's treaty right to whale:</u>

[9] See *Committee for Humane Legislation, Inc. v. Richardson*, 414 F. Supp. 297, 302 (D.D.C. 1976), aff'd, 540 F.2d 1141 (D.C. Cir. 1976); see also, Kokechik Fishermen's Ass'n v. Secretary of Commerce, 839 F.2d 795 (D.C. Cir. 1988).

Considering the MMPA's broad moratorium on take and the fact that Congress did not include the Makah Tribe or any other United States coastal tribe with a history of whaling or, as is the case for the Makah, a treaty right explicitly recognizing the tribe's whaling right, the MMPA exception language is ample and indisputable evidence that the Makah's treaty right was abrogated by the MMPA. Supreme Court precedent supports this position.[10]

Indeed, given the significance of the MMPA, the myriad interests[11] engaged in lobbying for or against the legislation, and the vast number of politicians, aides, and experts involved in both drafting the bill and in achieving its adoption, it is inconceivable that no one, particularly the Makah Tribe, advised Congress of the tribe's treaty language or of its tradition of whaling. Alternatively, if such communications never occurred, this demonstrates that no one, particularly the Makah Tribe, cared enough or was sufficiently concerned about its treaty language to bring it to the attention of Congress at that time. Abrogation of said treaty language is, therefore, inferred as a result of Congress not being asked to recognize or preserve the Makah's interest in whaling when promulgating the MMPA.

While the abrogation claim was raised in both *Metcalf v. Daley* (214 F.3d 1135 (9th Cir. 2000)) and *Anderson v. Evans* (314 F.3d 1006 (9th Cir. 2002) (rehearing en banc denied and opinion amended 350 F.3d 815 (9th Cir. 2003)), the courts have not ruled on that claim. Consequently, while it is inevitable that a court will eventually have to render a decision on the abrogation claim, NMFS should have, but failed to, discuss the issue in the DEIS. NMFS is well aware of this argument and, therefore, in its summary of the relevant laws applicable to Makah whaling, should have explained the relevant case law on treaty abrogation and made clear the reasons why it believes the MMPA did not abrogate the Makah's treaty language regarding whaling. It should include such a discussion in a revised analysis.

2. <u>The Makah MMPA waiver application:</u>

In this case, because of the MMPA's moratorium on take of marine mammals, the Makah Tribe is seeking a waiver to that prohibition as directed by the court in *Anderson v. Evans*. While the Makah Tribe does not agree with the ruling in *Anderson* and believes that its "treaty right" trumps the MMPA, it elected to pursue a waiver. In its 2005 application, the Makah include several elements or provisions that warrant additional scrutiny or are worth noting for the purpose of this comment letter.

[10] *See U.S. v. Dion*, 476 U.S. 734 (1986), which held that the Bald and Golden Eagle Protection Act abrogated the rights of the members of the Yankton Sioux Tribe under the 1858 treaty to hunt bald or golden eagles on the Yankton Reservation.

[11] These interests included Native American Tribes and organizations, states, industry, and non-governmental organizations.

Treaty of Neah Bay:

While the Makah attempt to address the specific criteria contained in the MMPA, which must be met to obtain a waiver (discussed in more detail below), it also relies on its "treaty right" to justify a waiver. Yet the Treaty is not the end all, be all; rather, it is limited by the MMPA.

The Treaty of Neah Bay was one of the Stevens Treaties, negotiated by Isaac Stevens, the Governor of Washington Territory, with leaders of the Northwest Tribes that occupied what is now the State of Washington. These treaties guaranteed signatory tribes "the right of taking fish at usual and accustomed grounds and stations … in common with all citizens of the Territory." The Treaty of Neah Bay explicitly references whaling: "the right of taking fish and of whaling or sealing at usual and accustomed grounds and stations is further secured to said Indians in common with all citizens of the United States." See Treaty of Neah Bay at Article 4.

In its repeated references to the treaty language in the DEIS, NMFS fails to include the "in common with" language. While the courts have interpreted that language, the layperson who may read the treaty will likely be confused by this language, which suggests the Makah Tribe can only engage in whaling if other United States citizens are also able to engage in the same activity. In 1855 that was the case, but today, US citizens are prohibited from intentionally killing any marine mammals. NMFS needs to provide additional discussion of judicial interpretations of this treaty language to ensure that all stakeholders have a common understanding of the meaning of the "in common with" language and, more broadly, the limitations inherent to the Makah's treaty right. The Coalition provides its understanding of the treaty language and the limitations on the treaty here.

Generally, the courts have interpreted the phrase "in common with" to establish "a cotenancy, in which neither party may 'permit the subject matter of [the treaty] to be destroyed.'" *Anderson v. Evans*, 314 F.3d 1006 (9th Cir. 2002) (quoting *United States v. Washington*, 520 F.2d 676, 685 (9th Cir. 1975)). *See also United States v. Washington,* 761 F.2d 1404, 1408 (9th Cir.1985) (recognizing that "in common with" has been interpreted to give rise to cotenancy-type relationships).

The treaties guarantee tribes the right to harvest an equal portion of the available resource, not just an equal opportunity to do so with non-Indians. *Washington v. Washington State Commercial Passenger Fishing Vessel Ass'n*, 443 U.S. 658, 679 (1979) (holding that the Stevens treaties guarantee tribes the "right to take a share of each run of fish that passes through tribal fishing areas"). That right is subject to federal and state regulation, provided that the regulation is *nondiscriminatory*. *See Puyallup Tribe v. Dept. of Game of Wash.*, 391 U.S. 392, 398 (1968). The treaties do not guarantee an absolute right to fish or hunt; a state may limit the total treaty and non-treaty fish catch, for example, if regulation becomes necessary for the preservation of the species, is tailored to the conservation of that species, and is nondiscriminatory in its treatment of the Indians. *See Puyallup Tribe, Inc. v. Dept. of Game of State of Wash*., 433 U.S. 165, 176 (1977) (holding that state fishing regulation applies on-reservation because "[t]he police power of the State is adequate to prevent the steelhead from following the fate of the passenger pigeon"); *United States v. Oregon*, 657 F.2d 1009, 1016–1017 (1981) (affirming a total ban on tribal harvest of spring chinook salmon).

Because tribal treaty rights to hunt and fish can be regulated for the preservation of a resource, the question is not what the treaty guarantees, but rather what the applicable statute/regulation requires and whether it is non-discriminatory. The *Anderson* court accordingly found the MMPA applied to the Makah because the Makah can be regulated "in common with all citizens."

Limitations and legal implications of the MMPA waiver request:

The waiver request is limited to ENP gray whales only. It does not cover WNP gray whales, nor would it cover PCFG whales if NMFS determined – as it should – that PCFG whales should be designated as a separate stock (an issue that is further discussed below). Since the waiver, if issued, would not cover WNP gray whales, this raises questions about the legal implications for the Makah if it were to take a WNP gray whale. It is worth noting here that different provisions of the MMPA are applicable to "marine mammals" while others are applicable to marine mammal "species" or "population stocks." For example, the moratorium, waiver, take prohibitions, and permit language apply broadly to "marine mammals," (see 16 U.S.C. 1371(a); *Id.* at 1371(a)(3)(A); *Id.* at 1372; *Id.* at 1374), while the MMPA sections on depleted species and issuance of regulations refer to marine mammal "species" or "population stocks" (see *Id*. at 1362(1)(A); *Id*. at 1373). These differences may have implications for the Makah's MMPA waiver request.

While the likelihood of the Makah actually striking and killing a WNP gray whale may be remote according to NMFS (citing to Moore and Weller 2013), since take under the MMPA is broadly defined to include "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal," if allowed to whale, the Makah may take a WNP gray whale. Moreover, the MMPA's moratorium covers all takes, regardless of the likelihood of such take. Consequently, absent a separate waiver or any other legal authorization permitting the take of an endangered WNP gray whale, the Makah Tribe will be subject to prosecution under the ESA and MMPA.

The MMPA does provide for the incidental take of marine mammals listed under the Endangered Species Act through the acquisition of an "incidental harassment authorization" (IHA) or a "letter of authorization" (LOA) (for incidental take). If the Makah are granted a waiver to the MMPA and NMFS then determines that any "take" of WNP gray whale is incidental to the Makah's whaling operations, then the Makah would have to obtain an IHA or LOA. In this case, given that the duration of any waiver, if granted, would be valid for at least 10 years (see Alternative 6) and since the Makah would likely take and could potentially seriously injure or kill a WNP gray whale, more than one LOA would be applicable.

NMFS provides no explanation as to the legal implications of the Makah's waiver request being limited to ENP gray whales, nor does it discuss the applicability, or lack thereof, of its incidental take standards to the Makah Tribe's whaling plans. In order to obtain such an authorization, a request must be made by the applicant (in this case the Makah Tribe), NMFS must evaluate the impacts of the application pursuant to NEPA, it must publish a notice seeking public comment on the requested authorization, and then must decide whether the authorization should be granted under the relevant criteria contained in the MMPA. Since the existing DEIS does not address the issuance of any such authorization, the authorization process either must be pursued separately from the current DEIS decision-making process (presumably with a decision on a "letter of authorization" made prior to the completion of the present NEPA process) or NMFS must explain why the incidental harassment provisions of the MMPA are not applicable in this case.

Conversely, if the Makah Tribe is granted a waiver to hunt ENP whales and NMFS determines that any take, including serious injury or killing of a WNP whale, constitutes intentional take (since the purpose of the hunt is to kill a whale and because ENP, PCFG, or WNP whales cannot be distinguished by observation alone), then the issuance of a waiver will permit illegal take in violation of the MMPA's moratorium. If such take is considered to be intentional, the only way it can be permitted is if the Makah's waiver application is amended to include WNP gray whales.

Lack of accurate and complete analysis of impacts on Pacific Coast Feeding Group whales within the Oregon-Southern Vancouver Island region:

The Makah Tribe has requested, consistent with the recommendation in Calambokidis et al. (2004), that the primary area of emphasis for the impact of its proposed whale hunt on the PCFG of ENP gray whales be restricted to the OR-SVI region of the PCFG range. The OR-SVI region is larger than the Makah U&A but smaller than the full seasonal range of PCFG whales, which is from Northern California to Southeast Alaska. NMFS has included in the DEIS analysis of the impact of the Makah's proposed hunt (Alternative 2) and the other action alternatives (Alternatives 3-6) on PCFG whales within the OR-SVI region but, as discussed in more detail below, its analysis of the impacts on PCFG whales in the OR-SVI region is deficient. Moreover, despite the Makah Tribe's request to focus the analysis on OR-SVI PCFG gray whales and the *Anderson* court's emphasis on the need to consider impacts in the local area (e.g., the Makah

U&A), NMFS's analysis of Alternatives 3-6 calculated the PBR level using the larger PCFG population estimate instead of using the estimates for the OR-SVI and Makah U&A regions.

Additional limited waiver request:

Embedded within the Makah Tribe's request for a waiver of the MMPA's prohibition on taking marine mammals is a second request for "a limited waiver from the MMPA's prohibition on the sale of marine mammal products for the purpose of selling such traditional handicrafts." Makah Waiver Application at 3. No additional information about this second waiver request, including any explanation as to scope of the "limited waiver," is contained in the waiver application or in the DEIS. Since this additional waiver request clearly applies to the Tribe's interest in the sale of authentic native handicrafts manufactured from the non-edible byproducts of killed gray whales, it is imperative that additional information about this second waiver request and its implications be made available so that the public has a chance, as the law requires, to participate in the decision-making process inherent to the second waiver request.

3. NMFS must determine if PCFG whales are a separate stock under the MMPA:

Although the prohibition on taking contained in the MMPA is for "marine mammals," 16 U.S.C. 1372, the authorization of take is restricted to marine mammal "species" and "population stocks" 16 U.S.C. 1373. The MMPA defines the term "population stock" or "stock" as "a group of marine mammals of the same species or smaller taxa in a common spatial arrangement, that interbreed when mature." Unlike the Endangered Species Act, which permits the listing of "Distinct Population Segments," the MMPA does not provide protections for anything other than species or population stocks.

PCFG gray whales are not currently designated as a population stock or stock. The IWC's Scientific Committee, however, has determined that it is "plausible that the PCFG may be a demographically distinct feeding group,"[12] DEIS at 1-5, 3-157, while NMFS repeatedly reports in the DEIS that the PCFG "seems to be a distinct feeding aggregation and may warrant consideration as a distinct stock in the future" *Id.*

If the PCFG were designated as a stock, this would have significant implications for the PCFG and the Makah Tribe's whaling proposal. Among other things, a stock designation would permit the PCFG to be potentially designated as "depleted" under the MMPA if the current population size was below the optimum sustainable population (OSP) size (which has historically been interpreted by NMFS as 60 percent of the stock's carrying capacity). If designated as

[12] As explained in the DEIS, "although the IWC has not formally identified the PCFG as a stock, the Scientific Committee (IWC 2012a) noted that its implementation review of eastern North Pacific gray whales (with an emphasis on the PCFG) was "based on treating PCFG as a separate management stock" (which may not be equivalent to a stock as defined under the MMPA)." DEIS at 1-5.

"depleted," the Secretary would be barred from issuing any permit to allow take. While this bar could be overcome with an MMPA waiver, if the PCFG were designated as a stock, the current Makah waiver application would not cover PCFG whales. Instead, as explained above for WNP whales, the Makah could be prosecuted under the MMPA for illegally taking (intentionally or incidentally) a PCFG whale. The Makah would have to seek an LOA to permit incidental harassment and take, including serious injury and mortality, or it would have to amend its waiver application to include PCFG whales.

Considering the implications of the decision on whether PCFG whales are a stock, NMFS must suspend the current decision-making process and make a stock determination before continuing with the current analysis. Indeed, since the DEIS must provide the substantive evidence to support any decision made under the MMPA, NMFS must make a stock determination for PCFG whales as part of this decision-making process.[13] If NMFS determines, after providing an opportunity for public participation, that PCFG whales are a stock, this development would likely require a reassessment of the Makah's waiver request and, at a minimum, preparation of a supplemental DEIS. Conversely, it would be nonsensical to complete this MMPA waiver and NEPA process and then to conclude that the PCFG is a stock, as that could then require a full reevaluation of previous decisions with implications to the Makah Tribe, other interested stakeholders, and the gray whales.

The best available scientific information provides ample support for the designation of PCFG whales as a stock. While neither the MMPA nor its implementing regulations provide direction on how to determine if a group of marine mammals of the same species constitute a stock, NMFS has guidelines that it utilizes to make such determinations.

To determine if a group of marine mammals represent a stock, NMFS relies on its Guidelines for Assessing Marine Mammal Stocks (NMFS 2005 or GAMMS II). The original guidelines were developed in June 1994 and were finalized in 1995 to aid NMFS in preparing Stock Assessment Reports (SAR). Immediately thereafter minor revisions to the guidelines were proposed and a new version of the guidelines was published in 1997. NMFS (2005) represents the current version of the guidelines. However, based on a workshop held in 2011 to review the guidelines (referred to below as the GAMMS III workshop), NMFS published a Federal Register notice in 2012 soliciting public comment on proposed amendments to the guidelines. To date, NMFS has not finalized those amendments which, for the purpose of this analysis, will be referred to as GAMMS III Revisions 2011.[14]

[13] At a minimum, if NMFS makes a preliminary determination to issue an MMPA waiver to the Makah Tribe it must make a stock determination for PCFG whales before the administrative law judge hearing in order to meet the requirements of the MMPA.
[14] The revisions are available at http://www.nmfs.noaa.gov/pr/pdfs/sars/gamms3_appendix4.pdf

The MMPA defines "population stock" as "a group of marine mammals of the same species or smaller taxa in a common spatial arrangement that interbreed when mature." NMFS (2005). In interpreting this definition, NMFS considers the objectives of the MMPA, including maintaining the health and stability of the marine ecosystem and that "…species and population stocks of marine mammals…should not be permitted to diminish beyond the point at which they cease to be a significant functioning element in the ecosystem of which they are a part, and consistent with this major objective, they should not be permitted to diminish below their optimum sustainable population." *Id.*

In the 2005 GAMMS report, a stock is deemed a management unit if it constitutes a "demographically isolated biological population." NMFS has interpreted this concept to be synonymous with "demographically independent biological population" in subsequent applications of the guidelines since the "demographically independent" better reflects the intent of both the MMPA and those who prepared the GAMMS II report.[15] Furthermore in Weller et al. (2013), the use of demographic independence in defining a stock was articulated as follows:

> The GAMMS III workshop recommended revising the SAR guidelines to reflect that the intent of the GAMMS II guidelines (NMFS 2005) was to base stock identification on demographic independence as noted in Eagle et al. (2008) and proposed that the term demographic isolation be replaced with "demographic independence" as follows:
>
> > (1) "For the purposes of management under the MMPA, a stock is recognized as being a management unit that identifies a demographically independent biological population."
> >
> > (2) "Demographic independence means that the population dynamics of the affected group is more a consequence of births and deaths within the group (internal dynamics) rather than immigration or emigration (external dynamics). Thus, the exchange of individuals between population stocks is not great enough to prevent the depletion of one of the populations as a result of increased mortality or lower birth rates."
>
> In other words, the participants at the GAMMS III workshop viewed this as a semantic issue where the term demographic independence is a better description for the current GAMMS guidelines definition than is the term demographic isolation.

Further, Weller et al. (2013) explained that:

[15] Pers. comm. with Shannon Bettridge, NOAA/NMFS (July 29, 2015)

> "This interpretation of "isolation" differs substantively from how it is used within the GAMMS guidelines definition above, wherein allowance is made for some level of exchange of individuals between stocks. The TF (Task Force) concurred that in spite of using the term "isolation," the actual definitions under the current GAMMS guidelines … are more consistent with MMPA objectives to protect population stocks than with the objective of protecting just subspecies and species.
>
> Given that the draft GAMMS guideline revisions from the GAMMS III workshop have not yet been formally approved, the TF agreed to use the current GAMMS guidelines definition (NMFS 2005) for the purposes of their discussions and deliberations but noted that the actual definition used in the two versions (for demographic isolation and demographic independence) is essentially the same in that neither implies true "isolation" within the context of the MMPA.

Consequently, for the purpose of defining a stock, NMFS uses the concept of "demographic independence" instead of "demographic isolation." Simply stated, the definition of "demographic independence" is a situation where "the population dynamics of the affected group is more a consequence of births and deaths within the group (internal dynamics) rather than immigration or emigration (external dynamics)." GAMMS Revisions 2011.

A variety of information can be used to identify a stock. This can include information about the prospective stocks such as: distribution and movements; population trends; differences in morphology, life history, genetics, parasites, and oceanographic habitats; and contaminant and natural isotope loads. (NMFS 2005). A comparison of population trends of the same species occupying different areas can also be used to assess potential stock status, since different trends would suggest that the stocks are not "strongly linked demographically." *Id*. Similarly, morphological or genetic differences in animals from different regions are evidence that these populations are demographically independent.

In examining recruitment dynamics in a prospective stock, a failure to detect differences in immigration or emigration rates does not mean that a population is not demographically independent. In some cases, while dispersal rates may be sufficient to "homogenize morphological or genetic differences detectable between putative populations," they may not be sufficient to deliver enough recruits from an unexploited source to an adjacent exploited sink population which could cause the sink population to no longer be a functioning element of its ecosystem. *Id*.

As an example, NMFS (2005) notes that it is common to have human-caused mortality restricted to a portion of a species' range. Depending on the magnitude of such concentrated mortality, it could lead to population fragmentation, a reduction in range, or even the loss of undetected populations. This would only be mitigated by high immigration rates from adjacent areas. If such immigration rates are unknown or are insufficient to mitigate the level of mortality, the affected group of whales may not remain a functioning element of its ecosystem or it may diminish below OSP.

If there is inadequate information about stock structure and fisheries mortality is greater than a PBR calculated from the abundance just within the oceanographic region where the human-caused mortality occurs, managers should seriously consider dividing a species into stocks within designated and defensible management units. *Id*. Such management units could be designated in "distinct oceanographic regions, semi-isolated habitat areas, and areas of higher density of the species that are separated by relatively lower density areas." *Id*. Such areas have often been found to represent true biological stocks where sufficient information is available or when such evidence is known.

Notably, in trans-boundary situations, if a stock's range spans international boundaries or the boundary of the US Exclusive Economic Zone (EEZ), an international management agreement for the species is recommended. Until such an agreement is adopted, if a stock is migratory, the fraction of time in US waters should be noted, and the PBR for US fisheries should be apportioned from the total PBR based on this fraction.[16]

In regard to PCFG gray whales, compelling evidence exists that there is a genetic substructure within the ENP population (DEIS at 3-59, 3-94). For example Lang et al. (2011), based on samples taken from PCFG gray whales and ENP gray whales on the northern feeding grounds, demonstrated small but statistically significant mitochondrial DNA differences demonstrating site fidelity to the southern feeding area. DEIS at 3-60. Although no significant differences in microsatellites (from nuclear DNA) were seen between whales from the different areas, Lang et al. concluded that these results indicate "that structure is present among gray whales using different feeding areas, matrilineal fidelity plays a role in creating such structure, and individuals from different feeding areas may interbreed." *Id*. In a more recently published paper, Lang et al. (2014; Attachment 2) states that their "findings support recognition of the PCFG of gray whales as demographically independent based on the significant differences in mtDNA between the PCFG and whales feeding further north."[17] Frasier et al. (2011) also concluded that PCFG gray whales likely mate with ENP whales but their findings that there were significant differences in mtDNA haplotype distribution and in estimates of long-term effective

[16] This raises a question as to whether, in calculating a PBR for the OR-SVI PCFG whales that PBR should be lowered based on the proportion of OR-SVI gray whales in Canada.
[17] Furthermore, Lang et al. (2014) notes that "although uncertainty remains, our results indicate that it is plausible that the PCFG represents a demographically independent group and suggest that caution should be used when evaluating the potential impacts of the proposed Makah harvest on this group of animals."

population size between PCFG and ENP whales were a result "of maternally directed site fidelity of whales to different feeding grounds." DEIS at 3-125 (see also Lang et al. 2011).

The existing data appears to be equivocal on the recruitment mechanism for PCFG whales. Studies that have found significant differences in mtDNA haplotype frequencies between PCFG whales and whales sampled in the northern areas suggest that the "use of some feeding areas is being influenced by internal recruitment (matrilineal fidelity)." DEIS at 3-127, 3-130. However, Ramarkrishnan et al. (2001), based on an analysis of samples collected from whales within the PCFG range found that the genetic diversity and number of mtDNA haplotypes "were greater than expected if recruitment into PCFG were exclusively internal," DEIS at 3-124, suggesting that there may be some external recruitment into the PCFG gray whale population via immigration. DEIS at 3-127. As explained in GAMMS II, however, a lack of conclusive evidence as to the immigration or emigration rates or mechanisms does not disqualify a feeding aggregation of whales from being designated as a stock.

Based on this and other evidence, a 2012 NMFS task force concluded that there "remains a substantial level of uncertainty in the strength of the lines of evidence supporting demographic independence of the PCFG." DEIS at 3-129. Evidence in favor of demographic independence includes the fact that PCFG gray whales are the "only feeding group that does not rely on dynamics of a subarctic ecosystem" and that "this uniqueness may provide important flexibility to the species as a whole given potential challenges in a changing sub-arctic ecosystem." *Id.* Other supporting evidence includes the persistent return of individual whales to specific feeding areas which "strongly suggests that site fidelity is key to maintaining gray whales as a functioning element of this ecosystem," (DEIS at 3-129), and that data documenting "internal calf recruitment … may actually be an underestimate because of survey limitations." DEIS at 130.

For those who question whether PCFG whales exhibit demographic independence, they point to evidence demonstrating ongoing external recruitment into the PCFG, although it is conceded that there is "considerable uncertainty as to whether external recruitment exceeds internal recruitment." DEIS at 3-130. In addition, they claim that genetic analyses using mtDNA and nuclear DNA have not shown a significant difference between the PCFG and larger ENP population when, in fact, mtDNA analyses have demonstrated such differences. While nuclear DNA analyses have not revealed similar results, this does not disqualify a group of whale from being designated as a stock. External recruitment of ENP whales migrating through the PCFG range is also used to question a stock determination even though the mere fact that such external recruitment may occur does not disqualify PCFG whales from being designated a stock. Indeed, as noted in NMFS (2005), if the population dynamics of the affected group is more a consequence of births and deaths within the group (internal dynamics) rather than of immigration or emigration (external dynamics), the group can qualify for a stock designation.

Other evidence that supports the designation of the PCFG as a stock includes:

- Since Punt (2015; Attachment 3) determined that PCFG population is at 50 percent of its carrying capacity and given that NMFS reports that at current rates of recruitment, PCFG abundance trends appear to be flat, DEIS at 4-100, 4-84, if external recruitment was the primary mechanism for PCFG whales then population numbers should be increasing. This could suggest that internal recruitment is a more important mechanism for maintaining PCFG numbers and, therefore, would support a stock designation. In addition, if PCFG gray whales were designated as a stock then, at 50 percent of carrying capacity, they would not be at OSP and any intentional take by the Makah would be prohibited.
- If the Makah are allowed to whale, particularly under Alternative 2, the killing of up to six ENP gray whales (which may include PCFG whales) each year would constitute the largest source of reported human-caused mortality for gray whales in US waters. As it is not clear that such concentrated mortality (i.e., in the Makah U&A) would be replaced or how such recruitment is likely to occur, the PCFG gray whales in these smaller regions may no longer be a functioning element in the ecosystem, which would violate the MMPA. Furthermore, for the Makah U&A, the potential mortality of gray whales, including PCFG whales, could be well above the PBR for this region.
- The potential for PCFG whales to be a buffer for the species against adverse impacts attributable to climate change in the Arctic cannot be ignored in making this determination. Given that the evidence demonstrates maternally-driven recruitment into the PCFG and noting the high site-fidelity of some PCFG whales to particular regions, simply assuming that ENP whales will fill PCFG vacant niches is risky given the potential importance of PCFG whales. Moreover, if the PCFG represents an ecological/population buffer against the impact of climate change induced changes in the Arctic, then the removal of any PCFG may prevent full development of the buffer. NMFS should err on the side of caution to designate PCFG as a stock to provide protection and to ensure that they continue to serve their role as a functioning element of the ecosystem as required by the MMPA.
- While the apparent stability of the PCFG population is a concern if it is well under K, the stability of this feeding aggregation is nonetheless noteworthy and suggests that the aggregation is exploiting important habitat and should be protected because it may be in the early stages of speciation or developing more complex population structure.

Given this evidence and the critical importance of a stock determination for PCFG gray whales in light of the Makah Tribe's proposed hunt, NMFS has to make this determination before continuing with the current decision-making process.

4. <u>The use of .50 or larger caliber rifles to kill gray whales does not comply with the MMPA's humane take standards:</u>

Even if a waiver is granted to the Makah Tribe, this only exempts the tribe from the prohibition against taking marine mammals under the MMPA. Other provisions of the MMPA, including the requirement to issue regulations and permits to govern the taking of gray whales, would be applicable. Any regulations proscribed must set forth the manner of take that will be allowed, while the requisite permits must specify the location and manner in which marine mammals may be taken. In addition, the Secretary must determine that the manner of take is humane. The MMPA defines the term "humane," in the context of taking a marine mammal, to mean the "method of taking which involves the least possible degree of pain and suffering practicable to the mammal involved." 16 U.S.C. § 1362(4).

Additional information about this standard is included in the Act's legislative history which provides that:

> 'Humane' in the context of taking marine mammals means the method of taking which involves the least possible amount of pain and suffering which can be inflicted upon the animals involved. It is not a simple concept and involves factors such as minimizing trauma to groups of highly intelligent, social animals such as whales and porpoises where the taking of any member may be distressing to the group. In many cases, where an animal may not be taken humanely the bill will prevent that animal from being taken at all.

H.R. REP. NO. 92-707 (1971), *reprinted in* U.S.C.C.A.N. 4144, 4154.

NMFS references the MMPA's "humane" mandate throughout the DEIS. This is particularly relevant in regard to the Makah's proposal to kill gray whales considering the increasing public concern for the suffering of animals, including those who are hunted, the ongoing consideration of cetacean welfare within the IWC, and since the gray whale illegally harpooned (four times) and shot (16 times) by rogue Makah whalers in 2007 took at least 11 hours to die.

In its waiver application, the Makah have proposed to use a .50 caliber rifle as the primary killing weapon after a gray whale is struck and penetrated by a steel toggle-point harpoon. The Makah used a .577 caliber rifle in the 1999 hunt and a same rifle along with smaller caliber weapons during the 2007 illegal hunt. Both weapons have been deemed to be adequate to kill gray whales, DEIS at 2-30, 3-169, 3-364 citing (Ingling 1999, Beattie 2001, and Graves et al. 2004). In their analyses of these two weapons, however these experts only compared the two larger caliber rifles against each other and against smaller caliber weapons; they did not test them against explosive grenades containing black powder or penthrite. One of the experts (Dr. Ingling) cited by NMFS in the DEIS suggested the .577 rifle may be preferable because it is lighter, has a 3-shot magazine, and it is quieter. NMFS, however, notes that gun manufacturers have improved the .50 caliber rifle to meet or exceed the alleged benefits of the .577 rifle. NMFS, therefore, concluded, “we consider the Tribe’s proposed .50 caliber rifle, with its readily available supply of ammunition, the weapon that Makah hunters would most likely use.” DEIS at 3-170.

As reported in the DEIS, the whale harpooned and shot in 1999 took a total of eight minutes to die from the initial harpoon strike to no evidence of life. DEIS at 1-38, 4-76. Both NMFS and the Makah seem to suggest that this is sufficiently “humane” and opine that, with experience, the time to death will decline if the Makah are allowed to kill gray whales. However, whether a kill with a high caliber rifle takes five or eight minutes or longer, that death is not instantaneous or near instantaneous and does not meet the “least possible degree of pain and suffering” standard under the MMPA particularly when less cruel killing methods are available. Furthermore, to use a single event (or a sample size of one) to determine if high caliber rifles are “humane” killing weapons or that the time to death will decrease with more experience is entirely inappropriate since, if the Makah had killed more whales in 1999 or in 2007, the time to death for those whales could have been longer.

Although NMFS appears to be prematurely satisfied that the .50 caliber rifle can “humanely” kill a gray whale, it did expand the analysis in the DEIS to consider the potential use of black powder and penthrite explosive grenades. Such grenades could either be delivered using a darting gun or a shoulder gun. A darting gun consists of a barrel to hold the explosive projectile which is attached to the wooden shaft equipped with a toggle point harpoon. DEIS at 2-13. A shoulder gun is like a rifle but designed to fire explosive grenades. For the Makah, just as they propose to use a rifle as the primary killing weapon after a harpoon has penetrated a whale, explosive grenades would be used in the same manner. A primary killing method is required in any gray whale hunt since a steel toggle-point harpoon, even if it is delivered in a perfect strike to the most sensitive part of the whale’s body, will not kill the animal. DEIS at 3-167.

The evidence contained in the DEIS, taken from a number of studies or reports from whaling activities in Alaska, Russia, Greenland, and Norway, provide compelling data demonstrating that explosive grenades containing penthrite are the least cruel existing method for killing such large whales and should be the only method NMFS permits the Makah Tribe to use if it, wrongly, grants the waiver application and prevails in any subsequent judicial proceedings.

The Alaskan Eskimos utilize explosive grenades as both their primary and secondary killing weapons. DEIS at 3-164. These grenades are delivered using hand thrown darting guns or a shoulder gun. The grenades either contain black powder or penthrite, although penthrite is preferred because black powder can taint the taste of whale meat. *Id.* After the grenade penetrates the whale’s body, it detonates and kills via shock waves and tearing of tissues, hemorrhage, and/or damage to internal organs caused by shrapnel. DEIS at 3-167. According to NMFS, a whale can respond to being struck with a grenade by death, insensibility, and stunning as well as diving, thrashing, and ramming boats. *Id.* (citing Knudsen and Øen 2003, Øen 1995, and Bockstoce 1986).

Such actions, however, are generally short in duration since penthrite results in the rapid death of a whale in most instances. Evidence of this is contained in the DEIS and includes:

- Øen (2006) noted that the instantaneous death rate in Norwegian minke whale hunts in which penthrite grenades were employed had increased from 17 percent from 1981 to 1983 to 80 percent in 2000 to 2002 due primarily to improved grenades and training. Overall, 95.5 percent of whales are killed with the first strike by a penthrite grenade. DEIS at 3-171.
- In a study of the killing efficiency of black powder and penthrite grenades used in the Alaskan bowhead hunt, Øen (1995) reported that seven of the eight whales struck with penthrite grenade(s) died from the first grenade thrown while the eighth whale required three grenades before he/she died. In addition, the results demonstrated a reduced time to death for whales struck with penthrite versus black powder grenades. In 1988, seven of the eight bowhead whales struck with penthrite grenades were landed (one died but was lost) and five of the whales (63 percent) died instantaneously or in less than 5 minutes, DEIS at 3-172, 3-176.
- In 2010, eight bowhead whales struck with penthrite grenades and five were landed after instantaneous or near instantaneous kills. DEIS at 3-174 (citing IWC 2011d). Of the remaining whales, one was lost under the ice, one sank after being killed, and in one whale the grenade did not explode and the whale was lost. *Id*.
- In the 2011 bowhead whale hunt, of the 38 whales landed, 26 whales were reported as instantaneous or near instantaneous kills including all but three of those taken using penthrite grenades. *Id*.
- In 2011, the then Chairperson of the AEWC reported that penthrite grenades "can reduce the time to death for a bowhead whale to four seconds," this being the length of time on the grenade's fuse." DEIS at 3-173, 3-177.
- Øen (2015; Attachment 4) reported the time to death data collected during the Icelandic fin whale hunt in 2014 revealed that "84% of the whales had died instantly." In that hunt, "the whales were killed with 90 mm Kongsberg harpoon canons and Whale Grenade-99 modified with 100 g of pressed penthrite as explosive. Grenade detonation in the thorax (chest), in or at the thoracic spine, neck or brain resulted in 100% instant death."

Notably, bowhead whales are larger than gray whales and, consequently, it is expected that, if a hunt were permitted, penthrite grenades would more rapidly kill gray whales. Nevertheless, despite this and other evidence contained in the DEIS demonstrating that penthrite grenades are a less cruel killing method compared to rifles, NMFS still claims that it is "uncertain what the average time to death would be for gray whales killed in a Makah gray whale hunt using explosive projectiles as the striking and killing weapons" although it then concedes that "it is possible that average time to death would be lower than with the alternate method (toggle-point harpoon and rifle) because the striking weapon has the potential to quickly kill the whale or render it insensible." DEIS at 4-77.

The DEIS also notes that, at an IWC workshop on Whale Killing Methods held in 2003, the United Kingdom presented a paper indicating that whales could experience stress as a result of being pursued which, in turn, can result in stress-related symptoms such as impaired immune defense, reduced fecundity, a failure to grow, and potentially succumb to "exertional myopathy." DEIS at 3-166. NMFS, in response, reported that exertional myopathy has not been reported in gray whales and that "there are no data at present to evaluate what level of activity would be required to induce this in gray whales." *Id.* What NMFS fails to disclose is what efforts have been made by its own scientists or others to examine whether pursuit results in stress related complications, including exertional myopathy. Just because exertional myopathy has not been reported in gray whales, doesn't mean that the risk is not real.

Finally, while the method of killing whales is directly relevant to "humane" concerns associated with the hunt, the efficiency of the hunt is also a critical consideration. Since struck and lost whales could be whales that are injured and suffering, a less efficient hunt will result in greater cruelty than a highly efficient hunt. The hunting proposal submitted by the Makah Tribe (Alternative 2) is the least efficient of all the action alternatives at 57 percent. DEIS at 4-78. The other action alternatives, according to NMFS, have predicted hunt efficiencies of 67 percent (Alternative 3), 100 percent (Alternative 4), 80 percent (Alternative 5), and 100 percent (Alternative 6). DEIS at 4-78/4-79.

Given the foregoing evidence and recognizing that the MMPA requires NMFS to mandate the most "humane" method for taking marine mammals, if NMFS wrongly elects to grant the Tribe's waiver application, it must require the use of explosive grenades containing penthrite as the primary as well as secondary killing method for gray whales. The fact that such grenades and the darting or shoulder guns used to fire the grenades into a whale are expensive is immaterial in this case. The MMPA does not allow cost to be considered in determining the most "humane" method available to kill a marine mammal. Conversely, allowing the Makah to kill gray whales with either the .50 caliber or .577 caliber rifles would violate the "humane" requirement contained in the Act. Furthermore, although significant concerns about public safety in regard to the use of these powerful rifles are addressed elsewhere in this comment letter, requiring the use of penthrite grenades would substantially reduce risks to public safety, as the grenades, due to their weight, have a significantly smaller range than a bullet (i.e., a grenade certainly could not travel as far as 5 miles like a bullet fired from a .50 caliber rifle).

Endangered Species Act

The Endangered Species Act is the nation's preeminent law protecting federally listed threatened and endangered species and their habitats. Its purpose is "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions" identified in the ESA. ESA Section 2(b). Furthermore, Congressionally-designated policy requires that "all Federal departments and agencies shall seek to conserve endangered species and threatened species and shall utilize their authorities in furtherance of the purposes of this Act." *Id.* at Section 2(c).

Section 7 of the Act mandates that "each federal agency … in consultation with and with the assistance of the Secretary, insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species." ESA Section 7(a)(2). To facilitate compliance with the consultation process, "each Federal agency shall … request of the Secretary information whether any species which is listed or proposed to be listed may be present in the area of such proposed action." *Id.* at Section 7(c)(1). If the "Secretary advises, based on the best scientific and commercial data available, that such species may be present, such agency shall conduct a biological assessment for the purpose of identifying any endangered species or threatened species which is likely to be affected by such action" *Id.*

As indicated in the DEIS, there are 14 federally listed endangered (nine species) or threatened (five species) in or near the Project Area. NMFS does not identify any species proposed to be listed under the ESA that may exist in or near the Project Area, although it does identify the sea otter (Washington stock) as a species considered to be endangered by the State of Washington. DEIS at 3-206. Based on a review of information about state and federally protected species maintained by the Washington Department of Fish and Wildlife (accessible at http://wdfw.wa.gov/conservation/endangered/All/), it appears that there may be other federally protected species, particularly fish, including a number of stocks of salmon, that may live in or near the Project Area that were not identified in the DEIS. NMFS also fails to indicate if critical habitat has been designated for any federally protected species other than the Southern Resident killer whales in the Project Area. NMFS must disclose all federally listed threatened and endangered species in the Project Area and provide analysis of how the proposed hunt may affect those species and their habitat, particularly any critical habitat designated for the species. As NMFS has apparently failed to disclose all relevant information about ESA-protected species in the DEIS, this constitutes a violation of NEPA.

Furthermore, NMFS provides no discussion of the ESA consultation requirements and its efforts to satisfy that mandate. There is no reference to any discussion with its own protected species division or with the USFWS regarding federally protected species in the Project Area. Nor does NMFS report whether it is preparing a biological assessment, if said assessment is completed, and/or if it has initiated or concluded its own internal consultation process or the consultation requirement with the USFWS for protected species under its jurisdiction. NMFS must provide assurance that it has complied or is complying with the ESA. Ideally, NMFS should provide the public with an opportunity to participate in the consultation process but, at a minimum it must disclose that it has or is engaged in consultation and, if completed, share the results.

National Environmental Policy Act

NEPA is the basic national charter for protection of the environment. 42 U.S.C. § 4321 et seq. It requires that "environmental information is available to public officials and citizens before decisions are made and before actions are taken." 40 CFR § 1500.1(b). Said information "must be of high quality" and subject to "accurate scientific analysis." *Id.* Ultimately, a NEPA analysis and decision-making process is "intended to help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore, and enhance the environment." *Id.* at § 1500.1(c).

An Environmental Impact Statement (EIS) as required under NEPA "shall provide full and fair discussion of significant environmental impact and shall inform decisionmakers and the public of the reasonable alternative which would avoid or minimize adverse impacts or enhance the quality of the human environment." *Id*. at § 1502.1.

Impacts, in the context of NEPA, are synonymous with "effects." NEPA requires agencies to evaluate the direct, indirect, and cumulative impacts or effects of the proposal or any alternatives. Any alternatives included in a NEPA document must be reasonable, include reasonable alternatives not within the jurisdiction of the lead agencies, must include a no-action alternative, *id.* at § 1502.14(a)(c) and (d), and can also include alternatives that may require legislation to implement. DEIS at 2-2 citing 46 Federal Register 18027(2b). Qualitatively, reasonable alternatives include those alternatives that are practicable or feasible from a technical and economic standpoint and that use common sense, rather than being simply desirable from the standpoint of the applicant. DEIS at 2-2. The agency is required to "rigorously explore and objectively evaluate all reasonable alternatives" *Id.* at § 1502.14(a) and, for those alternatives considered but eliminated from detailed study, must discuss the reasons for eliminating alternatives from substantive analysis. *Id.*

Council on Environmental Quality (CEQ) regulations implementing NEPA – with which all agencies must comply – do not define "reasonable alternative" but explains that "reasonable alternatives to proposed actions will avoid or minimize adverse effects of these actions upon the quality of the human environment." 40 CFR § 1500.2(e). However, the National Oceanic and Atmospheric Administration's NEPA Handbook states "reasonable alternatives are those that may be feasibly carried out based on technical, economic, environmental and other factors, and meet the purpose and need for the proposed action (citing 40 CFR § 1502.14)." See NOAA NEPA Handbook at 5.4.4.1. This latter requirement – that a reasonable alternative meets the purpose and need for the proposed action – is not reflected in the NEPA statutory language or in the CEQ's NEPA regulations, including at § 1502.14, and consequently, may not be lawful. Indeed, as explained in more detail below, if a federal agency on its own behalf or when acting on behalf of a third party can dictate a particular outcome of a NEPA process by crafting its purpose and need to achieve that outcome – which is precisely what has been done here – it makes a mockery of the entire NEPA process.

In most cases, the agency should identify the "agency's preferred alternative or alternatives" unless another law prohibits the identification of a preferred alternative. 40 CFR § 1502.14(e). As explained in the NOAA NEPA Handbook, a "proposed action" and a "preferred alternative" are sometimes synonymous, while in other cases, a "proposed action" reflects a more general objective while the preferred alternative describes how the objective will be achieved. NOAA NEPA Handbook at 5.4.4. For NMFS, as stated in NAO 216-6: Environmental Review Procedures for Implementing the National Environmental Policy Act, if it does not have a preferred alternative, it "must provide a range of alternatives or other indication of the alternatives most likely to be selected, thus informing the public of the likely final action and its environmental consequences" so that "the public is … able to more effectively focus its comments." NAO 216-6 at 5.04(a)3. NMFS has not provided such an explanation in the DEIS.

The identification of alternatives (including any proposed action), description of the affected environment, and the analysis of environmental consequences are considered the "heart of the environmental impact statement." 40 CFR § 1502.14. An agency is required to "present the environmental impacts of the proposal and the alternatives in comparative form, thus sharply defining the issues and provide a clear basis for choice among options by the decisionmaker and the public." *Id.*

In addition, an EIS must include a discussion of "any adverse environmental effects which cannot be avoided should the proposal be implemented, the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and any irreversible or irretrievable commitments of resources which would be involved in the proposal should it be implemented." *Id*. at § 1502.16. The DEIS does not include a discussion of any of these required elements.

1. <u>NMFS has failed to provide a reasonable range of alternatives in the DEIS:</u>

The DEIS evaluates the environmental impact of six alternatives. Unfortunately, these alternatives do not comply with NEPA requirements to consider all reasonable and feasible alternatives. Additional alternatives, as described below, should have been evaluated in the DEIS. Two of these alternatives, both of which the Coalition would fully support, were not evaluated at all in the DEIS or were considered and rejected.

The first is a non-lethal use alternative whereby NMFS, other federal agencies, and even non-governmental organizations would collaborate with the Makah Tribe to establish marine animal (including whales) watching operations in Neah Bay. Such operations could incorporate the use of the traditional canoes for coastal animal watching excursions or employ motorized vessels to permit coastal and offshore excursions. Properly trained Makah tribal members could act as vessel captains, operators, paddlers, and naturalists on such vessels while the actual operation would be fully owned and operated by members of the Makah Tribe.

Considering, as described in the DEIS, the significant marine diversity and aesthetic beauty found in Northwest Washington, including in the Makah U&A, and the current lack of any marine wildlife viewing operations in the Neah Bay area, such an alternative would provide a unique opportunity for visitors to Neah Bay. In addition to creating paid employment on the Makah reservation, if properly marketed, such operations would increase visitation to Neah Bay, which would likely translate into increased revenue for the tribe and individual business owners for accommodations, food, services, and miscellaneous purchases. Unlike existing whale and other marine wildlife viewing operations in Washington or the Vancouver area, the Makah Tribe could use its programs to introduce visitors to its history, culture, and traditions (including its traditions related to whaling), which would then be reinforced if visitors also toured the Makah Cultural and Research Center (Museum).

If this alternative were evaluated and ultimately selected, the Makah Tribe would not give up its treaty right to whale but, rather, would agree to suspend its pursuit of an MMPA waiver and its resumption of whaling. While this alternative would not permit the Makah Tribe to kill whales, the Tribe could still use products from any drift/stranded or entangled whales that died and practice all of its traditions related to whaling. It could also, consistent with NMFS whale-watching regulations, interact with gray and other whale species in a non-lethal manner that would create jobs, increase visitation to the refuge, increase revenues, and provide an educational value for tourists.

A second reasonable alternative involves providing compensation to the Makah Tribe in exchange for its agreement to suspend its pursuit of an MMPA waiver and cease its efforts to resume whaling. A version of this alternative was considered in the DEIS but rejected (DEIS at 2-30/2-31). This alternative would not involve only financial compensation to the Tribe but, could also include the transfer of land, provision of equipment/supplies needed by the Tribe, federal grants to address known needs of the Tribe and/or individual tribal members, and/or increase the allocation of fishing quotas consistent with conservation needs, along with a federal funding package the Makah could use to address the many needs in Neah Bay. Some of those needs are referenced in the DEIS and include the development of the Makah Tribe's marine program and its harbor at Neah Bay, an upgraded marine fuel float, creating a deep harbor entry area, and a cruise ship facility. DEIS at 3-22.

Other potential uses of such federal assistance or funds, which would provide even greater benefits for more reservation residents and are also identified in the DEIS, are: expanding the reservation's forested land base, studying the feasibility of a marine fish hatchery; diversifying the Makah Tribe's fishing industry (particularly the whiting fishery); constructing a visitor center along with an associated ocean front cabin resort and motel, a boardwalk, a wellness/medical center, senior citizens apartments, housing for medical clinic workers, baseball fields, trails for tsunami escape corridors, walking paths, and a new Makah tribal council office; conducting road improvements; developing a new clean water source for the reservation, revitalizing the downtown area, expanding the Shi-Shi Trail, and upgrading the tribal communications network; developing wind energy generation units on the reservation; and facilitating improvements in the tribe's value-added seafood processing capacity. DEIS at 3-23.

If this alternative were selected, the Makah Tribe would retain its treaty right to whale but would agree to suspend pursuit of whaling for a set period of time (e.g., 25 years). This alternative is similar to the agreement reached by the Nuu-chah-nulth, a First Nations group that resides on Vancouver Island, with the Canadian government (see DEIS at 1-28). The benefits of such an alternative would be recognized by every tribal member who resides in Neah Bay and could be used to improve the quality of life on the reservation by improving urgent care capabilities, expanding existing medical facilities, enhancing the care of tribal elders, expanding and strengthening tribal substance abuse programs, improving housing standards, and meeting other urgent and critical needs in Neah Bay.

NMFS rejected this compensation alternative because it claimed that any of the activities under this alternative would be speculative and would involve uncertain negotiations between the Makah Tribe and other government and non-governmental entities. DEIS at 2-30. This is simply not accurate since, if such an alternative were selected, then once the negotiations on a compensation package began, specific components of such a package would be identified and articulated.

NMFS will also likely claim, as it already has for the second suggested alternative, that these alternatives cannot be selected as they do not satisfy the purpose and need for either the Makah Tribe or NMFS. As explained above, however, this claim is not consistent with NEPA. Even if it were, as also noted above, NMFS must restate its purpose and need (and delete the Makah Tribe's purpose and need) to ensure the NEPA decision-making process is legitimate (i.e., by ensuring the No Action Alternative is a viable alternative that can be selected at the conclusion of the NEPA decision-making process).

Another alternative that should have been evaluated would combine many of the most conservative elements of the existing action alternatives. In this case, such an alternative would permit whaling during a split season (i.e., three weeks in December and May), all whaling would be required to occur at least five miles offshore, maximum annual take would be limited to one whale (and no more than 6 over six years), a limit of a single struck and lost whale (with any lost whale counted as a PCFG whales), a limit on the take of PCFG whales to be 10 percent of the OR-SVI PBR (.23),[18] with no carryover of any unused limit, and expiration of the MMPA waiver and any associated regulations and permits after ten, three, and three years, respectively. In addition, the Makah Tribe would be required to use penthrite grenades as its primary killing weapon. Such an alternative would allow the Makah to take a limited number of whales during time periods when the risk to WNP gray whales would be reduced. It would also provide increased protection to PCFG whales that occur within the OR-SVI area (the area that the Makah Tribe identified as the recommended region for analysis) by imposing a restrictive take limit which, if a PCFG whale were killed, would require a hiatus in the hunt for as many as four years. In addition, because the hunt would take place well offshore and would require the use of penthrite grenades, it would result in more rapid death to struck whales and would reduce threats to public safety. The expiration of the permits, regulations, and waiver would ensure that NMFS revisits its decision with some frequency in order to make any adjustments as dictated by scientific evidence and social concerns (i.e., adaptive management).

While the Coalition would not support this alternative, it should have been evaluated since it combines many of the most conservative collections of elements from the other action alternatives, which would permit the Makah Tribe to engage in ASW but would limit the impact of any hunt to ENP, PCFG, and WNP gray whales and be more humane.

2. NMFS has failed to disclose all relevant information and to provide a clear and accurate analysis of the environmental consequences of the no action and action alternatives:

[18] Section 118 of the MMPA sets a goal of reducing incidental mortality of marine mammals in commercial fisheries to "insignificant levels approaching a zero mortality and serious injury rate." 16 U.S.C. § 1387, DEIS at 2-21. NMFS considers this goal as being met when commercial fisheries result in a mortality rate of marine mammals that is 10 percent or less of PBR. *Id*.

The affected environment and environmental consequences sections of the DEIS provide the heart of the analysis. The former is intended to fully document the characteristics of the affected environment, while the latter considers the impacts on that environment of the alternatives evaluated in the DEIS. Because of the linkages between these sections of the DEIS, they will be considered together here. Analysis is not provided of each of the environmental variables (e.g., water quality, public services) contained in the DEIS. This is not to suggest these variables are not important but only that the Coalition does not have substantive concerns with the relevant analyses contained in the DEIS, unlike the variables discussed below.

Prior to discussing the categories of environmental consequences where the Coalition has substantive concerns, there are broader issues relevant to the content of the affected environment and environmental consequences sections of the DEIS.

NEPA requires federal agencies to disclose all relevant information in an EIS. Here, the DEIS does not satisfy this important standard, as critical information has not been disclosed. Where NMFS has failed to fully disclose all relevant information in any of the categories of environmental consequences evaluated in the DEIS, a discussion of the missing information and its relevance to analysis of environmental impacts is included below. In some cases, NMFS has claimed relevant information is not available. While the Coalition questions the legitimacy of many of these claims, that analysis is also incorporated below.

The CEQ NEPA implementing regulations explicitly address how federal agencies are to deal with incomplete or unavailable information. For incomplete information that is "essential to a reasoned choice among alternatives and the overall costs of obtaining it are not exorbitant, the agency shall include the information in the environmental impact statement." 40 CFR § 1502.22(a). For information that cannot be obtained "because the overall costs of obtaining it are exorbitant or the means to obtain it are not known," the agency must provide, in the DEIS: "1) a statement that such information is incomplete or unavailable; 2) a statement of the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment; 3) a summary of existing credible scientific evidence which is relevant to evaluating the reasonably foreseeable significant adverse impact on the human environment, and 4) the agency's evaluation of such impact based upon theoretical approaches or research methods generally accepted in the scientific community." *Id.* at § 1502.22(b)(1-4). NMFS has failed to provide the required statement for information that it deems to be unavailable for analysis in the DEIS.

3. <u>NMFS has failed to define the impact levels used in the DEIS:</u>

The DEIS is also missing critical information relevant to the impact levels relied on in the analysis of environmental consequences. Impact thresholds for the purpose of this discussion are the terms used to identify the physical or temporal severity and/or the geographic scope of the environmental impacts caused by action alternatives. Throughout the DEIS, NMFS uses terms such as "negligible," "minor," "small," "temporary," "short-term," "no appreciable effect," "improbable," "localized," and other terms to describe its assessment of such impacts. NMFS "interprets" "negligible" in the DEIS to mean "an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival (50 CFR § 216.103)," DEIS at 2-21, but it fails to provide a definition for any of the other impact level terms used in in the document.

The definition of "negligible" cited above is relevant to NMFS's analysis of incidental take of marine mammals by United States citizens engaged in specific activities (other than commercial fishing) within a specified geographic range. *Id.* It is not clear if NMFS is applying this same definition in the context of its analysis of the environmental impacts of the Makah Tribe's proposed whale hunt in the DEIS. If not, then NMFS has not provided a definition of "negligible" in the DEIS. If so, its use of this definition raises additional questions since, as NMFS notes in the DEIS, "in practice, we consider an incidental take that does not exceed 10 percent of PBR to have a negligible impact" DEIS at 2-21 (citing 64 Fed. Reg. 28,800, May 27, 1999).

Since, in the present context, the take of gray whales may be intentional and, at least for PCFG gray whales under several alternatives, the level of take will be at or in excess of PBR, it would not appear that the use of this term is appropriate. Furthermore, some claims of a "negligible" impact in the DEIS have nothing to do with impacts to a species or population stock, further suggesting that the definition of "negligible" in the DEIS is not relevant to the use of "negligible" in evaluating the environmental consequences of the proposed Makah hunt.

Moreover, with the exception of a few instances where it includes text in parentheticals to ostensibly explain the meaning of the term being used, NMFS has failed to include any definition of any of the other impact thresholds in the DEIS.

NMFS is well aware of the fundamental need to define such impact thresholds. For example, its Final Environmental Impact Statement for Issuing Annual Quotas to the Alaska Eskimo Whaling Commission for a Subsistence Hunt on Bowhead Whales for the Years 2013 through 2018 (Bowhead EIS),[19] published in January 2013, includes a section (see pages 74-76 in Bowhead EIS) explaining the "Steps for Determining Level of Impact." In that section, NMFS explains the legal basis for having to define impact levels:

> The CEQ regulations implementing NEPA state that an EIS should discuss the significance, or level of impact, of the direct, indirect, and cumulative effects of

[19] Available at: https://alaskafisheries.noaa.gov/protectedresources/whales/bowhead/eis0113/final.pdf

> the proposed alternatives (40 CFR § 1502.16), and that significance is determined by considering both the context in which the action will occur and the intensity of the action (40 CFR § 1508.27). Context and intensity are often further broken down into components for impact evaluation. The context is composed of the extent of the effect (geographic extent or extent within a species, ecosystem, or region) and any special conditions, such as endangered species status or other legal status. The intensity of an impact is the result of its magnitude and duration. Actions may have both adverse and beneficial effects on a particular resource. A component of both the context and the intensity of an effect is the likelihood of its occurrence.
>
> The combination of context and intensity is used to determine the level of impact on each type of resource. The first step is to examine the mechanisms by which the proposed action could affect the particular resource. For each type of effect, the analysts develop a set of criteria to distinguish between major, moderate, minor, or negligible impacts. The analysts then use these impact criteria to rank the expected magnitude, extent, duration, and likelihood of each type of effect under each alternative.

NMFS then goes on to include a number of definitions of different impact levels. For example, as to the impact of the proposed action and any alternatives on bowhead whales, NMFS defines "negligible," "minor," "moderate," and "major" based on the relevant "Q" values from the 2006 stock assessment report for this stock of bowhead whales. For other variables evaluated, NMFS provides definitions of terms such as "temporary," "long-term," "moderate," "frequent," "infrequent," and "likely."

In its Supplemental Draft Environmental Impact Statement on the Effects of Oil and Gas Activities in the Arctic Ocean (March 2013), it provides a more comprehensive (and useful) suite of definitions of impact levels used in its analysis. In that document, NMFS defines: "low," "medium," and "high" in regard to the intensity (magnitude) of the impacts; "temporary" and "long-term" in the temporal context of the duration of the impact; "local," "regional," and "state-wide" in regard to the extent of the impact; and "common," "important," and "unique" in terms of the value of the resources that may be impacted. It then, for its "qualitative thresholds," provides a definition of "negligible," "minor," "moderate," and "major." In that NEPA document, "negligible" is defined as "impacts (that) are generally extremely low in intensity (often they cannot be measured or observed), are temporary, localized, and do not affect unique resources." This definition is different from the definition of "negligible" in the context of incidental take analyses.

In the context of the DEIS, not only has NMFS failed to define the impact levels that it has used in its analysis, but it has even failed to provide a full complement of impact levels as reflected in the other NEPA documents identified above.

Importantly, it is not just a matter of defining impact levels, but the impact levels used also must be developed so they are distinguishable, such that the public and decisionmakers are able to easily understand the difference between the various levels used (e.g., how a "negligible" impact is distinguished from a "minor" impact).

As noted previously, the alternatives, affected environment, and environmental consequences sections of any EIS is considered the "heart" of the analysis and an agency "should present the environmental impacts of the proposal and the alternatives in comparative form, thus sharply defining the issues and providing a clear basis for choice among options by the decisionmaker and the public." 40 CFR § 1502.14. In order to sharply define the issues and to ensure, post-decision, that the agency's analysis of impact levels was accurate, it follows that the impact levels used must be meaningful, distinguishable, quantifiable, and/or measureable. If not, then the impact levels effectively become irrelevant since there would be no mechanism to differentiate between the reported impacts. In other words, the agency's analysis would be based largely on speculation as to severity of any impacts.

In *Bluewater v. Salazar* (721 F.Supp.2d 7 D.D.C. (2010)), the National Park Service was criticized for its failure to use meaningful, distinguishable, quantifiable, and measureable impact thresholds in its impairment analysis of allowing jet skis use in the Gulf Islands National Seashore. The court went into great detail to explain why impact levels (or thresholds) in the context of the NPS impairment standard must be distinguishable from each other. While the NPS impairment standard is not a component of NEPA, the impact level concept is exactly the same, suggesting that impact levels contained in NEPA documents must, at a minimum, meet the standards imposed in *Bluewater*.

Given the critical importance of the impact analysis in any EIS, the failure by NMFS to define the impact levels used in the DEIS, to provide a full complement of impact levels (i.e., to address the intensity, temporal context, extent, resource value, and physical impact of an action and its alternatives), and to differentiate between impact levels, is not an error that can be corrected in a Final EIS. Rather, at a minimum, NMFS needs to suspend the current NEPA process while it prepares a Supplemental EIS to address this (and other deficiencies) in the DEIS.

Other Federal Agencies and Additional Legal Concerns

1. NMFS has failed to adequately evaluate how the proposed whale hunt would impact other federal agencies with jurisdiction within the Project Area or to clearly explain management authorities of those agencies:

The Obama Administration has led a push towards the use of ecosystem-based management of our marine resources. In its 2011 EBM Strategic Action Plan Outline, the National Ocean Council (NOC) defined EBM as:

> an integrated approach to resource management that considers the entire ecosystem, including humans, and the elements that are integral to ecosystem functions. EBM is informed by science to conserve and protect our cultural and natural heritage by sustaining diverse, productive, resilient ecosystems and the services they provide, thereby promoting the long-term health, security, and well-being of our Nation.

In a 2013 report to the NOC, the Ocean Research Advisory Panel (ORAP) stated:

> EBM is an integrated approach to management that drives decisions at the ecosystem level to protect the resilience and ensure the health of the ocean, our coasts and the Great Lakes. EBM is informed by science and draws heavily on natural and social science to conserve and protect our cultural and natural heritage, sustaining diverse, productive, resilient ecosystems and the services they provide, thereby promoting the long-term health, security, and well-being of our Nation.

As described in the DEIS, the project area encompasses several federally designated and managed areas, including the Olympic Coast National Marine Sanctuary (OCNMS), the Washington Islands National Wildlife Refuges, Olympic National Park, and internationally designated areas, including a United Nations World Heritage Site and the Olympic Biosphere Reserve, as well as the Makah and Ozette Reservations. To be consistent with EBM, NMFS must take into consideration the environmental impacts of a proposed hunt on this larger geographic region, which it has not done in this DEIS, as explained below.

There are a number of federal agencies that manage lands or waters within the Project Area. These agencies include NOAA, the National Park Service, and the United States Fish and Wildlife Service. For each of the areas managed by these agencies, there are separate statutes and regulations that dictate wildlife management requirements.

Olympic Coast National Marine Sanctuary (OCNMS):

The OCNMS is managed by NOAA's Office of National Marine Sanctuaries. As noted in the OCNMS Final Management Plan and Environmental Assessment, the OCNMS encompasses 2,500 square nautical miles of marine waters off of Washington's Olympic Peninsula coast. See Figure 1. Its location enhances protections to the region's natural integrity provided by both Olympic National Park and the Washington Maritime National Wildlife Refuge Complex. The area's nutrient-rich waters contribute to the high primary productivity within the OCNMS, which attracts twenty-nine species of marine mammals, some of the largest seabird colonies in the continental United States, and a variety of commercially important fish species. It also supports the critical habitats of a number of unique communities of organisms, including deep sea coral and one of the world's most diverse seaweed communities.

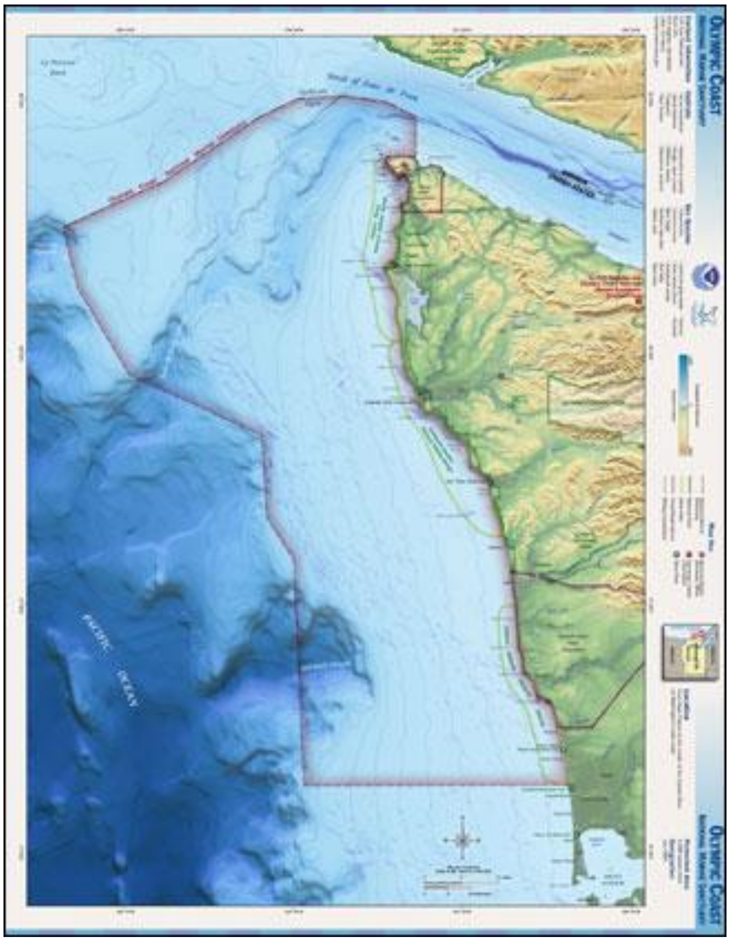

Figure 1: Map of OCNMS (available at http://sanctuaries.noaa.gov/pgallery/atlasmaps/oc.html)

The OCNMS is managed pursuant to the National Marine Sanctuaries Act (NMSA). The NMSA, enacted in 1972, authorizes the Secretary of Commerce to designate and protect areas of the marine environment with special national significance due to their conservation, recreational, ecological, historical, scientific, cultural, archeological, educational, or esthetic qualities as national marine sanctuaries. The primary objective of the NMSA is to protect marine resources, such as coral reefs, sunken historical vessels or unique habitats. Section 304(d) of the NMSA requires federal agencies whose actions are "likely to destroy, cause the loss of, or injure a sanctuary resource," to consult with the program before taking the action. The program is, in these cases, required to recommend reasonable and prudent alternatives to protect sanctuary resources. 16 U.S.C. § 1434(d).

The boundaries of the Makah U&A appear to overlap with the boundaries of the northern portion of the OCNMS. Regulations relevant to the OCNMS generally prohibit the taking of marine mammals and other species in or above the sanctuary, except if such taking is authorized by several laws or treaties. Specifically, the regulations prohibit:

> Taking any marine mammal, sea turtle or seabird in or above the Sanctuary, except as authorized by the Marine Mammal Protection Act, as amended, (MMPA), 16 U.S.C. 1361 *et seq.,* the Endangered Species Act, as amended, (ESA), 16 U.S.C. 1531 *et seq.,* and the Migratory Bird Treaty Act, as amended, (MBTA), 16 U.S.C. 703 *et seq.,* or pursuant to any Indian treaty with an Indian tribe to which the United States is a party, provided that the Indian treaty right is exercised in accordance with the MMPA, ESA, and MBTA, to the extent that they apply.

15 CFR § 922.152(a)(6)

While the whaling provisions in the Treaty of Neah Bay would appear to secure the Makah Tribe's ability to hunt whales within the OCNMS, information in the OCNMS Final Management Plan and EA suggests that a management plan is required to facilitate this exemption to the general prohibition against taking marine mammals in the OCNMS. As explained in the Final Management Plan and EA:

> NOAA's implementation of the NMSA and its duty to implement the federal trust responsibility toward American Indian tribes complement and support one another. The purposes and policies of the NMSA include the following, *"to maintain the natural biological communities in national marine sanctuaries, and to protect, and where appropriate restore and enhance natural habitats, populations, and ecological processes."* This statutory mission supports NOAA's implementation of its trust responsibility for the protection of treaty trust resources, tribal access to treaty resources and the sustainable development of treaty rights. One of the purposes and policies of the NMSA is *"to develop and implement coordinated plans for the protections and management of [sanctuaries] with …Native American Tribes and organizations…and other public and private interests concerned with the continuing health and resilience of these marine areas."* This policy statement in the NMSA supports OCNMS's efforts to defer to tribal management plans that achieve the statutory mission and obligations of OCNMS.

> Finally, the NMSA's objective *"to facilitate to the extent compatible with the primary objective of resource protection, all public and private uses of the resources of"* national marine sanctuaries supports implementation of NOAA's trust responsibility to protect the exercise of treaty rights, now and in perpetuity. The NMSA and the federal trust responsibility provide one basis, among many, for the determination OCNMS regulations do not restrict the ability of Coastal Treaty Tribes to exercise their treaty protected rights (15 CFR 122.152(f)). The Coastal Treaty Tribes and NOAA strive to develop joint activities and projects, and to engage in the collaborative development and implementation of coordinated plans for the management and protection of treaty resources, to ensure resilience of those resources, and to promote the continuing health of the OCNMS ecosystem.

(Final Management Plan and EA at 10; emphasis added).

This language indicates that OCNMS and the Makah Tribe either must develop a coordinated plan for the protection and management of treaty resources or the OCNMS can defer to a management plan promulgated by the Makah Tribe. Any such plan, however, must provide for the protection of treaty resources, ensure the resilience of those resources, and promote the continuing health of the OCNMS ecosystem. NMFS does not provide any information in the DEIS to suggest that such a management plan for gray whales or for all sanctuary resources that may be exploited by the Makah Tribe has been developed. If such a plan exists, it should be disclosed as part of the NEPA process. If no plan is available, the Makah must not be allowed to engage in whaling within the OCNMS until it, ideally in collaboration with OCNMS representatives, promulgates a plan. Such a plan should be subject to public notice and comment before it is finalized.

Washington Islands National Wildlife Refuges:

The Washington Islands National Wildlife Refuges include the Flattery Rocks, Quillayute Needles, and Copalis National Wildlife Refuges. See Figure 2. The refuge complex is under the jurisdiction of the US Fish and Wildlife Service (USFWS). For management purposes these refuges are managed as part of a complex. Flattery Rocks National Wildlife Refuge (NWR) is the furthest north of all three refuges and is the refuge most likely to be affected by the proposed Makah hunt. See Figure 3.

In 1907, President Theodore Roosevelt signed Executive Order 703, establishing the Flattery Rocks Reservation. That EO specified that:

> It is hereby ordered that all small, unsurveyed and unreserved islands lying off the coast of the State of Washington in the Pacific Ocean, between latitudes 48° 02' North and 48° 23' North, among which are those named and commonly known as Spike Rock, Father and Son, Bodiel-teh Islets, Flattery Rocks, Ozette Island and White Rock, as the same are shown upon coast survey chart No. 6400, or upon the General Land Office map of the State of Washington, dated 1887, and located within the area segregated by a broken line and shown upon the diagram hereto attached and made a part of this order, are hereby reserved end set aside for the use of the Department of Agriculture, as a preserve and breeding ground for native birds and animals. This reservation to be known as Flattery Rocks Reservation.

In 1940, by proclamation, Flattery Rocks, Quillayute, and Copalis reservations were redesignated as national wildlife refuges. In 1970, all three refuges were designated as wilderness areas.

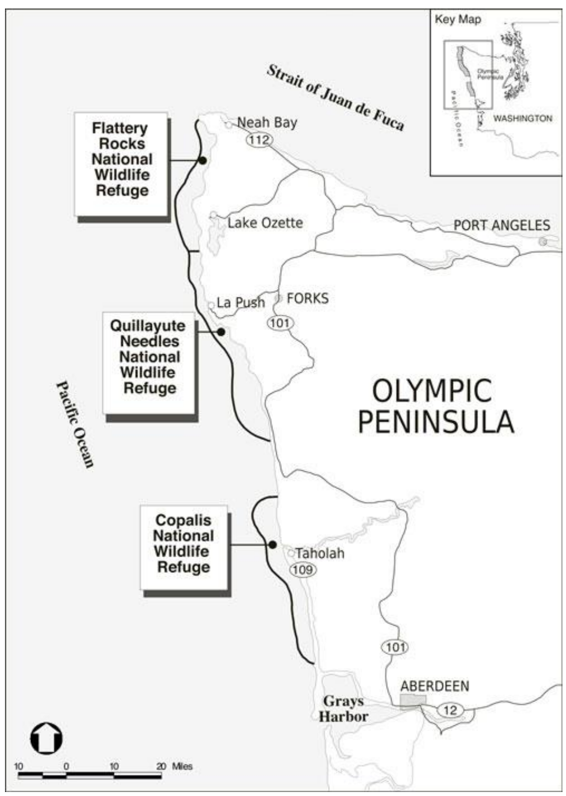

Figure 2: Map of the Washington Islands National Wildlife Refuges (available at http://www.thearm chairexplorer.com/washington/w-images/nwr-photos/Washington_Maritime_NWRC_Ma.jpg)

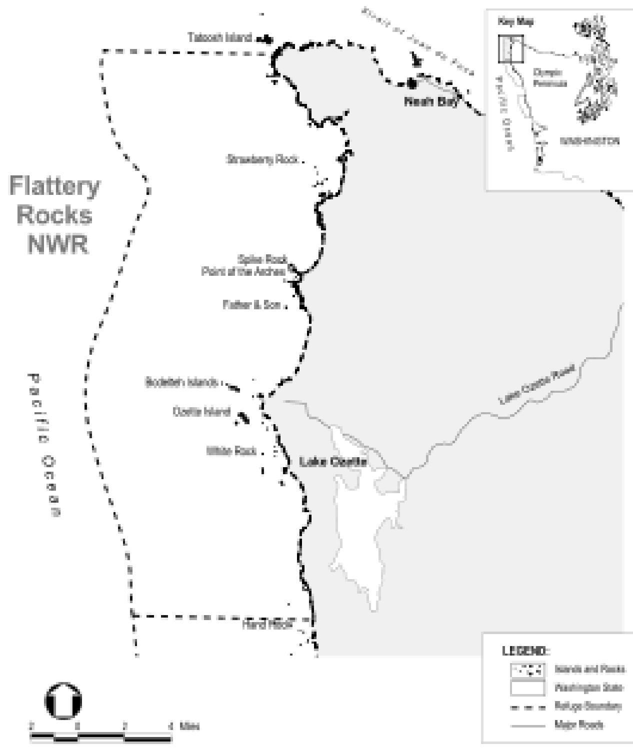

Figure 3: Map of Flattery Rocks National Wildlife Refuge (available at https://upload.wikimedia.org.wikipedia/commons/thumb/7/70/Flattery_Rocks_NWR_Map.svg/283px-Flattery_Rocks_NWR_Map.svg.png

Management of Flattery Rocks NWR is complicated given the multiple agencies, state and federal, and tribal that have separate or overlapping jurisdiction for the management of natural resources in the area. As explained in the Washington Islands National Wildlife Refuges Comprehensive Conservation Plan and Environmental Assessment (CCP/EA):

> The Service (USFWS) is responsible for most of the islands, rocks, and seastacks above the mean high water line. As with other national wildlife refuges, the Service is responsible for any wildlife, fish, and plants that occupy the Washington Islands NWRs whether they are seasonal or permanent residents. This includes seabirds, shorebirds, and marine mammals that use the Refuges' islands and shoreline. Although Service responsibilities cover terrestrial environments, the Refuges are vitally linked with the surrounding marine environment and its resources.

The waters surrounding the Flattery Rocks NWR are largely managed by the OCNMS although, given the purpose of the refuge to protect birds and animals and the legally designated refuge boundary that includes a large amount of ocean habitat, the USFWS must have some role in the management of this wildlife, including ocean species.

Management of Flattery Rocks NWR is governed by the National Wildlife System Administration Act, as amended by the National Wildlife Refuge System Improvement Act (16 U.S.C. § 668dd et seq.). While hunting can be permitted on national wildlife refuges, the USFWS must engage in an independent planning process to open a refuge to hunting or to amend or modify hunting practices once a refuge has been opened to hunting. In addition, refuge-specific hunting regulations must be promulgated. The Flattery Rocks NWR is not open to hunting or fishing, as there are no refuge-specific hunting or fishing regulations published in the Code of Federal Regulations (see 50 CFR 32.67).

Since the waters surrounding Flattery Rocks NWR appear to be managed by ONNMCS up to the "higher high water mark on Refuge islands," it would appear any hunting of whales by the Makah Tribe within the boundaries of the Flattery Rocks NWR does not require refuge-specific hunting regulations. However, if such hunting resulted in adverse impacts to the birds and mammals that utilize the islands, beaches, and rocky outcrops within the Flattery Rocks NWR, or if the Makah were to land a struck whale on lands under the jurisdiction of the USFWS, then the USFWS would have the authority to act to protect such species and their habitat despite NMFS's jurisdiction over whales under the MMPA and ESA. More than likely, given USFWS NWR regulations and policies, the Makah would not be authorized to land a whale onto any of the islands within the Washington Islands National Wildlife Refuges complex absent prior authorization to do so. As explained in the CCP/EA, the USFWS can enter into Memoranda of Understanding with tribal governments to permit their use of refuge lands and resources but, in this case, there is no evidence such an MOU has been negotiated between the Makah Tribe and the USFWS.

Given the confusing mixture of management jurisdictions among federal, state, and tribal agencies in this region, NMFS must include a more detailed analysis of the various agencies and their management responsibilities in a revised EIS. In particular, it must identify the legal standards, including those relevant to the USFWS, that govern management of terrestrial and aquatic species in the area and under what circumstances the agencies have a role in the wildlife management decision-making process. Furthermore, NMFS must clarify if the Makah can land a dead whale on USFWS refuge lands, what permits would be required to do so, and evaluate how that could impact refuge wildlife, including refuge birds, and wildlife habitat. While the DEIS does provide some broad analysis of the impacts of a hunt on birds, other marine mammals, and intertidal habitat, it fails to provide the level of detail that is required by NEPA in an EIS.

Olympic National Park:

Olympic National Park (ONP) is administered by the National Park Service (NPS). ONP protects 922,651 acres of three distinct ecosystem types: glaciers, coastline, and old growth and temperate forests. As described in ONP's Final General Management Plan and Environmental Impact Statement (ONP GMP EIS), the park provides habitat for 70 unique stocks of Pacific salmon and steelhead, 29 species of native freshwater fish, 1,100 species of native plants, 300 species of birds, including the federally protected marbled murrelet, and 70 species of mammals. ONP GMP EIS at 3. The 70-mile long, 43,000 acre Pacific coastal strip and off-shore islands of ONP provides protection to beached, intertidal areas, and rocky tidal pools as the park's boundary extends seaward to the "lowest low tideline." *Id.* See Figure 4. In addition, 95 percent of the park, including its coastal strip, is Congressionally designated wilderness managed pursuant to statutes governing national parks and the Wilderness Act (16 U.S.C. § 1131, et seq.).

Figure 4: Map of Olympic National Park (available at http://media.away.com/gifs/states/wa/m_olymov.gif)

ONP is managed pursuant to the NPS Organic Act (16 U.S.C. § 1, et seq.). The fundamental purpose of the NPS is to "promote and regulate the use of the Federal areas known as national parks, monuments, and reservations … as provided by law, by such means and measures as conform to the fundamental purpose of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." 16 U.S.C § 1. Furthermore, the "authorization of activities (in national parks) shall be construed and the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established, except as may have been or shall be directly and specifically provided by Congress. 16 U.S.C § 1a-1.

Regulations specific to ONP indicate that "all hunting or the killing, wounding, or capturing at any time of any wild bird or animal, except dangerous animals when it is necessary to prevent them from destroying human lives or inflicting personal injury, is prohibited within the limits of the park…" The Secretary of the Interior is also required to promulgate "regulations as he may deem necessary and proper for the management and care of the park and for the protection of the property therein, especially for the preservation from injury or spoliation of all timber, mineral deposits, natural curiosities, or wonderful objects within the park, and for the protection of the animals and birds in the park from capture or destruction, and to prevent their being frightened or driven from the park…" As dictated by statute, "possession within the park of the dead bodies or any part thereof of any wild bird or animal shall be prima facie evidence that the person or persons having the same are guilty of violating this Act." 16 U.S.C. § 256b.

While the majority of ONP is inland and, therefore, not likely to be directly impacted by the proposed hunt, the coastal portion of ONP could be affected. Such impacts could include park visitors observing a hunt, a dead whale being towed back to the Makah reservation, a whale injured by a hunt that strands on ONP lands, or a whale struck and lost by the Makah if it were to wash up on to ONP lands. In addition, albeit unlikely, Makah whalers under certain circumstances, including inclement weather or equipment failure, may elect to land a whale on ONP lands even though this would be illegal under existing ONP regulations.

With the exception of conceding that visitors to ONP may be able to see or hear a whale hunt, NMFS failed to consider other potential adverse impacts to ONP visitors like those summarized above. In addition, it did not provide any discussion in the DEIS about the laws relevant to the protection of ONP, what the Makah would be authorized to do (or not to do) on lands and waters under jurisdiction of ONP, nor did it adequately consider the requirements of the Wilderness Act in the context of Makah whaling.

<u>The Wilderness Act</u>

The Wilderness Act permits the designation of wilderness areas in order to protect these areas from increasing human population, expanding settlements, and growing mechanization. 16 U.S.C. § 1362.2(a).

A wilderness is defined as "an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain," that retains "its primeval character and influence," where "natural conditions" are preserved, where there is no "natural improvements or human habituation," and that "generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable." *Id.* at § 1362.2(c). Such areas are to be "administered for the use and enjoyment of the American people in such manner as will leave them unimpaired for future use as wilderness, and so as to provide for the protection of these areas, (and) the preservation of their wilderness character…"*Id.* at § 1362.2(a). Within wilderness areas, "there shall be no temporary road, no use of motor vehicles, motorized equipment or motorboats, no landing of aircraft, no other form of mechanical transport, and no structure or installation within any such area." *Id.* at § 1364.4(c).

NMFS has failed to evaluate the environmental impacts of the proposed whale hunt in the context of the Wilderness Act and its stringent standards for the protection of wilderness areas.

NMFS has failed to disclose all relevant information and to provide a clear and accurate analysis of the environmental consequences of the No Action and action alternatives:

The affected environment and environmental consequences sections of the DEIS provide the heart of the analysis. The former is intended to fully document the characteristics of the affected environment, while the latter considers the impacts on that environment of the alternatives evaluated in the DEIS. Because of the linkages between these sections of the DEIS, they will be considered together here. Analysis is not provided of each of the environmental variables (e.g., water quality, public services) contained in the DEIS. This is not to suggest that these variables are not important but only that the coalition does not have substantive concerns with the relevant analyses contained in the DEIS, unlike the variables discussed below.

<u>NMFS has failed to properly evaluate the impact of a proposed whale hunt on ENP, PCFG and WNP gray whales:</u>

This section provides an overview of each of the alternatives in the context of the potential timing of the hunt, number of hunting (and scouting) days, number and type of vessels involved in hunt related activities, number of ENP and PCFG whales killed, likelihood of striking a WNP, likely number of whales killed, number of unsuccessful harpoon attempts, number of approaches to whales, the number of shots fired, and the number of grenade explosions.

As indicated below, there are a number of questions, concerns, and errors in the analysis of the environmental impact of the proposed whale hunt on ENP, PCFG, and WNP gray whales. Most of these issues are raised in the analysis of specific alternatives. Some of the issues raised under one alternative may be also applicable to another alternative. In those instances, such relationships are noted in the text. Before engaging in an alternative-specific analysis, there are broader issues and concerns that warrant discussion and review.

Scope and focus of DEIS analysis:

In regard to the scope or focus of the analysis, as explained in the *Anderson* opinion and as quoted in the DEIS:

> Even if the eastern Pacific gray whales overall or the smaller PCFG group of whales are not significantly impacted by the Makah Tribes' whaling, the summer whale population in the local Washington area may be significantly affected. Such local effects are a basis for a finding that there will be a significant impact from the Tribe's hunts. Thus, if there are substantial questions about the impact on the number of whales who frequent the Strait of Juan de Fuca and the Northwest Washington coast, an EIS must be prepared.

DEIS at 3-122.

In the DEIS, NMFS attempts to evaluate the environmental impacts of the hunt on PCFG whales and those PCFG whales in the OR-SVI and Makah U&A regions. The Makah U&A region, as evaluated in the DEIS, does not include any portion of the Strait of Juan de Fuca as the Makah Tribe's proposal explicitly excluded whaling in the Strait. Consequently, if approved, a hunt would only be permitted in the Northern Washington PCFG region. In the waiver application, the Makah Tribe requests that the analysis of the impacts to PCFG whales be focused on those whales within the OR-SVI region. That region encompasses the Makah U&A and, based on PCFG observation records, there is considerable exchange or mixing of PCFG whales within the OR-SVI and Makah U&A regions. As explained below, the analysis provided by NMFS does not consistently focus or apply the correct statistics to the OR-SVI or Makah U&A regions, as requested by the Makah Tribe or directed by the court.

Pacific Coast Feeding Group:

The DEIS contains a large amount of information about PCFG whales. This information includes data (numbers and percentages) on gray whales in the PCFG observed over time, seen more than once, seen by PCFG region, and newly seen by year. The assortment of numbers and percentages used throughout the DEIS can be confusing and difficult to follow. For the purpose of this analysis, the key PCFG information contained in the DEIS is:

- Since 1977, approximately 650 gray whales have been seen at least once in the PCFG range from June 1 to November 30 and about half of these whales have been seen two or more times over the years. The whales seen more than once meet the definition of PCFG relied on in Alternatives 3-6 of the DEIS. DEIS at 3-144.
- Of the 603 whales observed in the PCFG range after June 1 from 1996 through 2011, 309 (51 percent) have never been resighted in the PCFG region, while 44 of the 603 (7.3 percent) have been resighted every summer and 265 (44 percent) have been seen more than once but not in every year. DEIS at 3-137 (citing Calambokidis et al. 2014).[20]
- 35.5 to 58.8 percent of whales seen in at least one year in the PCFG region from Northern California to Northern British Columbia were seen at some point within the Makah U&A, while 41.4 to 78.9 percent of whales seen within the PCFG region over at least two years were seen at some point within the Makah U&A. DEIS at 3-139 (citing Calambokidis et al. 2014).
- Based on PCFG observation records collected from 1996 through 2012, of the 181 whales sighted in the Northern Washington PCFG region (which corresponds to the proposed hunt area) prior to June 1, 73 (40.33 percent) were seen in the PCFG range after June 1, 67 (37.02 percent) were seen in the OR-SVI area after June 1 and 60 (33.15 percent) were seen in the Northern Washington-Strait of Juan de Fuca (i.e., the Makah U&A) area after June 1. DEIS at 3-140 (citing Calambokidis et al. 2014).
- The annual average of newly seen whales in the PCFG range, based on data from 1996-2012, was 35.4, 23.8, and 12.1 for PCFG, OR-SVI, and Makah U&A regions, respectively. DEIS at 3-147. The annual average of newly seen whales that were recruited into the PCFG population was 14.3, 11.8, and 6.1 for the PCFG, OR-SVI, and Makah U&A areas, respectively. DEIS at 3-148.
- The number of PCFG whales increased from 38 in 1996 to over 219 in 2005. The population has been relatively stable since 2002. The most recent (2012) population estimate was 209 animals. DEIS at 3-146. Within this region, the number of whales identified in the June through November period has averaged 146 whales from 1996 through 2012. DEIS at 3-148. Of these 146 whales, on average 35 are newly seen whales each year and 14 of these are recruited into the PCFG population (i.e., seen again in a subsequent year). *Id*. For calculating the PBR level, the Nmin for the PCFG whales is 173. DEIS at 3-145 (citing Carretta et al. 2014).

[20] It is not known why the numbers cited in the DEIS and repeated in this summary do not add up to 603 whales. NMFS may want to confirm that these numbers are accurate.

- For OR-SVI whales, the number of animals increased from 25 in 1996 to 181 in 2008, with the most recent population estimate (2012) being lower but stable at approximately 155 animals. DEIS at 3-154. Within this region, the number of whales identified in the June through November period has averaged 95 whales from 1996 through 2012, ranging from 30 in 2002 to 128 in 2001, with 127 in 2012. *Id*. Of these 95 whales, on average 24 are newly seen whales (ranging from 8 to 56 with 28 in 2012) and 12 of these (ranging from 3 to 37 with 3 seen in 2012) are recruited into the PCFG population (i.e., seen again in a subsequent year). DEIS at 4-86.[21] For calculating the PBR level, the Nmin for OR-SVI PCFG whales is 152. DEIS at 3-154 (citing Calambokidis et al. 2014).
- For Makah U&A whales, the number of animals increased from 18 in 1996 to 82 in 2008, with the most recent population estimate (2012) being somewhat lower but stable at approximately 77 whales. DEIS at 3-155. Within this region, the number of whales identified in the June through November period has averaged 33 whales from 1996 through 2012, ranging from 8 in 2002 to 75 in 2008. *Id*. Of the 33 whales, on average 12 are newly seen whales (ranging from 1 to 29 with 22 seen in 2012) and 6.1 of these (ranging from 2 to 17 with 4 seen in 2012) are recruited into the PCFG population (i.e., seen again in a subsequent year). DEIS at 4-86.[22] For calculating the PBR level, the Nmin of the Makah U&A whales is 73. DEIS at 3-155 (citing Calambokidis et al. 2014).
- Although the IWC has not formally identified the PCFG as a stock, its Scientific Committee noted that its Implementation Review of ENP gray whales (with an emphasis on the PCFG) was "based on treating the PCFG as a separate management stock (which may not be equivalent to a stock as defined under the MMPA)." DEIS at 3-156, footnote 53 (citing IWC 2012). The IWC has also determined that it is plausible the PCFG may be a "demographically distinct feeding group," DEIS at 3-123, while NMFS concludes that PCFG whales "appear to be a distinct feeding aggregation and may warrant consideration as a distinct stock [under the MMPA] in the future." *Id*. at 3-68, 3-123/3-124, 4-62, 4-65.

It is important to note that PCFG surveys cannot locate and identify every potential PCFG whale. Due to the size of the PCFG range, it is simply impossible to comprehensively survey the

[21] NMFS should reexamine these numbers, particularly the number of newly seen whales, given contradictions in the DEIS 3-154 and 4-86. This discrepancy may be due to how the data are presented in Calambokidis et al. (2014). They are presented as the average number of whales identified per year (95) (page 9) and as the average number of unique whales seen in Table 2 (page 32).

[22] NMFS should reexamine these numbers, particularly the number of newly seen whales, given contradictions in the DEIS at 3-155 and 4-86. This discrepancy may be due to how the data are presented in Calambokidis et al. (2014). They are presented as the average number of whales identified per year (33) (see page 9) versus as the average number of unique whales seen in Table 2 (page 32).

entire area each year. In addition, a lack of personnel, equipment, time, and funds do not allow for the survey metrics to be consistent each year. Consequently, the number of PCFG whales seen each year represents only a rough approximation of the whales actually observed each year. There are two reasons for this: there are likely more whales present each year than are photographed and identified, and it is likely that some whales were present in a previous year but were not photographed and identified. DEIS at 4-66. For example, from 1999 to 2011 there were 14.3 new recruits on average annually in the PCFG, of which 12.5 were not identified as calves, while 1.8 were. The calf estimate could possibly be higher because some of the new whales may have entered the PCFG earlier as calves and were not seen. *Id*.

Interestingly, when the PCFG, OR-SVI, and Makah U&A PBRs are compared to the PBR for the California/Oregon/Washington stock of sperm whales or the ENP stock of blue whales, those populations are much larger than any of the groups of PCFG gray whales, but their PBR is either half (for the sperm whale) or just slightly higher (for the blue whale) compared to the PBR for PCFG whales.

For example, for the CA/OR/WA stock of sperm whales, the estimated population size is 971 animals (Carretta et al. 2013), Nmin is 751, and the recovery factor is 0.1 (because the species is designated as endangered), resulting in a PBR of 1.5 animals. DEIS at 3-211. Using the estimate of 197 PCFG gray whales,[23] there are nearly 5 times as many sperm whales as PCFG whales yet, because the sperm whale is designated as endangered, its PBR is nearly half that of PCFG whales. Similarly, the ENP blue whale has an estimated abundance of 2,497 (Carretta et al. 2013). Despite there being 12.6 times more blue whales than PCFG whales, the recovery factor used for the blue whale is 0.3 (used for endangered species with a minimum abundance estimate of more than 1,500 and a CV Nmin of <0.5), resulting in a PBR (3.1) only 0.4 more than the PCFG PBR (2.7).

While PCFG whales are not presently designated as endangered or depleted, given their low population numbers, the potential for them to be designated as a stock in the future, and remembering the precautionary principle, the PCFG PBR should be calculated using a 0.1 recovery factor. If this were done, the PCFG PBR would be 0.54, while the corresponding PBRs for OR-SVI and Makah U&A PCFG whales would be 0.47 and 0.23, respectively.[24] Alternatively, if the 0.3 recovery factor was used (even though the number of PCFG gray whales is nowhere near a minimum population of greater than 1,500 animals), the PCFG, OR-SVI, and Makah U&A PBR levels would be 1.6, 1.4, and 0.7, respectively.

[23] 197 is the abundance estimate for PCFG whales used in the DEIS even though it is not the most recent abundance estimate, which is 209 whales. Calambokidis et al (2014).

[24] For these calculations, the Nmins for PCFG, OR-SVI, and Makah U&A that are included in the DEIS were used, along with the larger .062 Rmax (instead of the default value of .04).

The potential impact of each action alternative on PCFG whales, including those that utilize the OR-SVI and Makah U&A, along with WNP gray whales if the maximum permitted number of strikes is used, is summarized in Table 1.

Table 1. Estimated number of strikes on PCFG, OR-SVI, Makah U&A, ENP, and WNP whales per year in each PCFG region analyzed in the DEIS under each alternative based on maximum permitted strikes. (Data from Tables in DEIS on pages 4-16, 4-25, 4-29, 4-36, and 4-40/41).

	Percent of PCFG Whales (March-May)	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6
Maximum Number of Strikes (ENP)		7	6	1	5	3.5 (7 over 2 yrs)
PCFG	40.33	2.8	2.4	1	0.20	1.4
OR-SVI	37.02	2.6	2.2	1	0.18	1.2
Makah U&A	33.15	2.3	2.0	1	0.16	1.3
WNP		0.012	0.010	0	0.009	0.006

In regard to the potential impact of any of the action alternatives on PCFG whales, including whales in the OR-SVI and Makah U&A, NMFS largely dismisses any meaningful effects.

In evaluating the environmental impacts of the proposed hunt to PCFG whales, for Alternatives 3-6, NMFS concludes that "gray whales would continue using these survey areas during summer months" because: 1) the PCFG mortality limit is more restrictive than the bycatch formula used in Alternative 2; 2) struck and lost whales will count as PCFG whales; 3) other human-caused mortality will be subtracted from the calculated PBR (for Alternatives 4 and 6 only); 4) the IWC analysis demonstrates that PCFG whales would remain viable with a Makah hunt; 5) PCFG whales are dense and abundant in the OR-SVI area; 6) PCFG whales are highly mobile within the PCFG range; 7) many new and returning whales are available to replace killed whales; and 8) gray whales continue to return in large numbers to feeding areas (Chukotka) where scores are actively hunted and killed. DEIS at 4-89, 4-96, 4-103, 4-111, 4-118.

This suggestion that a hunt will not have any adverse impact on PCFG whales flat out contradicts other statements in the DEIS. For example, NMFS concedes in the DEIS that if external recruits don't replace killed PCFG whales, then under each of the action alternatives, it is "likely that the number of whales would decrease."[25] DEIS at 4-89, 4-96, 4-103, 4-111, 4-118. Considering that scientists continue to obtain data to better understand PCFG recruitment mechanisms, this possibility should not simply be dismissed to satisfy the Makah. This possibility is consistent with another statement in the DEIS that "killing even a few animals per year (especially over an extended period of time) from the relatively small PCFG stock could have long-lasting impacts for a group of whales whose population dynamics are not well understood." DEIS at 5-3. Indeed, considering the level of site fidelity seen in some PCFG whales, it is possible that removals of whales from the Makah U&A could result in a localized depletion that would require an extended time period to recover. Unlike calves of PCFG females who are known to be recruited into the feeding aggregation, it may take a unique ENP whale to not just use PCFG range but to use it annually (i.e., to become a PCFG recruit). If that unique whale is not common, then perturbations to PCFG whales may not be reversed for some time.

In regard to the specific conclusions noted above, the Coalition questions whether PCFG whales are "dense and abundant in the OR-SVI area," whether there are "many new and returning whales available to replace killed whales," and whether whales will continue to return to the OR-SVI area if subjected to hunting. As indicated above, from 1996 to 2012 the average number of whales seen in the OR-SVI area was 155. Considering the size of the area, this number hardly suggests a "dense and abundant" distribution. Furthermore, on average, only 12 whales per year are recruited into the OR-SVI region, which does not qualify as "many new and returning whales" available to fill the gaps left by any whales the Makah might kill or whales that may leave the hunt areas due to impacts of the hunt. These conclusions should be revisited.

Finally, assuming new whales will readily fill gaps left by dead whales based on the Chukotkan gray whale hunt may not be accurate, particularly considering that the Makah U&A is within the OR-SVI region. The mere fact that Chukotkan natives have killed an average of 116 gray whales over the past ten years (2004-2013)[26] is not sufficient information to determine if the characteristics of the whales' distribution have changed over time as a result of hunting pressure. To make that determination, additional information is necessary regarding catch-per-unit effort, the spatial and temporal distribution of the whales within their Russian feeding areas, how actual kill locations have changed over time (if at all), and if whales on the Russian feeding areas demonstrate different behaviors (i.e., alertness, flight response) to the approach by or presence of a vessel, including a whaling vessel. Even if maternal site fidelity to the feeding areas draws whales back to such areas year after year, it is still possible that their

[25] This finding is included in the analysis of Alternative 4. However, NMFS also notes in the DEIS that "Alternative 4 is less likely to affect PCFG viability compared to Alternatives 2 and 3 because the hunt would target males and would not affect matrilineal recruitment." DEIS at 4-101.
[26] Data obtained from https://iwc.int/table_aboriginal

distribution (within their feeding areas) or behaviors have been changed as a consequence of the hunt.

Similarly, for PCFG whales, unless maternal fidelity is specific to the Makah U&A region, PCFG whales have alternative feeding areas from North California to Southeast Alaska. That is, the Makah U&A, although it may be a desirable location for PCFG whales based on prey abundance, may be abandoned for alternative feeding areas – literally only miles away – if hunting is allowed. This means PCFG whales would no longer be "functioning elements of [the Makah U&A] ecosystem."

In addition, considering that gray whales have been largely protected along the entire west coast of North America for decades (with the exception of the gray whales killed in 1999 and 2007), gray whales are not accustomed to being hunted in this region (unlike Chukotkan gray whales who are subjected to hunts every year). Consequently, the behavioral impact of a hunt on an OR-SVI PCFG whale could be vastly different from how gray whales in Russia respond to a hunt; "naïve" OR-SVI whales may be more likely to abandon the area because of the novel, negative stimulus posed by a hunt. NMFS must reevaluate this analysis, recognizing that comparing the reactions of PCFG whales with those of Chukotkan whales may not be valid. It should seek out information, perhaps from new stocks of whales that suddenly became subject to a novel threat, to determine if those reactions could provide any guidance to how PCFG gray whales may react to a hunt.

NMFS must also reconsider its use of the Chukotkan whale hunt as a proxy for how a Makah hunt could physically and behaviorally impact PCFG whales. This analysis must consider the impacts within the PCFG and OR-SVI regions. It also should more comprehensively evaluate the impact of a hunt on PCFG whales in the Makah U&A region given the direction from the *Anderson* opinion to consider the impacts of a hunt on whales in the specific project location (i.e., the Makah U&A).

NMFS also claims the "loss of a feeding aggregation such as the PCFG may not affect the viability of the overall ENP stock" because "sighting data and diet studies indicate that ENP gray whales, including PCFG whales, have the ability to switch feeding areas over time." DEIS at 4-64. This statement ignores NMFS's determination that PCFG whales "may provide important flexibility to the species as a whole given potential challenges in a changing sub-arctic ecosystem," DEIS at 3-129, and also ignores the fact that the loss of this feeding aggregation would remove it as a functioning element of this ecosystem. In addition, in its analysis of Alternative 2, NMFS concedes "If PCFG whales are uniquely adapted to exploit feeding areas in the southern portion of the ENP summer range, and that adaptation were lost if the PCFG were compromised, Alternative 2 has the potential to affect the long-term viability of the ENP stock as a whole." DEIS at 4-82. Such conflicting statements and conclusions must be clarified and, in this particular case, NMFS must remove from its analysis any assertion that PCFG whales can be sacrificed without potentially significant adverse impacts to ENP gray whales and, in fact, to the entire population if the ongoing changes in the Arctic begin to adversely affect ENP gray whales.

Western North Pacific gray whales:

For WNP gray whales, NMFS relies entirely on the analysis by Moore and Weller (2013) to assess the potential of a Makah whale hunt to impact this endangered population of whales. Their analysis included consideration of the action alternatives evaluated in the DEIS. Their findings are presented in Table 2.[27]

Table 2: Percent Chance of Approaching, Attempting to Strike, or Striking One WNP Gray Whale Over Six Years

	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6
Approaching	97	97	≈0	72	97
Attempting to strike	35	31	≈0	27	20
Striking	7	6	≈0	5	4

While their modelling results provide probabilities for a WNP gray whale to be approached/pursued, subject to an unsuccessful harpoon attempt, or struck is low, it is not zero (except under Alternative 4, where the risk is likely near zero). Notably, any of these outcomes reflects a "take" under the MMPA and, if not authorized by permit or included in the waiver application,[28] could lead to prosecution of a Makah whaler and his crew for violating the MMPA and ESA. Furthermore, whether these probabilities accurately reflect the real risk is uncertain.

In the analysis by Moore and Weller, the percent chance over six years of actually striking at least one WNP "was relatively low but non-trivial," of attempting to strike at least one WNP gray whale was "fairly high," and of approaching at least one WNP whale was "high." DEIS at 3-93. Overall, Moore and Weller conclude the tribe "might strike a whale (WNP) approximately

[27] These findings, as indicated in the DEIS, are also based on a separate communications between NMFS and J. Moore.

[28] WNP gray whales are not included in the Makah Tribe's waiver application. In addition, the Makah could not qualify for any type of harassment authorization if it is allowed to hunt and any take of a WNP gray whale is considered intentional.

once every 100 years." *Id*. Even if this is accurate, NMFS determined "the loss of a single whale, particularly if it were a reproductive female, would be a conservation concern for this small stock," DEIS at 3-93/3-94, 4-82, 4-92, while the IUCN has "emphasized the urgent need for a comprehensive international strategy to eliminate or mitigate anthropogenic threats facing WNP gray whales throughout their range." DEIS at 3-94.

Furthermore, the analysis by Moore and Weller examined only the numerical probability of being affected by the hunt based on the total number of WNP gray whales and the proportion of the population known to have emigrated to the ENP gray whale range. They didn't consider any variable linked to time spent in the ENP range or, more specifically, in the Makah U&A. This is not a trivial concern since the more time a WNP gray whale spends in the hunting area, particularly during the time when a hunt is permitted, the greater the probability of an approach, pursuit, strike attempt, or strike.

Even NMFS notes that "Sakhalin whales were seen in an area of the ENP (i.e., Vancouver Island) where some whales tend to linger and feed during the northbound migration," and that "the long distance and potential open water crossing required for transit from the ENP to the WNP may make it more advantageous for whales to spend time feeding in the Pacific Northwest prior to undertaking a westerly passage to Sakhalin." DEIS at 3-89 (citing Darling et al. 1998 and Weller et al. 2012).

Another concern independent of any statistical probability of WNP whales being struck, killed, or even approached during a hunt is the fact that none of the action alternatives require the comparison of any photographs taken of killed and landed whales with the WNP gray whale photo-id catalog maintained by Alexander M. Burdin of the Vyatka State Agricultural Academy, Kirov, RUSSIA. Considering the critically endangered status of WNP gray whales and the fact that each whale is critical to the short and long-term conservation and recovery of the population, any hunt must include a photo-id requirement for WNP gray whales. While NMFS suggests in the analysis of each action alternative that, if a gray whale is taken and landed, it will be possible to determine if it is a WNP whale based on comparing photographs to the WNP photo-id catalog, DEIS at 4-82, 4-92, this is not reflected in the description of any of the alternatives. At present, all the action alternatives require photographs of gray whales killed by the Makah to be compared only with the PCFG photo-id catalog maintained by the Cascadia Research Collective. If NMFS grants the Makah request for a waiver and permits the Tribe to whale, it must include a requirement in the waiver, regulations, or permit language that all landed whales must be photographed and the images compared to both the PCFG and WNP photo-id catalogs. In addition, tissue samples from any dead whale must be taken for DNA analysis to obtain a greater understanding of gray whale genetics and population/feeding aggregation relationships.

NMFS also asserts that it might be possible to determine if a struck gray whale, even if it were lost, is a WNP whale. DEIS at 4-92, 4-99, 4-114. Unless the Makah or NMFS intend to take photographs of any targeted whale before he/she is struck with a harpoon or shot with a bullet or grenade or unless a WNP whale is otherwise marked or tagged, it is unclear how this could be accomplished. NMFS must clarify the methodology that would be employed to determine if a struck and lost whale is a WNP whale.

Alternative 1:

This is the No Action Alternative. If selected it would deny issuance of the requested MMPA waiver to the Makah Tribe. However, this alternative does not prevent the Makah Tribe from revitalizing its whaling traditions and/or continuing to engage in any rituals, songs, dances, ceremonies, or story telling that has reportedly been ongoing since the tribe ceased whaling in the 1920s. It also, as indicated in the DEIS, does not prevent Makah whalers from constructing whaling canoes, from engaging in physical training as practiced in the past, or in using the canoes in the Makah U&A as long as no protected marine mammal species is taken in violation of the MMPA.

In the DEIS, NMFS repeatedly claims that Alternative 1, if it were selected, would not reduce the number of gray whales killed since the United States would likely transfer its allocation of gray whales back to the Russian Federation for its native hunters consistent with a bilateral agreement between Russia and the United States. DEIS at 4-8. While the return of any unused quota to the Russian Federation may occur, that does not necessarily mean the same number of whales (i.e., 140 per year as currently permitted by the IWC) would be killed each year. The Chukotkan natives do not currently take the full quota allocation, averaging 126 whales annually from 2009 through 2013.[29]

At present,[30] if the no action alternative were selected, it would not necessarily correlate to an increase in Russian ASW kills. Conversely, if one of the action alternatives were selected, this would result in an increase in the number of whales killed because any gray whales killed by the Makah would be added to those killed by the Russian native whalers. Historically, the only other group that killed gray whales was Alaska Natives, who killed a total of seven from 1985 through 1995 but, at present, do not have an IWC-approved quota for gray whales.

Moreover, even if the United States transfers its gray whale quota to the Russian Federation, the additional whales that could be killed by the Chukotkan natives would likely not be the same animals that could have been killed by the Makah. In particular, transferring the quota

[29] Data obtained from https://iwc.int/table_aboriginal
[30] Based on discussions at recent IWC meetings, the Russian Federation may attempt to increase the ASW quota for gray whales in the future to compensate for “stinky” whales that are reportedly inedible.

would indisputably prevent the killing of PCFG and WNP gray whales, since neither group of whales are subject to hunting by Chukotkan natives. For the WNP and PCFG gray whales, this would be significant given their low population numbers and the many threats they face.

Benefits could also accrue to those who regularly observe PCFG whales and who may have named or otherwise developed a particular connection with select, distinguishable whales (this is further discussed below). Other benefits of selecting Alternative 1, whether the quota is transferred to the Russian Federation or not, would include preventing gray whales from being intentionally killed in United States waters by an aboriginal group that does not qualify for an IWC-approved ASW quota. This could be of great importance to the majority of Americans who oppose whaling.

As previously noted, the Coalition supports this alternative and believes it is the only alternative that is consistent with federal law.

Alternative 2:

This is the Makah Tribe's proposed alternative. It is the most liberal of the alternatives, allowing the most strikes per year, the most hunting days (along with Alternatives 3 and 6), the largest number of whales that could be killed per year (six) with a limit of 24 whales over six years, as well as the largest number of PCFG whales likely to be killed each year (2.8). The allowable bycatch limit (ABL) for PCFG whales calculated for this hunt is three,[31] which is in excess of the current calculated PBR for PCFG whales (2.7). It would limit strikes to seven per year or 42 over six years, allow for three stuck and lost whales per year or 18 over six years, and would not permit any carry-over of any unused annual limits. All landed whales would be photographed in order to compare them to the photo-identification catalogs of PCFG gray whales (this would be an element common to all of the action alternatives) maintained by the Cascadia Research Collective. Whaling under this alternative would not occur in the Strait of Juan de Fuca, nor could it occur within 200 yards of Tatoosh Island or White Rock.

Under this alternative, edible products from the hunt could not be sold, but could be consumed locally or shared with relatives on or off the reservation and with non-relatives on or off the reservation with whom the Makah whalers have familial, economic, social, or cultural ties. Non-

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[31] As defined in the Makah Tribe's waiver application, the allowable bycatch level (ABL) is the "number of whales from the Pacific Coast Feeding Group that may be taken incidental to a hunt directed at the migratory portion of the Eastern North Pacific stock of gray whales. The ABL is calculated using the Marine Mammal Protection Act's potential biological removal approach but the minimum population estimate is based on the number of previously seen whales in the Oregon-Southern Vancouver Island survey area." DEIS at iv-v. Since the Makah Tribe uses the maximum recovery factor in calculating the ABL, the resulting number is larger than the PBR for the entire group of PCFG gray whales. This is problematic as it provides no buffer for other forms of anthropogenic mortality if the full ABL is taken.

edible products from any killed whale could be used to manufacture authentic native handicrafts that could be sold anywhere in the United States. [32]

Notably, the PBR calculation used in this Alternative is based on the abundance estimate for PCFG gray whales in the OR-SVI region. This is consistent with the Makah Tribe's waiver application, which recommended the analysis area be the OR-SVI region in order to limit the potential impact of a hunt on PCFG whales. This is also consistent with the recommendation of Calambokidis et al. (2004), who identified the OR-SVI region as the most appropriate for the hunt analysis given the significant mixing of whales between the Makah U&A and OR-SVI PCFG regions.

NMFS does not sufficiently highlight this caveat in its analysis of Alternative 2, nor does it employ the same limitation when evaluating the other action alternatives. It is precautionary to use the OR-SVI region instead of the entire PCFG region for the analysis. While consistent with the *Anderson* opinion's emphasis on evaluating the local impacts to gray whales, extending the analysis to Makah U&A whales would also be appropriate. It is therefore astonishing NMFS continues to evaluate impacts to PCFG whales at the largest possible scale. NMFS should prepare a revised analysis that utilizes the OR-SVI region as the primary analysis area for direct hunt effects or, ideally, that focuses the analysis on the OR-SVI and Makah U&A areas for all action alternatives.

If this alternative is selected and the Makah are allowed to kill up to 3 PCFG whales per year, this take would not only be in excess of the current PBR but it would not provide a buffer to compensate for any other anthropogenic mortality of PCFG whales, which could adversely affect the PCFG. Indeed, as noted in the DEIS, "as long as the total number of animals removed from the population as a result of human sources is no more than the calculated PBR of an affected stock of marine mammals, then the removals will not prevent the stock from recovering to, or being maintained within its OSP." DEIS at 3-55. Given this, even NMFS admits that the "Tribe does not propose to account for other sources of mortality when setting ABL for PCFG whales." DEIS at 2-10.

According to the Makah Tribe's 2005 waiver application, the ABL was to be calculated from a "conservative abundance estimate based on the number of gray whales that are seen in more than one year in the OR-SVI survey area between June 1 and November 30." Makah Waiver Application at ii. The abundance estimate used in the calculation is 165, which is the number of PCFG whales observed in the OR-SVI area in 2012. DEIS at 3-146 (citing Calambokidis et al. 2014). Based on that number, the Nmin is 152 which, when combined with an Rmax of 0.04

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[32] As noted previously, the Coalition asserts that permitting the sharing of edible whale products throughout the United States would not be consistent with the IWC Schedule language for ENP gray whales.

(which is the Rmax used only for the analysis of Alternative 2), and a recovery factor of 1,[33] the PBR or ABL is three whales.

The Tribe proposes to stop hunting when the ABL is reached. The ABL will be dynamic and will be calculated annually based on PCFG observation data for the June through November period before any Makah hunt were to occur. To determine when this ABL is reached, all cataloged whales seen between June 1 and November 30, even if seen only once, would be used to define a PCFG whale. A second definition, whales seen at least twice over two or more years in the PCFG range from June 1 through November 30, is used in the analysis of the other action alternatives. The Makah's definition would mean that any landed whale could be categorized as a PCFG whale based on a single observation in the PCFG range in past seasons, even though it may not actually be a PCFG whale. However, the Makah's proposal does not count whales struck and lost against the ABL for PCFG whales.

The Makah Tribe's proposal does require photographs to be taken of any landed whales for comparison to the catalog of PCFG gray whales maintained by the Cascadia Research Collective. As indicated above, this must be amended to also require the comparison of photos of landed whales with the WNP photo-id catalog and the collection of tissue samples for DNA analysis.

This photo-identification requirement was recommended by the IWC Scientific Committee, which analyzed two possible hunt variants. Although both variants were deemed acceptable, neither corresponded exactly to the hunt proposal submitted by the Makah Tribe to the IWC; therefore, the Scientific Committee expressed concern that the actual conservation outcome of the proposed hunt was not tested. DEIS at 3-160. More specifically, the "aspect of the proposed hunt that had not been evaluated was the interaction between the actual number of strikes per month during the hunting season (December through May) and the assumption of whether a struck and lost whale belongs to the PCFG." *Id*. Despite this concern, the Scientific Committee indicated if hunt variant 1 (the variant that did not count struck and lost whales against ABL) was used, then it should be accompanied by a photo-id program to "monitor the relative probability of harvesting PCFG whales in the Makah U&A" with the results presented to the Scientific Committee each year. DEIS at 3-159.

Another potential flaw in the Scientific Committee's evaluation is that it assumed "a consistent level of non-hunting human-caused mortality." DEIS at 4-66. Considering the myriad threats facing gray whales throughout their migratory range and since those threats (i.e., oil spills, ship strikes, climate change impacts, ocean acidification) are increasing, not decreasing in severity,

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[33] This recovery factor is used based on the Tribe's claim that the ENP stock of gray whales is not listed under the ESA and has been undergoing a steady or declining level of removals by aboriginal hunters. Makah Needs Statement at 30.

this assumption is almost certainly going to be violated, making all the impact predictions underestimations.

Alternative 3:

This alternative would not allow the Makah to strike a whale unless it was five or more miles offshore. It would also count struck and lost whales as PCFG whales, would establish a PCFG PBR of 2.7 whales (with a sub-quota of 1.6 females), and set the struck and lost limit at 2 whales. DEIS at 2-18. In addition, this alternative limits the number of whales killed annually to a maximum of five (24 over six years), allow only six strikes (36 over six years), restrict the number of struck and lost whales to two per year (12 over six years), and would limit the landing of PCFG whales to 2.7 with a subquota limit of 1.6 female PCFG whales. Under this alternative, any struck and lost whale would be considered a PCFG whale and would count toward the quota. All other elements of this alternative are identical to Alternative 2.

For struck and lost whales, they would be counted against the PCFG mortality limit in proportion to the availability of PCFG whales in the coastal portion of the Makah U&A from March through May. DEIS at 4-20. Calambokidis et al. (2014) determined that, of 181 whales observed in the Northern Washington PCFG Region (which is included as part of the Makah U&A) from March to May from 1996 to 2012, 40.33 percent were observed in the PCFG range after June 1, 37.02 percent were seen in the OR-SVI range after June 1, and 33.15 percent was seen in the Makah U&A after June 1. DEIS at 3-140. In determining the proportion of stuck and lost whales that would be counted as PCFG whales, NMFS uses the 40.33 percent applicable to the entire PCFG range.

The NMFS definition of a PCFG whale is a whale seen more than once over two or more years. Percentages used in this (and other action alternatives) presumably should reflect that definition. However, according to Calambokidis et al. (2014), the 40.33 percent figure refers to whales seen only once, while 36.46 percent would be the corresponding figure for whales that meet the PCFG definition used by NMFS. This may mean the 37.02 and 33.15 percentages do not reflect the NMFS definition of PCFG whales either. NMFS should revisit these figures to ensure they are consistently reflective of the agency's definition of PCFG whales.

The proportion of struck and lost whales that would be considered PCFG whales will change over time based on new data from PCFG surveys. As with Alternative 2, however, the schedule for this adjustment is unclear. Presumably data collected in the summer immediately prior to any hunting season would be used. However, that raises concerns as to whether the proportion of PCFG whales observed in different PCFG regions from June through November would correspond to proportions seen during a hunt that could occur from March to May of the following year. Alternatively, data to identify proportional presence could be collected contemporaneously with a hunt. NMFS fails to adequately explain how it will determine the percentages to use in this alternative (as well as Alternatives 4, 5, and 6). For example, while this will require the continuation of the PCFG monitoring program (which the Coalition assumes will be coordinate d by the Cascadia Research Collective), NMFS does not explicitly disclose who would perform this work. Further NMFS doesn't address how any changes to the PCFG mortality limit would be communicated to the Makah, law enforcement authorities, and the public.

This Alternative also establishes a sub-quota for females which is based on both the percent of PCFG whales present during the hunting period and the proportion of females within the entire PCFG population (which is currently 59 percent). Consequently, if using the 40.33 percent figure, a struck and lost whale would count as 0.24 PCFG female (0.4033 x 0.59). The use of the 0.59 figure is inconsistent with the findings of Ramarkrishan et al. (2001) and Steeves et al. (2001), who reported a significant male bias in the PCFG of 1.8 to 1 (N=45) and 1.7 to 1 (N=16), respectively. Makah Waiver Application at 27. NMFS must revisit this analysis to determine which correction factor is accurate.

Alternatively, because there is a struck and lost limit of 2, it is unnecessary to use these calculations at all. It would be simpler and far more precautionary to consider any whale struck and lost as a PCFG whale and, in order to maximize protection for PCFG females, to assume that each lost whale is female. Alternative 3 must be adjusted accordingly to be more precautionary.

As for the risk to WNP gray whales, while the offshore hunt location could reduce the potential risk to WNP gray whales, NMFS concedes there are "insufficient data to discern whether hunters would be more or less likely to encounter WNP whales if hunting is restricted to offshore area at least 5 miles from the coast, but tracking data for two whales indicate that they could be encountered in such areas." DEIS at 4-92.

In calculating PBR under this alternative (and for Alternatives 5 and 6), NMFS relies on data contained in Carretta et al. 2014. The gray whale population estimate in Carretta et al. (2014) is from 2006-2007, making it 8-9 years old. As indicated in NMFS (2005), "the minimum population estimate of the stock should be considered unknown if 8 years have transpired since the last abundance survey of a stock." Consequently, as long as NMFS continues to rely on the gray whale population estimate from Carretta et al. (2014) it cannot calculate a PBR for the ENP or PCFG whales. Even if NMFS claims the 2006-2007 estimate is only 8 years old and therefore still appropriate to use to calculate PBR, by the time NMFS completes this decision-making process the estimate will be significantly more than 8 years old.

An updated gray whale population estimate from 2010-2011 was published in new draft Stock Assessment Reports (SARs) for marine mammals in the Pacific Ocean (Carretta et al. 2015), but those SARs have not been finalized. This is presumably why NMFS was unable to include the updated estimate in the DEIS. However, given the restrictions associated with using a population estimate that is 8 or more years old to calculate PBR, NMFS must use the updated estimate in its decision-making process. While the public comment period on Carretta et al. (2015) has closed, given the importance of the gray whale population estimate to this issue and the DEIS analysis, the Coalition recommends that NMFS republish just the ENP and WNP draft SARs for public review and suspend the current decision-making process until any comments are evaluated and those SARs are finalized.

Regardless of which gray whale population estimate is used, the PBR calculation should be based on the OR-SVI Nmin rather than the Nmin for the entire PCFG range. This would be consistent with both the Makah's request (as reflected in Alternative 2), which was intended to limit the potential impact of a hunt on PCFG whales, and the direction provided by the *Anderson* opinion, which was particularly concerned with the potential for a hunt to impact the local gray whale population (i.e., the population in the Makah U&A).

Alternative 4:

This alternative, if selected, would allow whaling from June 1 through November 30 each year and would retain the prohibition on hunting in the Strait of Juan de Fuca and within 200 yards of Tatoosh Island or White Rock. Under Alternative 4, the hunt would be limited to seven days, the Makah could only strike male ENP whales, struck and lost whales would count as PCFG whales, and the PBR for PCFG whales would be a single whale. This alternative would permit up to five whales to be killed and seven struck per year with a struck and lost limit of a single whale and no carry-over of any unused annual limits. Due to the timing of this hunt, there would be close to no risk of hunters approaching, attempting to strike, or striking a WNP gray whale but PCFG whales would be killed. In addition, under this alternative "any whale landed would be presumed to be a PCFG whale even if it did not match a known PCFG whale." DEIS at 2-20.

In calculating PBR for PCFG gray whales under this alternative, NMFS utilized a conservative recovery factor of 0.35, while also subtracting estimated mortalities from other human causes (0.45) as reported in the ENP gray whale SAR (Carretta et al. 2014). DEIS at 2-19. According to Wade (1998), this restrictive recovery factor would allow the PCFG whales to equilibrate at 80 percent of carrying capacity over a 200 year period. *Id*. This results in a PBR of 1.43, which NMFS rounds down to 1 for use in this alternative. Since this alternative will necessarily target PCFG whales given the hunting period, a restrictive limit on PCFG gray whale mortality is appropriate. Notably, if the analysis under this alternative used the OR-SVI or Makah U&A regions, the corresponding PBR levels would be 1.19 and 0.34, respectively.

While this alternative is unique in that it explicitly targets ENP male whales, NMFS doesn't explain how Makah whalers, if permitted to whale, will be able to limit their pursuit and killing of whales to only males. This must be clarified. In addition, the deficiencies identified in the other alternatives are relevant here as well (i.e., use of an 8-year-old population estimate and lack of clarification on how, when, and by whom PCFG data will be collected in order to update the PBR calculations).

Alternative 5:

This alternative would permit whaling during a split season (December 1-21 and May 10-31), but it sets the PBR level for PCFG whales at 0.27 (10 percent of the current PBR for PCFG gray whales as reflected in Carretta et al. (2014)) and requires that stuck and lost whales (with a limit of a single whale) be counted toward PBR in proportion to their presence in the Project Area. Notably, if the PBR level in this alternative was calculated using the Nmins for the OR-SVI and Makah U&A regions, they would be 0.23 and 0.11, respectively.

This alternative is intended to reduce the potential for take of WNP gray whales based on limited data suggesting that WNP gray whales have not been observed in the Makah U&A during the split season dates. It is possible that, as scientists continue to monitor WNP gray whales, they will be found in the ENP regions during the split season dates.

The total days available for hunting under this alternative would be 14.7 to 22.[34] Under this alternative, as many as five non-PCFG whales could be killed each year, but NMFS anticipates an average of no more than four ENP whales to be killed annually. Even this would be unlikely, according to NMFS, given the PCFG struck-and-lost limit. In fact, NMFS anticipates that only one whale will be killed every five years under this alternative. If so, this alternative could substantially reduce the number of ENP gray whales killed by the Makah should a hunt be approved, which in turn would reduce risk to PCFG and WNP gray whales.

Although more conservative and Alternative 2, 3, and 6, this alternative suffers from the same deficiencies as in the other action alternatives (i.e., use of an 8-year-old population estimate and lack of clarification of how, when, and by whom PCFG data will be collected in order to update the PBR calculations).

Alternative 6:

Alternative 6 shares many of the same characteristics as Alternatives 2 and 3 in regard to the number of days available to hunt and the timing of the hunt. However, under this alternative

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[34] The DEIS contains two different estimates for the number of hunting days under this alternative. Compare DEIS at 4-34 ("22 days of hunting in May") to DEIS at 4-35 ("14.7 hunting days per year").

the Makah could kill a maximum of four whales in any single year and could not kill more than 7 whales over two years. The maximum number of PCFG whales that could be killed under this alternative would be 3.5 per year, but 1.4 would be more likely, according to NMFS, due to struck and lost whales being limited to 3 and a PBR level set at 2 per year. Struck and lost whales would be counted as PCFG whales in proportion to their presence in the Project Area and there would be no carry-over of unused whales. This alternative would also impose a 10-year limit on the duration of any MMPA waiver and any regulations issued pursuant to the waiver would expire after three years. The limitations on the duration of the waiver and regulations are appropriate, as this will provide an opportunity to adjust the terms of the hunt, or cancel it altogether, depending on a review of the relevant data. Under the other alternatives the waiver would be valid indefinitely.

This alternative also suffers from the same deficiencies as identified in the other action alternatives (i.e., use of an 8-year-old population estimate lack of clarification of how, when, and by whom PCFG data will be collected in order to update the PBR calculations).

Given the deficiencies noted above with respect to alternatives 2-6, the Coalition presents a seventh alternative at page 38 of this letter. This alternative combines some of the more conservative elements from alternatives 2-6. While the Coalition would not support this seventh alternative, it is included to highlight NMFS' deficiency in presenting a comprehensive analysis of alternatives.

NMFS has failed to disclose all relevant information regarding marine species, including marine plants and invertebrates, and has downplayed the potential impact of a whale hunt on these species and the local ecosystem:

NMFS fails to disclose all relevant information about marine species in the DEIS. It includes information about ocean current patterns, the influence of upwellings on marine productivity, and the impact of large scale environmental perturbations (e.g., Pacific Decadal Oscillation, El Nino, La Nina) on the marine ecosystem. DEIS at 3-98. It also provides general information about phytoplankton, zooplankton, and other marine species, including marine plants, marine mammals, and marine birds.

What is lacking, however, is information relevant to evaluating the environmental impact of the hunt on many of these species. In particular, despite asserting that any impacts of a gray whale hunt on benthic marine plant, macroalgal species, shellfish, and kelp raft communities would be "negligible" due to high levels of background disturbance and a strong capacity of these species for growth and recolonization (DEIS at 4-56, 4-58, 4-59, 4-60), there are no data in the DEIS upon which to make that determination. Specifically, NMFS did not disclose any information about the composition, abundance, diversity, or productivity of marine plants, macroalgal species, and/or shellfish in the Project Area. This assertion may be true and may simply be common knowledge among NMFS and local biologists in the area but, for the purpose of a NEPA analysis, the evidence supporting a conclusion must be disclosed instead of asking the public to trust that an otherwise unsubstantiated finding is correct.

The potential environmental impacts of the proposed hunt on other wildlife species are largely dismissed by NMFS for all species either because the impacts will be "temporary (lasting a few minutes to a few hours)" and "localized (occurring near the hunt)." DEIS at 4-123, 4-126, 4-137, 4-143, 4-144. It also claims that the "number of marine mammals that would potentially occur close enough to hunting activities to be affected by the associated noise would probably be low." DEIS at 4-123. Only Alternative 4 is identified as having greater potential impacts on other wildlife since the hunt would occur during the summer when it is more likely to disrupt key activities such as breeding and nesting (although the limited number of hunting days under Alternative 4 could mitigate such impacts). DEIS at 4-142, 4-143.

The alleged lack of impacts of the hunt may be more wishful thinking than substantive finding, since a hunt is not merely a carved wooden canoe with a crew of Makah whalers pursuing a gray whale. Rather, given the significant controversy inherent to a Makah whale hunt, the atmosphere surrounding a hunt (if the 1999 hunt is any guide) is akin to an aquatic three-ring circus, with whalers, support personnel, media representatives (on land and sea and in air), law enforcement personnel, federal and state wildlife officials, and protesters (on land and sea) all seeking to achieve a certain objective. Such activities will contribute to the harassment of wildlife in the Project Area above and beyond the baseline disturbance from recreational boaters/anglers, commercial shipping, and private and commercial air traffic.

Instead of seriously considering this threat, NMFS compares it to a normal level of recreational angler trips, to suggest that the impacts would be similar. This is nonsense. While most humans using the Project Area may have no intention of disrupting or harassing other wildlife, including protected species, such impacts are inevitable. For seals that are hauled out on a beach, for nesting birds, or for other species engaged in daily behaviors (e.g., feeding, breeding, resting), the impacts of a hunt could be deadly, sub-lethal or, at a minimum, disruptive.

The scientific literature is replete with studies on the adverse impact of stress on birds, terrestrial and aquatic mammals, fish, and reptiles (e.g., Kuczaj 2007; Attachment 5). The potential for sub-lethal stress to adversely impact a host of species in or near the Project Area has not been even remotely evaluated by NMFS. Its attempt to evaluate the potential effects of stress on gray whales was similarly deficient as it largely disregarded such an impact claiming that stress-related symptoms triggered by pursuit have not been documented in gray whales. DEIS at 3-166. More than likely, such symptoms have not been documented because no one has specifically studied stress in gray whales.

Even if an animal does not flee from a threat, this does not mean it is not undergoing significant stress. In terrestrial mammals, for example, even if animals become habituated to particular perturbations in their environment, they may still experience elevated chronic stress levels, which can translate into reduced survival, a decline in productivity, or increased susceptibility to disease (Martin et al. 2011) NMFS must reconsider its analysis of such impacts to other marine species (i.e., mammals, fish, reptiles, and birds) and, in particular, focus on the potential impacts and implications of the hunt causing acute stress or contributing to chronic stress in these species.

As previously explained, NMFS has failed to explain the ESA consultation requirements or to provide any information about that process for federally listed threatened and endangered species in the Project Area. The DEIS does not describe whether NMFS has engaged or is engaging in the required internal and external reviews. While WNP gray whales are likely the most critically endangered species within the Project Area that could be impacted by a proposed hunt, there are several other endangered or threatened marine mammals, sea turtles, birds, and fish that may be affected by the proposed hunt and related activities. NMFS completely failed to even disclose that there are a number of federally protected fish, including salmon, in the Project Area that could be indirectly impacted by a hunt.

In general, for imperiled species within the Project Area, NMFS discounts potential impacts due largely to the rarity of the species. That is, it assumes that if a species is rare in the region the impacts of the proposed hunt will be limited. However, it is this rarity that should be of considerable concern and must merit additional analysis since, if there were an impact, its consequences would be more significant from a conservation standpoint on a rare species than on a species that is common. Recently, in *Conservation Council for Hawaii v. NMFS* (2015 WL 1499589 at *50 (D. Hawaii Mar. 31, 2015)(Attachment 6), the court criticized NMFS for dismissing potential adverse impact caused by training and testing activities of the US Navy conducted in its Hawaii-Southern California Training and Testing Study areas on imperiled species. Specifically, in regard to WNP gray whales, the court wrote:

> For Western North Pacific gray whales, NMFS says it does “not expect any western North Pacific gray whales to be involved in a ship strike event” because of “the low number of western North Pacific gray whales in the HSTT Study Area.” ECF No. 67-19, PageID # 12641. But if Western North Pacific gray whales are so scarce in the area, why does NMFS proceed to authorize mortalities for that species and on what basis does NMFS conclude that those mortalities in an area where the species is low in number “would not appreciably reduce the Western North Pacific gray whales’ likelihood of surviving and recovering in the wild”?

This same concept is applicable here in that the rarity of a species should not be used to disregard the potential adverse implications of an impact and, indeed, if anything, such impacts should be subject to more careful review when they could affect imperiled species.

For ESA-listed bird species (i.e., the short-tailed albatross and marbled murrelet), as well as the bald eagle (which is protected under the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act), NMFS again discounts the potential impact of a hunt (claiming that the risk of potential disturbance to albatross and murrelet is "extremely low" to "low," respectively, while indicating that it is unlikely that any whale hunt activities would occur close to bald eagle nests). DEIS at 4-127, 4-128. NMFS, however, failed to disclose sufficient information about these species to permit any assessment of these claims. For example, for the albatross it failed to disclose information about estimated population numbers, trends, likelihood of the species' presence in the project area, distribution and movement data, nor did it discuss the threats to the species. For the murrelet, the analysis was somewhat more robust, but much of the same information was lacking for that species. Failing to disclose such information violates NEPA.

NMFS concedes that the ESA-listed species that have the highest likelihood to encounter hunt-related activities include killer whales and humpback whales. Southern Resident killer whales (J, K, and L pods) are listed as endangered under the ESA. NMFS reports that, when this stock of killer whales was listed, the listing factors included noise and disturbance of vessel traffic. DEIS at 4-124. It also concedes that "disturbance from vessels, aircraft, and weapons associated with whale hunting also has the potential to disrupt the ability of killer whales to communicate or find prey." DEIS at 4-124/4-125. With only 80 Southern Resident killer whales remaining, NMFS is rather cavalier in its dismissal of the potential impacts of a whale hunt on this stock or its critical habitat (i.e., "none of the proposed alternatives would appreciably affect these elements[35] of critical habitat for this species" DEIS at 4-125). A far more detailed analysis of the impacts of any potential hunt on this population must be conducted in the context of NEPA and pursuant to the consultation requirements of the ESA.

For non-listed marine birds, NMFS makes conclusions for which there is no supporting evidence, does not provide a conclusion as to the potential impact of the hunt, dismisses potential impacts as "temporary and localized," DEIS at 4-130, or indicates that long-term effects on local populations "cannot be determined with certainty." DEIS at 4-144. For marine birds inhabiting beaches, bays, and estuaries, NMFS concedes that gunfire and helicopter noise "is particularly likely to flush birds off nests if it occurs close to shore where these birds are

[35] As stated in the DEIS, the elements referred to here are the primary constituent elements for the Southern Resident killer whale critical habitat. They include 1) water quality to support growth and development; 2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development as well as overall population growth; and 3) passage conditions to allow for migration, resting, and foraging XXXX or critical habitat for this species. DEIS at 4-125

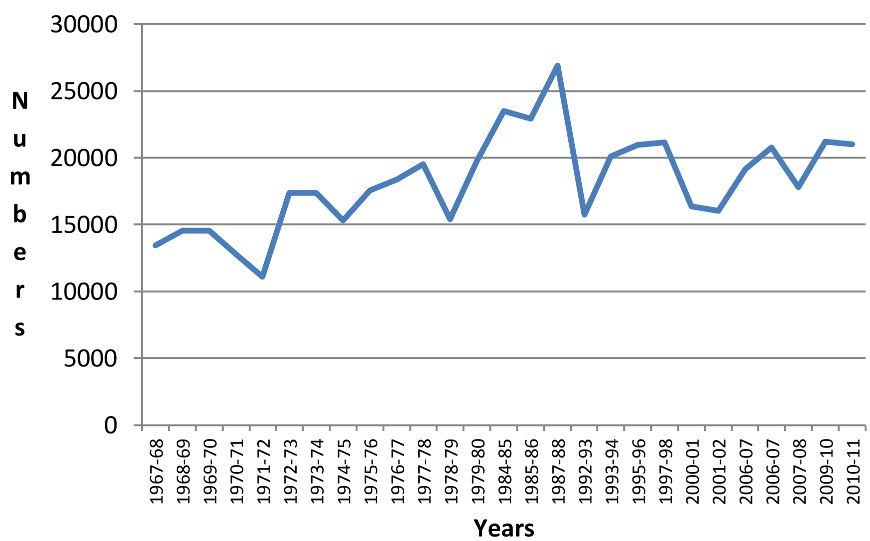
nesting or if they are foraging just off shore" but then concludes that it is "difficult to determine what impact this type of direct short-term effect would have on the long-term productivity of populations as a whole, although it might be a negligible loss." DEIS at 4-130. Or it claims such long-term effects "cannot be determined with certainty." DEIS at 4-139. Assuming that an impact "might be negligible" without providing evidence to support such a finding is reckless and may reflect an effort to discount some impacts of the proposed hunt. Similarly, for birds inhabiting coastal headlands and islands, despite concluding that "ledge nesting birds in the project area may be easily flushed off nest sites, leading to abandonment, predation on eggs or chicks, and subsequent nest failure," NMFS fails to make a determination as to the impact of the hunt on this assemblage of birds. *Id*.

NMFS has failed to fully disclose all relevant information about gray whales and has downplayed potential adverse impacts on the species posed by a Makah hunt:

Gray whale population trends and carrying capacity

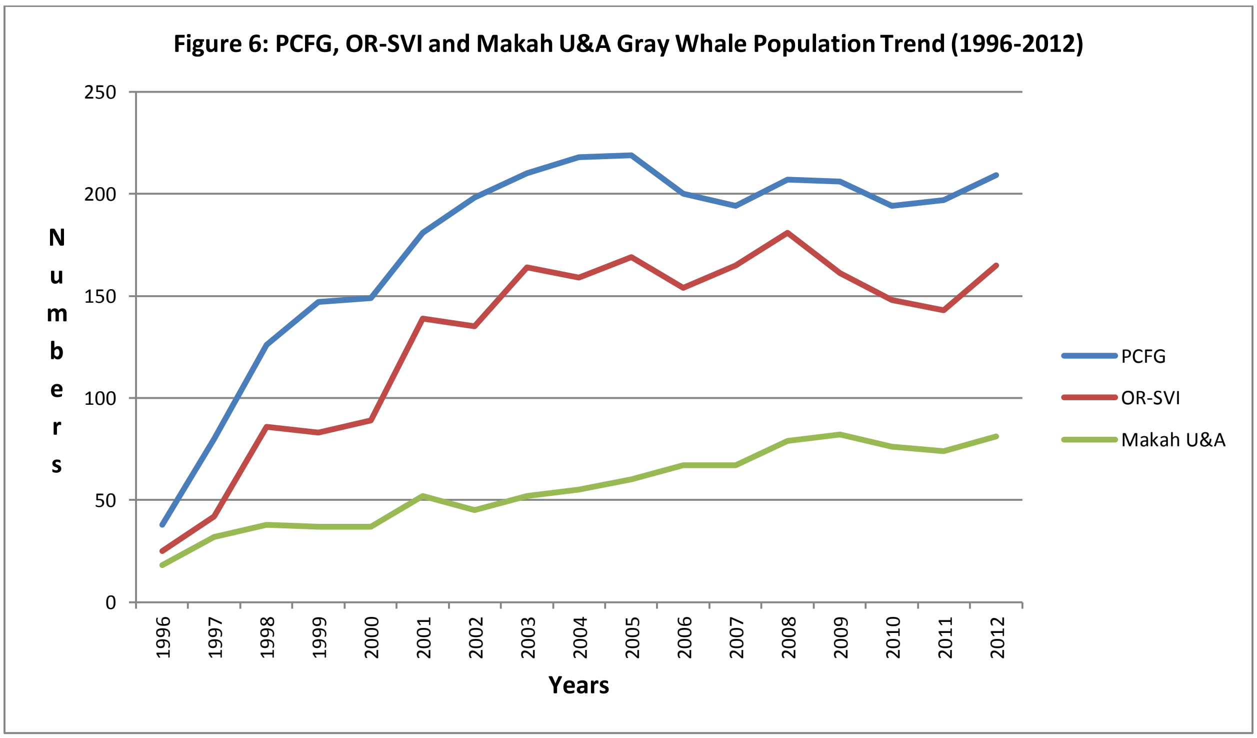
As reported in the DEIS, the estimated average annual rate of population increase for WNP gray whales is 3.3 percent per annum. DEIS at 3-67 (citing Cooke et al. 2013). The ENP gray whale population trajectory has remained relatively flat since 1980. DEIS at 3-110 (See Figure 5[36]). This suggests that the ENP gray whale population is at carrying capacity (or K), that births largely equal deaths, or there are other factors, natural or anthropogenic, that are preventing the ENP gray whale population from increasing its numbers.

Figure 5: ENP Gray Whale Population Trend (1967-2011)



[36] Data obtained from DEIS at 3-111.

Similarly, NMFS reports that the PCFG abundance trend appears to be flat at the current rate of recruitment. DEIS at 4-84, 4-100 (See Figure 6[37]). Noting that Punt (2015) found that PCFG whales are at 50 percent of K, the long-term stability of this population should be cause for concern, since the population should be increasing in size toward the region's carrying capacity. It is not entirely clear why the PCFG population's numbers have stabilized but, since they are only at 50 percent of K, permitting their lethal take by authorizing a Makah whale hunt is not appropriate. If Punt's estimate of K for the PCFG is correct, then it would qualify for a depleted designation if it were designated as a stock, which would prohibit NMFS from authorizing lethal take through a Makah whale hunt.



In regard to carrying capacity, NMFS reports that it interprets K as the "current" capacity versus the habitat's historic capacity. DEIS at 3-52. To substantiate that claim, NMFS cites from Gerodette and DeMaster (1990) who, in contrast to the NMFS claim, report that:

> in the context of OSP determination and as used in this paper, carrying capacity refers to an equilibrium population level before impact by man, either direct (through harvest or

[37] Data obtained from DEIS at 3-145/3-146.

> incidental killing) or indirect (through habitat degradation or harvest of predator, prey, or competitor species).

Id.

This quoted text contradicts the NMFS claim above. NMFS must clarify this issue and provide additional analysis of its recent practice in the use of current or historical K when, for example, making depleted designations for species or stocks.

Lack of disclosure of critical information and deficient analysis of impacts

The Project Area is confined primarily to the marine waters, islands, and land area near the Makah Tribe's U&A in the Pacific Ocean and Strait of Juan de Fuca that may be directly or indirectly affected by one or more of the project alternatives. DEIS at 1-3. In terms of any direct impacts of the hunt, this Project Area may be sufficient. However, as to indirect effects, the scope of the DEIS should have been extended to the entire range of ENP gray whales, as was done for the cumulative impacts analysis. In particular, with respect to the disclosure of information relevant to the analysis, NMFS should have provided more information about gray whales and their habitat throughout this larger area.

NMFS has disclosed some information about gray whales and their habitat in Alaska and elsewhere along the migratory corridor. The DEIS includes information about killer whale predation on gray whales, amphipod availability on gray whale feeding grounds in the Arctic, and briefly references the ecological regime shift that is ongoing in the Bering Sea. While some of this information is relevant to the cumulative impacts analysis, ENP gray whales would be killed in the proposed hunt. Therefore, given changing habitat conditions (particularly in the Arctic), there is a compelling need to disclose additional information about the ecology, prey species, distribution, movements, and habitat use patterns for gray whales in the Arctic.

Ocean warming caused by climate change is altering gray whale distribution, causing them to expand their summer range in order to find new feeding areas. DEIS at 3-196. This is due to changes in prey abundance, composition, productivity, and distribution. Indeed, the Arctic is experiencing a regime shift whereby a benthic ecosystem is transitioning into a pelagic ecosystem, as Arctic waters warm due to climate change (Grebmeier et al. 2006). In the past, a large proportion of the zooplankton and phytoplankton, including under ice algae, would die and settle to the ocean floor where it would sustain an enormous benthic community, including energy-rich amphipods. As the oceans have warmed, the zooplankton and phytoplankton blooms are occurring earlier and much of their production is being consumed by pelagic fish that have immigrated into the area. Without as much primary production settling to the ocean bottom, the abundance, density, and composition of the benthic invertebrate community has declined. DEIS at 3-99, 3-197.

This is consistent with findings by Highsmith and Coyle (1992), Grebmeier et al. (2006), and others who have studied the implications of this regime shift. In the Chirikov Basin, amphipod populations declined 30 percent between 1986 and 1988, DEIS at 3-99 (citing Highsmith and Coyle 1992, Sirenko and Koltun 1992), which, over time, forced gray whales to find alternative feeding areas. DEIS at 3-99. As a result, gray whale numbers in the Chirikov Basin were 3 to 17 times lower in 2002 compared to numbers observed in the 1980s. *Id*. (citing Moore et al. 2003, Grebmeier et al. 2006). Gray whales are now observed in areas that were historically devoid of the species or where the species was rare, including in the south-central Chukchi Sea, just north of St. Lawrence Island in the Bering Sea, and in the Beaufort Sea. *Id*. This, along with the reduction in sea ice, has contributed to a one-week delay in the timing of the southbound migration, DEIS at 3-100, resulting in a larger proportion of gray whales giving birth along the migratory route outside of the protective confines of the Mexican lagoons. This, in turn, has increased the risks to newborn gray whale calves as a consequence of predation, increased energy use for thermoregulation, and other threats (e.g., ship strikes, exposure to pollution, oil spills and seepage) that are more prominent along the west coast of the United States compared to those faced in or near the Mexican lagoons.

While some have suggested that gray whales, as generalist feeders, may adapt well to climate change impacts to their Arctic feeding areas, this may not be true. At present it is, at best, difficult to accurately predict what impact the changing Arctic will have on gray whales. Some of the information that would be needed – which is the evidence that should have been disclosed in the DEIS – includes data on the:

1) abundance, composition, diversity, and productivity of amphipods throughout the Arctic including in the Chukchi and Beaufort Seas;

2) the availability of pelagic prey for gray whales both in currently occupied Arctic feeding areas but also throughout Arctic waters given their expanding range;

3) the caloric content and energy value of potential gray whale prey in the Arctic;

4) ocean substrate survey data to determine potential future feeding areas for the species (particularly in regard to amphipod availability, given their preference for particular substrate types);

5) species-specific data on fish that are increasing in density in Arctic waters, including their preferred prey, to assess if gray whales will be competing with such fish for pelagic prey; and,

6) an assessment of any new potential health threats to gray whale in the form of exotic or invasive species, including viruses, bacteria, parasites, and natural toxins (e.g., saritoxin, domoic acid) that may be more prevalent or have greater pathogenicity as Arctic waters warm.

In addition, NMFS must disclose if there is any evidence of radionuclide contamination in Arctic waters linked to the Fukushima nuclear reactor meltdown in Japan in 2011. Only with such information can there be any meaningful analysis of the long-term survival potential of ENP gray whales.

Whether such evidence applies primarily to the analysis of indirect or cumulative impacts (which is addressed below), it should have been disclosed in the affected environment section of the DEIS so that interested stakeholders could consider and evaluate it in light of the full suite of potential impacts of the hunt.

NMFS also addresses the impact of PCFG whales within the ecosystems they occupy. This is a critically important issue, as it is directly relevant to the MMPA requirement to ensure that marine mammals remain a significant functioning element in the ecosystem. While ENP gray whales may transit the Project Area relatively quickly during their south or northbound migrations, there is also evidence that some ENP gray whales may linger within the range of the PCFG, including in the OR-SVI and Makah U&A, primarily to feed. While these whales will have an effect on the ecosystem while present in the area, PCFG whales have a far greater impact given their presence throughout the spring, summer, and fall. While present, PCFG whales can have substantial impact on the pelagic and benthic environments, which, in turn, can benefit other species.

Instead of acknowledging such potential effects, NMFS reports that "none of the action alternatives has the potential to appreciably affect the physical features and dynamic processes of the pelagic or benthic environments." DEIS at 4-51, 4-54. NMFS claims that these environments are subject to far greater impacts from larger scale oceanographic processes. The Coalition does not dispute that there are larger scale processes, including ocean currents, upwelling, oscillation events, and other factors that influence the pelagic and benthic ecology of the project area, but NMFS is evaluating the impacts at too large a scale and in doing so has wrongly dismissed the potential impact of a hunt on the role of gray whales in influencing pelagic and benthic ecology in the Project Area.

Gray whales are important to the ecological structure of the Bering Sea. Though they can consume pelagic prey, as primarily bottom feeders they suck up mouthfuls of sediment, which is then resuspended in the water column (Grebmeier and Harrison 1992, Oliver and Stattery 1985). In the early 1980s when the gray whale population contained approximately 16,000 individuals, it was estimated that they resuspended approximately 1.2 x 10^8 m^3 of sediment during a summer feeding season (Johnson and Nelson 1984, Nerini 1984). Resuspended sediments include various nutrients, microorganisms, invertebrate species that provide benefits to ocean ecology, as well as food to other species, including seabirds (Obst and Hunt 1990). PCFG whales provide the same ecosystem service in their range and, thereby, provide important benefits to the structure and function of the ecosystem, as well as to other species in the area. Dismissing such impacts, as NMFS has done in the DEIS, is wrong.

Indeed, if the hunt results in a reduction in gray whales in the Project Area, given the influence of gray whales on benthic ecology, this loss could at least result in an appreciable effect on ecology of the Makah U&A and OR-SVI. In addition, since gray whales, as generalist feeders, also consume pelagic prey, their impact on the structure and function of the pelagic ecosystem could also be higher than considered by NMFS. Quantifying this impact, however, is not possible given the lack of any specific data on benthic and pelagic species, their abundance, composition, productivity, and distribution within the project area. NMFS needs to disclose such information in the DEIS.

<u>NMFS has failed to adequately evaluate the economic impacts of the proposed whale hunt:</u>

As an initial matter, the description of the economic environment in the affected environment section of the DEIS is confusing. The variable use of numbers in some cases and percentages in others creates a data set that is difficult to interpret. NMFS should, at a minimum, review this section with the intent to clarify the statistics by, for example, consistently using numerical followed by percentage values in parentheses. For example, where the DEIS reports that "the per capita income of Makah Reservation tribal members is lower than per capita income countywide, registering 54 percent of the countywide level in 2010," DEIS at 3-281, it should insert a numerical value before the "54 percent" reference. By doing so, NMFS could then confirm that all of the data contained in any of the economic tables contained in the DEIS are accurate.

In addition, NMFS should compare the economic values contained in the DEIS on pages 3-246 to 3-269 with the data contained in the environmental justice section of the DEIS on pages 3-270 to 3-281 to ensure that they are consistent. Such a comparison would be unnecessary if NMFS removes the Environmental Justice text from the DEIS as recommended below.

The Coalition has no reason to question the accuracy of the economic data presented in the DEIS, although it is concerned that, as presented, the data used may not be consistent throughout the document. We note, however, that the overall economic impact analysis is incomplete.

NMFS's evaluation of the impacts to economics is based on the following economic variables: potential change in revenue, employment and/or economic value associated with tourist-related business activity; change in household consumption of whale products and manufacture and sale of traditional handicrafts; and economic impacts to the whale-watching industry, commercial shipping, and sport and commercial fishing, and hunt-related management and law enforcement. DEIS at 4-148. Based on an analysis of the information contained in the DEIS, there are a number of questions and concerns that NMFS must address.

Prior to articulating those concerns, there are several key statements or conclusions in the DEIS that are relevant to the analysis and must be noted and discussed. These include:

- The Makah Tribal Council financially supported the whaling crews in 1999 and 2000, but in 2002 the Council decided to end financial support for whale hunts, leaving it up to the whaling families to financially support any hunts consistent with tribal traditions. DEIS at 3-283, 4-147. Because of this, the economic impact analysis in the DEIS does not include an assessment of the economic burden on Makah tribal members or households that may choose to engage in whaling. The Coalition supports this decision and notes that, should the Makah Tribal Council elect to financially support tribal whalers in the future, NMFS must reevaluate the economic impacts of the hunt, since funds expended on whaling could not be spent on meeting other needs of the Makah people on the reservation. Moreover, if the Makah Tribe seeks federal funds (i.e., taxpayer money) for the purpose of subsidizing whaling from NMFS or any other agency, this too should trigger at least a supplemental Environmental Assessment under NEPA.
- The potential for any changes on the reservation under any of the alternatives to have a noticeable effect on economic conditions in Clallam County is negligible, because economic contributions by the Makah reservation to the countywide economy are so small. DEIS at 4-147. Given this conclusion it also would hold that the economic impacts of the No Action Alternative would also be negligible in the context of the economic conditions in Clallam County.
- There are no economic data demonstrating any positive economic impact from the influx of visitors during previous hunt-related events as a result of an increase in the number of rooms rented or in other economic activities in the region. DEIS at 4-149. This is notable since, as indicated below, NMFS ignores this point when evaluating the alternative-specific economic impacts. Nor has NMFS disclosed any economic data to suggest that there was any positive economic impact for Clallam County or the Makah reservation subsequent to the hunt because of the media attention focused on the Makah Tribe.
- Figures are not available for the amount of revenue generated by reservation tourism and recreation or the number of jobs and amount of personal income that depend on

visitor spending. DEIS at 4-148. This statement is at least partially false, given that the DEIS did include statistics in regard to the number of persons purchasing permits to recreate on the reservation, including to use the Cape Flattery trail, and the number of non-tribal members visiting the Makah Cultural and Research Center. It is also inconceivable that additional tourism data are not available. Surely the Makah or NMFS (or its environmental consulting firm Parametrix) could have surveyed any inns, hotels, motels, lodges, tourist cabin owners, or other tourism-linked companies on the reservation to obtain data on the nightly room rentals and/or other tourist expenditures. Similarly, considering that the Makah have attempted to improve the marketing of Neah Bay as a tourist destination through Washington State and through the Affiliated Tribes of Northwest Indians, DEIS at 4-419, the Makah Tribal government must have data that documents what impact, if any, such marketing efforts have had on tourist visits to the reservation. Since NMFS has not satisfied the requirements of NEPA in regard to incomplete or unavailable information in this case, it must secure this information and use it in a revised analysis.

- There is no evidence that calls for boycotts of Olympic Peninsula tourism as a result of the 1999 hunt had any negative economic impact on tourist businesses in the area. DEIS at 4-150. While this may be true, using this to predict the future is naïve. During the 1999 and 2000 hunts, it was known that litigation was being pursued that could stop the hunt. Consequently, although some advocated a tourism boycott of the Olympic Peninsula, others elected to determine the outcome of the judicial process instead of immediately supporting a boycott. If, as a result of this decision-making process, an MMPA waiver is granted and legal efforts to stop the hunt are not successful, there may be a renewed and more vigorous effort to promote a tourism boycott that could have adverse economic impacts on the Makah reservation and other businesses on the Olympic Peninsula.
- No revenue would be made from the sale of whale meat but such products would meet the nutritional needs of Makah families. DEIS at 4-150. NMFS also claims that "attaching a dollar value to food products from harvested whales is difficult," *id*., but that whale products could "potentially replace foods that families would otherwise have to purchase." *Id*. This statement is not entirely accurate since, as explained below, an estimate can be obtained as to the value of the reported 8-20 pounds of whale meat per capita and 16 to 20 pounds of oil or blubber per capita based on similar, currently available food products. With that estimate, the alleged economic benefit to Makah families if the whale hunt were to be allowed can be quantified.
- The Makah Tribe has a long tradition of manufacturing carvings, baskets, and other items for sale to collectors and tourists. Tribal artisans also produce carvings, jewelry, and silk screen designs for sale in local shops and regional galleries. DEIS at 4-151. Despite this claim, NMFS provides no data in the DEIS on the annual revenue generated

by the sale of these products. As explained below, this is relevant to the environmental impact analysis when NMFS asserts that whaling will increase revenue for tribal artisans because it will allow them to manufacture and sell native handicrafts from whale bone, baleen, and other non-edible parts of the whale. In addition, NMFS needs to provide some data on the value of native authentic handicrafts manufactured from whale products. Such data may be available from Native Alaskan artists who utilize non-edible products from the bowhead whale hunt to manufacture authentic handicrafts. Quantifying this potential effect requires understanding the current value of Makah authentic native art/handicraft sales and of the potential revenue that could be gained by selling native handicrafts manufactured from whale products.

- Information on the current number of whale-watching expenditures, passengers, revenues, and employment numbers in the Washington/British Columbia areas is "not available." DEIS at 4-152. In addition, NMFS claims that "current revenues of whale-watching operations are unknown, and there is no information available or that could reasonably be obtained that would allow an estimation of how much whale watching revenues might decrease if gray whale behavior or numbers were altered by a Makah hunt." DEIS at 4-154. Despite admitting to not having such data, NMFS reports that it is "unlikely that whale hunting under any of the action alternatives would have more than a negligible effect on whale-watching revenues or employment within or outside the Project Area." DEIS at 4-152. It is inconceivable that the whale-watching data reported above were not reasonably attainable. It could be that neither NMFS nor Parametrix (the consulting firm paid by NMFS to prepare the DEIS) endeavored to obtain the data but, surely, had NMFS contacted whale watching companies, they likely could have provided requested revenue, expenditure, passenger, and employment numbers. NMFS has not complied with the NEPA requirements in regard to incomplete or unavailable information, so since this information is reasonably available, NMFS must obtain it and use it in a revised analysis. It is also reasonable to conclude that tourists may not wish to watch whales they believe might be killed in a Makah hunt, which would result in a decrease in whale-watching bookings in the region and indeed throughout the North American Pacific coast. Claiming this likelihood is negligible because the Chukotkan hunt does not have a similar effect is disingenuous, given the attention the Makah hunt has received in the past by US media, compared to the relative lack of attention US media pay the Chukotkan hunt. Further, the remoteness of the Chukotkan hunts makes whale watching there currently almost impossible and therefore not a good comparison. Therefore, the conclusion in the DEIS that a hunt would have a negligible impact on whale-watching revenues is not necessarily true.
- Costs associated with any proposed hunt would include approximately $75,000 per year to continue a photo-identification study of PCFG gray whales, $263 per day to cover the costs of NMFS observers, and $91,670 per day for law enforcement costs, with the bulk

of the costs borne by the United States Coast Guard to cover the costs of its aircraft and vessels. DEIS at 4-155/4-156.

In evaluating the impacts of each action alternative, NMFS dismisses any potential impact on whale-watching operations as a result of a change in behavior of gray whales in response to vessels. This is based on the Chukotkan gray whale hunt in Russia, which has been ongoing, largely without any stoppage, for centuries. NMFS claims that the hunt "has not translated into a general avoidance of boats by gray whales." DEIS at 4-153. This is a rather simplistic analysis of the potential impact of a hunt in the Washington region on gray whale behavior. First, NMFS has not disclosed sufficient information in the DEIS to permit a credible assessment of the impact of a Chukotkan hunt on gray whales. While the Russians continue to kill approximately 123 gray whales per year, DEIS at 3-162, NMFS has not provided any information about catch-per-unit-effort, any change in gray whale distribution within their Russian feeding grounds, any change in the temporal use of near shore habitats, or any change in their behavior on those feeding grounds in response to vessels (i.e., are they more alert or more likely to flee compared to gray whales using feeding grounds within the Arctic waters of the United States where they are protected).

Although matrilineal site fidelity may be the dominant factor drawing gray whales into Russian feeding grounds where they are subject to hunting, it would not be surprising if there have been some changes, even if only subtle, in gray whale behavior within the Russian feeding grounds. For example, it is well known that white-tailed deer can learn where and when they are safe from hunters and where and when they are not. This allows deer to utilize forage resources by night in areas open to hunting during the day, only to return to more protected areas during the day. If white-tailed deer have this capacity, it is likely gray whales do as well. In other words, gray whales may recognize, after decades of near complete protection in Mexico, along the west coast of the US and Canada, and in US Arctic waters that they are safe from hunting, while those who occupy Russian waters may demonstrate different behaviors intended to minimize their risk of lethal take while in that area. NMFS must explore this issue in more detail before making such overreaching comments about the potential impact, or lack thereof, of any hunt on gray whale behavior.

NMFS also must consider how a hunt by the Makah Tribe, which would include harassment of gray whales through pursuit, unsuccessful harpoon attempts, and potential injury to gray whales due to non-lethal strikes of a harpoon or bullet, might impact the behavior of gray whales in the larger eastern Pacific region. The impact of the proposed hunt on gray whale behavior is not addressed in the DEIS. Similarly, NMFS entirely ignores the possibility that a Makah hunt could influence the popularity of gray whale watching along the entire Pacific coast of North America, including the unique experience of interacting with gray whales and their calves in the lagoons in Mexico.. It is possible that people interested in undertaking a gray whale watching excursion may choose to skip such a trip if they are aware that the whales they would observe could be killed in a hunt in US waters. At a minimum, the enjoyment of watching gray whales would likely be diminished if tourists were aware of the potential danger posed by Makah whalers.

In evaluating each action alternative, NMFS suggests each is likely to increase tourism to the Makah reservation. DEIS at 4-158, 4-162, 4-164, 4-168. This assumes that non-tribal members have an interest in watching the killing or butchering of a whale or that media attention to the hunt will increase tourism to the reservation. This claim completely ignores evidence from the 1999 hunt, as contained in the DEIS, that the Seattle Times reported that of the 400 calls it received after the 1999 hunt ran 10 to 1 against the hunt (DEIS at 3-286) and that more residents of Clallam County expressed disapproval of the hunt than expressed support. *Id*. at 3-288. If anything, given that most US citizens are opposed to whaling, including aboriginal whaling when the tribe does not have a legitimate need for whales, it is more likely the action alternatives will result in a reduction in tourism to the Makah reservation.

Similarly, for each action alternative, NMFS claims there will be a negligible change in whale-watching revenue. DEIS at 4-159, 4-162, 4-167, 4-168. This conclusion is curious considering NMFS claims data on whale-watching operation revenues was not reasonably available.

NMFS also claims, for each of the action alternatives, that the increase in the availability of whale meat/blubber/oil for consumption and non-edible whale products for use by artisans will provide an economic value for members of the Makah Tribe. DEIS at 4-160, 4-163, 4-166, 4-168. For the non-edible products, without data on current sales of Makah artisan products and some assessment of the value of products manufactured from whale baleen or bone, the alleged impact of a whale hunt on artisan revenues cannot be quantified.

For edible products, NMFS should have provided an estimate of the value of such products so as to quantify the potential savings to Makah tribal households. For example, the June 2015 price for uncooked beef steak in the western US is $7.67 per pound,[38] while olive oil (which, for this analysis is being used to represent whale blubber/oil; olive oil is often used to flavor foods as the Makah traditionally used whale oil) costs approximately $5.46 for 25.5 ounces[39] or $27.40 per gallon (which corresponds to $3.28 per pound). Using these figures, the estimated 8 to 20 pounds of whale meat would correspond to a value of $61.36 to $153.40, while the 16 to 20 pounds of blubber/oil would correspond to a value of $52.48 to $68.52. Combined, the value of the meat and blubber/oil would be $113.84 to $221.92. Depending on the household or family income of the Makah families that choose to consume whale products, the savings accrued by consuming these products may or may not be significant to a family/household

[38] See http://www.economagic.com/em-cgi/data.exe/blsap/APU0400FC3101
[39] http://www.walmart.com/ip/Great-Value-100-Extra-Virgin-Olive-Oil-25.5-oz/10316039

annual budget. This assumes any savings accrued from the consumption of whale products will not be spent on other food items.

In regard to the potential impacts of a hunt on law enforcement/management costs, Table 4-14 in the DEIS provides a summary of the estimated enforcement-related costs (including the costs for NMFS observers) of each alternative. These costs would range from a maximum of $5.6million per year under Alternatives 2, 3, and 6 to a minimum of approximately $717,000 per year under Alternative 4. As indicated previously, the majority of these costs will be borne by the United States Coast Guard, yet NMFS provides no discussion of whether the Coast Guard has the funds to cover this cost, if Congress would allocate funds for the Coast Guard to cover such costs, or how Coast Guard funding for these costs could impact other Coast Guard operations in the Washington area, including search and rescue, homeland security patrols, and any drug interdiction efforts. While admittedly the Makah hunt, if allowed, will not occur in the immediate future, given federal budgetary realities there must be some discussion of whether the funds needed to pay for a hunt are or would be available and if they would impact other Coast Guard operational programs. Similarly, since funds allocated by the Coast Guard and NMFS to a potential hunt are collected from taxpayers, if a waiver is granted then NMFS is effectively subsidizing with taxpayer dollars a hunt the public may strongly oppose. This impact to the taxpayer was not evaluated in the DEIS.

There are other gaps in the economic impact analysis that must be addressed. First, NMFS has not disclosed any information about the total amount of federal funds expended since the mid-1990s in an effort to facilitate the Makah's resumption of whaling. This would include, but not be limited to, costs for NEPA compliance, consultations with the Makah and other agencies, fees paid to consultants, legal costs, costs associated with scientific research relevant to the proposed hunt, and costs incurred in obtaining past ASW gray whales quotas from the IWC. This is directly relevant to any analysis of economic impacts of a Makah hunt, as it would provide interested stakeholders with additional information about the true costs of the Makah's whale hunting proposal.

Finally, NMFS completely fails to include any information about the economic value of gray whales. This is not uncommon, as most agencies, when evaluating the environmental impacts of an action that will affect a species, fail to recognize that the species has worth beyond its value, economic or otherwise, to humans (i.e., for hunting, fishing, or wildlife watching/tourism). This value extends well beyond the value to a whale watching company, to include the ecological value of gray whales (i.e., the value gray whales provide as part of an ecosystem, including as prey, predator, and how their behaviors may affect other marine species and the marine environment) and their intrinsic or existence values.

Calculating such intrinsic values can be done using an economic tool known as contingent valuation (CV). CV has historically been used by the Department of the Interior and the Department of Commerce, including NMFS, to assess the intrinsic value of natural resources lost as a result of an oil spill. Indeed, federal law requires that such intrinsic values be assessed in order to calculate the amount of damage caused to the environment. This damage calculation is used to assess penalties against those responsible for the damage. The CV concept, however, is equally applicable in this context and could – and should – be used to assess the intrinsic or existence value of a gray whale, in order for the cost of losing a whale due to a Makah hunt to be considered in the economic analysis. The CV process utilizes surveys to determine, in this case, the value local residents, regional residents, and citizens nationally apply to gray whales. The purpose of the analysis is to collect value data both from those who may observe gray whales in the wild and from those who have never seen, and may never see, a gray whale in the wild.

The Department of Commerce is well aware of CV as its National Oceanic and Atmospheric Administration empaneled a number of distinguished social scientists in the early 1990s to determine if CV "is capable of providing reliable information about lost existence or other passive-use values."[40] The report provided support for the use of CV to calculate such existence or passive-use values and included a series of recommendations to direct such assessments. NMFS must engage in this type of analysis using the CV methodology (or something similar), so that it can obtain data on the intrinsic value of gray whales to include in a revised analysis.

NMFS has improperly applied the environmental justice concept to the proposed Makah whale hunt:

NMFS has grossly misapplied the environmental justice requirements contained in Executive Order (EO) 12898 in the DEIS (59 Federal Register 7629, February 16, 1994). This EO mandates that "… each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States …" DEIS at 4-173, EO 12898 at 1-101.

Traditionally, this concept has been applied to, for example, the impact of constructing a road, refinery, waste storage facility, or feedlot in areas where the majority of the population is minority or low income. The idea is to ensure such populations are not disproportionately

[40] See Arrow, K., R. Solow, P.R. Portney, E.E. Leamer, R. Radner, and H. Schuman. Report of the NOAA Panel on Contingent Valuation. January 11, 1993 (available at http://www.economia.unimib.it/DATA/moduli/7_6067/materiale/noaa%20report.pdf).

impacted or unduly burdened by such a project compared to other human populations (i.e., non-minority and middle/upper income).

Here, however, NMFS is attempting to evaluate the environmental justice implications of allowing or not allowing a minority group, the Makah Tribe, to engage in whaling; an activity that the Makah have not pursued, save for once, for nearly 90 years. If the Makah Tribe was currently whaling and the government was considering prohibiting the hunt, the environmental justice implications of such an action would be relevant. Or, if the government was considering the construction of a road, military base, mine, port, or missile silo on or near the Makah reservation, environmental justice concerns would be applicable.

Attempting to apply such an analysis to an activity for which there has been such an extended period of inaction, however, is entirely inconsistent with the intent of the Executive Order. Indeed, the Coalition challenges NMFS to identify any other instance where it or any federal agency has applied the environmental justice analysis in the same manner as it has here.

An examination of EO 12898 reveals other elements that further demonstrate the inapplicability of its use in the present situation. For example, Section 2-2 states that:

> "Each Federal agency shall conduct its programs, policies, and activities that <u>substantially affect human health or the environment</u> in a manner that ensures that such programs, policies, and activities do not have the effect of excluding persons (including populations) from participation in, denying persons (including populations) the benefits of, or subjecting persons (including populations) to discrimination under, such programs, policies, and activities, because of their race, color, or national origin" (emphasis added).

Although unstated in the analysis in the DEIS, NMFS may be engaging in this analysis based on claims that depriving Makah access to whale meat, blubber, and oil is substantially affecting the health of the Tribe. As previously explained, however, this is not supported by the evidence.

Section 4-4 of the EO is specifically focused on subsistence consumption of fish and wildlife. This section mandates that federal agencies do the following:

> 4-401. Consumption patterns. In order to assist in identifying the need for ensuring protection of populations with differential patterns of subsistence consumption of fish and wildlife, Federal agencies, whenever practicable and appropriate, shall collect, maintain, and analyze information on the consumption patterns of populations who principally rely on fish and/or wildlife for subsistence. Federal agencies shall communicate to the public the risks of those consumption patterns.

> "4–402. Guidance. Federal agencies, whenever practicable and appropriate, shall work in a coordinated manner to publish guidance reflecting the latest scientific information available concerning methods for evaluating the human health risks associated with the consumption of pollutant-bearing fish or wildlife. Agencies shall consider such guidance in developing their policies and rules."

NMFS may believe these mandates permit the application of environmental justice in the case of the Makah whale hunt. If anything, based on the lack of any credible data or analysis in the DEIS on the fish and wildlife consumption patterns of Makah tribal members (i.e., what wildlife species are consumed, the quantity consumed, the contaminant profile of each consumed species), NMFS has clearly failed to comply with this section of EO 12898. Indeed, the only information contained in the DEIS regarding Makah consumption patterns of fish and wildlife includes statements about how frequently Makah families consume traditional foods, how many times per week they eat fish, how many pounds of fish they eat each year, and that they also engage in subsistence hunting of terrestrial wildlife.

NMFS also provides no information in the DEIS to suggest it has worked collaboratively with other agencies to publish guidance on methods used to evaluate the human health risks associated with the consumption of pollutant-bearing fish or wildlife or that it relied on such guidance in evaluating the environmental impacts of consuming gray whale products by the Makah. NMFS does provide data on contaminant loads in some species of fish and wildlife in the DEIS. It also refers to Washington State standards for what amount of whale blubber may be safe to consume (see DEIS at 3-373: "(e.g., an 8-ox [227 gram] meal size) yields a calculated 'allowable consumption rate' of 0.43 meals of blubber per month." It does not, however, identify any federal standards or guidelines for what is considered an acceptable or safe level of contaminants in fish and wildlife species used for subsistence purposes. Nor does it suggest that it has provided – or will provide – any guidance to the Makah in regard to its consumption of gray whale food products.

While the EO provides broad standards for all federal agencies to meet, it does not establish agency or department-specific standards for environmental justice review. Rather, Section 1-103 mandates that:

> "… each Federal agency shall develop an agency-wide environmental justice strategy, as set forth in subsections (b)–(e) of this section that identifies and addresses disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations. The environmental justice strategy shall list programs, policies, planning and public participation processes, enforcement, and/or rulemakings related to human health or the environment that should be revised to, at a minimum: (1) promote enforcement of

> all health and environmental statutes in areas with minority populations and low-income populations; (2) ensure greater public participation; (3) improve research and data collection relating to the health of and environment of minority populations and low-income populations; and (4) identify differential patterns of consumption of natural resources among minority populations and low-income populations. In addition, the environmental justice strategy shall include, where appropriate, a timetable."

What NMFS fails to disclose in the DEIS is that the Department of Commerce (DOC) has adopted an Environmental Justice Strategy (DOC Strategy).[41] In this strategy, the DOC does specify that:

> "During National Environmental Policy Act reviews of major agency actions, <u>any potential disproportionate and adverse environmental or health effects</u> on low-income or minority populations are considered." (emphasis added) DOC Strategy at II.B.1.

Notably, this DOC language is not consistent with the EO language, which refers to a "substantial" effect on human health or the environment. Nevertheless, even without reference to a substantial effect, the impacts of the proposed whale hunt (or lack thereof) on the environment and health of the Makah people do not meet this standard and, therefore, the environmental justice analysis in the DEIS is improper. First, there would be no adverse environmental impacts if NMFS rejects the Makah Tribe's request for a waiver. Indeed, as documented in the DEIS, all of the adverse environmental impacts (differentiating environmental from cultural, social, and subsistence use impacts) would occur if NMFS allows the Makah to whale.

Moreover, as previously stated, NMFS concedes that "there is insufficient information to conclude that the lack of fresh whale products under the No-action Alternative would be expected to negatively alter current dietary conditions for any tribal member," DEIS at 4-259, so denying the waiver would have no known health effects on the Makah. If anything, as also conceded by NMFS, whale products, particularly blubber, "would likely contain higher levels of certain contaminants (e.g., PCBs) than other foods consumed by the Makah," DEIS at 4-257, suggesting that allowing a whale hunt could be adverse, not beneficial, to the health of the Makah people. The environmental justice analysis in the DEIS, however, fails to consider how allowing a whale hunt could adversely impact the health of the Makah Tribe.

In the DOC Strategy, NOAA is identified as an operating unit of the DOC that is in a position to advance environmental justice for affected populations. DOC Strategy at II.B.2.i. This is done through five overarching NOAA programs or activities; recovery of protected species, sustaining

[41] The Department of Commerce Environmental Justice Strategy is available at:
http://open.commerce.gov/sites/default/files/DOC_Environmental_Justice_Strategy.pdf

healthy coastal ecosystems, habitat protection, climate change and weather. While all of these programs or activities may be broadly relevant to the Makah (and indeed directly relevant to the conservation status of gray whales), only the recovery of protected species—gray whales—is directly relevant here. For the recovery of protected resources, the Strategy contains the following mandates:

> • NOAA will continue its current research and management activities to determine the impact of subsistence harvest on protected resources, and the impacts of other factors (e.g., commercial fishing, habitat loss, renewable energy development, oil and gas production, and pollution) on subsistence activities.
>
> • NOAA will continue to conduct research to determine the status of North Pacific marine mammals used by indigenous peoples. In addition, NOAA will continue to support the Eskimos' full participation in the International Whaling Commission and provide information in support of sustaining the bowhead whale quota allocated to subsistence use.
>
> • NOAA will also ensure that the activities it authorizes are conducted in a manner that ensures no unmitigatable adverse impacts on subsistence use of marine mammals. DOC Strategy at II.B.2.i.a.

None of these mandates specifically mention the Makah, as they do Alaska Natives. None are directly relevant to any decision by NMFS regarding the Makah Tribe's MMPA waiver application. Indeed, notably, there is no language in the DOC Strategy suggesting that NOAA will support the Makah Tribe's full participation in IWC meetings or that it will provide information to support or sustain the ASW quota for gray whales for the Makah.

Based on the foregoing evidence, NMFS has improperly included an analysis of environmental justice effects in the DEIS and it must be removed from future documents.

Regarding the analysis itself, it is, predictably, entirely one-sided. The criteria used to evaluate the environmental justice impacts were economics, ceremonial and subsistence resources, and the social environment. DEIS at 4-174. In regard to the latter criterion, NMFS concluded that "it is not possible to determine if the action alternatives would result in disproportionately high and adverse social effects on the Makah Tribe." DEIS at 4-176.

As for economic impacts, this analysis was linked to the potential effects of each alternative on tourism, with NMFS asserting, albeit inaccurately and without any supporting data, that a hunt would increase tourism to the Makah reservation. This ignores the widespread opposition to the Makah whale hunt in Clallam County and the broader region based on public outrage expressed in association with the 1999 hunt (see DEIS at 3-286, 3-288). It also ignores NMFS' own determination that there are no economic data demonstrating any positive economic impact from the previous hunt related events, DEIS at 1-149, nor has NMFS provided any evidence that there was an positive economic impact post-hunt as a result of media coverage of the event. Nevertheless, based on the NMFS claim that a hunt will increase tourism to the reservation, it concluded that the action alternatives would not have a disproportionately adverse impact on the Makah Tribe compared to the No Action Alternative.

Predictably, the NMFS analysis of the impacts of the proposed hunt on the ceremonial and subsistence criteria concludes that action alternatives would "have positive ceremonial and subsistence effects associated with a resumption of a Makah whale hunt." DEIS at 4-176. Conversely, it claims that the No Action Alternative - by preventing the preparation, hunting, butchering, sharing, consuming, dancing, singing and rituals associated with whale hunting - would result in a "disproportionate share of the adverse effects on subsistence uses, traditional knowledge and activities, spiritual connection to whale hunting, and cultural identity … upon the Makah Tribe." *Id*.

This analysis entirely ignores any consideration of the health effects of a whale hunt in the context of a review of environmental justice, although it is highlighted in EO 12898 and in the DOC Strategy. This is not to suggest that NMFS should merely add such information to the environmental justice text in any revision to the DEIS since, as recommended above, the entire section should be struck from the analysis due to non-relevance. Rather, this is noted to demonstrate that, as presented, the analysis does not even include a key element that is a focus of the EO.

<u>The DEIS contains substantial evidence to suggest the Makah Tribe does not have a subsistence or cultural need to whale or for whale products:</u>

The discussion of subsistence use in the DEIS largely focuses on the Makah Tribe's historic whaling practices and its traditional use of whale and whale products for ceremonial purposes and how these activities, if reinstated, may affect the social environment on the reservation. In other words, the analysis of the impacts of a whale hunt on subsistence use overlaps with the Tribe's desire for whaling and whale products for its traditional ceremonies, rituals, and other cultural practices. This section does not address any nutritional need for whale products, as this was evaluated separately in the DEIS. In addition, since this section of the DEIS shares a number of similarities with the analysis of environmental impacts of the proposed hunt on the social environment, these sections are analyzed together. The latter section evaluates the impact of a whale hunt on the social relationships among supporters and opponents of the proposed Makah hunt.

One critical element in evaluating subsistence and cultural need in this context is whether, in fact, the Makah Tribe has a legitimate subsistence/cultural need for whaling and whale products. Nevertheless, setting aside for the moment any discussion of whether the Makah Tribe has continued to practice its traditions associated with whaling (e.g., ceremonies, rituals, dances, songs, stories), the role of tradition in any potential future whale hunt must be addressed.

The DEIS and its appendices are replete with information about historical traditions associated with the Makah whale hunt. What is not clear is whether the Makah Tribe, if granted the authority to kill whales, will continue to practice such traditions. Considering the apparent importance of the Tribe's cultural and spiritual connection to whales, it would be expected that such traditional rituals, including frequent bathing, rubbing the body with nettles, and sexual abstinence would be continued. However, in the DEIS, the only statement regarding such practices being followed if the Makah Tribe resumes whaling is that "whaling team members may also partake in spiritual preparations." DEIS at 2-16 (emphasis added).

The Coalition is not advocating that the Makah Tribe must follow all of the past traditions. For example, in regard to the methods used to kill the whales, if whaling is allowed, the method used must, by law, cause the least suffering and cruelty (i.e., must be the most humane). The traditional methods of killing a whale with cold harpoons and floats, where the whale would sometimes linger for days before dying, are clearly no longer acceptable. To that end, if the Makah Tribe and NMFS elected to only utilize motorized vessels in order to reduce the amount of harassment inherent to a hunt and to more effectively and efficiently kill the whale (ideally utilizing an explosive grenade as the primary killing weapon), the Coalition, based on humane concerns alone, would not object. However, notwithstanding the killing methods, considering that the Makah Tribe's hunt, if allowed, represents a form of cultural ASW (since the evidence of subsistence or nutritional need is lacking), it is expected that all *cultural* traditions will be followed. Many of those traditions are described below.

While the Coalition reemphasizes its recognition of the Makah Tribe's history of whaling, the DEIS and its appendices contain considerable information suggesting the traditions the Tribe has claimed have continued during its nearly 90-year hiatus in whaling may not have been consistently practiced over the years. In this regard, the Makah Tribe has a dilemma. If it can prove, as it claims, that it has continued to engage in traditional whaling practices for the past nine decades, then this raises the question of why it needs to kill any whales to satisfy a cultural need. Alternatively, if it cannot prove that it has continually practiced such traditions, then the claims that it and the United States government have used to suggest that the Tribe can meet the "continuing traditional dependence on whaling"[42] language in the IWC's definition of ASW would simply not be true.

Admittedly, because Makah whaling has historically only been conducted by a limited number of powerful and influential families, some families may have retained and shared their whaling traditions more consistently than other families. Nevertheless, given that only a limited number of families had the qualifications, skill, and rank to engage in whaling, it is unclear if that social hierarchy will limit the number of families that can participate in any future whaling (if permitted) and whose members could serve as whaling captains. If only select families among the Makah Tribe qualify, through their ancestry, to engage in whaling, then NMFS should identify which families would have the authority to whale. This would allow the agency to gather more information from those families about their financial resources (i.e., can they afford to conduct whaling if it were allowed) and their history of sharing, both within their family and with other tribal members, of their family-specific whaling traditions (at least those traditions that are not secret). Conversely, if any member of the Makah Tribe, if he/she has the equipment and funds and regardless of ancestral connections to whale, can engage in whaling, then this raises questions about the Tribe's alleged cultural connection to whaling.

Traditionally, a Makah whaling canoe was helmed by the whaler or headman and contained seven crew members. Whalers, who provided the equipment for whaling and owned important ceremonial privileges acquired through heredity, were ranked at the top of the Makah society social pyramid. The whaler was also believed to have the ability to "interact with the natural and the supernatural to assure a successful hunt." 2002 Needs Statement at 9/10. Furthermore, given the hierarchy in Makah society (i.e., nobles, commoners, and slaves), DEIS at 3-295, positions on whaling crews "were restricted to men who could withstand the rigors of intensive ritualized training, possessed the hereditary access to the position and its ritualized knowledge, or underwent a supernatural encounter which engendered the gift of whaling ability." Makah Waiver Application at 6. The safety and success of the hunt was not limited to the crews' training, strength, or stamina, as it depended on the observance of rituals by the whaler, his crew, and their families. *Id*.

Training included "ritual bathing, praying, rubbing the skin with boughs or nettles, and imitative performance." DEIS at 3-297. Many if not all such rituals were conducted at secret locations and varied for each whaling family. Such details like the "bather's costume, the prayers, and the type of branches the whaler used were private knowledge that was passed from one generation to the next according to the rules of inheritance." *Id.*

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[42] The Coalition believes that any claim that the Makah Tribe has continually engaged in traditional practices related to whaling does not meeting the "continuing tradition dependence on whaling and use of whales" standard to obtain an ASW quota as explained previously in this comment letter.

For the whaler's wife, tradition held that her movement during a hunt would determine the behavior of the whale. DEIS at 3-297. If she moved too much, the whale being pursued by her husband would be "equally active and difficult to spear." *Id*. Conversely, if she lay quietly, "the whale would give itself to her husband." *Id*. Lack of attention to such traditions, which included other proscribed behaviors, "could result in the capture of a whale that was not fat or large enough, or cause the harpooned whale to run out to sea instead of in toward the shore." 2002 Needs Statement at 11. For the chief whaler and his wife, the traditions required even greater sacrifice as "the whaler and his wife observe a long and exacting course of purification, which includes sexual continence and morning and evening baths at frequent interval from October until the end of the whaling season … about the end of June." *Id*. If the Makah Tribe desires to hunt whales to honor tradition, it would follow that tribal members would willingly follow such traditional practices.

Evidence of potential disruptions to the alleged sharing of whaling traditions extends back to even before the Treaty of Neah Bay was signed. According to the Makah Tribe's 2002 needs statement, in 1853, the Makah Tribe was devastated by an epidemic of smallpox. This and other diseases reduced the Tribe's population by 75 percent by 1890, resulting in the loss of much family-owned information that was therefore never passed down to younger generations. 2002 Needs Statement at 21. While this was and is a tragic period in Makah history, it is simply a fact that it caused the abrupt loss of knowledge about critical components of rituals and ceremonies. *Id*.

Considering the loss of historic knowledge during long ago epidemics and, more recently, the lengthy hiatus in whaling during which many of those alive in the 1920s passed away, and the potential lapse in transmitting traditions within a family, it is unclear how many Makah whaling families can demonstrate an unbroken link to the past. In the various Makah Tribe's needs statements submitted to the IWC, such links are assured, but beyond the words on the page, no other proof has been offered to verify such claims.

Although it is commonly reported that the Makah ceased whaling in the late 1920s, the decline of whaling as a tribal tradition extends to the mid-1800s, even before commercial whalers decimated gray whale numbers. DEIS at 3-302. At that time, as a result of contact with non-Indian traders and explorers who had come to the Pacific Northwest, whale products, particularly oil, became more of a marketable good than a subsistence need. Although the Makah had already been engaged in the trading of whale products, the new visitors to Neah Bay provided a new market for whale oil. By the late 1840s and 1850s, as the market for whale oil and dogfish oil increased, the whale oil purchased from the Makah Tribe (and presumably other Native Americans) became a major export of the Hudson Bay Company. 2002 Needs Statement at 17. By 1852, the Makah "were trading or selling some 20,000 gallons of whale oil and fish oil each year, with this amount escalating to 30,000 gallons per annum over the next two decades." *Id*. at 18. Whales had apparently become a cash commodity for the Tribe.

As whale populations declined in the 1870s, whaling by the Makah diminished in frequency, reportedly because it became too cost prohibitive. Makah Waiver Application at 8. Profits from whale products also declined. 2002 Needs Statement at 21. At that time, the Makah Tribe "increased their seal hunting efforts to compensate for a less profitable whale hunt."2002 Needs Statement at 20. Given their sealing and navigational skills, Makah tribal members were hired to work on commercial sealing ships plying the waters of the Washington coast and Vancouver Island in search of fur seals; the European-American ship owners relied on the Makah Tribe's aboriginal wage-labor force to succeed at sealing. DEIS at 3-304. The profits accrued from the seal hunts permitted Makah tribal members to purchase and operate their own schooners and, in a role reversal, they began to hire non-tribal navigators. 2002 Needs Statement at 20. By 1891, "sealing became so lucrative for the Makah and west coast native hunters that their traditional whaling expeditions virtually ceased." *Id*.

In 1897, an international convention signed by the United States effectively banned pelagic seal hunting. At that time, given the diminished number of gray whales, the intensive investment in time and ritual preparation to hunt whales "was too difficult to justify." *Id*. at 23. Consequently, in 1905 there were only three recorded whale hunts undertaken by the Makah whalers (although the success of these hunts is not known). *Id.* at 23.

Without whaling or sealing, Makah men engaged in a new, more productive venture – ocean fishing – that would continue to make use of their exceptional navigational and seafaring skills. 2002 Needs Statement at 23. At that time (the early 1900s), fishing "had become a more effective venture than whaling prior to the turn of the last century." *Id*. As noted in the 1889 Annual Report to the Commissioner of Indian Affairs:

> "the Makahs catch a great many fish, which they ship three times a week to Seattle, where they have a good market for them. They have caught and shipped as high as 10,000 pounds of halibut in one day." 2002 Needs Statement at 23.

As both gray and humpback whale populations continued to decline and as more Makah men shifted toward "the very successful subsistence and commercial venture of ocean fishing," whale hunts became an even riskier investment. 2002 Needs Statement at 24.

Based on these historical accounts, while the Makah Tribe has a long history of whaling, its whaling practices transitioned from true subsistence to a profit-making operation by the mid-1800s. Once profits from the sale of whale oil declined, the Makah Tribe transitioned to sealing to continue to profit from Northwest Washington's bountiful wildlife. When that hunt was largely banned by an international convention, the Makah transitioned again to ocean fishing –

an activity that continues today and that, given the revenue produced, must provide some Makah with substantial income.[43] Cumulatively, this evidence raises additional questions about the claims that the Makah have continually practiced and passed down from generation to generation their traditions related to whaling, given that, for many ancestral whaling families, whaling has not been practiced for approximately 165 years.

Despite a 90-165 year hiatus in whaling, the DEIS indicates that recently the "Makah Tribe has attempted to revive its cultural traditions for the past three decades" in order to "combat social disruption resulting from the rapid changes of the last century and a half," causing high rates of teenage pregnancy, students dropping out of high school, substance abuse, and juvenile crime. DEIS at 3-282, Makah Waiver Application at 9. To reverse these trends, the Makah "have reinstated numerous song, dance, and artistic traditions." *Id*. The Coalition supports the revival of the cultural traditions but notes that "revival" clearly suggests that these traditions – particularly those tied to whaling – have *not* been continually practiced since the late 1920s when the Tribe gave up whaling.

Furthermore, recognizing that these revitalizations were undertaken to address certain social ills on the reservation, NMFS has not provided any data to demonstrate the impact of such cultural revival on the rate of, for example, teenage pregnancy, substance abuse, or juvenile crime on the Makah reservation. Nor has it cited to any other data – for example from other Native American tribes – to suggest that, in this modern era, reviving cultural traditions can influence the rate of such societal ills. For example, have efforts by the United States Fish and Wildlife Service to facilitate the acquisition of feathers from bald eagles and other raptors for Native American tribes to use in their cultural celebrations helped any of those tribes in reducing social ills on the relevant reservations? The Coalition is not suggesting that restoring cultural traditions cannot aid in addressing social ills on reservations, but such claims have to be proven with credible data versus mere opinion.

Surely, the Makah Tribe has monitored and measured the rates of these societal ills that are of concern on the reservation and can demonstrate a trend in those rates over the past three decades. If such data were available, a proper analysis would also require the consideration of other tools, methods, or strategies the Makah Tribe may have implemented over the past decades, so that the impact of cultural revival can be considered in the full context of other methodologies used to address these problems. According to tribal survey results, "an overwhelming majority (93.9 percent) of the village believes the resumption of the whale hunt has positively affected the Tribe and 51.6 percent specifically cited moral and social changes as

[43] According to data in the DEIS the salmon fishery out of Neah Bay generated annual revenue between $226,000 to 1.4 million between 2003 and 2011, DEIS at 3-260,while overall commercial fish landings to Neah Bay for 2007-2011 were valued at 5.9 to 9 million dollars each year.

the most important benefit," 2002 Needs Statement at 1, but no other metrics have been provided to quantify such positive change.

Other examples of statements that call into question whether the Makah have continued to practice whaling traditions are evident throughout the DEIS and its appendices. For example, NMFS notes that the Makah Tribe's "desire to reinvigorate the whaling tradition never dissipated," DEIS at 3-306, which suggests the traditions have not continued, at least not substantially, over time. Similarly, NMFS concedes that "many traditions related to whaling have waned, however, since the Makah Tribe's cessation of the hunt in the 1920s." DEIS at 3-309. The DEIS also notes that "tribal members reported that whaling songs and rituals also resumed following the 1999 hunt, with more people participating in family songs and sharing traditional knowledge," DEIS at 3-313 (citing Braund and Associates 2007), which is counter to the claim that such traditions were continuously practiced since the 1920s.

NMFS also concedes in the DEIS that while the continuous practice of a cultural activity makes it "more likely that knowledge of that activity will pass from generation to generation," should there be "a hiatus in practicing the activity, the knowledge may be lost." DEIS at 4-197. Such a loss could take time, but inevitably "knowledge of specific elements of the activity wanes as elders die." *Id*. If that is true, given the Makah Tribe's nearly 90-year hiatus in whaling (with the sole exception of a whale killed in 1999), it would follow that the cultural knowledge of whaling has, at least, diminished, if not been largely lost.

If traditions regarding whaling, including the transfer of recipes on how to prepare whale meat and blubber, had been passed down between family members, then those receiving whale products after the 1999 hunt would have been able to use those recipes to prepare the meat and blubber consistent with tradition. Yet, according to tribal survey results, the majority of respondents "reported a desire to learn more about preparing whale products and using whalebone." DEIS at 3-313. While some "households began to use recipes held in family confidence for decades," others experimented with "techniques used for other sea creatures like seals and fish," suggesting those who experimented didn't have traditional family recipes. Even Makah whalers, after the 1999 hunt, expressed an interest in learning more about the "ancient activity of whaling," again calling into question the transmission of whaling traditions among family members. *Id*. Similarly, the Makah Tribe reports that "community members are ready to rise to this challenge and re-learn the techniques necessary to make the food from the whale a part of Makah life again," 2002 Needs Statement at 38, providing further evidence that such techniques have not been passed down through the generations.

According to the data in the Makah Tribe's 2002 needs statement from the first tribal household survey, of the 61.3 percent of survey respondents who received whale meat after the 1999 hunt, 41.5 percent made jerky, 43.9 percent ate roasts, 41.5 percent cooked stew, 35.4 percent grilled steaks, and 34.1 percent smoked meat; what is not clear is whether any of this was done with the use of traditional recipes passed down through the generations. 2002 Needs Statement at 15. Another 19.5 percent of respondents utilized "innovative methods" for preparing whale meat, including stir frying, kippering, deep frying, barbecuing, and boiling," *id*. at 16; this would suggest that these tribal members did not rely on traditional recipes to prepare whale meat. Similarly, for the 75.4 percent of survey respondents receiving blubber, 22.4 percent smoked it, 37.9 percent rendered the blubber into oil, 6.9 percent pickled it, 48.3 percent boiled it, and 65.5 percent ate the blubber raw, *id*., although again it is not clear if they used traditional recipes to prepare the blubber.

While traditions and traditional techniques do change with time, this occurs when these traditions are in continuous use. When *reviving* traditions that have fallen out of use, simply substituting modern methods of food preparation and recipes arguably defeats the purpose.

Makah whalers participating in the 1999 hunt also had "to learn whaling techniques and traditions from knowledgeable Canadian elders." DEIS at 3-315. While it is understandable that no Makah whalers in 1999 would be skilled in the killing technique (as none had ever killed a whale) the fact that they had to learn whaling traditions from Canadian elders suggests whaling traditions had not been passed down through their own families. Also, considering the fact that many of the whaling traditions are apparently family-specific, they were likely taught traditional practices that were inconsistent with those followed by their ancestors.

Even the process of butchering the whale killed in 1999 created confusion, as the Makah whalers and other tribal members apparently didn't know how to butcher the whale or have the requisite tools to do so. DEIS at 3-381. According to Renker (2012):

> Butchering the gray whale proved a huge task for the Makah people. Lack of familiarity with gray whale anatomy, tools poorly adapted for gray whale meat and blubber, and logistical issues presented immediate obstacles for the butchering process which began on Front Beach. Some confusion also centered on whale parts other than meat and blubber. DEIS at 3-381

Indeed, some of the Makah tribal butchering crew included tribal members who had traveled to Alaska to learn the processing techniques. DEIS at 3-382. On the day of the kill, they also had assistance from an Alaska Native. *Id*. As recorded in video footage of the 1999 hunt, at the end of the day, even though the butchering process had not been completed, the Alaska Native, one or more NMFS officials, and a number of bystanders were left alone with the carcass to continue the flensing process.[44] According to Sepez (2001), the "1999 whale harvest yielded

[44] The videotape footage was obtained by Erin O'Connell on May 18, 1999. A DVD of the footage will be mailed to NMFS to be part of the administrate record for the DEIS. Since it is submitted as part of the record it will need to

approximately 2,000 to 3,000 pounds of meat and 4,000 to 5,000 pounds of blubber," DEIS at 4-196, although there's no information as to how much meat and blubber may have been lost due to the difficulties butchering the whale.

Furthermore, although not reported by NMFS, given the difficulty the Makah whalers faced during the butchering process, it is possible they failed to comply with traditions associated with whale flensing, which were dictated by strict protocols that identified "the sequence of the butchering, the portions of the whale reserved for ceremonial use, and the portions to be distributed to the crew and other village inhabitants." Makah Waiver Application at 6. Tradition associated with the flensing process was not limited to protocols on how to butcher and apportion the whale but included who would make the first cut into the whale and the "need to decorate the whale with eagle feathers and white down." DEIS at 3-299. The chief whaler was responsible for entertaining the villagers with his family's songs and imitations while adorned in ceremonial gear. He was given the dorsal section of the whale, the section richest in oil, for his family's use, although it was often sold. *Id*. Based on eyewitness accounts of the flensing process in 1999, none of these practices were followed.

Much of the data the Makah Tribe uses to try to justify the resumption of whaling comes from the various household surveys that have been conducted on the reservation (in 2001, 2006, and 2011). These surveys, which were essentially identical, were prepared and the results analyzed by Dr. Ann Renker. Dr. Renker, however, is hardly an objective or independent expert in regard to Makah whaling, given that she is a longtime resident of Neah Bay and is married to a Makah whaler who is a current member of the Makah Whaling Commission. Consequently, whether these surveys provide a legitimate picture of the Makah Tribe's interest in resuming whaling, its use of whale products, and the cultural value of whaling to the Tribe is open to debate. Furthermore, as is the case with any survey, the design or content of the survey can be created to achieve a particular outcome.

The administration of the first survey in 2001 raises additional questions about its legitimacy. In that year, of 217 Makah households reportedly randomly selected to participate in the survey, 159 agreed to participate. This means that 58 (27 percent) elected not to participate. The reasons why those families elected not to participate in the survey were not disclosed (if even known). Although the DEIS contains conflicting information on this point, at least four households that were selected to participate in the survey either declined to participate or were not allowed to participate due to their known opposition to Makah whaling (compare DEIS 3-310 to 2002 Needs Statement at 49). Those conducting the survey filled in the survey for

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be reviewed, including by agency decision-makers, so that they are familiar with its content. The content includes video and sound of the Alaskan native asking where the Makah were and if anyone knew how to reach them and explaining that he was "really tired right now and there is no one helping us." A NMFS official is also seen and heard on the DVD complaining about the lack of Makah present to help clean the whale intestines.

those four families, marking a negative response for all questions regarding support of the hunt or use of whale products. DEIS at 3-310. Reportedly, this was done "to minimize external influences on the survey administration." 2002 Needs Statement at 49.

In regard to those survey results, based on the results of the 2001 survey, only 38 percent of surveyed households reported participation in post-hunt ceremonies in 1999, DEIS at 3-312, and only 30 percent reported they "cooked whale meat." Makah Waiver Application at 10. Such percentages seem to be inconsistent with the claims of the importance of whaling to tribal members and to revive tribal culture. The percentage of Makah Tribal members participating in ceremonies related to whaling increased to 42.2 percent based on the results of the 2006 Household Survey (Renker 2007) but that statistic was not reported in the results of the 2012 Household Survey (Renker 2013).

Collectively, this evidence raises serious concerns about whether the Makah Tribe can demonstrate either a cultural or subsistence need for whaling and whale products. While the Coalition concedes that the information summarized above is only a fraction of the relevant evidence presented in the DEIS, NMFS must reinvestigate the claims of cultural and subsistence need with the Makah to confirm or reject the Tribe's alleged needs.

Notwithstanding the foregoing evidence that questions whether the Makah Tribe has a credible cultural or subsistence need for whaling and whale products, NMFS concludes in the DEIS that the action alternatives will facilitate subsistence use of whale products on the reservation consistent with the tribe's cultural and ceremonial needs and that whaling will improve the social environment on the reservation. Conversely, the No Action Alternative in both cases would prevent the Makah Tribe from exercising a treaty right, would prevent them from accessing freshly killed whale products not only for nourishment but would also adversely impact their cultural identity, sense of self-sufficiency, the self-esteem of the tribe and its individual members, and their trust in the United States government. In particular, according to NMFS, the impact of the No Action Alternative on subsistence use would: erode tribal identity in the absence of opportunities to participate in an activity central to Makah cultural identity; provide the community little or no incentive to work cooperatively to prepare for the hunt, to harvest, butcher, share and eat whale or to participate in song and dance festivals to celebrate the harvest; adversely affect community and individual pride and self-esteem, particularly among Makah tribal members who support the hunt; reinforce that the Makah are not in control of their destiny and would undermine a sense of autonomy within the community; and reinforce the Makah's feeling of disillusionment with the federal government. DEIS at 4-201.

Considering that the Makah Tribe has not been able to regularly engage in whaling since at least the late 1920s (and likely since the mid-1850s), this description of the implications of the No Action Alternative seems disingenuous, as it suggests the Makah Tribe is currently whaling and the United States is considering ending the practice. The reality is that no evidence has been offered to confirm the Makah are suffering from such cultural ailments. Indeed, since the Makah have been living without whaling for nearly 90 years, the description of the No Action Alternative proffered by NMFS is a significant overstatement of present day reality. It should be amended to reflect the fact that the Tribe has adapted to life without whaling and, while some may desire to resume a hunt, not doing so will not cause the cultural, spiritual, or physical collapse of the Makah Tribe as suggested in the DEIS.

NMFS has failed to comprehensively evaluate the adverse impacts of the proposed hunt on aesthetics:

NMFS concedes that a hunt may have impacts on the aesthetics of people who live and recreate near or in Neah Bay. It notes that, if the hunt is conducted 1-2 miles from shore, then there are few vantage points on land. However, "activities closer to shore, (e.g., towing a dead whale and butchering it) would be more readily viewed." DEIS at 4-227. It then contradicts itself and reports that "under all action alternatives, interested observers could view a whale being hunted, towed to shore, or butchered from numerous points along the shoreline near Neah Bay and, to a lesser degree, the Pacific coast portion of the Makah U&A." DEIS at 4-228. It claims that such impacts could be positive for those who may have an interest in observing a hunt and the butchering of a whale or negative for those who have no interest in observing whaling or the flensing process. DEIS at 4-228.

This is a simplistic analysis that doesn't do justice to the potential adverse aesthetic impacts associated with a hunt. This is because NMFS has based its analysis largely on the potential for observing certain activities associated with a whale hunt versus considering how such observations may impact a person's experience on the Olympic Peninsula (i.e., how the actual experience contrasts with the expected experience of using public lands in or near the Project Area). Nor is the scope of its analysis sufficient to capture the full range of aesthetic impacts.

Many who visit the Olympic Peninsula do so to enjoy Olympic National Park (ONP) or to explore the rugged Washington coastline. ONP includes a 70-mile-long coastal strip that is designated wilderness. Those who visit wilderness areas often do so to enjoy a primitive and relatively pristine experience in an area where the human imprint is, by law, supposed to be minimal if not non-existent. The experience of solitude and serenity is often a key attribute of the desired experience when using wilderness and backcountry areas of national parks. For such a visit to be disrupted by images of a whale hunt, the associated chaos surrounding the hunt, weapon fire, and the possibility of seeing a dead or dying whale is not consistent with the wilderness experience. For those who recreate along the Washington coast, they do so to enjoy the scenic beauty, and marine wildlife; very few if any expect a trip to the coast to include scenes of a whale being pursued, harpooned, shot, and killed, or the frenzy of media, protestors and law enforcement that is likely to accompany a hunt. NMFS has failed to consider such impacts in the DEIS. The analysis that should be undertaken is not just about how many people may observe a whale hunt or from what vantage points but, rather, has to evaluate how such observation will affect the tourist's (or resident's) experience based on his or her purpose for recreating (or living) in the area.

Tourists, residents, anglers, commercial shippers, among others, also use the Pacific Ocean for recreation, sport, or work. While the Coast Guard's RNA and MEZ may alert boaters to a hunt, permitting (or requiring) them to leave the area, it doesn't mean that they could not be adversely impacted by the hunt (due to disruption of otherwise legal activities which could cause economic loss or disrupt recreational activities) or through the mere contemplation of a whale being killed whether they observe it or not. Indeed, this same impact could affect anyone nationally or internationally that opposes the hunt. In *Fund for Animals v. Ridenour*, Civ. No. 91-0726 (D.D.C. 1991), the court held that that merely contemplating the killing of a bison near Yellowstone National Park was sufficient harm to demonstrate legal standing. These impacts were not evaluated in the DEIS. Nor did NMFS consider the impact to a resident, tourist, or boater upon seeing a whale that is injured or dying as a consequence of a Makah hunt (i.e., a struck and lost whale) in the ocean or stranded. Each of the action alternatives set a limit on the number of struck and lost whales so the potential to observe an injured or dying whale is real.

Finally, NMFS only considers the impact of the hunt on the economics of whale-watching in the DEIS. Such impacts, however, extend well beyond economics to include adverse effects on the social environment and on the aesthetic experience of those who enjoy observing whales in their natural habitat. NMFS largely dismisses the potential of the hunt to impact whale-watching operations, claiming that there are no such operations in the immediate project area and that it had no information to suggest that the hunt would stop people from taking whale-watching trips nearby. DEIS at 4-152. It also asserts that Washington-based whale-watching companies will not expend the time or funds necessary to access whales in the Makah U&A and, therefore, won't be adversely impacted by the proposed hunt. *Id*. Finally, it claims that because gray whales are not typically targeted by most whale-watching operators in the region, a decrease in gray whale numbers would not appreciably impact the public's incentive to pursue whale watching in the PCFG range. DEIS at 4-153. These conclusions are either wrong or not supported with any credible evidence.

The issue is not only about watching a whale die but, again, it must extend to the knowledge of the hunt and the contemplation of a whale being killed. For those who enjoy observing gray whales throughout their migratory range, from the Mexican lagoons to Alaska, the knowledge that the whales that they observe and, in some cases know by name, could be killed in a Makah hunt could result in emotional harm or cause them to choose not to partake in future whale-watching trips or visit the region. Indeed, contrary to the claim by NMFS that gray whales are not targeted by most whale-watching operations, a few minutes of online research revealed three operations in Oregon (oregonwhales.com, The Whale's Tail Chartered Whale Watching, and Tradewinds Charters) that appear to focus on gray whales.

Notably, several whale-watching operations offer whale adoption programs for named PCFG whales. For example, oregonwhales.com Whale Research EcoExcursions currently has a number of PCFG whales up for adoption (e.g., Scarback, Rambolina, Zebra Stripe). In addition, the company blogs on the activities of whales that it observes. On July 27, 2015, the blog entry was:

> Whale sightings have been excellent as usual. Ginger, Ridgeback, and Pearl have been in the bay and very active. There were 4 whales at on (sic) time in and around our boats. I have identified and along with my team, suggested by a group on one of our trips named a new whale, "BANDIT". A beautiful female with a large band of white on her dorsal area. Also we saw a couple of Mola Mola (Ocean Sunfish), one of which was over 8ft in size and lazily swam right up to the boats. We have had a 100% sighting rate for many weeks now. Trips leave every day from 8am every 2 hours through 6 pm and sometimes sunset tours. We would love to teach you all about our whales and other wildlife. Also check out our Baja information. We are going to Baja in February to see and pet the friendly gray whales. This is the only place in the world where you can have this kind of interaction. It is awesome!!!"
>
> (see http://www.oregonwhales.com/daily.html).

Cascadia Research Collective also provides an opportunity for people to adopt PCFG whales (see http://www.cascadiaresearch.org/adopt.htm).

As these websites reveal, many PCFG whales have names, they are known, and there may be people who have bonded to these animals. During excursions run by oregonwhales.com, clients are introduced to individual PCFG whales and are provided information about each whale and his or her history. While it is not known how many whale-watching operations from Alaska to Mexico promote PCFG whales, for those who do they are creating a connection between their clients and individual whales. If their clients, or those who adopt a whale, were to learn that their whale was killed by the Makah Tribe, the emotional impact could be significant. Even NMFS concedes that "many people who watch whales in the project area on a regular basis attach existence values to individual PCFG whales that regularly visit the area." DEIS at 4-188.

The likelihood that the public, including those who participate in whale-watching, will oppose the Makah hunt is high. Evidence of this is included in the DEIS (see DEIS at 3-286 and 3-288). In addition, according to Hoyt and Hvenegaard (2002), 75 percent of whale watchers surveyed in California said it was "morally wrong" to kill whales, while whale watchers surveyed in Vancouver registered an average score of 4.47 (based on a survey scale of 1 to 5, with 5 being "strongly agree") to the statement "it is wrong to kill whales." Another survey of New England whale watchers found that 83 percent agreed it was "morally wrong" to kill whales, regardless of the reason.

One need only consider the ongoing international outrage surrounding the case of Cecil, the lion from Zimbabwe, to understand the potential for adverse social impacts associate with the killing of a single, named whale. In that case, an American trophy hunter was involved in a hunt that illegally lured Cecil out of a national park after which he shot and injured him with an arrow. The injured lion was then tracked and killed, skinned and beheaded after 40 hours of suffering.[45] The social media backlash has been massive and the trophy hunter has disappeared from public view. NMFS has not evaluated such impacts in the DEIS related to the killing of a gray whale. Nor has it considered how, if the Makah Tribe is allowed to whale indefinitely, the hunt could harm the reputation of the whale-watching industry in Washington, Canada and throughout the species' migratory range; people may choose to avoid whale-watching or visiting the coast because they do not want to view whales who could be killed by the Makah Tribe.

<u>NMFS has failed to adequately evaluate the risks to public safety inherent to the proposed gray whale hunt:</u>

The DEIS significantly underestimates the substantial risk to public safety inherent to any Makah whale hunt. Unlike the Alaskan, Russian, or Greenlandic ASW hunts that take place in extremely remote regions of the world, the Makah hunt, if permitted, would occur in a region that is much more populated, is a destination for millions of tourists annually, and where commercial and recreational shipping/vessel operations are common. As an example of the population differences, there are an estimated 3,439,809 people live in the Washington Metropolitan Area (which comprises the Seattle-Tacoma-Bellevue region of Washington)[46] and, based on the 2010 US population census results, 71,404 people lived in Clallam County, WA.[47] This compares to a total of 736,732 people in the entire state of Alaska in 2014,[48] including only 4,373 (as of 2013) in Barrow, AK[49] (one of 11 whaling villages).

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[45] See K. Rogers, American Hunter Killed Cecil, Beloved Lion That Was Lured Out of Its Sanctuary, New York Times, July 28, 2015 (available at http://www.nytimes.com/2015/07/29/world/africa/american-hunter-is-accused-of-killing-cecil-a-beloved-lion-in-zimbabwe.html?emc=eta1).
[46] See http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=DEC_10_DP_DPDP1&prodType=table?
[47] See http://www.peninsuladailynews.com/article/20110225/NEWS/302259982
[48] See http://quickfacts.census.gov/qfd/states/02000.html
[49] See https://www.google.com/?gws_rd=ssl#safe=active&q=how+many+people+live+in+Barrow%2C+AK

According to tourism data contained in the DEIS, 3 million people visit the Northern Washington Coast every year to enjoy the beautiful scenery, pristine wilderness, and opportunities to view wildlife. DEIS at 3-331. More specifically, Olympic National Park attracted an average of 3.0 million visitors per year between 2006 and 2010, with more than half of those visits occurring during the months of July through September, with an additional 25 percent occurring during the months of March through June. *Id*. Within the Makah reservation, 16,000 people visited the Cape Flattery Trail each year from 2005 through 2011, with more than 80 percent of those visits occurring during the months of July, August, or September. *Id*. For those using the area for commercial and recreational boat trips, 80 percent of such trips occur from May through August, six percent from November to March, with another four, seven, and three percent in April, September, and October, respectively. DEIS at 3-341.

While the risks to public safety may be lower during a hunt conducted in the winter months or offshore, simply due to the lower number of persons in the vicinity, even those hunts could adversely affect persons occupying any hunt support vessels, media vessels, or vessels operated by protesters. This is due to the likelihood of more challenging sea conditions further from shore potentially resulting in an errant shot, DEIS at 4-246, or an increased risk of boating accidents where any needed medical assistance would not be readily available. Conversely, a hunt conducted during the spring months or over the summer (Alternative 4) would increase public safety risks, although, if conducted well offshore, the risks would be less than if conducted near shore.

The use of high-powered rifles poses a significant public safety concern. As indicated in the DEIS, a 750 grain bullet fired from a .50 caliber rifle can travel nearly 5 miles. DEIS at 3-169 (citing Graves et al. 2004). A bullet from a .577 rifle, because it has a lower ballistic coefficient and greater rate of drop, would be expected to result in a shorter range than a bullet fired by a .50 caliber rifle, *id*., but that range is not identified in the DEIS. Due to the distance that such bullets can travel, Kline (2001) stated that “no firing should be conducted within 6,670 yards from shore and advised that a ricochet could travel almost 1,860 yards off the line of fire.” DEIS at 3-363.The use of an explosive projectile would substantially reduce the public safety risks since such grenades, due to their weight and size, will have only a very limited range.

If there were no public safety risks associated with the hunt, there would have been no need for the Coast Guard to establish a Regulated Navigation Area (RNA). In finalizing its rule establishing the RNA after the 1999 hunt, the Coast Guard reported that “the uncertain reactions of a pursued or wounded whale and the inherent dangers in firing a hunting rifle from a pitching and rolling small boat are likely to be present in all future hunts, and present a significant danger to life and property if persons or vessels are not excluded from the immediate vicinity of the hunt.” DEIS at 3-10 citing 64 Federal Register 61212 (November 10, 1999), DEIS at 3-349. The Coast Guard also created a 500 yard Moving Exclusionary Zone (MEZ) around tribal hunting vessels in order to ostensibly "keep protesters, reporters, and spectators out of the area where life and property would face the greatest risk of endangerment from an injured or pursued whale or a round from a .50 caliber rifle." DEIS at 3-349. Consequently, even the Coast Guard's 500 yard RNA is likely not sufficient to eliminate the potential risks to other vessels, including protest vessels, in the vicinity of the hunt.

The Makah Tribe has established, in its 2013 Whaling Ordinance,[50] rules that are intended to address the risks of the whale hunt. These rules include drug and alcohol testing of the riflemen, training and certification programs, and requirements regarding when a shot can be fired. DEIS at 2-15.[51] More specifically, the Makah Tribe has developed the following safety standards for any hunt:

> The Makah safety officer has authority to determine whether visibility is less than 500 yards in any direction in which case the whaling captain suspends the hunt; safety officer would not authorize the rifleman to discharge the weapon unless the barrel of the rifle was above and within 30 feet or less from the target area of the whale; safety officer would not authorize the rifleman to discharge the weapon unless the field of view is clear of all persons, vessels, buildings, vehicles, highways, and other objects or structures that if hit by a rifle shot could cause injury to human life and property. DEIS at 3-351.

The risks to public safety inherent to any Makah whale hunt are not limited to the weapons used or vessel collisions, since a struck gray whale can also pose a significant threat to public safety by ramming nearby boats or swamping the Makah canoe. DEIS at 4-249. While those vessels, including any Makah canoes, closest to the injured whale would be most at risk, an injured and distressed gray whale could cover a fair distance in a short period of time. As explained in the DEIS, the Russian Federation reported that of the 129 gray whales killed in its 2007 hunt, 49 animals (or 39 percent) were highly aggressive and even attacked hunting boats. DEIS at 3-166. Such violent struggles by struck gray whales can, as reported in the DEIS, "result in vessels being capsized, persons on vessels being knocked in to the water, or individuals become entangled in the lines fastened to the whale." DEIS at 3-357.

[50] The mere existence of a 2013 Makah Whaling Ordinance is of concern to the Coalition since the current decision-making process will likely take years to complete. Consequently, it is unclear why the Makah would expend the time and resources to create and approve a whaling ordinance when they cannot currently whale and may not receive the requested MMPA waiver. Perhaps the Makah Tribe presumes that it will receive a waiver given its treaty right, or its adoption of a new whaling ordinance may suggest that the outcome of this NEPA/MMPA process has been predetermined, which is illegal. The Makah Whaling Ordinance is discussed in greater detail in a latter section of this comment letter.

[51] NMFS suggests that the alcohol testing requirement for Makah riflemen is contained in the 2013 Makah Whaling Ordinance but a review of that ordinance reveals no such requirement.

Given the sheer numbers of people who live and recreate in the vicinity of any potential Makah whale hunt, there is a significant public safety risk associated with the hunt. Conducting a hunt well offshore with a strongly enforced RNA, and using explosive grenades as the killing weapon, would reduce public safety risks compared to conducting a hunt near shore using high-powered rifles. Nevertheless, even with an offshore hunt, there would still be a risk to the whalers, their support personnel, the Coast Guard (and other enforcement agency personnel), the media, protesters, and innocent onlookers, not just from the use of rifles as the primary killing weapon but also from a wounded whale. Regardless of where the hunt occurs, if rifles are used, the likelihood of *every* shot being fired at a safe downward angle, given that the rifleman is aiming at a swimming whale from a moving boat on a rolling ocean, is low. Consequently, a misfired bullet could travel an extended distance, potentially hitting something or someone and causing damage, injury, or death. Even with an RNA, an MEZ, and Makah safety standards, the potential risk of the whale hunt to public safety in such a highly populated and trafficked area is simply too high to justify a hunt for a Tribe that does not need to hunt whales. NMFS must reevaluate its analysis of the public safety risks inherent to the whale hunt and provide a more detailed and comprehensive risk assessment.

<u>The DEIS fails to substantiate the need for whale meat or other products to benefit the health or nutrition of the Makah Tribe:</u>

The Makah Tribe has repeatedly claimed in need statements submitted to the IWC that marine foods, including marine mammal products, are of nutritional importance in the diet of tribal members. In making this claim, the Makah Tribe has described the alleged nutritional benefits of whale products and the notion that access to whale products would help alleviate poverty on the reservation by providing food that would be shared and free of charge, reducing costs of store-bought foods. DEIS at 1-31.

Prior to contact with Europeans, the Tribe was able to exploit land and sea animals, including elk, deer, bear, seal, and a diverse population of fish, shellfish, and other marine species. Whale meat and oil were among their principle foods. 2002 Needs Statement at 33.

Traditionally, the Makah Tribe consumed nearly every edible part of whales, including the meat, organs, and blubber. In addition, whale oil extracted directly from dead whales or rendered down from blubber was widely used. Considering that some of the traditional hunts could take days to complete,[52] the oil was often the most important product from the whale, as

[52] According to the Makah Tribe's 2005 waiver application, historically some hunts occurred 30 or more miles from shore, even though at that time the Makah were using the traditional hand-carved canoes. Makah Waiver

it did not spoil as quickly as the meat. DEIS at 3-367, DEIS at 3-300. Interestingly, due to the tendency of whale meat to spoil easily, particularly when the process of towing a dead whale back to land could take several days, whale meat was not as important in the pre-contact and historical diet of the Makah compared to whale oil. 2002 Needs Statement at 33. Indeed, as the Makah Tribe concedes, only "about ten percent of the food the Makah people derived from whales can be attributed to meat." *Id*. Whale oil, which was not subject to spoilage, could be stored and used indefinitely, assuming it was rendered properly. *Id*.

While the historical quantity of whale products consumed per capita was not reported in the DEIS, Sepez (2001) calculated that the whale killed in 1999 resulted in about 2.4 pounds of whale meat and product per capita on the reservation, with an additional amount consumed at the community potlatch. DEIS at 3-367. In the future, if the Makah are allowed to resume whaling, Renker (2012) determined that if an average of four whales were killed per year, the hunts would yield 8 to 20 pounds of whale meat and 16 to 20 pound of oil or blubber per Makah tribal member (with a smaller amount of oil due to the rendering process). *Id*. Based on the reported number of Makah tribal members (1,121) living on the reservation in 2010, DEIS at 4-196, this would equate to 8,968 to 22,420 pounds of meat and blubber and 17,936 to 22,420 pounds of oil/blubber.

Results of the survey of Makah tribal members conducted in 2001 revealed that "most reservation households now desire whale products to be a regular part of their diets" with 86.5, 72.4, and 55.8 percent of respondents desiring whale meat, whale oil, and blubber respectively.[53] Makah 2002 Needs Statement at 2. Desiring to have whale meat and oil, however, is not the same as needing these products to reverse any health concerns caused by decades without access to such products. The Makah Tribe claims in its needs statement that the "restored (whale) hunt provides modern Makah people with a rich source of traditional foods which are nutritionally superior to many non-indigenous provisions which are available in the community," *Id*. Yet, it provides no evidence to substantiate that claim nor does it concede, as is made clear in the DEIS, that the same alleged benefits from whale products can be obtained from other marine foods.

As to the alleged consequences of not having regular access to whale products in their diet, in the Makah Tribe's 2002 needs statement, the majority of the claims regarding the health consequences of not eating a traditional diet are based on health concerns for American Indians generally, instead of focusing on particular health/disease conditions experienced by

Application at 5. At that time, the process of killing a whale "could take up to three to four days" followed by up to two days to tow the whale back to shore. *Id*. at 6.

[53] The percentages declined in 2006. Survey results that year revealed that 71.7, 67.1, and 47.4 percent of survey respondents desired whale meat, oil, and blubber, respectively. DEIS at 4-203.

members of the Makah Tribe specifically. For example, the needs statement claims the following regarding the health of American Indians:

- American Indians are generally considered to be one of the unhealthiest populations living within the United States. This observation is especially true for natives living within the confines of a reservation. Infant mortality and life expectancy rates for reservation residents are the lowest of all American citizens. 2002 Needs Statement at 35.

- Diminished life expectancy on American Indian reservations is compounded by the fact that certain systemic illnesses linked to food and nutrition appear in a statistically higher percentage among these populations. Diabetes, for example, is 234% more prevalent among American Indians than in all other US races. *Id*.

The only specific information about health concerns contained in the needs statement relevant to the Makah Tribe is that they "did not utilize plant foods to a great degree" in their historical diet, and thus they "still experience many digestive problems with diets high in fiber and cruciferous vegetables," 2002 Needs Statement at 35. In addition, it is noted that some tribal members, particularly descendants of whaling families, are frequently affected by rheumatoid arthritis and diabetic neuropathy. Reportedly, digestive disorders seem to be an issue for members of other Native American tribes who live along the NW coast, as the Makah Tribe reports that it "have the highest rate of digestive illnesses of all American Indian people and are the leading cause of hospitalizations." 2002 Needs Statement at 37. Yet no evidence is provided that whale products, especially to the exclusion of other marine foods, will address these digestive disorders.

Notably, when discussing the value of essential fatty acids (EFAs) in their diet, the Makah Tribe refers not to cetacean or even gray whale EFAs but, rather, to marine EFAs. 2002 Needs Statement at 37. General marine EFAs have reportedly improved conditions such as rheumatoid arthritis and diabetic neuropathy. Since the benefits can be obtained from any marine EFA, however, this does not provide justification for killing gray whales.

Today, the Makah tribal members consume a large quantity of subsistence food. Reportedly, "a majority of Makah households use traditional Makah foods (i.e., fermented salmon eggs, smoked fish heads and backbones, halibut cheeks and gills, and dried fish) at least once a week." Makah Waiver Application at 9. The DEIS reports both terrestrial and marine species (primarily fish) are taken in subsistence hunts. It does not, however, disclose any information about the quantity of terrestrial wildlife killed, the amount of meat/fat/other edible products obtained from those animals, nor does it provide any information regarding contaminant profiles of such subsistence foods. For fish, it is estimated the Makah consume 126 pounds of fish per capita each year, which is eight times higher than the average American. DEIS at 3-367 citing Sepez (2001), Makah Waiver Application at 9. Yet, again NMFS does not provide any data as to the contaminant loads contained in fish products regularly consumed by the Makah. Western foods are also available on the reservation, although NMFS does not disclose the type of such foods or the quantities consumed.

In evaluating the human health impacts of a whale hunt, NMFS considered three issues: the potential nutritional benefits associated with consuming whale food products; the potential for exposure to contaminants in food items from the whale harvest; and the potential for exposure to food-borne pathogens in food items from the whale harvest. DEIS at 4-256. NMFS concedes, however, that due to uncertainties associated with this analysis, it is not possible to "predict whether any of the alternatives would result in a net positive or negative effect on human health." *Id*.

Indeed, the DEIS lacks data needed to even begin to evaluate the alleged nutritional benefits of whale products to the Makah Tribe. This includes: a baseline evaluation of the health status of Makah tribal member (or at least data on a representative sample of tribal members), a lack of species-specific (terrestrial and marine) data on Makah consumption of subsistence foods; the quantity of such foods consumed per capita per week, month, or year; the nutritional value of such products; the contaminant loads of such products; the amount and type of western foods consumed; current health conditions of Makah tribal members (i.e., prevalence of heart disease, diabetes, kidney disease, obesity, and other diet or lifestyle-related diseases), and evidence of lifestyle factors that may affect disease conditions (i.e., activity levels, smoking, drinking, illegal drug use).

NMFS recognizes this void, given its own disclosure of a litany of information that would be required to determine if consuming freshly killed gray whale products would improve nutrition among the Makah. Such deficiencies include the current types and level of nutrition present in Makah tribal members' existing diet; what parts of the whales and how much would be consumed; what currently consumed food items and associated nutritional levels would be replaced by whale products; and how such food items are collected, stored, and prepared for consumption. DEIS at 4-257. NMFS claims that "none of this information is currently available or could reasonably be obtained" but it failed to meet the required standards for incomplete or unavailable information under NEPA. If the Makah or NMFS want to ever meaningfully address the Makah's alleged need for whale products, they would have to, at a minimum, collect and analyze this type of information.

In the DEIS, NMFS asserts that "whale products have a similar nutritional profile as other finfish, shellfish, wild game and domestic meats," DEIS at 3-368, that whale oils and blubber provide a richer source of energy (calories) than other food types listed in Table 3-46, DEIS at 3-370, while whale meat has higher levels of iron.[54] *Id*. NMFS concedes, however, that gray whale meat, blubber, and oil are not necessary to obtain the alleged nutritional benefit claimed by the Makah, since many of the vitamins, essential elements, and both essential and beneficial polyunsaturated fatty acids found in whale products can be obtained from other marine mammal food products, DEIS at 4-256, as well as from fish oils, vegetable oils, soybeans, nuts, meat from terrestrial mammals, and vitamin and other nutritional supplements. DEIS at 3-268, 4-256. For example, essential fatty acids that have reportedly been found to be beneficial in controlling diabetes, kidney disease, heart disease, hypertension, and other similar health problems, are found in fish food products. *Id*.

Fundamentally, despite the Makah's claims to the contrary, NMFS concludes in the DEIS that "there are no data to suggest that current diets of individual Makah members sufficiently lack (the) nutritional benefits" ascribed to whale products. DEIS at 4-259. Furthermore, as admitted by NMFS, "there is insufficient information to conclude that the lack of fresh whale products under the No Action Alternative would be expected to negatively alter current dietary conditions for any tribal member." *Id*.

<u>NMFS has failed to adequately evaluate the potential impact of environmental contaminants from whale products on the health of Makah Tribal members:</u>

There are a number of chemical compounds in the environment, including in the marine environment, which can have direct lethal effects or insidious sub-lethal effects on individual animals. Sub-lethal effects include impaired reproductive, metabolic, and immune functions. DEIS at 3-178. Such chemicals include organochlorines (e.g., DDT, PCB, dioxins, furans), heavy metals (e.g., copper, mercury, lead), and newly emerging chemicals (e.g., flame retardants). *Id.* The three heavy metals of greatest concern to cetaceans are mercury, cadmium, and lead. DEIS at 3-179 (citing O'Shea 1999).

The health of a gray whale is not always indicative of its contaminant load. For example, as revealed in the DEIS, the mean concentrations of PCBs (1200 µg /mg) and DDTs (520 µg/mg) in the blubber of gray whales that stranded in 1999 were well below levels measured in gray whales harvested in Russian waters (PCBs 630 µg/mg and DDT 150 µg /mg). DEIS at 3-373. Furthermore, the concentrations of chlordanes, DDTs, dieldrin, hexachlorobenzene, mirex, and PCBS in gray whales collected during Russian hunts in the Bering Sea in 1994 were two to three times lower than those measured in stranded gray whales collected over the 1990s in Washington. *Id.*

Such contaminants also occur and are documented in the diets of native subsistence populations. DEIS at 3-372. In determining the potential risk for members of the Makah Tribe to

[54] Notably, Table 3-46 does not provide any data for gray whale meat, blubber, or oil.

be exposed to contaminants, their existing and ongoing exposure to such toxins must be considered. For the Makah, due to their high consumption of seafood products, including finfish and shellfish, it is likely that they are exposed to high levels of contaminants.

This risk is also linked to the level of contaminants in gray whales. While gray whales are generalist feeders, their reliance on bottom feeding to acquire energy-rich amphipods exposes them to various contaminants that may settle to the ocean floor. Their pelagic prey may also contain contaminants through bioaccumulation or as a consequence of the contaminant loads in the waters in Washington State. Indeed, as noted in the DEIS, a number of "researchers have documented concentrations of organic and inorganic contaminants in the tissue (blubber, muscle, organs, etc.) of the gray whales proposed for hunting by the Makah." DEIS at 3-378 (citing numerous studies).

Importantly, as noted in the DEIS:

> "...concentrations for some of these contaminants in whale blubber can be quite high, resulting in quite low 'allowable consumption rates.' For example, the unweighted average PCB concentration for the 11 gray whale blubber samples in Table 3-47 is 44 µg /kg. While the Washington State Department of Health has not developed screening levels for gray whale blubber, this value – combined with the estimated per capita blubber consumption rates in the Tribe's needs statement (approximately 20-25 grams/day…) and other values applied by the Washington Department of Health (e.g., an 8-oz [227-gram] meal size) – yields a calculated 'allowable consumption rate' of 0.43 meals of blubber per month." DEIS at 3-374.

Notably, as also explained in the DEIS, this example is based on non-cancer endpoints and if cancer endpoints were used, the allowable consumption rates would be lower. *Id*.

While the concentration of persistent organic pollutants in whale blubber is typically higher or comparable to those in other tissues, heavy metal concentrations are typically higher in muscle tissues compared to blubber. Mean metal concentrations (in µg/kg dry weight) found in gray whales, as reported in the DEIS, range from 0.4 to 0.86 cadmium, 3.1 to 4.1 copper, 305 to 1,009 iron, 0.6 to 1.11 lead, 0.33 to 0.8 manganese, 0.145 mercury, 1.39 nickel, and 120 to 279 zinc.

Considering that contaminants are already found in foods presently consumed by the Makah, including fish and shellfish, as well as store-bought food, whether adding whale products will have a positive or negative effect is unclear. Since, as NMFS admits, no database is available to "compare the amount of contaminants currently being consumed by the Makah Tribe with the amount of contaminants found in fresh whale products," it is "difficult to determine the net change in contaminants to which tribal members would be exposed." DEIS at 4-257.

Nevertheless, since whale products, particularly blubber, "would likely contain higher levels of certain contaminants (e.g., PCBs) than other foods consumed by the Makah," *id*., NMFS cautions that whale products may exceed levels that trigger human health concerns based on guidelines published by state and federal agencies. *Id.* Similarly, NMFS reports that "changes in the quantity of freshly harvested whale consumed would probably not appreciably change the potential for food-borne illness to occur in Makah tribal members." DEIS at 4-258.

There are several deficiencies in the analysis of the impact of environmental contaminants in the DEIS.

First, NMFS has failed to disclose sufficient data to evaluate the relevant impacts of such contaminants on the Makah if they are allowed to hunt whales. Not only are there apparently no data on the current contaminant loads in Makah tribal members from their high-fish diet, but NMFS provides no data on the contaminant profiles of the fish species and other food products typically consumed on the Makah reservation.

Second, although NMFS refers to state and federal food safety standards in the DEIS, it fails to identify those standards, fails to provide any reference to them so that interested stakeholders could examine them, and fails to compare those standards, with the sole exception of the PCB example provided above, to the concentration of contaminants documented in gray whales.

Third, many of the studies cited in Tables 3-47 and 3-48 are also rather dated, which calls into question the accuracy of the documented concentrations in terms of what may be found in gray whales today. Despite these deficiencies, to be precautionary, particularly with regard to the health of Makah tribal members and recognizing that NMFS concedes that consuming whale products may trigger health concerns; NMFS should deny the MMPA waiver application on health grounds alone. Surely NMFS does not want to authorize a gray whale hunt when there is a distinct possibility that consumption of products from the hunt could compromise human health.

<u>NMFS has failed to adequately evaluate the precedential impacts of the issuance of a waiver to the Makah Tribe:</u>

One of the key issues emphasized in the *Anderson* opinion was the potential for a Makah whale hunt to create the precedent for other whale hunts in the United States and around the world. In evaluating this potential impact, NMFS considers the potential change in the number of requests for MMPA waivers to permit the killing of marine mammals in US waters (other than whales) and for regulatory action to permit the killing of whales in US waters. DEIS at 4-260. The DEIS identifies a number of US tribes between the Aleutian Islands and California who hunted gray whales and/or used drift whales for subsistence as part of their cultural and religious traditions. These tribes include the Aleuts, Koniag, Chugash, Tiglit, Haida, Tsimshian, Nootka, Makah (including the Ozette), Quileute, Klallam, and Chomash. DEIS at 3-176. However, this list is incomplete, as it does not include any tribes that live on the east or Gulf coasts that may have historically hunted whales.

NMFS concedes the fact that Northwest Indian tribes have previously expressed an interest in killing marine mammals, that an authorization of a Makah gray whale hunt could revive the interest of the Makah or other tribes in hunting marine mammals, and that it could increase interest by non-Indians in sport or commercial hunting of marine mammals. DEIS at 4-261. Despite this concession, NMFS largely dismisses the potential for an increase in waiver requests if the Makah's MMPA waiver is granted, claiming, for example, that "history suggests that there is little interest by other native groups to seek authorization to harvest whales." *Id*.

This conclusion may be misplaced, however, since both the Makah and other US coastal tribes, including those on the east and Gulf coasts, may simply be waiting for the outcome of the Makah waiver application before proceeding with their own request for whales or other marine mammals. While there is no evidence yet that this will occur, tribes with an interest in obtaining a waiver would not help their own cause – or the cause of the Makah to obtain a waiver to kill gray whales – if they were to prematurely announce their intent before the current process ended. Such an announcement would support the argument that the Makah Tribe's waiver application has had a significant precedential impact, thereby supporting a denial of the waiver.

Many tribes, particularly in the Northwest, have expressed a desire to kill seals and sea lions, given the perceived conflict with fisheries, particularly salmon fisheries. The Northwest Indian Fisheries Commission recently opined that "harbor seal and sea lion populations must be brought back into balance with the reality of today's ecosystems, which cannot support their steadily increasing numbers."[55] It is myopic for NMFS to conclude that the outcome of the Makah Tribe's waiver application will have no influence on the likelihood of these tribes applying for their own waivers. Even the Makah Tribe may choose to pursue additional waivers if its whaling waiver is obtained, considering that it ceased authorizing tribal members to take any marine mammals in 2005 as a result of the *Anderson* opinion. DEIS at 3-215.

Furthermore, the recent decision in *United States v. Washington* opens the door to a significant increase in MMPA waiver requests. In that case, initiated by the Makah Tribe to determine the boundaries of the usual and accustomed fishing grounds of the Quileute and Quinault tribes, the court concluded that "'fish as used in the Treaty of Olympia encompasses sea mammals and that evidence of customary harvest of whales and seals at and before treaty time may be the basis for the determination of a tribe's U&A." *United States v. Washington*, No. C70-9213, slip

[55] See http://nwifc.org/2015/04/10158/

op. at 78 (W.D. Wa. July 9, 2015; Attachment 7).[56] This is now a legal precedent defining a treaty right to fish to encompass the hunting of marine mammals, including cetaceans. Therefore, the Coalition concludes that MMPA waiver applications are very likely to increase. Admittedly, the ruling in *United States v. Washington*, issued on July 9, 2015, was not available to NMFS when it prepared the DEIS, but it now represents new information that must be considered as NMFS continues with the NEPA and MMPA waiver processes.

NMFS concludes that "it is also unlikely that other countries could use authorization of a Makah whale hunt under Alternatives 2-6 as leverage for increasing commercial or scientific whaling." DEIS at 4-267. To support this conclusion, NMFS cites to the skirmish between Japan and the United States over the Alaskan bowhead whale quota in 2002. While it is true this situation did not result in a "fundamental change in the United States position" on commercial or scientific whaling, it did result in the United States voting in favor of Japan's small-type coastal whaling proposal at a special meeting of the IWC called to address, in particular, the bowhead quota. In that case, though the US vote for small-type coastal whaling did not practically benefit Japan (as there were sufficient no votes to block the proposal even with the United States voting in support), it was clearly a psychological victory for Japan given by the United States in order to secure the bowhead whale quota. To think that Japan would not attempt to block a US ASW quota in the future to compel a change, even temporary, in a US position at a future IWC meeting is naïve.

Admittedly, the Makah ASW request may not provide Japan with the same leverage over the United States as did the bowhead whale quota. This is because the Makah ASW quota is for a small number of whales and, if blocked, the repercussions are not as significant for the Makah as are the implications for Alaska Natives. The Makah, as Japan is well aware, have not regularly engaged in whaling for nearly 90 years (and potentially as long as 165 years) and have access to a variety of other foodstuffs. Conversely, the bowhead quota is for a larger number of whales for which the 11 Alaskan whaling villages have a genuine nutritional, subsistence, and cultural need.

Furthermore, the suggestion that ASW was not a consideration in the effort to construct an agreement leading up to the 2010 IWC meeting that, if approved, would have undermined the commercial whaling moratorium is also without merit. The principal reason the US ASW quotas were not challenged at the 2007 meeting, held in Anchorage, AK, is because the late Senator Ted Stevens negotiated an agreement, believed to be unwritten, with Japan. In its simplest terms, that agreement ensured that Japan did not object to the United States quota request, particularly its request for bowhead whales, at the Anchorage meeting in exchange for US

[56] In the opinion, the court provides significant details as to the history of whaling, sealing, and fishing by both the Quileute and Quinault tribes. It also identifies several other tribes that also had a tradition of whaling.

leadership in the process that led to the proposed “deal” to lift the commercial whaling moratorium, which was soundly rejected at the 2010 IWC meeting.

Finally, NMFS’ dismissal of the potential adverse precedent that Makah whaling could have on other IWC countries seeking whaling opportunities for their own people, including aboriginal people, is in error. Fundamentally, the mere fact that the United States was able to secure a quota for the Makah in 1997, given that the Tribe did not qualify (and still does not qualify) for an ASW quota, has already substantially weakened the ASW criteria within the IWC. NMFS even admits that the Makah whale hunt is different from other aboriginal subsistence hunts because of “the Tribe’s 70-80 year hiatus in whaling.” DEIS at 4-268. While approval of the Makah quota as recently as 2012 has not been explicitly used by any country to seek IWC approval to allow its own people to engage in whaling, this may occur in the future. Indeed, considering that the Makah hunt has been prevented from occurring as a result of legal action, if NMFS is able to ultimately permit the Makah to begin to actively use the IWC-approved quota, this could be the trigger that other countries are waiting for to exploit the 1997 decision.

This does not mean that the damage done by the United States to the ASW standards in 1997 cannot be reversed. This is possible, but only if the US denies the Makah Tribe’s MMPA waiver request and does not pursue another gray whale ASW quota for the Makah at any future IWC meetings. This would not erase the adverse precedent set in 1997, but it would return some integrity to the IWC’s ASW standards.

<u>NMFS has failed to fully disclose all relevant information regarding the cumulative impact of the proposed hunt and to adequately analyze such impacts:</u>

NEPA requires federal agencies to evaluate the cumulative impact of any proposed action or other alternatives on the environment. Under NEPA, a “cumulative impact” is defined as an “impact on the environment which results from the incremental impact of the action when added to the past, present, and reasonably foreseeable future actions, regardless of what agency (federal or non-federal) or person undertakes such other actions. DEIS at 5-1 and 40 CFR § 1508.7. Much of the information contained in the cumulative impact analysis (CIA) section of the DEIS overlaps with information regarding other threats to gray whales. Consequently, those issues are addressed together in this section of the comment letter.

The geographic and temporal scope of the CIA included the entire range of ENP gray whales over an indefinite time period. DEIS at 5-2/5-3. These provide an appropriate scope for the CIA although, considering that WNP gray whales are known to emigrate into the ENP region and that one or more could theoretically be killed as a result of the hunt, not including the WNP range in the CIA is in error. DEIS at 5-2. Surely, if a Makah hunt resulted in the death of a WNP gray whale then understanding the impact to a critically endangered population of gray whales given other existing and increasing threats would be relevant and should have been included in the CIA.

In its analysis of the CIA, NMFS ostensibly evaluated past, present, and reasonably foreseeable actions in the following categories: harvest of gray whales, shipping, military exercises, fisheries, tourism, marine energy and mining projects, scientific research, natural mortality, climate change and US government policy. DEIS at 5-4. The background portion of the analysis simply confirms that these activities will continue in the future and will impact gray whales to some degree. NMFS then attempts to evaluate the actual cumulative impacts of these different actions in the section 5.2 of the CIA but its analysis is woefully inadequate. Consequently, it is of no surprise that NMFS concludes that nearly all of the 15 environmental factors evaluated will not result in a significant cumulative impact. The only exceptions to this is for the environmental justice and ceremonial and subsistence resources factors where NMFS concluded that Makah Tribe would experience negative cumulative effects if Alternative 1 (the No Action Alternative) was chosen. DEIS at 5-43, 5.44.

For some actions analyzed, NMFS claims that information was not available (e.g., from the Canadian, Russian, or Mexican governments) to assess certain actions under the control of those countries that may impact gray whales or their habitat. NMFS provides no information about the effort made to obtain such information, causing the Coalition to question whether NMFS adequately attempted to secure such evidence by, for example, contacting the relevant government agencies. Nevertheless, NMFS has failed to comply with the NEPA requirements as to unavailable and incomplete information, which further undermines the sufficiency of its CIA. This error must be corrected in a revised analysis either by obtaining the missing information or providing the requisite evaluation of the relevance of the information to the environmental impacts of the proposed action as required by NEPA.

Similarly, the CIA provides no evidence that NMFS contacted relevant state or provincial agencies to obtain information about past, present, and reasonably foreseeable state-approved actions that may impact gray whales and their habitat. The definition of "cumulative impact" explicitly includes actions by non-federal agencies. Yet, NMFS has apparently limited its analysis to those actions authorized and/or undertaken by federal agencies.

In California, for example, the California Coastal Commission (CCC) is responsible for approving projects that may impact coastal resources, yet there is no indication that NMFS reached out to CCC for information relevant to the CIA. Washington and Oregon have agencies similar to the CCC that review and approve coastal projects. At a minimum, NMFS must contact all appropriate state agencies in Alaska, Washington, Oregon, and California to seek information about coastal projects authorized at the state level that may impact gray whales. It must also contact authorities in British Columbia, Canada and in the state of Baja California Norte and Baja California Sur to seek out information from them to include in the CIA. In addition, NMFS should compile a list of all of the relevant IHAs, LOAs, and other authorizations (as published in the Federal Register) that it has issued at least over the past five years in order to include that information in the CIA.

While many of the individual projects authorized by NMFS (or by other countries or agencies) may not, independently, pose any substantive threat to gray whales, when considered together - as is the entire purpose of the CIA - the impacts become significant. Merely asserting that certain actions will continue into the future and that they will or will not result in cumulative impacts - as NMFS has done in the DEIS – entirely ignores the purpose of a CIA.

That purpose is to combine all of the past, present, and reasonably foreseeable future action that may impact, in this case, gray whales and to subject them to a comprehensive and scientifically robust analysis to determine how, when combined, will impact gray whales today and into the future. Such an analysis cannot be based merely on speculation and opinion but rather, must be credible with predictions or projections about how present and future actions will effect gray whale populations and their habitat. Qualitative conclusions are not entirely sufficient in a legitimate CIA unless they are confirmed through a quantitative analysis.

While there is no required methodology for conducting a CIA, a method that would be advisable in this case would involve a modelling exercise to quantify the potential short and long-term cumulative impacts of the various impacts in order to predict potential outcomes under different scenarios.

NMFS has not engaged in such an analysis in the DEIS. Indeed, the foundation of its CIA is speculation and opinion without any substantive underlying analysis. In many cases, while NMFS acknowledges current and future impacts, it doesn't take the next step to assess the cumulative impact of such threats on gray whales and their habitat or, what analysis it provides is deficient. Until NMFS provide a legitimate CIA in a revised analysis it must not continue the current decision-making process.

For the remainder of this section, the Coalition provides a summary of some of the relevant present and future threats to gray whales. While NMFS has included many of these in the DEIS, in many cases the information is inadequate or incomplete. In other instances NMFS has ignored an existing or future threat that it should have considered.

Harvest of gray whales

As discussed in this comment letter, permitting a new intentional take of gray whales by granting the Makah Tribe's request for an MMPA waiver is biologically reckless. There are too many ongoing threats to the species throughout its range, including in the PCFG region, to purposefully allow additional take. For WNP and PCFG, such take is particularly alarming given their small population sizes. Indeed, even NMFS concedes that "killing even a few animals per year (especially over an extended period of time) from the relatively small PCFG could have long-lasting impacts for a group of whales whose population dynamics are not well understood." DEIS at 5-3. Furthermore, since so little is known about the long-term implications of Arctic ecosystem changes attributable to climate change, there is no guarantee that the ENP gray whale population is secure.

The CIA in the DEIS, had it been done objectively and through a quantitative assessment of the combined threats to gray whales and their habitat, would have concluded that the cumulative impacts are substantial. Conversely, based on its deficient analysis, NMFS found that when adding potential impacts of a gray whale hunt under Alternatives 2 through 6 to past, existing, and future levels of disturbance then "reasonably foreseeable future actions would not be expected to have cumulative effects on gray whales in the PCFG, local survey areas within the PCFG range, and individual gray whales. DEIS at 5-40. Of note, NMFS doesn't appear to make a CIA finding for ENP gray whales (nor for WNP gray whales which, in error, it neglected to consider in the CIA.

Shipping

The DEIS includes information about current shipping traffic and how it will increase throughout the range of the ENP gray whales in the future. DEIS at 5-8/5-9. It recognizes that this will increase risks to gray whales as a consequence of ship strikes, ocean noise, and potential fuel spills. Id. at 5-8. It finds that shipping is a reasonably foreseeable future action, but fails to engage in any legitimate quantitative analysis of the potential threats of shipping traffic to gray whales in relationship to the actions identified.

Military exercises

NMFS largely discounts the potential cumulative impacts of military exercises (in waters of the US, Russia and Mexico).

NMFS reports that it was unable to obtain any information about military activities conducted by Mexico and Russia within their respective Exclusive Economic Zones. For Canada, NMFS notes the role of Maritime Forces Pacific (MARPAC) in ensuring the training and operational readiness for the Royal Canadian Navy but claims that it could not find information detailing the types of training or testing that MARPAC conducts within the NMFS CIA analysis area. The failure of NMFS to obtain such information is an ideal example of a weakness in the CIA. It is improbable that if NMFS or the US State Department, on behalf of NMFS, sought the relevant information from Mexico, Canada, and Russia that those governments would not have responded at least to provide basic information about relevant military training activities in the analysis area. Without that information, the CIA is incomplete.

As for the analysis of the impacts of military activities in US waters, NMFS evaluates the impacts of activities conducted within the Southern California Range Complex (SCRC), Northwest Testing and Training Range (NWTTR), and the Gulf of Alaska Range Complex (GOA). The potential impacts from these testing and training exercise include noise (from ships, explosives, sonar), direct harm (from ship strikes, projectiles, underwater explosions, consumption of expended materials), and indirect harm (hearing impairment and loss, disrupting communications, noise masking, behavioral impacts, general harassment).

Instead of providing a credible analysis of these impacts, NMFS largely dismisses any significant threat to gray whales by citing to its relevant Biological Opinions for the different ranges and complexes. These Biological Opinion's generally conclude the overall impact from such exercises, which they concede will result in harassment (primarily Level B). Notably, for the SCRC, NMFS has authorized 15 Level A takes (through harassment) of ENP gray whales and, in addition, 15 whale injury, mortality, or serious injuries for 15 gray whales of which three, shockingly, can be WNP gray whales. Considering that this population of gray whale is critically endangered, that level of mortality or serious injury rate is excessive. Furthermore, relying on old Biological Opinions for this CIA is inappropriate. NMFS should have engaged in a new analysis of these impacts specific to gray whales and their habitat.

In general, for all gray whales subject to military testing and training activities, NMFS dismisses potential adverse impacts claiming that "any stress responses or disruptions of normal behavior patterns of gray whales would not continue long enough to have fitness consequences for individual animals because these whales are likely to have energy reserves sufficient to meet the demands of their normal behavioral patterns and the additional demands of any stress responses." DEIS at 5-15. Of course, NMFS provides no data to support its contention that gray whale exposure to such military training exercises will be only temporary nor has it disclosed evidence to substantiate the assertions that gray whales have sufficient energy reserves to both meet daily demands and to deal with acute or chronic stress impacts. NMFS must provide such data if it wants to ensure that its CIA is credible and legal.

While NMFS concedes that in past Biological Opinions, WNP gray whales were not considered, it is evaluating impacts to that population in pending decisions regarding continuation of military testing and training activities in the NWTTR and the GOA ranges. In regard to the SCRC, a court recently ruled in favor of plaintiffs challenging a Biological Opinion prepared by NMFS to evaluate the impacts of the military's training and testing in that region. *Conservation Council for Hawaii v. NMFS* (2015 WL 1499589 at *48-50 (D. Hawaii Mar. 31, 2015).

In particular, given the increasing body of scientific evidence documenting the adverse impact of ocean noise, including sonar and seismic testing, on marine mammals and other ocean species, this issue in particular warranted far greater analysis in the CIA. Indeed, surprisingly, while NMFS provides some information about ocean noise in the affected environment and environmental consequences sections of the DEIS, it virtually ignores the issue in its CIA. Not only can such anthropogenic noise directly harm whales through temporary or permanent hearing loss, but the behavioral implications of acute and chronic exposure to human-caused noise sources can cause behavioral changes that can have serious consequences to gray whales. This can include disrupting feeding and breeding activities, abandonment of preferred habitat, and avoidance reactions that may result in increased stress and have adverse bioenergetics consequences.

Considering the increase in anthropogenic noise in the Pacific Ocean, including noise associated with military operations, and recognizing that climate change will increase human activities in the Arctic which, in turn, will increase noise impacts, NMFS must provide a far more substantive and scientifically robust evaluation of noise impacts in a revised document.

Fisheries

NMFS acknowledges the adverse impacts of various fisheries on gray whales and concedes that reported fishery-related mortality is an underestimate of actual mortality. This is, in part, due to the lack of observer coverage in many of the west coast fisheries that are known to pose a risk to gray whales. For example, no observers are assigned to most of the Alaskan gillnet fisheries, including those in Bristol Bay known to interact with gray whales. DEIS at 41. Similarly, due to a lack of observer data for mortality in Canadian commercial fisheries, data is not available but NMFS estimates it to be approximately two whales per year. The DEIS contains no information about any commercial fishery-related mortality of gray whales in Mexico.

Overall, NMFS reports a known, but minimum, estimate of commercial fishery-related mortality was 12.25 ENP gray whales between 2007 and 2011 (Carretta et al. 2014), or an average of 2.45 gray whale per year. DEIS at 3-195. This is limited to reported mortalities in US waters only indicating that the actual number is larger if mortalities in Mexico and Russia were included.

NMFS provides some limited gray whale entanglement data for Mexico for 2013 where six gray whales were reported entangled in fishing gear . DEIS at 5-19. For Russia, NMFS reports that no data on gray whale entanglements were available, *id*., and apparently none could be obtained from Canada either. For PCFG gray whales, for the same period of time, the DEIS reports a mortality rate of one whale or 0.15 whales per year; figures that must be underestimates given the commercial fishing activity within the PCFG range. Punt and Moore (2013) estimate that reported strandings of gray whales represent only 3.9 to 13 percent of actual mortality. DEIS at 3-193. Consequently, average actual fishery-related gray whale mortalities in US waters may range from 18 to 62 animals annually.

When evaluating the cumulative impacts of this action in relationship to the hunt, NMFS should not use reported mortality rates as that will significantly underestimate actual mortality. Furthermore, while the reported mortality statistics above are for US fisheries, there is likely unreported mortality associated with other forms of mortality (i.e., ship strikes, sonar use, seismic testing). If the mortality rate from Punt and Moore is used to determine actual mortality for all types or reported mortality, the estimated number of whales lost due to human-caused mortality may be far higher than expected.

Since gray whales are known to sink when they die, NMFS needs to identify unreported mortality rates for these other forms or mortality so that it can conduct a credible quantitative CIA as well as to determine if human-caused mortality exceeds PBR. This is precisely the type of analysis that NMFS should undertake in a comprehensive CIA.

Tourism

NMFS notes that the number of people engaging in whale-watching in the ENP increased from 2.8 million in 1998 to over 3.3 million in 2008. DEIS at 5-20. Since 2008 the numbers have likely increased. NMFS also acknowledges that the activity of commercial whale-watching vessels and private recreational boats has increased concerns about potential effects on gray whales. DEIS at 5-22. The Coalition concurs with this assessment. While whale-watching provides a unique opportunity for millions of people annually to enjoy whales in their natural habitat, to learn about marine species and marine ecology, and that whale-watching generates billions in revenue worldwide, it is not with potential risk to marine wildlife. Improperly or non-regulated whale-watching operations or even an excessive number of operators in a concentrated area can have adverse impacts on marine mammals and other species.

This constitutes another threat to gray whales which has not been sufficiently studied to understand the full range of direct and indirect impacts to these animals. NMFS has also failed to quantify this effect in its CIA in order to better understand its impact in the context of other impacts on gray whales and their habitat. Instead of engaging in such an analysis, NMFS has concluded that whale-based tourism is a reasonably foreseeable future action that will continue to impact gray whales throughout their range in the ENP. DEIS at 5-22. It does not appear that the CIA provides a determination as to the cumulative impacts to gray whales as a result of tourism when considered alongside the proposed hunt.

Marine energy and mining projects

NMFS discloses information about active and proposed energy and mining projects within the range of the gray whale. For example, it notes the proposed construction of a number of Liquefied Natural Gas terminals (DEIS at 5-9) while also providing some data on oil spills particularly in Washington State waters. It provides a basic explanation of oil and gas development in the Arctic and both its role and the role of the Bureau of Ocean Energy Management in overseeing, authorizing, or permitting such projects.

What it fails to do, however, is to engage in a credible analysis of the direct and indirect impacts of these projects on gray whales and their habitats. There's no serious analysis of the impacts of oil/gas exploration or production activities on gray whales (i.e., seismic testing, drilling noise, ship traffic), no substantive discussion of the lethal and sub-lethal impacts of oil on gray whales, and no assessment of the potential for a significant oil spill within the range of the gray whale or how such a spill would impact gray whales and their habitat. In the Arctic, since summer is the only time when drilling can be commenced, a spill associated with production processes would occur when gray whales are in the region. Given the controversy surrounding President Obama's recent decision to allow Shell Oil to drill in the Arctic, this emphasizes the need for a more complete analysis. The notion that such spills are unrealistic or unlikely due to the efforts made by the oil and gas companies to prevent such accidents is not (and never has been) cause for complacency particularly as a result of the Deepwater Horizon spill in the Gulf of Mexico several years ago.

Notably, NMFS failed to even disclose a mining project in Mexico that may significantly impact gray whales. Although not yet approved, a large phosphorous mining operation has been proposed in the Gulf of Ulloa between Apreojos and Cabo San Lazaro, Mexico. A summary translation of the first few paragraphs of the Environmental Impact Statement[57] prepared on the proposed mine states that:

[57] The EIS can be accessed at: http://consultaspublicas.semarnat.gob.mx/data/expediente/bcs/estudios /2014/03BS2014M0007.pdf

- The project is to be located within the Mexican EEZ in the Gulf of Ulloa, on the west coast of Baja California Sur between Apreojos and Cabo San Lázaro, about 22 km off the coasts.
- It is projected that 7 million tons of phosphates will be extracted each year for a period of 50 years, equal to a rate of 19,178 tons a day; the digging will be done 24 hour per day, 7 days per week or each year.
- The EIS does not mention the total quantities of other materials that would also be removed and then returned to the ocean as waste. An analysis by Dr. Janette Murillo Jimenez, however, indicated that to produce the quantity of phosphate indicated 150,000 tons of sediment would need to be removed daily. "These quantities are so large that they would require more than one processing vessel, would generate a plume of sediment and waste, of which argillaceous particles would be left permanently in the water in the area due to the continual agitation."
- The company seeking the permit, Exploraciones Oceánicas, S. de R.L. de C.V. (a subsidiary of a US company Odyssey Marine Exploration Inc, Omex) is a vessel salvage company which has no experience in submarine dragging, and even less in mining phosphates. In other countries in which similar proposals have been presented they have not been approved, and Namibia has a moratorium on such activities. This is due to concerns about fisheries.

Furthermore, in a recent article published in Excelsior[58], a periodical in Mexico, Dr. Jorge Urban-Ramirez, head of the Marine Mammal Research Program from the Universidad Autónoma de Baja California Sur, noted that the project would impact the migratory route of gray whales which for millennia have traveled 10,000 kilometers from the Arctic Ocean, through the Bering and Chukchi Seas between Alaska and Siberia, to the Baja California, peninsula in order to rest and give birth.

Dr. Urban-Ramirez, who is respected gray whale biologist with 32 years invested into the study of the species, states that “the underwater noise from the mining activity would mask the acoustic communication that exists between the whales principally in the Laguna complex at Bahia Magdalena, the closest point to the Don Diego (name of mining project) project, where every year a large number of gray whale calves are born,” and that “the greatest potential damage is to the north where the mothers with calves will be precisely in the drag zone.”

While he reports that the noise generated by the mine, if it were allowed, would not kill gray whales, it would trigger a behavioral response that would cause them to divert from their

[58] See http://www.excelsior.com.mx/nacional/2015/01/18/1003281

normal migratory route which, in turn, would result in greater energy expenditures while also potentially adversely impacting the whale-watching tourism industry in the area.

Natural mortality

NMFS notes the potential impacts of killer whale predation on gray whales but largely ignores the role of sharks as natural predators of gray whales, particularly gray whale calves. In addition, it does not sufficiently consider the potential impact of predation on gray whales in the context of the other threats and stressors on the population. For example, the delay in the south of the southbound migration, which is linked to ocean warming in the Arctic and the expansion of the gray whales' range, has led to an increase in births outside of the Mexican lagoons. Some births are now occurring in coastal waters as far north as central California. Gray whale calves born in these areas are more susceptible to predation than those born in the lagoons. NMFS has not quantified such impacts for the purpose of its CIA. Nor has it considered predation severity throughout the migratory range. Unimak Pass, Alaska, is an area where gray whales may be most susceptible to predation by killer whales, who take advantage of this relatively narrow passage way to kill gray whales. NMFS must provide a far more substantive analysis of the impact of predation on gray whales as both a separate threat to the species as well as in the context of a credible CIA.

Climate change

As previously noted, ocean warming caused by climate change is significantly impacting the Arctic. A regime shift is ongoing whereby a benthic driven ecosystem is transitioning into a pelagic system. This has significant potential implications to gray whales and their prey, including amphipods. As the composition and density of fish stocks increase in Arctic waters, benthic productivity is declining, forcing gray whales to expand their range. The consequences of this shift are documented in the scientific literature but, more recently, evidence of this shift is available in the form of an agreement between the US, Russian Federation, Canada, Norway, and Denmark (representing Greenland) to prevent unregulated commercial fishing in the Arctic. This agreement, signed on July 16, 2015 is a product of the regime shift in the Arctic linked to climate change. According to a press release issued by the US State Department about the agreement:

> The declaration acknowledges that commercial fishing in this area of Arctic Ocean – which is larger than Alaska and Texas combined – is unlikely to occur in the near future. Nevertheless, the dramatic reduction of Arctic sea ice and other environmental changes in the Arctic, combined with the limited scientific knowledge about marine resources in

> this area, necessitate a precautionary approach to prevent unregulated fishing in the area.[59]

The countries have agreed to initiate research in the region to better understand changes occurring to the Arctic. It is precisely this type of precautionary approach that must be applied in the context of the Makah hunt. Given the need to better understand the changing Arctic environment and what it means to whales and other Arctic and sub-Arctic species, permitting direct lethal take of gray whales at this time is reckless.

Another threat to gray whales linked to climate change is ocean acidification. NMFS provides some information about this threat in the DEIS. It notes, for example, that ocean acidification can change the chemical composition of ocean water, which will decrease its ability to absorb sound, thereby making the oceans even noisier than they are at present. DEIS at 3-198. While this could cause both direct and indirect adverse impacts on gray whales, the fact that ocean acidification will reduce the abundance and types of shell forming organisms, “many of which are important in the gray whales diet,” DEIS at 3-197, is also a significant concern. While gray whales are expanding their range to find additional food sources, such an expansion will be irrelevant if potential prey species are eliminated or reduced as a consequence of climate change.

Climate change is also increasing human activities in the Arctic, including oil and gas exploration and development and shipping traffic . Both of these activities also can adversely impact gray whales directly and indirectly as well as by impacting their habitat.

NMFS provides some information about hypoxic zones in the DEIS but its analysis is deficient. While it notes that such zones are now increasingly linked to climate change (as well as associated with poor land management activities), it fails to disclose where such zones exist within the ENP gray whale range, if the zones are increasing in size, if they are more prominent in certain seasons, or what direct or indirect impacts they have on gray whales and gray whale prey. Nor has NMFS adequately consider these zones in the CIA.

What NMFS failed to address in its assessment of climate change in the CIA is the predicted “strong” El Nino event for the upcoming winter season.[60] Considering that this prediction was made by NOAA, it is troubling that it was not addressed in the CIA. During a previous “strong” El Nino in 1997-1998, the ENP gray whale population was significantly and adversely impacted as

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[59] Available at http://www.state.gov/r/pa/prs/ps/2015/07/244969.htm
[60] See https://www.climate.gov/news-features/blogs/enso/june-el-ni%C3%B1o-update-damn-torpedoes-full-speed-ahead

a result of substantial mortality. During and after that event, ENP population estimates declined from over 20,000 whales in the late 1990s to approximately 16,000 in the early 2000s. While no one can predict if this predicted El Nino will have similar impacts, the precautionary principle mandates that this potential be considered in management decisions.

Finally, NMFS fails to discuss "the blob," a warm water anomaly in the Northeast Pacific that has led to significant ecological destruction. Bond et al. (2015)(Attachment 8).

US government policy

This issue was addressed previously in this comment letter. No further comments are necessary.

Additional Comments:

The environmental consulting firm used by NFMS to prepare the DEIS has an unacceptable conflict of interest:

NMFS hired Parametrix, a Washington state-based environmental consulting firm, to prepare the 2008 and 2015 DEIS documents. In 2008, AWI and other NGOs raised concerns that Parametrix had a conflict of interest, as it had done work for the Makah Tribe (e.g., on the Cape Flattery Scenic Byway Corridor Management Plan). In 2008, Parametrix had a contract with NMFS and the Makah Tribe simultaneously. Appendix C-22. NMFS dismissed these concerns, claiming that: 1) Parametrix and its subcontractors signed disclosure statements affirming "that there is no conflict of interest by being employed by both the Tribe and NMFS (*id*. at C-23); 2) due diligence reviews by NMFS of Parametrix's role as a contractor for the Tribe did not pose a potential for conflict (*id*.); and 3) "no biased information could be inserted into the DEIS under our sole supervision." *Id*. NMFS also noted that producing an EIS is the responsibility of the Federal action agency and that it did "not consider the relationship between Parametrix and the Tribe to have compromised the integrity of Parametrix's work product." *Id*.

These statements do not reassure the Coalition that Parametrix does not have a conflict of interest and that its role in preparing NEPA documentation for the Makah hunt did not compromise the objectivity and integrity of the 2008 and now the 2015 DEIS documents. In the list of preparers of the DEIS (DEIS at 8-1/8-2), NMFS fails to include the affiliations of all but two of the 27 people identified. One person whose affiliation was disclosed was the DEIS project manager for Parametrix and the other is a NMFS employee. Independent research conducted by the Coalition reveals that of the remaining 25 people identified, 12 are employed by NMFS, nine are (or were) employed by Parametrix, and four were employed elsewhere.

Beyond mere affiliation, however, an examination of the Parametrix website (http://www.parametrix.com/) reveals the following description of who the firm serves:

> Parametrix has served more than 50 tribes, pueblos, and rancherias. We support tribal governments' long-term visions, concern for future generations, and efforts to strengthen their sovereignty. Integrity and trust are the foundation of our efforts to serve tribes and provide the highest level of client service.
>
> We frequently assist tribal clients with infrastructure improvements, economic development, environmental planning and protection, and comprehensive land use planning—all critical to enhancing the quality of life in tribal communities and creating economic self-sufficiency for members and business. We often assist tribes in identifying and obtaining grant funding through our understanding of BIA processes, other governmental funding programs, and innovative partnerships.
>
> We are proud of the relationships we have built with our tribal clients and are committed to growing and nurturing these relationships in the future.

(accessed at http://www.parametrix.com/who-we-serve/tribes-pueblos-rancherias)

This webpage includes a picture of Parametrix employees and Makah Tribal officials. See Figure 7. It is not just a picture that causes concern, but Parametrix's support for "tribal governments' long-term visions" and "strengthen[ing] their sovereignty," which suggests an inherent bias in favor of the Tribe's interests. Such support is admirable, but not for a consulting firm supposedly providing an objective and scientifically sound work product evaluating the environmental impacts of Makah whaling.

Figure 7: Lower left image is of a Parametrix project on the Makah reservation. Available at http://www.parametrix.com/who-we-serve/tribes-pueblos-rancherias

Given the close past and present ties between Parametrix and the Makah Tribe, the use of Parametrix to prepare the DEIS was a poor choice and raises serious questions about the credibility of the content and impartiality of the analysis. While this error cannot be undone, NMFS must cease its relationship with Parametrix and either engage in an internal reevaluation of the content and analysis in the DEIS or hire a new environmental consulting firm with no ties to the Makah or other Native American tribes to perform such a reevaluation.

The Makah Tribe's promulgation of its 2013 Makah Whaling Ordinance raises concerns about the integrity of the DEIS process:

Included in the DEIS is a 2013 Makah Whaling Ordinance that was enacted by the Makah Tribe in August 2013. While the Makah Tribe can adopt any ordinances it deems appropriate, the adoption of a whaling ordinance in 2013 is odd. Considering that the present DEIS would not be published for another 20 months, that the NEPA and MMPA processes that must be completed to determine if the Makah Tribe will receive a waiver could take several years, and that, without the waiver, the Makah Tribe cannot whale, it seems unusual for the Tribe to expend the time, energy, and resources to develop and promulgate a whaling ordinance. While this may simply represent a choice made by the Makah Tribe, it could also reflect the Makah Tribe's understanding that it will receive a waiver and will be allowed to resume whale hunting. If NMFS has tacitly or expressly conveyed any guarantees to the Makah Tribe to cause them to develop such an understanding, it means the outcome of this planning process has been predetermined, in violation of NEPA.

As NMFS may recall, in *Metcalf v. Daley* (214 F.3d 1135 (9th Cir. 2000)), the appellate court found in favor of the plaintiffs because NMFS entered into a cooperative agreement with the Makah Tribe days before it published its Final EA and Finding of No Significant Impact. The court held this action predetermined the outcome of the NEPA process. The facts here are different, but the concern is the same. While it is unknown if NMFS suggested, recommended, or directed the Makah Tribe to adopt a whaling ordinance in 2013, this issue warrants some discussion and explanation by NMFS.

Conclusion:

Based on the foregoing evidence and analysis, NMFS must deny the Makah Tribe's request for an MMPA waiver application and terminate the NEPA process. There is no other legal option. It is time for this 20-year effort to end. The Makah Tribe does not qualify for an IWC-approved ASW quota and NMFS cannot issue an MMPA waiver to allow a Makah hunt without violating the law. Furthermore, as exhaustively demonstrated in this letter, the DEIS is woefully inadequate—failing to satisfy the requirements of NEPA. The purpose and need statements are invalid, NMFS has not considered a reasonable range of alternatives, it has failed to disclose all relevant information, and its analysis of the environmental consequences of the hunt is neither complete nor accurate.

If NMFS, despite the overwhelming evidence, makes a preliminary determination to issue the MMPA waiver, the Coalition will participate in the process in order to demonstrate conclusively that issuance of the waiver is illegal and that, therefore, the Makah's whale hunt cannot be allowed.

Thank you in advance for considering this information. Should you have any questions or require additional information, please contact me at dj@awionline.org or, by telephone, at (609) 601-2875.

Sincerely,

DJ Schubert
Wildlife Biologist

cc: Dr. Rebecca Lent, Executive Director, Marine Mammal Commission

Attachments:

Attachment 1: C. Wold and M. Kearney. 2015. The Legal Effect of Greenland's Unilateral Aboriginal Subsistence Whale Hunt. American University International Law Review. Vol. 30, Issue 3, Article 5.

Attachment 2: Lang, A. R., Calambokidis, J., Scordino, J., Pease, V. L., Klimek, A., Burkanov, V. N., Gearin, P., Litovka, D. I., Robertson, K. M., Mate, B. R., Jacobsen, J. K. and Taylor, B. L. 2014. Assessment of genetic structure among eastern North Pacific gray whales on their feeding grounds. Marine Mammal Science, 30(4), 1473–1493. doi:10.1111/mms.12129

Punt, A.E. 2015. An Age Structured Model of Exploring the Conceptual Models Developed for Gray Whales in the North Pacific. SC/SC65b/BRGx.

Attachment 4: Øen, E.O. Killing efficiency in the Icelandic fin whale hunt 2014. Report to the Directorate of Fisheries in Iceland, February 19, 2015. Wildlife Management Service-Sweden.

Attachment 5: Kuczaj, S. 2007. Considerations of the Effects of Noise on Marine Mammals and other Animals. International Society for Comparative Psychology.

Attachment 6: Conservation Council of Hawaii v. United States

Attachment 7: United States v. Washington

Attachment 8: Bond, N.A., Cronin, M.F., Freeland, H., and Mantua, N. 2015. Causes and impacts of the 2014 warm anomaly in the NE Pacific. Geophysical Research Letters. 42.

Review of the status of the western North Pacific gray whale; stock structure hypotheses, and recommendations for methods of future genetic studies.

JOHN W. BICKHAM[1], JENNIFER M. DUPONT[2], AND KOEN BROKER[3]
[1]*Battelle Memorial Institute, 10777 Westheimer, Suite 1105, Houston, TX 77042*
[2] *ExxonMobil Upstream Research Company, Houston, Texas 77252*
[3]*Shell Global Solutions International, Lange Kleiweg 40, 2288 GK Rijswijk, The Netherlands*
Contact email: bickhamj@battelle.org

ABSTRACT

The North Pacific Gray whales (*Eschrichtius robustus*) are considered to consist of a large (19,000) eastern population and a small (ca. 155) western population. Genetic comparisons between eastern and western gray whales indicate that the populations are distinct. However in recent years, satellite tagging and photographic and genetic matches have provided evidence of overlap of the migration routes of the eastern and western populations and raise questions as to whether these whales are distinct populations. This paper reviews the issue of stock structure of North Pacific gray whales and the status of the western gray whale population. We present a range of plausible stock structure hypotheses and a discussion of genetic methods needed to test them.

Introduction.—The gray whale (*Eschrichtius robustus*) was once common in the North Pacific and North Atlantic Oceans but was extirpated from the Atlantic by the early 1700s. The extant North Pacific population is considered to be comprised of two populations or stocks. An eastern North Pacific population (eastern gray whales) winters in the subtropical waters of Baja, Mexico and migrates along the continental shelf of western North America primarily to summer feeding grounds in the Bering, Chukchi and Beaufort Seas. A western North Pacific population (western gray whales), the subject of this paper, inhabits summer feeding grounds in the Sea of Okhotsk, off the northeast coast of Sakhalin Island and the southeastern coast of the Kamchatka Peninsula. However, its migratory and wintering habits are not well known. Information collected since the 1930s show the western gray whale to migrate in coastal waters of Japan and South Korea to wintering habitat somewhere in the South China Sea (Weller and Brownell, 2012). Recent genetic studies suggest that eastern and western gray whales are discrete (Lang et al., 2011a).

Both the Atlantic and Pacific populations were hunted extensively and over-hunting likely contributed to the extinction of the Atlantic population (Mead and Mitchell, 1984; Weller and Brownell, 2012). The Pacific populations were reduced to very low numbers as well. With regard to the level of depletion of the Pacific population, Alter et al. (2012) estimate the number of mature females at the bottleneck to be approximately 1,300. This estimate is based on genetic diversity of the extant North Pacific gray whale population and thus includes both stocks in its calculations. Pre-commercial whaling population size of the eastern Pacific gray whale population was estimated to be 15,000 to 20,000 based on an examination of whaling records (Henderson, 1984). However, little is known of the historical population size of the western North Pacific population. Berzin and Vladimirov (1981) estimated that the western North Pacific population numbered 1,000 to 1,500 individuals prior to 1910, and this number has been generally accepted. However, Alter et al. (2007, 2012a) used genetic methods to estimate historical population sizes and concluded that the Pacific population, including both eastern and western stocks, likely numbered approximately 100,000 individuals prior to whaling. The relative sizes of the eastern and western populations were not estimated. Notwithstanding the uncertainty of the pre-exploitation size of the western North Pacific gray whale, it clearly had a much larger distribution than the population that now summers in the Sea of Okhotsk (Reeves et al., 2008) and it was reduced to a much smaller size than the eastern population.

Currently, the western population only numbers about 155 (IUCN 2012a) and is considered as critically endangered (IUCN, 2008). Only 32 reproductive females have been documented in this population (Burdin et al., 2011) and the loss of a single reproductive female annually could be sufficient to lead to the loss of the population (IWC, 2006, pp.10, 67). This contrasts markedly with the eastern population which was reduced to approximately 2,000 but has made a strong recovery and now numbers about 19,000 (Laake et al., 2009). Potential threats to the western population include accidental takes by fishermen (IWC 1994; Kato et al., 2006), poaching, ship strikes, pollution, and oil and gas development near their summer feeding sites.

The western North Pacific gray whale population is believed to have been comprised of two subpopulations; a small Japanese subpopulation that wintered in the straits between the islands of Honshu, Kyushu and Shikoku, and summered north of the island of Hokkaido (Andrews, 1914; Mizue, 1951) and the Okhotsk-Korean subpopulation that summered in the Sea of Okhotsk and wintered in Korea and China. Whales of the latter population were hunted near Sakhalin Island, the Kuril Islands, and Korea in the first half of the 20th Century (Brownell and Chun, 1977) but by 1966 the population was considered to be extinct (Bowen 1974; Weller et al., 2002; Cooke et al., 2008). However, in the late 1960s and the 1970s small numbers of whales in groups of one to three were sighted in the Sea of Okhotsk, South China Sea and the Sea of Japan (Ilyashenko, 2011). The population was estimated to be 100-200 individuals by Berzin and Yablokov (1978; cited in Ilyashenko, 2011). In the 1980s larger groups of whales began to be observed.

It is generally assumed that the small population of whales that summers off the northeastern coast of Sakhalin Island is the surviving remnant of the western North Pacific gray whale population (Weller et al., 1999, 2012). Occasional sightings or strandings of whales in Japan, Korea and China give credence to the belief that this population summered in the Sea of Okhotsk and migrated south to wintering sites in Asia which is thought to be the historical migration pattern of the western North Pacific gray whale. One ostensibly migrating whale killed in Japan was matched photographically to a whale photographed as a calf in the Sea of Okhotsk (Weller et al., 2008; Weller and Brownell, 2012) providing the first confirmation of this migratory corridor in recent times. Since 2002 photographic and biopsy data have been collected from the whales that summer in the Sea of Okhotsk on the northeastern coast of Sakhalin Island and southeast Kamchatka (Tyurneva et al., 2012). Genetic studies have compared these whales to various samples taken from the eastern North Pacific gray whale population using mitochondrial DNA (mtDNA) sequences which track maternal lineages, and a moderate number (8-13 depending on the study) of microsatellite loci which are biparentally inherited markers. Both the mtDNA and microsatellite loci show statistically significant differentiation of the eastern and western populations (Lang et al., 2010).

Taken together, the evidence appears to support the hypothesis that this small population is the remnant of the once presumed extinct western North Pacific gray whale population. However, in 2010 a satellite tag was placed on a 13-year old male western gray whale off the northeast coast of Sakhalin Island (Mate et al., 2011). The whale, known as “Flex” began his migratory journey on December 12, 2010 by travelling eastward to the west coast of the Kamchatka Peninsula. He swam around the southern tip of Kamchatka and proceeded north along the coast to Kamchatka Bay. By January 3, 2011 Flex began to swim east across the Bering Sea towards the North American continent. He crossed the Gulf of Alaska and arrived at the coast of Washington, USA by February 2, 2011. The transmitter failed three days later on February 5 near the Oregon coast with Flex apparently heading south along the North American coast.

Better data were obtained from a transmitter placed on a female western North Pacific gray whale at Sakhalin named “Varvara” in 2011. That transmitter lasted for more than a year and Varvara was tracked from Sakhalin to the eastern North Pacific gray whale wintering areas off western Baja, Mexico, and then back again to Sakhalin (IUCN 2012b).

Flex’ surprising journey prompted examination of other possible records to determine if the whales that summer in the Sea of Okhotsk might generally migrate to and from North America rather than, or in addition to wintering habitats in Asia. Matches of photographs of whales taken at Sakhalin were made with photographs of whales from British Columbia (n = 6, Weller et al., 2011) and Mexico (n = 13, Urban et al., 2012) and genetic matches (n = 2, Lang et al., 2011a) of whales biopsied at Sakhalin and Southern California have now been reported as well as the whales with satellite tags (unpublished). Thus, a total of 23 whales have been identified that have travelled between the Sakhalin Island summering localities and North America. This represents approximately 15% of the western North Pacific gray whale population.

Clearly questions remain about the population biology of the whales that summer in the Sea of Okhotsk. Central to this is the finding of significant mtDNA and nuclear gene differences between this population and the eastern gray whales in the face of what appears to be a high level of mixing. This paper seeks to clarify the potential stock structure scenarios that are consistent with the data on genetics, distribution and movements of these whales and makes recommendations regarding genetic methods to help resolve the issue.

Genetic differentiation of western and eastern North Pacific gray whales.—The genetics of the western North Pacific gray whale population has been studied and compared to the eastern gray whale population using mtDNA (LeDuc et al., 2002; Kanda et al., 2010; Meschersky et al., 2012), nuclear microsatellites (Lang, 2010; Lang et al., 2010b), and both (Lang et al., 2011a). These studies consistently show evidence of genetic divergence between the populations expressed as statistically significant differences in mtDNA haplotype frequencies (Fst) and microsatellite allele frequencies (Fst). The level of genetic diversity (e.g., heterozygosity) is similar for microsatellites as is nucleotide diversity of mtDNA, but mtDNA haplotype diversity is substantially greater for the eastern population than for the western population (Lang et al., 2011a). The findings that two of the estimates of genetic diversity are similar and the values for these estimates are fairly high indicate that a substantial amount of genetic variation exists within the small western population, despite the severe population reduction caused by hunting. However, the distributional pattern of haplotypes is distinct between the two populations with two haplotypes being of very high frequency in the western population (haplotype A, 0.51 and B, 0.44) whereas the most common haplotype in the eastern gray whale population was 0.15

(haplotype A). The genetic results are consistent with the two populations being distinct, and of drastically different sizes especially with respect to the number of breeding females.

The question of genetic distinctness between the two populations, however, seems to be inconsistent with the observation of a substantial (but as yet unknown) proportion of western gray whales migrating to North America rather than to wintering habitats in Asia. And it must also be recognized that an apparently high level of (primarily) male mediated gene flow has been documented by Lang et al. (2011a) who report a significant Fst for microsatellites for females, but not for males between the eastern and western populations. (When the sexes are combined the analysis shows a significant Fst, but when sexes are analyzed separately only the female comparison is significant. Of course, statistical power is inevitably lost when the sample sizes are reduced for separate analyses of the sexes.). The fact that both males and females in approximately equal numbers (but from an admittedly small sample size) of the western population are known to migrate to North America (Urban et al., 2012), further questions the population structure of gray whales in the Pacific basin.

Population structure hypotheses.—In light of the uncertainty of the nature and history of the western population it is useful to consider stock structure hypotheses that could be consistent with current information on genetics, movements, and distribution of the eastern and western North Pacific gray whale populations.

- Hypothesis 1: a single panmictic population (the eastern gray whales, the western population is extinct; no population structure within the eastern population).
- Hypothesis 2: a single metapopulation (the eastern gray whales includes a genetically distinct subpopulation that summers in the Sea of Okhotsk, genetic differentiation could be due to familial structure or founder effect, or driven entirely by matrilineal fidelity).
- Hypothesis 3: A large eastern population that co-inhabits with the surviving remnant of the western population on the summering range in the Sea of Okhotsk, but the two populations do not interbreed (eastern animals migrate to NA, western animals to Asia).
- Hypothesis 4: A large eastern population that interbreeds with the surviving remnant of the western population (eastern animals migrate to NA, western animals to Asia).
- Hypothesis 5: Two surviving populations, one very large eastern population and a small western population (ca. 155 animals). The Sea of Okhotsk population consists entirely of western gray whales which migrate to both NA and Asia.

These five hypotheses are not exhaustive of stock-structure possibilities but will serve to frame a discussion of what is needed from genetics to resolve the issue. To begin, it must be stated that the well entrenched hypothesis of two geographically isolated and genetically distinct pre-depletion North Pacific gray whale populations consisting of an eastern population that migrated along the North American coast and a western population that migrated along the Asian coast might not be correct. There is very good evidence of the two migratory corridors, but there is no data available regarding genetic differentiation of Asian and North American wintering populations. The best way, and perhaps the only way, of determining the genetic makeup of the pre-depletion western gray whale is by genetic analysis of historical samples as was previously suggested by Brownell et al. (2009). While tissue samples that predate the depletion are not available, bones, baleen or other sub-fossil materials, and even cultural artifacts from the period might be used. Such material has been successfully used to help reconstruct the population structure of bowhead whales (Alter et al., 2012b; Borge et al., 2007; Morin et al., 2012) and to investigate the impacts of whaling on eastern North Pacific gray whales (Alter et al., 2012a).

Hypothesis 1 considers a single panmictic population representing the extant eastern North Pacific gray whale population. The hypothesis implies both the absence of the (extinct) western gray whale, and a lack of substructure within the extant population. While the western gray whale might be extinct, clearly there is ample evidence of genetic differentiation of the Sea of Okhotsk population (Lang et al., 2011a) to reject the hypothesis of panmixia.

Hypothesis 2 considers the eastern population to be a metapopulation with subpopulations that can be somewhat genetically distinct but not necessarily completely isolated. There is already evidence that the eastern population is functioning as a metapopulation in that the Pacific Coast Feeding Group (PCFG) is genetically distinct in terms of mtDNA (Frasier et al., 2011) from the main population and the Sakhalin population might also be functioning as a "feeding group". Under this hypothesis the western population would not be a remnant of the pre-depletion western gray whale population, but instead a small population founded by a group of eastern emigrants that have diverged genetically due to a strong founder effect and genetic drift. This is consistent with the observations of no signature of a bottleneck and a non-significant Fst for males (Lang et al., 2011a). Thus the population that summers in the Sea of Okhotsk would represent an expanding population established by a small number of founders and whose genetic differentiation is driven by female fidelity to the summer feeding area. It is also consistent with the observed migration data wherein Sea of Okhotsk whales migrate to the NA wintering lagoons in Mexico. Whales that have migrated south along the Asian coast and to Japan are explained as wanderers from the eastern population as discussed in previous studies (Nishiwaki and Kasuya, 1970; Bowen, 1974; Ilyashenko, 2011).

Hypothesis 3 considers the whales summering in the Sea of Okhotsk to include animals of eastern descent along with the surviving remnants of the pre-depletion western North Pacific gray whale population. The two populations do not interbreed as mating takes place during migration toward the respective wintering areas. This is consistent with the genetics data, as well as the observations of movements between the Sea of Okhotsk and both NA and Asia. However, a Wahlund effect would be expected to cause diploid loci to be out of HW equilibrium and to be maintained across generations. A Wahlund effect is a reduction of observed heterozygosity in a sample caused by subpopulation structure. It stems from the fact that when samples from two populations with different allele frequencies are inadvertently mixed and analyzed as a single population, there appears to be a deficit of heterozygosity. This occurs even when both populations are in Hardy-Weinberg equilibrium. The severity of the Wahlund effect is determined by the degree of genetic differentiation of the two populations.

Hypothesis 4 also considers the whales that summer in the Sea of Okhotsk to include animals of eastern descent along with the surviving remnants of the pre-depletion western North Pacific gray whale population but in this scenario the two populations interbreed. This is consistent with the genetics data, as well as the observations of movements between the Sea of Okhotsk and both NA and Asia. The Wahlund effect would be reduced in each generation at a rate depending on the level of interbreeding.

Hypothesis 5 considers the Sea of Okhotsk whales all to be descendants of the pre-depletion western North Pacific gray whale population but the population includes animals that migrate to NA as well as animals that migrate to Asia. The Sea of Okhotsk whales that migrate to North America maintain a degree of reproductive isolation from eastern gray whales because of temporal differences in the timing of the migrations of the respective populations, during which time mating occurs. Under this scenario, one would expect to have observed significant bottleneck test results, but those tests are not very sensitive. This hypothesis is consistent with the data on gray whale movements, and the genetics data showing overall mtDNA and microsatellite differentiation of the eastern and western populations.

Of the five stock structure hypotheses given above the most unlikely is hypothesis 1 as there is ample evidence of genetic subdivision. Hypothesis 5 also seems unlikely as 1) the population does not show a significant signature of a bottleneck, 2) paternity analysis revealed a high percentage of "missing fathers" within this population (Lang et al., 2010a), these likely are part of the eastern gray whale population, and 3) the population possesses a number of nuclear microsatellite loci that are out of Hardy-Weinberg equilibrium which could be evidence of a Wahlund effect (mixing of populations).

So the most likely scenarios are hypotheses 2, 3 and 4 which differ in their assumption of whether the genetic signatures of population differentiation between the Sea of Okhotsk whales and the eastern gray whale population is due to founder effect resulting from a small number of eastern gray whales establishing the population (2) or the existence of surviving western gray whales (3 and 4), and if there are surviving western gray whales do they interbreed with eastern whales (3) or not (4). It is not possible to prove one way or the other which of these is correct with the current data so we will make recommendations as to the methods and sample design that could be followed to better understand the history and makeup of these populations.

Recommendations.—To establish the genetic makeup of the pre-depletion western North Pacific gray whale population we must obtain adequate samples of sub-fossil or cultural artifacts as explained above. This could be done by visiting appropriate museums that might have skeletal material, and possibly historical whaling sites in Japan, Russia and Korea. In addition, a much more extensive assessment of the genetics of the eastern population should be undertaken. This could include analysis of the samples already collected from the Mexican wintering lagoons, but also samples taken from summer feeding sites in the Bering and Beaufort Seas.

Clearly a weakness in the current data is the high proportion sampled of the small Sea of Okhotsk population versus the very low proportion sampled of the eastern North Pacific gray whale population. Based on current data one can conclude that the Sea of Okhotsk population differs significantly from the eastern gray whale samples that have been analyzed, but our confidence in saying they differ significantly from the eastern North Pacific gray whale population is dependent upon how representative are the current samples of the very large eastern population.

The most recent study (Aimee Lang, Pers. Comm.) to address the issue of genetic stock structure within the eastern Pacific gray whale included 177 individuals taken from the summer feeding grounds in the Pacific Northwest (northern California to British Columbia), Chukotka (Russia), and Barrow (Alaska). This latest study is an improvement over previous eastern gray whale genetic studies in that it included samples from animals from feeding sites, as opposed to only including samples from animals that stranded during migration. Nonetheless, the adequacy of sampling is still clearly not optimal as it fails to comprehensively cover the large summer range of the eastern gray whale and represents such a small fraction of the estimated 19,000 animals in the population.

The major point here is that our understanding of genetic diversity of the eastern North Pacific gray whale population is weak and will require analyses of large numbers of samples taken from feeding grounds and wintering grounds.

We must also improve upon the methods currently being used. The mtDNA control region is widely used in population and evolutionary studies of mammals including cetaceans. Nonetheless, it is known to have limitations especially due to homoplasy caused by recurrent mutations at hyper-variable sites (Phillips et al., 2009, 2012). To get around this problem, additional protein coding genes, which are more conservative and less subject to recurrent mutations, should be sequenced for all of the animals in the existing database as well as in the future. Minimally this should include two genes such as cytochrome b and ND2. This has already been done by Meschersky et al. (2012) and Alter et al. (2007) examined cytochrome b in eastern North Pacific gray whales. But if next generation sequencing is performed it could be possible to sequence the entire 16,000 bases of the mtDNA molecule.

We should also change the methods used to analyze nuclear DNA genetic markers. Microsatellite loci have an advantage over almost any other nuclear markers in typically possessing very high rates of mutation and hence high levels of variability. But the disadvantages of this method include 1) they are markers of identity by state rather than identity by descent, 2) they cannot be used effectively in analytical methods that are based on phylogenetic analyses, and 3) they are not easily reproduced from lab to lab. Whereas mtDNA studies use sequence analyses and build upon data produced in previous studies deposited in GenBank, microsatellite data must be generated anew for each study.

The current suite of microsatellite loci being used (Lang et al., 2011a) have the additional drawback that they have all been identified and developed from other species of whales. This has been shown to lead to problems with scoring due to potential inexact matches between the primer sequences of the source species compared to that of the species being studied. And, whereas there is no cause for questioning the veracity of the data produced in previous studies, it is simply not the best analytical method available today.

Single Nucleotide Polymorphisms (SNPs) have been shown to be more reliable in scoring, can be used in phylogenetic methods, are reproducible from lab to lab, and the sequences can be deposited in GenBank and thus built upon study by study as is presently done for mtDNA. Moreover, they can be used to analyze ancient or historical samples whereas microsatellites cannot (Morin et al., 2012). The only remaining advantage of microsatellites is that the larger number of alleles per locus provides greater analytical power than for SNPs. But even this can be compensated for by increasing the number of SNP loci. By using genomics methods, it is possible to identify and analyze thousands of SNP loci which provide the best possible resolution even in analyses requiring high analytical power such as kinship analyses.

With a large set of SNP loci available for analysis, studies can employ a wider variety of experimental designs depending upon the questions to be addressed. For example, markers can be selected for analysis from genes of the immune system, genes open to selection, neutral markers, DNA repair genes, etc. Since it is likely that in the future questions regarding gray whale genetics will expand beyond the current focus of gene diversity and population structure, a more robust tool kit for genetics is needed. Such studies might include examination of genes related to health (such as immune function), development, the sensory adaptations of gray whales (vision, hearing, and smell), longevity, detoxification systems, etc.

We propose that a gray whale genome program be initiated. Whereas the ultimate goal will be to sequence and annotate the genome of the species, the immediate goal of the program will be the development of a SNP panel for use in population genetics. Such a panel could be developed and the primers and methods published with data validation within two years. The methods of next-generation sequencing have advanced to the point where such a "reduced representation" genomic analysis can be done quickly and is less expensive than was possible just a few years ago.

Concluding remarks.—Because of the status of the western North Pacific gray whale as critically endangered according to the IUCN, the Scientific Committee of the International Whaling Commission has adopted a conservation plan and further recommended that a collaborative Pacific-wide study be developed under the auspices of the IWC (IWC 2011). The methods proposed in this paper, if developed and implemented, will provide data to better resolve issues, such as population structure and historical demography that are keys to the development of a sound conservation and monitoring program and will provide the opportunity for investigators to build upon databases developed in previous studies. Clarification of the demographic history of the extant North Pacific gray whale will also potentially impact the conservation status of the Sakhalin population. For example, if it is determined that this population is a subpopulation of the eastern gray whale (e.g., hypothesis 2) it might reduce the priority status of the population. However, if it is found that the Sakhalin population includes both eastern and western gray whales (hypotheses 3 and 4) the identification and protection of the small number of western gray whales would remain a high priority.

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Quantifying Uncertainty and Incorporating Environmental Stochasticity in Stock Assessments of Marine Mammals

John Robert Brandon

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University of Washington
Graduate School

This is to certify that I have examined this copy of a doctoral dissertation by

John Robert Brandon

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____

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Abstract

Quantifying Uncertainty and Incorporating Environmental Stochasticity in Stock Assessments of Marine Mammals

John Robert Brandon

Chair of the Supervisory Committee:
Professor André E. Punt
School of Aquatic and Fishery Sciences

Incorporating scientific uncertainty and accounting for potential effects of environmental variability in stock assessments are vital aspects of providing sound management advice. This dissertation focuses on these issues in the context of estimating sustainable quotas for aboriginal subsistence hunting of marine mammals.

Bayesian model averaging was used to take into account both parameter and model uncertainty in the assessment of the Bering-Chukchi-Beaufort Seas (BCB) stock of bowhead whales. The lower 5th percentile of the Bayesian model-averaged posterior for an aboriginal whaling catch quantity (Q_1^{1+}) was estimated to be 155 whales in 2002. This estimate provides confirmatory evidence that current catch quotas for this stock are sustainable.

In order to assess the robustness of Bayesian assessments to alternative methods for constructing a joint prior distribution which respects biological realism, sensitivity analyses were performed in the context of a risk assessment. The probability of meeting a management objective for aboriginal subsistence hunting was found to be robust for the data-rich BCB bowhead example. However, the data-poor East Greenland walrus example was shown to be sensitive to this issue.

A framework was developed and applied to the assessment of the eastern North Pacific stock of gray whales which incorporated environmental stochasticity by estimating the relationship between residuals in birth and survival rates to an environmental time series. The scenarios which accounted for the effect of the mortality event in 1999 and 2000 led to less optimistic estimates of population status during recent decades with concomitant recovery generally attributable to higher survival rates as opposed to higher birth rates. This framework was then used as an operating model conditioned on forecasts of sea-ice, which has been hypothesized to regulate recent calf production in the population. Future population trajectories were then used to test the performance of the current catch control rule for this stock. Performance was measured by the ability to satisfy different levels of future aboriginal subsistence need, and was shown to be satisfactory under the range of trials examined here.

The methods developed in this dissertation are generally applicable for providing management advice for exploited populations of marine mammals and other renewable natural resources.

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DEDICATION

To my father and mother, John and Dorothy Brandon.

Thank you.

INTRODUCTION

Incorporating scientific uncertainty and accounting for potential effects of environmental variability in stock assessments are vital aspects of providing sound management advice (Punt and Hilborn, 1997; Maunder and Watters, 2003). This dissertation focuses on these issues in the context of estimating sustainable catch quotas for aboriginal subsistence hunting of marine mammals. Case studies utilize data for three stocks subject to hunting: the Bering-Chukchi-Beaufort seas (BCB) stock of bowhead whales (*Balaena mysticetus*), walrus off East Greenland (EG) (*Odobenus rosmarus rosmarus*), and the eastern North Pacific (ENP) stock of gray whales (*Eschrichtius robustus*). Specifically, this work advances existing Bayesian stock assessment methods by examining and applying methods which: 1) account for model uncertainty through Bayesian model averaging; 2) evaluate the sensitivity of assessment results to alternative approaches for constructing coherent joint prior distributions which respect biological realism; 3) synthesize information relating environmental variables and population processes, and 4) use simulations to test the robustness of an existing management procedure given climate forecasts and plausible scenarios for how population dynamics might be affected by such. The overarching theme is incorporation of uncertainty at different levels (e.g. parameter, observation, process, and model uncertainty), to better represent and improve the current understanding of population dynamics and resulting estimates of sustainable catch quotas, hence providing the best available management advice.

A great deal of progress has been made during the last decade to better quantify and integrate various sources of uncertainty which are inherent in calculating sustainable catch quotas. The Scientific Committee of the International Whaling Commission (IWC) has played an instrumental role in the development of Bayesian stock assessment methods to meet this goal. The Bayesian methods that were pioneered by the IWC were initially in response to the challenge of providing management advice on catch quotas for the aboriginal hunt of BCB bowhead whales, given uncertainty surrounding biological parameters and stock abundance (Raftery *et al.*, 1995). Subsequent extensions of that approach have formed a widely accepted paradigm for integrating a variety of sources of information and concomitant uncertainty into fisheries stock assessments (Punt and Hilborn, 1997). However, one aspect of uncertainty that is still largely underestimated is model uncertainty (Clyde and George, 2004). While model selection has become an increasingly more popular tool (Burnham and Anderson, 2002), it is not always advisable to base inference on a single model or hypothesis. This is especially true when ambiguity exists with respect to which model best fits available observations. Indeed, this is exactly the case for the BCB bowheads; different population dynamics models are able to fit the data nearly equally well, yet the resulting estimates for quantities of management interest differ substantially among models. Model averaging provides an attractive technique for dealing with such a conundrum. Therefore, the first chapter of this dissertation expands upon earlier IWC assessments of the BCB stock of bowhead whales by explicitly accounting for this additional dimension of uncertainty, through Bayesian model averaging.

Bayesian analysis allow for various sources of prior knowledge (or ignorance), to be combined into a joint prior distribution, upon which inference may proceed for estimated parameters and derived quantities. However, some aspects of prior information may be inconsistent with each other. Such inconsistencies are likely to be more common for models that contain many estimated parameters that are functionally related. Bayesian stock assessments of marine mammals using deterministic age-structured population dynamics models are an illustrative example of this problem. In this context, life history parameters and the parameter for the population growth rate are functionally related, which raises two related issues: 1) placing explicit priors on each life history parameter as well as on the population growth rate parameter results in an incoherent joint prior distribution (i.e. two different priors on the estimated parameters), and; 2) certain combinations of values drawn from the priors may result in biologically implausible solutions for the remaining parameter (which can be solved for analytically, to form a coherent joint prior, given the functional relationship mentioned above). Different approaches have been applied in recent assessments of marine mammals to deal with this problem and the issue of how best to satisfy constraints on parameter values given the realm of biological plausibility. However, the sensitivity of assessment results to this issue has not been explored in any detail to date. Thus, the second chapter of this dissertation investigates the sensitivity of assessment and risk analysis results, using data-rich (BCB bowhead) and data-poor (EG walrus) case studies for comparison, to better understand the potential consequences of these alternative approaches on the estimates of sustainable catch quotas,.

It is becoming increasingly more certain that climate is changing at unprecedented rates (IPCC, 2007). Stock assessments of marine mammal populations conducted by the U.S. National Marine Fisheries Science Service (NMFS) and the IWC are generally based on age- and sex-structured population dynamics models, with density dependence acting on fecundity (Breiwick *et al.*, 1984; Punt, 1999a; Wade, 2002a). An underlying assumption of these models is that fecundity is related deterministically to the size of some component of the population, and is independent of changes in the physical environment. However, the number of studies providing evidence that environmental variability (e.g. timing and extent of sea-ice break-up) is correlated with female foraging and reproductive success are growing. Examples include: polar bears (e.g., Stirling *et al*. 1999), northern and Antarctic fur seals (Goebel, 2002; Forcada *et al.*, 2005), northeast Atlantic fin whales (Lockyer, 1986), north and south Atlantic right whales (Green *et al.*, 2003; Leaper *et al.*, 2006), sperm whales (Whitehead, 1997) and ENP gray whales (Perryman *et al*., 2002). Simmonds and Isaac (2007) review expected effects of climate change on a variety of marine mammal species, highlighting, "…the need to take projected impacts into account in future conservation and management plans, including species assessments."

Accordingly, management strategies should strive to be robust to a range of plausible consequences of climate change. This issue is of immediate importance to stocks of marine mammals in the arctic and sub-polar oceans, because it is in these areas of the world where the effects of climate change are likely to be most profound (ACIA, 2004). For example, climate forecasts predict a massive decrease in the extent of arctic sea ice (Overland and Wang, 2007). This change is expected to have major impacts on populations of marine mammals which live in or migrate to the arctic, many of which are also important to aboriginal subsistence and culture (Lowry, 2000). Consequently, understanding the biological influences of environmental variability, especially with regards to marine mammals in the arctic and sub-polar oceans, is an area of special concern to both conservation and management. Hence, the third chapter of this dissertation advances existing stock assessment methods for marine mammals by investigating a framework to synthesize information relating environmental variables and population processes. The goal of this work is to provide improved estimation and evaluation of management quantities and strategies given natural variability in ecosystem conditions, and forecasts of climate change. The ENP gray whale is used as a case study because this stock is currently the target of aboriginal subsistence hunting and there exists suitable data to complete the objectives of this research.

While stock assessments are an important aspect of monitoring recoveries and understanding population dynamics, management procedures are increasingly being adopted as a way for setting catch quotas to achieve sustainability and conservation goals (Butterworth, 2007; Punt and Donovan, 2007). A fundamental component of the selection of a management procedure is the use of computer simulations to examine the performance of a proposed catch control rule (for aboriginal subsistence whaling the IWC catch control rule is referred to as a Strike

Limit Algorithm, *SLA*, and determines the number of allowable "strikes" each year). Underlying the simulation testing structure is an operating model, which takes the major sources of identified uncertainty (e.g., population growth rate, stock structure, etc.) into account. The operating model corresponds to a hypothesized underlying 'true' state of nature and is used to generate the simulated data that is provided to the management procedure. Given this information, the strike (or catch) limit is computed by the management procedure and the resulting mortality subtracted from the population represented in the operating model. This feedback process is repeated as the underlying population is projected forward through time. At the end of the projection period, performance statistics are compiled based on management criteria. Often, multiple operating models are used during this process to investigate the performance of a proposed management procedure relative to alternative scenarios regarding the 'true' state and dynamics of nature. Recommend catch limits for ENP gray whales are based on the 'Gray Whale *SLA'*, which has undergone extensive simulation testing. However, it would be prudent to revisit the performance of these control rules given the availability of new and detailed forecasts for changes in sea ice, and evidence which suggests that variability in calf production for ENP gray whales may be related to variability in sea ice. Therefore, the fourth chapter of this dissertation involves the development of an operating model (based on the assessment in chapter 3) to evaluate the performance of the Gray Whale *SLA* and hence assess its robustness to environmental variation.

Objectives

The objectives of this dissertation are:

1. perform an assessment of the BCB stock of bowhead whales based on a variety of alternative population dynamics models, which represent competing hypotheses, and use Bayesian model averaging to incorporate model uncertainty in the resulting management advice;

2. perform and summarize the sensitivity of assessment and risk analysis results to alternative approaches for constructing a coherent joint prior while respecting biological realism. Compare the sensitivity of the results between data-rich (BCB bowhead) and data-poor (EG walrus) case studies;

3. develop methods for synthesizing environmental time series with existing stock assessment models for marine mammals, to capture alternative assumptions regarding biological processes (e.g. fecundity is not only related to population size, but also to some function of an environmental variable) and apply the framework to an assessment of the ENP gray whales; and,

4. use the framework developed in chapter 3 as an operating model within a simulation modeling approach, to evaluate the performance of the IWC Gray Whale *SLA* given hypotheses regarding the nature and extent of future environmental stochasticity and forecasts of a relevant climate index.

Chapter 1:

Assessment of the Bering-Chukchi-Beaufort Seas stock of bowhead whales using Bayesian model averaging[1]

ABSTRACT

Bayesian estimation methods are used to fit an age- and sex-structured population model to available data on abundance and stage-proportions (i.e., calves/mature animals in the population) for the Bering-Chukchi-Beaufort Seas stock of bowhead whales (*Balaena mysticetus*). The analyses consider three alternative population modeling approaches: 1) modeling the entire population trajectory from 1848**,** using the 'backwards' method where the trajectory is back-calculated based on assigning a prior distribution to recent abundance; 2) modeling only the recent population trajectory, using the 'forwards from recent abundance' method, where the population is projected forwards from a recent year and the abundance in that year is not assumed to be at carrying capacity; and 3) a version of 2) that ignores density-dependence. The 'backwards' method leads to more precise estimates of depletion level. In contrast, the 'forwards from recent abundance' method provides an alternative way of calculating catch-related quantities without having to assume that the catch record is known exactly from 1848 to the present, or having to assume that carrying capacity has not changed since 1848. Not only are all three models able to fit the abundance data well, but each is also able to remain consistent with available estimates of adult survival and age of sexual maturity. Sensitivity to the stage-proportion data and the prior distributions for the life history parameters indicates that use of the 1985 stage-proportion data has the greatest effect on the results, and that those data are less consistent with data on

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trends in abundance and age of sexual maturity. The analyses indicate that the population has approximately doubled in size since 1978, and the 'backwards' analyses suggest that the population may be approaching carrying capacity, although there is no obvious sign in the data that the population growth rate has slowed. Bayes factors are calculated to compare model fits to the data. However, there is no evidence for selecting one model over another, and furthermore, the models considered in this study result in different posterior distributions for quantities of interest to management. Posterior model probabilities are therefore calculated and used as weights to construct Bayesian model-averaged posterior distributions for outputs shared among models to take this ambiguity into account. This study represents the first attempt to explicitly quantify model uncertainty when conducting a stock assessment of bowhead whales.

1.1 INTRODUCTION

Bowhead whales (*Balaena mysticetus*) have been caught by Alaskan Eskimos in an aboriginal fishery for at least hundreds of years; active whaling started along the arctic coast around 1800-1700 BP (Braham, 1989; Dinesman and Savinetsky, 2003). A commercial fishery began takes from the Bering-Chukchi-Beaufort Seas (B-C-B) stock of bowhead whales in 1848, and the population is thought to have been severely depleted by the substantial commercial catches that occurred during the 1800s (Bockstoce and Botkin, 1983; Breiwick and Braham, 1990; Breiwick *et al*., 1984). Although the commercial fishery almost completely collapsed early in the 1900's, aboriginal catches of B-C-B bowheads continue (*e.g.*, Braham, 1995; George *et al.*, 1988; Suydam and George 2004).

Most of the B-C-B bowhead stock migrates seasonally along the north slope of Alaska between wintering areas in the Bering Sea and summer feeding areas in the Beaufort Sea. Surveys have been conducted during the spring migration past Pt. Barrow in eleven years since 1978 to estimate the abundance and trends of this population (George *et al.,* 2004). The ice-based counts have resulted in abundance estimates substantiated by estimates using mark-recaptures of individually identifiable whales in aerial photographs (da Silva *et al.*, 2000). These abundance estimates have served as the primary basis for assessments of the status of and management advice for the B-C-B bowhead stock by the Scientific Committee of the International Whaling Commission (IWC).

Given a history of catches, it was possible to conduct an initial assessment of the status of the population once the first abundance estimate was made in 1978. This assessment suggested that the population had experienced some recovery since its depletion in the 1800s, but that it was still below carrying capacity (Breiwick *et al.*, 1984). Breiwick and Braham (1990) noted that estimates of carrying capacity and depletion level are sensitive to the current estimated population size. However, it is now possible to make more precise estimates of these quantities (conditioned on the accuracy of the catch data and population dynamics model) because the number and precision of the abundance estimates has increased substantially.

Givens *et al*. (1993) and Raftery *et al*. (1995) introduced Bayesian methods (*e.g.*, Press, 1989) to the assessment of bowhead whales. These methods can make use of multiple sources of data and fully characterise uncertainty. Bayesian assessments of the B-C-B bowhead stock (e.g. Givens *et al*., 1995) using the BALEEN II model (de la Mare, 1989) have consequently been used extensively by the Scientific Committee of the IWC (Punt, 1999a). Although there was general agreement that using multiple sources of data in assessments was desirable, considerable debate ensued in the Scientific Committee of the IWC regarding the details of the statistical methods to be used in bowhead assessments (*e.g.*, Butterworth and Punt, 1995; Punt and Butterworth, 1999, 2000; Poole *et al*., 1999; Poole and Givens, 2001; Schweder and Ianelli, 2000). One troublesome outcome of the results in the standard ‘forwards from K’ assessment (i.e. projecting the population dynamics model forwards from a prior distribution for the population size in 1848, which was assumed to be carrying capacity) was that the observed rate of increase of the population (ROI) differed substantially from the resulting posterior distribution for the ROI, even though the data on ROI were the main data source used in the analysis (*e.g.* Punt and Butterworth, 1999; Raftery and Poole, 1997). This and other related issues were determined to be due in part to a methodological issue associated with the forwards method and the specification of prior distributions. It was also determined that these issues could essentially be resolved by the use of the 'backwards' method, in which no prior is specified for the population size in 1848; instead, a prior distribution is specified for the abundance in a recent year, and the population level in 1848 (assumed to be carrying capacity) is then back-calculated from that recent abundance (Butterworth and Punt, 1995; Punt and Butterworth, 1999; Poole and Raftery, 1998).

An important assumption made in bowhead assessments is that the catch history is known without error. It has been found that the catch record going back to 1842 for eastern North Pacific stock of gray whales cannot be reconciled with the population's current dynamics (Punt and Butterworth, 2002), without assumptions that the catch record has been substantially under-estimated and/or that carrying capacity has changed since the mid 1800s. While it appears from past assessments that the bowhead catch record can be reconciled with the current dynamics, it is still appropriate to investigate an alternative assessment that does not make use of the historical catch record. This can be achieved using the method developed by Wade (2002a) for gray whales, where a model is projected forwards from the abundance in a recent year, with a separate prior distribution specified for carrying capacity. Such an assessment does not use the historic catch record prior to 1978, and does not need to assume that carrying capacity has remained constant since the mid 1800s. Therefore, such an assessment should be robust to problems with these assumptions.

The 1998 assessment of the B-C-B bowhead stock (IWC, 1999; Punt, 1999b) used 'backwards' Bayesian estimation based on the BALEEN II model, and the then-available abundance estimates and the data on the proportion of calves and mature animals in the population during 1985-94 (the 'stage-proportion' data). New information available for this stock since the 1998 assessment includes: 1) a mark-recapture estimate of adult survival from aerial photographs (Zeh *et al*., 2002); 2) an estimated age at sexual maturity and an estimate of maximum age (George *et al*., 1999); 3) a recalculation of the stage-proportion data (Koski *et al*., 2006); and 4) an estimate of abundance for 2001 (George *et al.*, 2004).

This chapter examines the sensitivity of the results of the B-C-B bowhead assessment to: 1) modeling the entire population trajectory from 1848 (using the 'backwards' method); and 2) modeling only the recent period (where the population is projected forwards from a recent year, and the abundance in that year is not assumed to be at carrying capacity). A third set of analyses is conducted using a Leslie matrix with no density-dependence. The population model used in this assessment is the density-dependent Leslie matrix model (Leslie, 1945, 1948) developed by Breiwick *et al*. (1984) except that reproduction and natural mortality are assumed to occur before removal by catches. When parameterized in equivalent ways, the results of the BALEEN II model and this Leslie matrix model have been found to be nearly identical (Wade, 2002a; Punt and Butterworth, 2002).

This chapter also examines the sensitivity of the model outputs to the sources of data included in the assessment and the specifications for the prior distributions. Scenarios are specified to investigate the sensitivity of the results to data-based informative vs. uniform (less informative) prior distributions, as well as to how the stage-proportion data are constructed. The stage-proportion data are excluded altogether in some analyses, and varied in others based on whether the aerial photographic survey data from 1985[2] are included in their calculation or not. Within a scenario, identical prior distributions are assumed for the life-history parameters and matching data-sets are used in the likelihood function for each of the three modeling approaches to enable comparisons to be made among them.

Model uncertainty is accounted for within a Bayesian framework, and Bayes factors (Kass and Raftery, 1995) are calculated to quantify the evidence provided by the data in favour of the different modeling approaches. For the 'reference scenarios,' there is no evidence for selecting one model over another, but there are important differences in the estimates of quantities that would be of interest to management. Therefore, we follow the philosophy outlined by a number of authors (e.g., Kass and Raftery, 1995; Buckland *et al.*, 1997; Hoeting *et al.*, 1999; Patterson, 1999; Durban *et al.*, 2005; Raftery *et al.*, 2005) and present quantities of interest as Bayesian model averages; weighting the output of contending models based upon their relative likelihoods, as opposed to selecting between them.

1.2 METHODS

Available data

The population dynamics models are fit to three sources of data: 1) abundance estimates from ice-based surveys at Pt. Barrow, Alaska between 1978 and 2001 (Table 1.1); 2) proportion calves/mature animals in the population from 1985 to 1994 (Table 1.2); and 3) annual catches in individuals from 1848 to 2002 (Table 1.3).

All of these sources of data were used in the 1998 assessment but have been updated since. The first ice-based survey since 1993 was conducted in 2001, and has provided an abundance estimate for that year of 10,545 with a coefficient of variation of 0.128 (updated from George *et al.*, 2004 by Zeh and Punt, 2005). The

[2] 1985 appears to have been an anomalously late migration year; the aerial survey in 1985 is believed to have ended too early to have sampled the tail-end of the migration, typically when most cow/calf pairs are in the study area (Koski *et al.*, 2006)

catch data have been updated with the post-1998 catches and revisions to the catches for 1994-96. Two additional years of aerial photographic data have been analyzed since the previous assessment, and the stage-proportion data have been recalculated (Angliss *et al*., 1995; Koski *et al*. 2006).

Additional information available for this stock since the 1998 assessment includes a mark-recapture estimate of survival (Zeh *et al*., 2002), and a recent estimate of age of sexual maturity and the maximum age (George *et al*., 1999). This information was included in the analyses of this chapter as data-based informative priors (see the section on model parameters and prior distributions).

Population dynamics model

The underlying population model is a simplified age- and sex- structured Leslie matrix (Leslie, 1945, 1948) projected as:

$$\underline{n}_{t+1} = (\mathbf{A_t}\,\underline{n}_t) - \underline{h}_t \tag{1.1}$$

where:

$\underline{n}_t$ is vector of population size in each age class at the start of year *t* (defined when calving and natural mortality occur);

$\mathbf{A_t}$ is the Leslie matrix for year *t*; and

$\underline{h}_t$ is the vector of age-specific catches during year *t*.

The catches and birth rates are assumed to be equal for both males and females (i.e. the vectors above are divided equally by sex). The parameters that define the entries of the Leslie matrix are: 1) S_{juv}, the survival rate of immature whales (assumed identical for calves and juveniles); 2) a_T, the last age with survival rate S_{juv}; 3) S_a, the survival rate of mature whales; 4) a_m, the age at sexual maturity (the last age class with zero fecundity); 5) $f_{\max}$, the maximum fecundity rate; and 6) $a_{\max}$, the maximum age, after which survival becomes zero. Fecundity is assumed identical for all mature animals, and is calculated as the number of female calves per mature female. Recruitment to the fishery is assumed to be knife-edged and to occur at age 1, and the catch is distributed uniformly over all recruited age-classes (i.e., uniform selectivity across recruited age-classes).

The projections are initialized from a stable age distribution for the population in the year prior to that with the first catch (e.g. 1977 or 1847) based on the values for the parameters sampled from the prior. This population vector is then projected one year forward without catch, and the population vector re-scaled so that the 1+ population size in the year with the first catch equals that generated from the prior for 1+ abundance for that year.

Density dependence is assumed to affect fecundity according to**:**

$$f_t = f_0 + (f_{\max} - f_0)\left[1 - \left(\frac{N_t^{1+}}{K^{1+}}\right)^z\right] \tag{1.2}$$

where:

f_t is the fecundity during year *t*;

$f_{\max}$ is the maximum fecundity (in the limit of zero population size);

N_t^{1+} is the (1+) population size at the start of year *t*;

K^{1+} is the pre-exploitation (1+) population size;

z is the shape parameter; and

f_0 is the fecundity at carrying capacity.

Given values for the life-history parameters in the model, the value for f_0 is determined from the characteristic equation of the Leslie matrix given equilibrium conditions:

$$f_0 = \frac{1 - S_a}{S_{juv}^{(a_T)}\, S_a^{(a_m - a_T)}\,[1 - S_a^{(a_{\max} - a_m - 1)}]} \tag{1.3}$$

Model parameters and prior distributions

Table 1.4 lists the parameters and their priors used in three 'reference' scenarios. The population trajectory is modeled in three ways: 1) a density-dependent model initialized in 1848 (abbreviated: '1848 DD'); 2) a density-dependent model initialized in 1978 ('1978 DD'); and 3) a density-independent model initialized in 1978 ('1978 NON DD'). The six life-history parameters of the Leslie model are included in each of three models, but the remaining parameters differ among models. The '1848 DD' model includes a parameter for the population size in 1993, N_{1993}^{1+}, and one for the maximum sustainable yield level, $MSYL^{1+}$. The '1978 DD' model also includes the parameter $MSYL^{1+}$ but instead of placing a prior on N_{1993}^{1+} places one on N_{1978}^{1+}. This model also includes an additional (explicit) prior on the carrying capacity, K^{1+}. The '1978 NON DD' model includes priors on N_{1978}^{1+} and the maximum population growth rate in the absence of density dependence, r. For this model, fecundity and population growth rates apply only to the specified period, and where the distinction is appropriate, they are referred to as f and r. However, when methods are consistent across models, these rates are referred to as $f_{\max}$ and $r_{\max}$ for the sake of simplicity.

'Data-based' prior distributions are assigned to adult survival rate and the age at sexual maturity, and the maximum age of the Leslie matrix is determined from the results of recent research on ageing. The informative prior for S_a (Table 1.4) approximates the Bayesian posterior calculated for this parameter based on a mark-recapture analysis of photoidentification data (Zeh *et al.* 2002). Information on age-at-maturity is taken from a study by George *et al*. (1999) that estimated ages of caught animals based on the chemistry of eye lenses. Those authors fit a growth curve to these ages from known lengths, and combine this relationship with previous data on length at sexual maturity to provide an estimate of the age-at-maturity. The aging results also estimated some animals were older than the previously accepted maximum age, and this result is supported by the recent recovery of traditional whaling tools in five whales (reported in the same study). The maximum age in the Leslie matrix is therefore set to 200 to reflect this information.

Punt and Butterworth (1999) note that placing a prior on S_{juv} would be an instance of Borel's Paradox (i.e. effectively placing two priors on the same parameter) due to the functional relationships among the life-history parameters in an age-structured population model; instead the value of S_{juv} is solved for analytically in this study by rearranging the characteristic equation of the Leslie matrix given the values for the remaining five parameters and λ, the dominant eigenvalue of the Leslie matrix (i.e. $r_{\max}+1$) (Breiwick *et al*., 1984):

$$S_{juv} = \left[\frac{\lambda^{(a_m+1)} - S_a \lambda^{(a_m)}}{S_a^{(a_m - a_T)} f_{\max} \{1-(S_a/\lambda)^{(a_{\max}-a_m-1)}\}} \right]^{\frac{1}{a_T}} \tag{1.4}$$

The value for S_{juv} is forced to be less than that of S_a. If necessary, values for $f_{\max}$ and S_a are re-sampled (see below), until this condition is met, or 1000 re-samples occur. If this maximum is reached, a new value for $r_{\max}$ is re-sampled, and the process repeated until an acceptable sample from the prior occurs.

The priors for the remaining life history parameters are also based on available information. The prior distribution for $f_{\max}$ is based on an assumed range of a 2.5- to 4-year calving interval for large baleen whales (IWC, 1998). Note that $f_{\max}$ is specified in the standard Leslie matrix formulation as female calves per female per year (i.e., a fecundity rate of *0.125* implies a female calving interval of 8 years, and therefore a total calving interval of 4 years, assuming an equal sex ratio of calves). The age of transition from immature to adult survival is assigned a discrete uniform prior over the interval 0 to 8 years.

Output quantities

Posterior distributions are calculated for several output quantities that are functions of the parameters in Table 1.4. The maximum sustainable yield rate ($MSYR^{1+}$) is calculated as $\lambda - 1$ based on the f_t value associated with $MSYL^{1+}$. Maximum sustainable yield (MSY^{1+}) is calculated as the product, $MSYR^{1+} MSYL^{1+} K^{1+}$. Current replacement yield (RY^{1+}) is calculated as the difference between the number of 1+ animals in 2002 (prior to the removal of catches in that year) and the number of such animals at the end of 2001. The quantity Q_1^{1+}, designed to meet the intent of aboriginal whaling management objectives (Wade and Givens 1997), is also calculated. This quantity has the property that the proportion of net production allocated to recovery increases at higher levels of stock depletion[3]. Specifically:

$$Q_1^{1+} = \min(MSYR^{1+} * N_{2002}^{1+}, 0.9MSY^{1+}) \quad (1.5)$$

The post-model-pre-data distribution is reported for the parameters. This distribution arises after conditioning the specified priors on the model (i.e. by eliminating combinations of parameters for which the juvenile survival rate implied by equation (1.4) exceeds the adult survival rate drawn from the joint prior distribution). Likewise, post-model-pre-data distributions for output quantities are calculated as the distributions for these quantities in the sampled joint prior space.

Parameter estimation

[3] This definition applies to a population above some minimum level, P_{min} (assumed here to be $0.1K^{1+}$), below which catches are set to zero.

The Sampling-Importance-Resample (SIR) algorithm (Rubin, 1988; Smith and Gelfand, 1992; Wade, 2002a) is used to generate samples of parameter vectors (and output quantities of interest) from the posterior distribution. This algorithm involves randomly sampling a large number of parameter vectors $\underline{\theta}_i$ (draws) from the prior distribution. A population trajectory is then calculated for each vector of parameter values, and this trajectory is used to determine the likelihood of the data for each random draw. 10,000 draws (which form the numerical representation of the posterior distribution) are then selected by sampling (with replacement) from the initial samples from the prior, with probability proportional to the likelihood. Following Punt and Butterworth (1999) and Raftery *et al*. (1995), the SIR algorithm is considered to have converged if the number of unique parameter vectors in the sample from the posterior is fairly high (>5,000) and if the most frequently re-sampled parameter vector did not occur in the posterior sample more than ten times.

The total negative log-likelihood of a model trajectory, given a vector of parameters and the data, consists of contributions from four data sources: 1) the estimate of abundance for 1993; 2) the estimates of abundance for the remaining years; 3) the proportion of calves in the population; and 4) the proportion of mature animals in the population. The abundance estimates are assumed to be indices of the 1+ component of the population. The scientific surveys at Pt. Barrow are assumed to have occurred after the aboriginal catch, and the likelihood function is calculated accordingly (i.e. catches are removed before calculating the likelihood of the data for a given year). Model-predicted proportions are calculated over the period 1985 to 1994, as the actual stage proportions are based on data for these years.

The estimate of abundance for 1993 is assumed to be independent of the remaining estimates (Punt and Butterworth, 1999), and to have normally as opposed to log-normally distributed sampling error. The contribution of the abundance estimates to the negative of the log-likelihood function is:

$$L_1 \propto 0.5 \frac{(\hat{N}_{1993} - 8293)^2}{626^2} \qquad L_2 \propto 0.5 \sum_{t_1} \sum_{t_2} (\ell n \hat{N}_{t_1} - \ell n N_{t_1}^{obs})^T \Sigma_{t_1,t_2}^{-1} (\ell n \hat{N}_{t_2} - \ell n N_{t_2}^{obs}) \quad (1.6)$$

where:

N_t^{obs} is the estimate of abundance for year *t*;

$\hat{N}_t$ is the model estimate of 1+ abundance for year *t*; and

Σ is the variance-covariance matrix for the logarithms of the estimates of abundance (excluding 1993).

The estimates of abundance (Table 1.1) are based on combining the data from visual counts at Point Barrow, Alaska, and estimates of the proportion of animals which passed within visual range based on acoustic data. Equation (1.6) accounts for the correlation among the non-1993 estimates of abundance that arises because the proportion within visual range is treated as a random effect when constructing the estimates of abundance (Zeh and Punt, 2005).

The contribution of the proportion data to the likelihood function follows Punt (2006), i.e. given the bootstrapping approach adopted to calculate the length-frequency distributions from which the proportion data were calculated (Koski *et al.*, 2006), it was reasonable to assume that the estimates are normally distributed:

$$L_3 \propto \frac{1}{2(\sigma_{p_c})^2}(p_c - p_c^{obs})^2 \qquad L_4 \propto \frac{1}{2(\sigma_{p_m})^2}(p_m - p_m^{obs})^2 \quad (1.7)$$

where:

p_c^{obs} is the observed fraction of the population that consisted of calves between 1985 and 1994;

σ_{p_c} is the standard deviation of p_c^{obs};

p_c is the model-estimate of the fraction of the population that consisted of calves between 1985 and 1994;

p_m^{obs} is the observed fraction of the population that consisted of mature animals between 1985 and 1994;

σ_{p_m} is the standard deviation of p_m^{obs}; and

p_m is the model-estimate of the fraction of the population that consisted of mature animals between 1985 and 1994.

Model comparison

The three models considered in this chapter are compared using Bayes factors (Kass and Raftery, 1995). The Bayes factor is calculated as the probability of observing the data given one hypothesis (model) divided by the probability of observing the same data given an alternative hypothesis, i.e.:

$$B_{12} = \frac{pr\left(D|H_1\right)}{pr\left(D|H_2\right)} \tag{1.8}$$

In the context of model comparison, the hypotheses represent competing models and the Bayes factor is used as the evidence provided by the data in favour of one model over another. Although equation (1.8) has the form of a likelihood ratio, if there are unknown parameters in either of the competing models, the probability densities must be found by integrating, as opposed to maximizing, over the parameter space. Therefore, for a given a model, the probability of the data is:

$$pr\left(D|H\right) = \int pr\left(D|H,\theta\right) pr\left(\theta|H\right) d\theta \tag{1.9}$$

This integration is based on the sample from the prior using the equation:

$$\hat{pr}(D|H) = \frac{1}{n_1} \sum_{i=1}^{n_1} pr(D|\underline{\theta}_i, H) \tag{1.10}$$

where $\underline{\theta}_i$ is the i[th] (of n_1) samples from the prior distribution.

Model averaging

Model uncertainty is accounted for by calculating the posterior probability of each model conditioned on the data and the priors, and then combining results across models as a weighted average of the posterior densities for a quantity of interest (Kass and Raftery, 1995). Hoeting *et al*. (1999) provide a convenient method of calculating the posterior probability of model H_k (where, *k*=1,2, …, *K* models are being considered) based on Bayes' theorem:

$$pr(H_k|D) = \frac{pr(D|H_k)\, pr(H_k)}{\sum_{i=1}^{K} pr(D|H_i) pr(H_i)} \tag{1.11}$$

where $pr(H_k)$ is the prior probability that H_k is the true model and $pr(D|H_k)$ is the estimate of the probability of the data (equation (1.10)). All of the probabilities are conditional on the set of models being considered (Hoeting *et al*., 1999). For $f_{\max}$, $r_{\max}$ and quantities related to carrying capacity, only the two models incorporating density dependence could be used to derive model averages. Under the set of models considered, these posterior model probabilities were used to determine model-averaged posterior probability distributions for the model outputs, θ:

$$pr(\theta|D) = \sum_{i=k}^{K} pr(\theta|H_k, D)\, pr(H_k|D) \tag{1.12}$$

In the context of the SIR algorithm used here, Bayesian model averaging was accomplished by selecting a number of random draws from the posterior for each model and combining them to form a model-averaged posterior. This number was determined by the posterior probability for each model. All models were considered equally probable *a priori* (i.e. objective ignorance regarding the true model), so the posterior probability of a given model was determined using the values from equation (1.10) normalized to sum to one over models.

1.3 RESULTS

Fits to the data

Fig. 1.1 shows the fits to the abundance estimates for three reference scenarios and the Bayesian model average. All three models provide a relatively good fit to these data, although the abundance estimate for 2001 falls well above the upper 90% credibility limit from the '1848 DD' model. This occurs because the median of the posterior distribution for 1+ population size in 2002 for this model (9,496) is smaller than the posterior medians for the other two models (Fig. 1.2, Table 1.5).

The abundance estimates indicate the population has been increasing steadily over 1978-2001, and the data on adult survival, age of sexual maturity, and the stage-proportion data (excluding 1985) are all relatively consistent with this increase (i.e., the inclusion of those data in the analysis does not lead to the model being unable to mimic the abundance data).

Backwards to 1848 (density dependent model): 1848 DD

The upper left panel of Fig. 1.1 shows the posterior median time-trajectory of 1+ population size along with its 90% credibility interval for the reference scenario. The population size is estimated to have declined dramatically during the 1800s, being reduced to approximately half of its pre-exploitation level within five years of the start of the commercial fishery, and 10% of this size by the early 1900s. However, the population recovered steadily thereafter. The 90% credibility interval for the post-model-pre-data distribution for K^{1+} is [8,000-30,000], with lower values favoured (Fig. 1.2). In contrast, the 90% credibility interval for the posterior distribution of K^{1+} is [9,000, 14,000] (Table 1.5) indicating that the data update the prior distribution substantially. The 2002 population size is estimated to be above 50% of K^{1+}, and there is a high probability of it being above $MSYL^{1+}$ (Fig. 1.3, Table 1.5). The posterior distribution for replacement yield in 2002 has a mode around 200, with a lower 5th percentile of 61 (Fig. 1.4, Table 1.5). In contrast, the lower 5th percentile for Q_1^{1+} is 99 (Fig. 1.4, Table 1.5). These two quantities differ because the current population size is estimated to be larger than $MSYL^{1+}$, and approaching K^{1+}. Therefore, density dependence has slowed population growth and RY^{1+} has decreased. This is the same situation which led to the use of Q_1^{1+} as a more appropriate measure of sustainable catch (to achieve IWC management goals) for the eastern North Pacific stock of gray whales (Wade, 2002a).

The constraints imposed by the relationships among the life-history parameters constrained $r_{\max}$ to be less than about 0.07 (Fig. 1.3), although they also reduced the (prior) probability of values of $r_{\max}$ larger than 0.06. The posterior for $r_{\max}$ assigns most support to values larger than 0.03 (posterior median 0.041, Table 1.6). The posterior distributions for adult and immature survival favour higher values than implied by the prior distributions for these parameters, and that for a_{m} values lower than implied by the prior distributions (Figs 1.5 and 1.6). The post-model-pre-data distribution for fecundity favours higher values (~0.20, Fig. 1.6), but the posterior median is 0.171, or a calving interval of approximately 3 years (Table 1.6). The results in Figs 1.3, 1.5 and 1.6 show that the data are clearly capable of updating the prior distributions for the life-history parameters.

The results for this model are not particularly sensitive to changing the prior distributions for S_a and a_{m} and to ignoring the proportion data (Table 1.5). The most noteworthy feature of these sensitivity tests are the changes to the catch-related outputs (RY^{1+}, Q_1^{1+} and MSY^{1+}). Results are not shown in Table 1.5 for the case in which the 1985 stage-proportion data are included in the analyses due to computational difficulties in achieving convergence. Preliminary analyses including these data indicated, however, that they are inconsistent with what is known about bowhead life history and the time series of abundance estimates. This inconsistency was the cause of the inability to achieve convergence.

Forwards from 1978 (density dependent model): 1978 DD

The posterior for K^{1+} from this analysis is much more uncertain than that from the '1848 DD' analysis (Fig. 1.2). This is because this analysis ignores the information contained in the 1848-1977 catch record, and because the abundance estimates show no evidence for a reduction in trend (which would be expected as the population approaches carrying capacity) and, unlike the '1848 DD' model, the '1978 DD' model does not make the assumption that the population size in 1848 was K^{1+}. Therefore, although this model confirms that the population is increasing (Fig. 1.1), it infers that the population is currently at a much lower fraction of its (current) carrying capacity than the '1848 DD' model (Fig. 1.3; Table 1.5). The posterior for N_{2002}^{1+}/K^{1+} is strongly influenced by the prior distribution assumed for K^{1+} given the inability of the data to place an upper bound on K^{1+}. This is clearly evident from the results of the sensitivity test in which the upper limit of the prior for K^{1+} is increased from 30,000 to 100,000. The results for this sensitivity test imply an increase to the median of the posterior for K^{1+} of 165% and a reduction to the posterior median for N_{2002}^{1+}/K^{1+} of 62% (Table 1.5) as the upper bound for K^{1+} is increased by 233%.

Given that there is little independent information on which to base a prior distribution for K^{1+}, the choice of the prior for K^{1+} is essentially arbitrary, and it should be recognized that this 'forwards' analysis consequently does not provide robust estimates of quantities related to K^{1+} (such as N^{1+}_{2002}/K^{1+}). However, Punt and Butterworth (1999) note that some key management-related quantities (e.g., RY^{1+} and Q^{1+}_{1}) are relatively insensitive to the prior assumed for K^{1+}, so this approach still has some value. The implicit (post-model-pre-data) distribution for RY^{1+} favours (is skewed towards) values less than 200 (Fig. 1.4). Despite this, the posterior median is 324, with a lower 5th percentile of 147 (Table 1.5). A similar result is evident for Q^{1+}_{1}, with low values favoured by the post-model-pre-data distribution, but higher values supported by the data (median 295, lower 5th percentile 160)(Fig. 1.4, Table 1.5). In essence, the joint prior distribution for the parameter values, conditioned on the population dynamics model, is not neutral (non-informative) with respect to these catch-related quantities, but the data are influential enough to move the posterior distribution away from the mode of the prior distribution.

The posterior distributions for $r_{\max}$, $MSYR^{1+}$ and the life history parameters for this model are generally similar to those for the '1848 DD' model. The most noteworthy difference between the posterior distributions for the '1978 DD' and '1848 DD' models in Table 1.6 relates to the posterior median for S_{juv} which is larger for the '1978 DD' model. As was the case for the '1848 DD' model, there is again little sensitivity to changing the priors for S_a and for a_m, and ignoring the stage-proportion data (Tables 1.5 and 1.6). In contrast, inclusion of the 1985 survey data when calculating the stage-proportion data has a large impact on the results. Specifically, K^{1+} and $MSYR^{1+}$ are estimated to be lower, and N^{1+}_{2002}/K^{1+} higher, with the population estimated to be above $MSYL^{1+}$ with almost 100% probability. $r_{\max}$ is estimated to be higher (as the population is estimated to be closer to K^{1+}

and therefore experiencing a growth rate much lower than $r_{\max}$). The estimates of the catch-related quantities are considerably lower for this scenario (e.g. the posterior median and the lower 5% percentile for RY^{1+} are 166 and 44 respectively).

Forwards from 1978 (density independent model): 1978 NON DD

The posterior median for RY^{1+} for this model ranges from 310 to 414 across the scenarios (166-217 for the lower 5$^{\text{th}}$ percentile for RY^{1+}). The posterior for r for the '1978 NON DD' model is centred on lower values than those for the other two models (Fig. 1.3). This is to be expected because the r for the '1978 NON DD' model' pertains to the current rate of increase rather than the increase rate in the limit of zero population size. The inclusion in the analyses of the 1985 stage-proportion data is again very influential. For example, the posterior distribution for fecundity for the 'include 1985 proportion data' sensitivity test does not overlap with that for the reference scenario.

Model comparison and Bayesian model averages

Bayes factors based on pair-wise comparisons of models range from 1.10 to 1.51, and indicate that there is no evidence for selecting one model over another (Table 1.7). Rather, these Bayes factors imply that the best approach to summarizing the state of the B-C-B bowhead stock is to consider all three models, e.g. through Bayesian model averaging. Average likelihoods of draws from the initial sample range from 0.522 ('1848 DD') to 0.789 ('1978 NON DD'). The two models that involve forward projection from recent abundance ('1978 DD' and '1978 NON DD') have slightly higher average likelihoods, and hence posterior model probabilities, than the model which started the population projection in 1848, although differences are not large (Table 1.8).

The time-trajectory of 1+ population size (medians and 90% credibility intervals) from the Bayesian model-averaged posterior provides, as expected, a good fit to the abundance estimates (Fig. 1.1, lower panel). The fit to the estimate of abundance for 2001 for the model-averaged posterior is not quite as good as for the '1978 DD' and '1978 NON DD' models because of the impact of including the '1848 DD' model in the average. The model-averaged posterior distribution for K^{1+} (Fig. 1.2) has a mode close to that of the posterior median for the '1848 DD' model, and a long tail caused by the uncertainty associated from the '1978 DD' model. The model-average posterior for N^{1+}_{2002}/K^{1+} (Fig. 1.3) is wide, but less so than that for the '1978 DD' model. The model-averaged posterior for RY^{1+} is slightly irregular because it consists of the combination of a bimodal posterior (for the '1848 DD' model) and a symmetric posterior (for the '1978 DD' model). In contrast to the model-average posterior for RY^{1+}, that for Q^{1+}_{1} is quite symmetric (Fig.1.4, Table 1.5).

The '1978 NON DD' model estimates only the recent fecundity and rate of increase for the population, whereas the two density-dependent models estimate the maximum fecundity and rate of increase. Therefore, the posterior for $f_{\max}$ and $r_{\max}$ is averaged across the two models with density dependence only. Maximum fecundity and population growth rate are relatively consistent across these two models and have a median of 0.171 and 4.3% respectively (Fig. 1.6 and Fig. 1.3, Table 1.6). Likewise, both adult and juvenile survival rates are consistent across models, with a median for adult survival of 0.990 and for juvenile survival of 0.932 (Fig. 1.5, Table 1.6).

It is straightforward to calculate model-averaged posterior probability distributions given different prior probability distributions for the models. For example, the models based on starting the projections in 1978 could be assigned probabilities of 0.25 and that which starts the population projections in 1848, a prior probability of 0.5 to indicate, for example, that the assumption that carrying capacity has not changed over the last 150 years is equally as likely as some shift in the equilibrium population size during this time. Alternatively, the models with density-dependence could be assigned prior probabilities of 0.25 each, and that which ignores density-dependence a prior probability of 0.5.

1.4 DISCUSSION

The three models have shown a good concurrenence. However, use of the historic catch record leads to lower estimates of RY^{1+} because the analysis estimates the population to be close to carrying capacity and so the growth rate is reduced compared to that at low population size. However, there is no (visual) evidence in the abundance estimates for a reduction in trend. It therefore appears that it is the combination of the magnitude of the historical catches and the values for the biological parameters that determines the estimate of the carrying capacity. One implication of starting the population projection in 1848 is that the model under-predicts the 2001 estimate of abundance (probably because if the population is approaching carrying capacity, a near-linear growth in population size could not still be occurring). The '1848 DD' model is assigned less weight than the '1978 DD' and '1989 NON DD' models using Bayes factor, but the discrepancy between the predictions of the '1848 DD' model and the data remains sufficiently small that the '1848 DD' model cannot be rejected.

RY^{1+} is the catch that will keep a population at its current size. This quantity is less useful as the basis for management advice for the B-C-B bowhead stock now that at least some of the analyses suggest the recruited population may be approaching K^{1+}. Obviously RY^{1+} will be zero if the population stops increasing because it reaches carrying capacity. Q_1^{1+} is therefore a more appropriate catch-related quantity to examine because it does not become zero at carrying capacity. Furthermore, this quantity represents a catch level that has been argued to meet the requirements of aboriginal subsistence management (Wade and Givens, 1997; Wade, 2002a). The fact that there is no evidence to select one model over the others, and not all models result in similar estimates of catch quantities is a reason why model uncertainty is important to include when conducting assessments of marine renewable resources. The lower 5th percentile of the Bayesian model-averaged posterior of Q_1^{1+} is 155 whales, and represents our best estimate of the catch level that would meet the intent of aboriginal whaling management objectives, taking into account both parameter, and model uncertainty (to the extent that model uncertainty can be captured by the three models considered in this study). It should be noted, in light of recent discussions regarding stock structure (IWC, 2005b), that the results presented here are based on the assumption that the B-C-B population of bowhead whales is composed of a single stock.

The actual aboriginal catch quotas are driven by need, and have averaged 36 whales per year from 1978-2002. There appears to be little effect on population size due to this catch level. In fact, during this timeframe the B-C-B stock of bowhead whales is estimated to have more than doubled. Another way of putting an average take of 36 whales per year into perspective is to examine the annual net production over the last 25 years. If it is assumed that the population was increasing at a constant 3.5% per year (the median rate estimated from the density independent Leslie matrix analysis), the population increased by about 175 whales per year in 1978 (population size ~5,000), about 260 whales per year in 1990 (population size ~ 7,500), and about 350 whales per year in 2002 (population size ~ 10,000). Given that the population has increased from about 5,000 whales to about 10,000 whales, in this timeframe an average kill of 36 whales per year represents an annual catch rate between 0.35-0.70% of the total population size.

What is known about B-C-B bowhead life-history vital rates (survival, fecundity, etc.) appears consistent with the available data on trends in abundance and the proportion of the population in three stages (calves, immature and mature). Overall, the results support a value of r_{max} of between 0.03-0.05, a range often assumed for cetaceans, particularly species with delayed sexual maturity and a longer than 2-year calving interval (Reilly and Barlow 1986, Wade 1998, Wade 2002b). In light of the reproductive life-history of this species, the results make clear that the observed population growth rates can only be supported by extremely high survival rates, as already suggested by the estimates of adult survival (0.990) in Zeh *et al*. (2002), and the observations of exceptionally old individuals (George *et al*., 1999).

The analyses of this chapter are based on the same types of data that were available for the 1998 assessment of this stock. Several other sources of data exist. For example, Schweder and Ianelli (2000) examine whether the data on the age-composition of the 1973-93. Catches are consistent with the abundance and proportion data. Punt (2006) shows that it is possible to reconcile the abundance, proportion, length-frequency and age-composition data within a Bayesian framework. It would be straightforward conceptually (but perhaps computationally challenging) to use the approach outlined in this chapter to compare models that utilize these additional data sources. Bringing in those additional data, as well as doing a full model comparison of a variety of models, was beyond the scope of this chapter, but we agree this would be important future work, particularly in light of the methods now developed in Punt (2006).

This study represents the first attempt to quantify model uncertainty when conducting assessments of the B-C-B bowhead stock. The analyses consider three alternative models and take model uncertainty into account by weighting alternative models based on their posterior model probabilities and by calculating a Bayesian model-averaged posterior. The only previous attempt to consider model uncertainty when conducting assessments of whale stocks was by Wade (2002a), who compared models for the Eastern North Pacific stock of gray whales with and without additional variance about the abundance estimates. In that case, one model received almost all the weight making model-averaging redundant. In contrast, in this study all three models were assigned non-negligible weight and led to different estimates of quantities of interest (e.g., carrying capacity and related measures). The Bayesian model-averaged posterior distribution clearly represents our best efforts to incorporate all levels of uncertainty in the estimates of these quantities.

Table 1.1

Estimates, CVs (actually the standard errors of the log abundance estimates, which are approximately equal) and the correlation matrix for the indices of abundance for the Bering-Chukchi-Beaufort Seas stock of bowhead whales. Source: Zeh and Punt (2005).

Year	Estimate	CV	Correlation matrix											
1978	4,765	0.305	1.000											
1980	3,885	0.343	0.118	1.000										
1981	4,467	0.273	0.056	0.050	1.000									
1982	7,395	0.281	0.094	0.084	0.035	1.000								
1983	6,573	0.345	0.117	0.104	0.049	0.084	1.000							
1985	5,762	0.253	0.070	0.062	0.020	0.078	0.062	1.000						
1986	8,917	0.215	0.072	0.064	0.017	0.092	0.064	0.113	1.000					
1987	5,298	0.327	0.124	0.110	0.052	0.088	0.110	0.065	0.067	1.000				
1988	6,928	0.120	0.028	0.025	0.013	0.017	0.024	0.009	0.007	0.026	1.000			
1993	8,167	0.071	0.001	0.001	0.001	0.000	0.001	-0.001	-0.002	0.001	0.000	1.000		
2001	10,545	0.128	0.008	0.007	0.005	0.001	0.007	-0.004	-0.008	0.008	0.003	0.000	1.000	

Table 1.2

The proportion of observed calves (p_c^{obs}) and mature (p_m^{obs}) animals with associated standard errors, over the years 1985 to 1994. Proportions are given based on including and ignoring the anomalous 1985 data set, as well as those used in the previous assessment. Source: IWC (1999) and Koski *et al*. (2006).

Scenario	p_c^{obs}	σ_{p_c}	p_m^{obs}	σ_{p_m}
Exclude 1985	0.0580	0.0062	0.4366	0.0106
Include 1985	0.0309	0.0034	0.4160	0.0096
1998 assessment	0.052	0.0164	0.411	0.0286

Table 1.3

Catches of Bering-Chukchi-Beaufort Seas bowhead whales, 1848–2002. Values in parenthesis are the catches used by Punt and Butterworth (1999) in the 1998 assessment where these catches differ from those used in the present analyses.

Year	Total Kill	Year	Total Kill	Year	Total Kill	Year	Total Kill
1848	18	1887	240	1926	35	1965	14
1849	573	1888	160	1927	14	1966	24
1850	2067	1889	127	1928	30	1967	12
1851	898	1890	136	1929	30	1968	27
1852	2709	1891	284	1930	17	1969	32
1853	807	1892	346	1931	32	1970	48
1854	166	1893	180	1932	27	1971	25
1855	2	1894	234	1933	21	1972	44
1856	0	1895	117	1934	21	1973	51
1857	78	1896	118	1935	15	1974	42
1858	461	1897	130	1936	24	1975	32
1859	372	1898	309	1937	53	1976	74
1860	221	1899	234	1938	36	1977	72
1861	306	1900	148	1939	18	1978	15
1862	157	1901	55	1940	20	1979	20
1863	303	1902	162	1941	38	1980	32
1864	434	1903	116	1942	26	1981	26
1865	590	1904	86	1943	14	1982	14
1866	554	1905	105	1944	8	1983	16
1867	599	1906	69	1945	23	1984	16
1868	516	1907	96	1946	20	1985	14
1869	382	1908	123	1947	21	1986	22
1870	637	1909	61	1948	8	1987	29
1871	138	1910	37	1949	11	1988	28
1872	200	1911	48	1950	23	1989	25
1873	147	1912	39	1951	23	1990	41
1874	95	1913	23	1952	11	1991	47
1875	200	1914	61	1953	41	1992	46
1876	76	1915	23	1954	9	1993	51
1877	270	1916	23	1955	36	1994	39 (38)
1878	80	1917	35	1956	11	1995	56 (57)
1879	266	1918	27	1957	5	1996	42 (45)
1880	480	1919	33	1958	5	1997	62
1881	435	1920	33	1959	2	1998	51
1882	242	1921	9	1960	33	1999	47
1883	42	1922	39	1961	17	2000	42
1884	160	1923	12	1962	20	2001	67
1885	377	1924	41	1963	15	2002	44
1886	168	1925	53	1964	24		

Table 1.4

Prior distributions used for the reference scenarios for each model type. Dashes (-) represent prior distributions that are equal to those from the model in the column to the left (e.g. the 1978 NON DD model had the same prior on the size of the 1+ population in 1978 as the 1978 DD model). 'N/A' represents a prior that was not applicable to a certain model or models. Fecundity is defined as female calves per mature female. For the 1978 NON DD model r_{max} and f_{max} are not maxima, but constant values. Results from the reference scenario were used in all figures and when performing the Bayesian model averaging. The reference scenarios are based on the stage-proportion data set that ignores the data for 1985.

Parameter		Model Type		
		1848 DD	1978 DD	1978 NON DD
S_a	adult survival	N(0.990, 0.02), truncated at 0.940 and 0.995[a]	-	-
f_{max}	maximum fecundity	U[0.125, 0.200][b]	-	-
a_T	age-at-transition to adult survival	U[0, 8][c]	-	-
a_m	age-at-sexual maturity	N(20.0, 3.0) truncated at 13.0 and 26.0[d]	-	-
$r_{max} = \lambda - 1$	intrinsic population growth rate	U[0.005, 0.075][e]	-	-
N_{1978}^{1+}	1+ population size in 1978	N/A	U[3000, 9000][f]	-
N_{1993}^{1+}	1+ population size in 1993	N(7800, 1200)[g]	N/A	N/A
K^{1+}	1+ carrying capacity	N/A	U[8000, 30000][h]	N/A
$MSYL^{1+}$	*MSYL* in terms of the 1+ component	U[0.40, 0.80] [i]	-	-

Table 1.4 continued

a – based on the posterior distribution for adult survival rate obtained by Zeh *et al*. (2002).

b – the prior for the maximum number of calves (of both sexes) per mature female selected by the Scientific Committee of the International Whaling Commission was U[0.25, 0.4] (IWC, 1995). This is the corresponding prior given fecundity has been defined here as female calves per mature female per year.

c – selected by the Scientific Committee of the International Whaling Commission (IWC, 1995) although there is little information on the value of this parameter (Givens *et al*., 1995).

d – based on a best estimate of 20 years and a lower confidence for the age-at-maturity of 14 years (IWC, 1995).

e – preliminary trials indicated there was no posterior probability outside this range, which was confirmed in the final analyses. This range was therefore selected to improve the efficiency of the numerical integration while not affecting the results.

f – selected to encompass a plausible range of values for 1+ population size in 1978.

g – selected by the Scientific Committee of the International Whaling Commission (IWC, 1995) based on the prior distribution assumed for the Bayes empirical Bayes estimate of abundance (Raftery and Zeh, 1991).

h – based on the range selected by the Scientific Committee of the International Whaling Commission (IWC, 1995).

i – selected to encompass the range of values commonly assumed when conducting assessments of cetacean populations.

Table 1.5

Posterior medians (5th , 95th percentiles) for eight management-related quantities. This table includes results for all models and scenarios, and Bayesian model-averaged results for the reference scenarios. Model averages for all quantities, except RY and N^{1+}_{2002} (i.e., the two quantities not dependent on *K*), could only be based on the 1848 and 1978 DD models. Where noted, additional scenarios are based on the reference scenarios in Table 1.4, but changed to examine the sensitivity of the results to different proportion data sets and less informative priors. The uniform prior for S_a is U[0.940, 0.995], and that for a_m is Discrete U[13, 26]. Unique draws and the maximum number of times an individual draw is included in the final SIR resample are listed in rightmost two columns.

	N^{1+}_{2002}	K^{1+}	RY^{1+}	Q^{1+}_{1}	N^{1+}_{2002} / K^{1+}
1848 DD					
Reference scenario	9496 (8750 , 10180)	10960 (9190 , 13950)	171 (61 , 233)	228 (149 , 296)	0.888 (0.647 , 0.985)
No proportion data	9380 (8652 , 10070)	10980 (9245 , 14710)	160 (63 , 222)	216 (132 , 283)	0.874 (0.602 , 0.983)
Uniform priors on S_a and a_m	9488 (8782 , 10180)	10580 (9112 , 13610)	159 (59 , 229)	241 (158 , 301)	0.921 (0.674 , 0.986)
1978 DD					
Reference scenario	10670 (9042 , 12410)	20510 (11010 , 29120)	324 (147 , 501)	295 (160 , 439)	0.530 (0.356 , 0.925)
No proportion data	10410 (8740 , 12380)	20350 (10600 , 29070)	297 (119 , 519)	270 (136 , 457)	0.524 (0.348 , 0.930)
Include 1985 proportion data	9294 (7780 , 10720)	13510 (8110 , 28890)	166 (44 , 280)	193 (74 , 289)	0.705 (0.299 , 0.990)
Uniform priors on S_a and a_m	10820 (9124 , 12600)	19870 (10750 , 29090)	336 (138 , 525)	309 (168 , 459)	0.554 (0.362 , 0.947)
U[8000, 100000] prior on K	10830 (9160 , 12690)	54430 (14990 , 95500)	363 (188 , 566)	267 (136 , 426)	0.201 (0.110 , 0.710)
1978 NON DD					
Reference scenario	10740 (9130 , 12700)	N/A	366 (204 , 588)	N/A	N/A
No proportion data	11020 (9199 , 13130)	N/A	402 (206 , 654)	N/A	N/A
Include 1985 proportion data	10280 (8796 , 12090)	N/A	310 (166 , 511)	N/A	N/A
Uniform priors on S_a and a_m	11110 (9265 , 13050)	N/A	414 (217 , 644)	N/A	N/A
Bayesian model average	10276 (8907 , 12406)	13854 (9466 , 28475)	297 (92 , 539)	257 (155 , 412)	0.720 (0.372 , 0.980)

Table 1.5 continued

	MSYL^{1+}	*MSY*$^{1+}$	*MSYR*$^{1+}$	Unique draws	max sampled draw (n)
1848 DD					
Reference scenario	0.734 (0.639 , 0.793)	253 (166 , 329)	0.033 (0.019 , 0.048)	7399	9
No proportion data	0.703 (0.555 , 0.791)	240 (147 , 315)	0.032 (0.017 , 0.047)	9456	4
Uniform priors on S_a and a_m	0.740 (0.644 , 0.795)	267 (176 , 335)	0.035 (0.020 , 0.049)	6527	9
1978 DD					
Reference scenario	0.651 (0.573 , 0.779)	368 (206 , 599)	0.030 (0.018 , 0.043)	8992	5
No proportion data	0.661 (0.528 , 0.785)	341 (169 , 644)	0.029 (0.016 , 0.043)	9519	3
Include 1985 proportion data	0.607 (0.459 , 0.784)	225 (89 , 333)	0.025 (0.009 , 0.048)	8034	8
Uniform priors on S_a and a_m	0.654 (0.570 , 0.781)	379 (215 , 624)	0.032 (0.019 , 0.045)	7493	9
U[8000, 100000] prior on K	0.606 (0.523 , 0.777)	712 (282 , 1737)	0.025 (0.014 , 0.038)	7554	7
1978 NON DD					
Reference scenario	N/A	N/A	N/A	9262	5
No proportion data	N/A	N/A	N/A	9809	3
Include 1985 proportion data	N/A	N/A	N/A	6264	9
Uniform priors on S_a and a_m	N/A	N/A	N/A	8374	6
Bayesian model average	0.695 (0.581 , 0.788)	302 (180 , 555)	0.031 (0.018 , 0.046)		

Table 1.6

Posterior medians (5th , 95th percentiles) for eight life history-related quantities for all models and scenarios, and the Bayesian model-averaged results for the reference scenario. For the 1978 NON DD model, fecundity and population growth rate only apply to the specified period, and are referred to here as f and r. The model-averaged results for these rates are based only on the two models with density dependence, and refer to $f_{\max}$ and $r_{\max}$.

	S_a	S_j	$f_{\max}$ (or f)	$r_{\max}$ (or r)
1848 DD				
Reference scenario	0.989 (0.977 , 0.995)	0.926 (0.718 , 0.980)	0.171 (0.135 , 0.198)	0.041 (0.024 , 0.059)
No proportion data	0.991 (0.978 , 0.995)	0.957 (0.739 , 0.990)	0.181 (0.136 , 0.199)	0.046 (0.024 , 0.062)
Uniform priors on Sa and ASM	0.988 (0.972 , 0.994)	0.943 (0.786 , 0.981)	0.174 (0.138 , 0.198)	0.044 (0.026 , 0.059)
1978 DD				
Reference scenario	0.991 (0.979 , 0.995)	0.945 (0.765 , 0.988)	0.171 (0.133 , 0.198)	0.045 (0.025 , 0.063)
No proportion data	0.991 (0.978 , 0.995)	0.957 (0.753 , 0.990)	0.181 (0.136 , 0.199)	0.045 (0.025 , 0.062)
Include 1985 proportion data	0.993 (0.979 , 0.995)	0.981 (0.750 , 0.993)	0.182 (0.126 , 0.199)	0.049 (0.027 , 0.065)
Uniform priors on S_a and a_m	0.989 (0.974 , 0.995)	0.956 (0.816 , 0.988)	0.171 (0.135 , 0.198)	0.047 (0.027 , 0.064)
U[8000, 100000] prior on K	0.990 (0.978 , 0.995)	0.940 (0.752 , 0.987)	0.162 (0.130 , 0.197)	0.042 (0.025 , 0.061)
1978 NON DD				
Reference scenario	0.990 (0.977 , 0.995)	0.923 (0.717 , 0.978)	0.141 (0.127 , 0.163)	0.035 (0.022 , 0.049)
No proportion data	0.989 (0.975 , 0.995)	0.936 (0.684 , 0.985)	0.173 (0.132 , 0.198)	0.038 (0.022 , 0.053)
Include 1985 proportion data	0.989 (0.976 , 0.995)	0.823 (0.477 , 0.899)	0.197 (0.191 , 0.200)	0.031 (0.018 , 0.044)
Uniform priors on Sa and ASM	0.988 (0.973 , 0.995)	0.943 (0.783 , 0.982)	0.144 (0.128 , 0.166)	0.038 (0.023 , 0.052)
Bayesian model average	0.990 (0.978 , 0.995)	0.932 (0.733 , 0.984)	0.171 (0.133, 0.198)	0.043 (0.025, 0.062)

Table 1.6 continued

	a_m	a_T	p_c	p_m
1848 DD				
Reference scenario	16 (14 , 21)	5 (1 , 9)	0.055 (0.046 , 0.065)	0.436 (0.418 , 0.453)
No proportion data	17 (13 , 23)	5 (1 , 9)	N/A	N/A
Uniform priors on Sa and ASM	15 (13 , 20)	5 (1 , 9)	0.056 (0.048 , 0.065)	0.437 (0.420 , 0.454)
1978 DD				
Reference scenario	16 (13 , 21)	5 (1 , 9)	0.057 (0.048 , 0.066)	0.435 (0.418 , 0.452)
No proportion data	17 (13 , 23)	5 (1 , 9)	N/A	N/A
Include 1985 proportion data	20 (13 , 25)	5 (1 , 9)	0.034 (0.025 , 0.040)	0.424 (0.394 , 0.663)
Uniform priors on S_a and a_m	15 (13 , 19)	5 (1 , 9)	0.058 (0.050 , 0.066)	0.436 (0.419 , 0.453)
U[8000, 100000] prior on K	16 (14 , 21)	5 (1 , 9)	0.057 (0.049 , 0.067)	0.435 (0.417 , 0.453)
1978 NON DD				
Reference scenario	17 (14 , 22)	5 (1 , 9)	0.060 (0.054 , 0.068)	0.434 (0.417 , 0.450)
No proportion data	19 (14 , 23)	5 (1 , 9)	N/A	N/A
Include 1985 proportion data	18 (14 , 22)	4 (1 , 9)	0.081 (0.080 , 0.084)	0.424 (0.414 , 0.437)
Uniform priors on Sa and ASM	15 (13 , 21)	5 (1 , 9)	0.061 (0.054 , 0.069)	0.435 (0.418 , 0.452)
Bayesian model average	16 (14 , 21)	5 (1 , 9)	0.058 (0.049 , 0.067)	0.435 (0.417 , 0.452)

Table 1.7

Bayes factors for comparison of paired models. Evidence categories are modifications of the original categories of Jefferys (1961), as presented by Kass and Raftery (1995) and used by Wade (2002a) in an assessment of the Eastern North Pacific gray whales: >150 is decisive evidence, 12-150 is strong evidence, 3-12 is positive evidence, and 1-3 is not worth more than a bare mention. All comparisons are based on the results of the reference scenarios.

Models	Bayes factor	Evidence for the first model
1978 DD *vs* 1848 DD	1.37	Not worth more than a bare mention.
1978 NON DD *vs* 1848 DD	1.51	""
1978 NON DD *vs* 1978 DD	1.10	""

Table 1.8

The average likelihood (Eq. 10) and posterior model probabilities used in the Bayesian model averaging. It was only possible to consider the two DD models for averaging quantities related to carrying capacity. All models were considered equally likely *a priori*.

		Posterior model probabilities for models considered	
Model	Average Likelihood	All three	1848 DD and 1978 DD
1848 DD	0.522	0.258	0.422
1978 DD	0.715	0.353	0.578
1978 NON DD	0.789	0.389	N/A

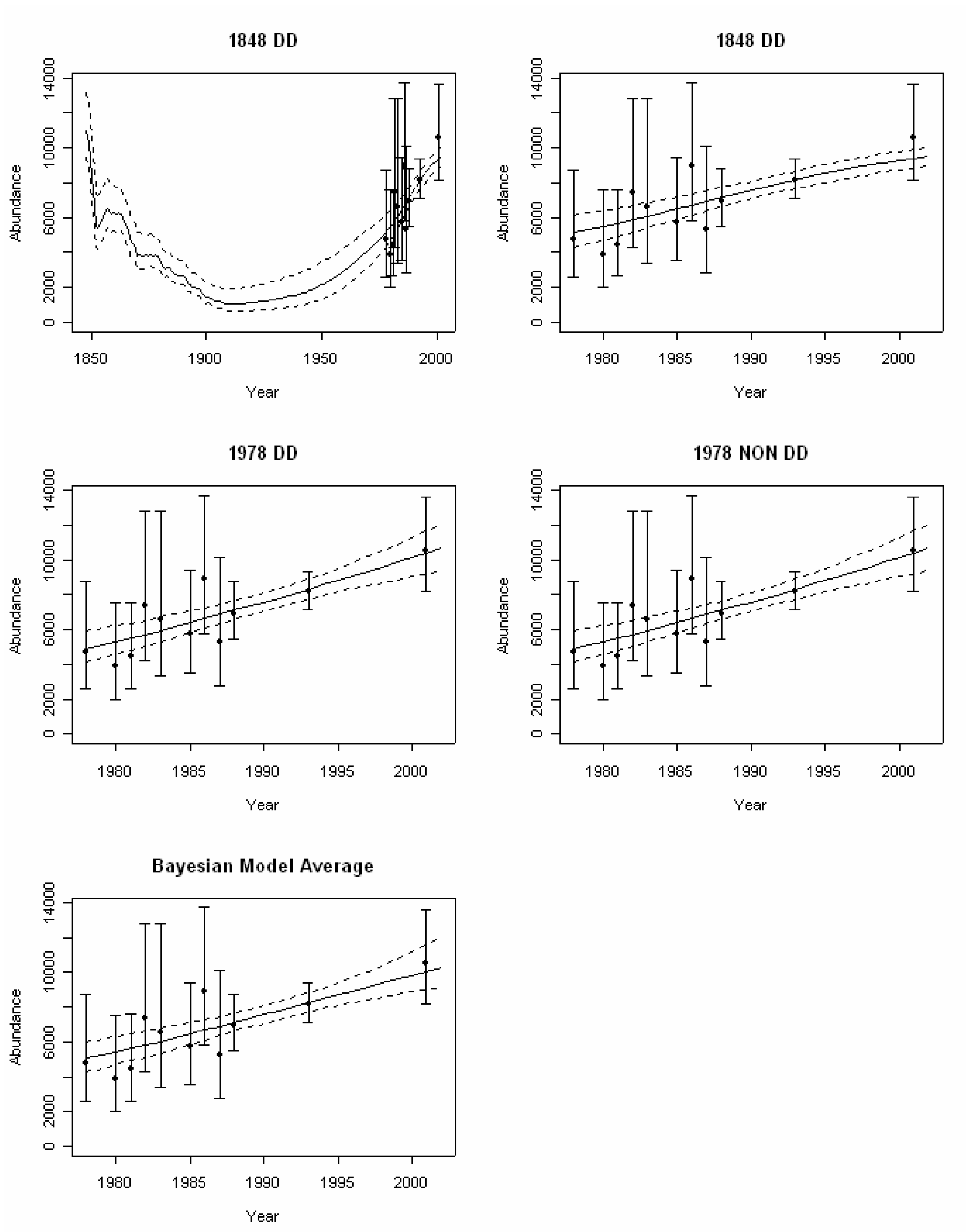

Figure 1.1: Time trajectories (medians and 90% credibility intervals) for 1+ population size for the three reference scenarios and the Bayesian model average. The two uppermost plots are for the 1848 DD model, showing the entire trajectory from 1848, and only the recent trajectory from 1978 for comparison. Error bars represent 95% CI's, and are assumed to be log-normally distributed for all abundance estimates except 1993 (second to last), which is assumed to be normally distributed.

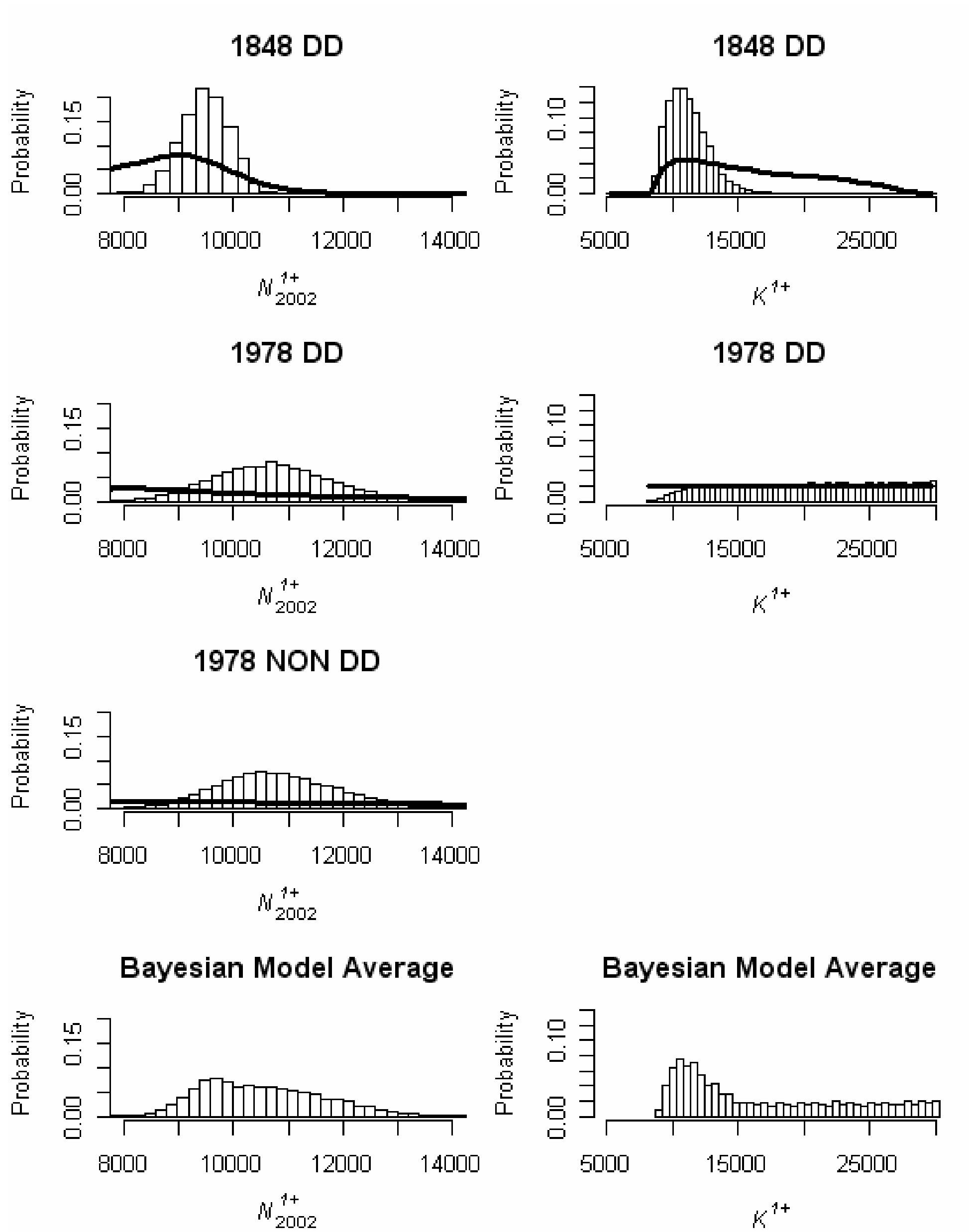

Figure 1.2: and Posterior (vertical bars) and post-model-pre-data (solid lines) distributions for 1+ population size in 2002, N^{1+}_{2002} (left panels) and 1+ carrying capacity, K^{1+} (right panels). Results are shown for only two of the three reference scenarios for K^{1+}, and the Bayesian model average for K^{1+} is based on the results of these two scenarios only.

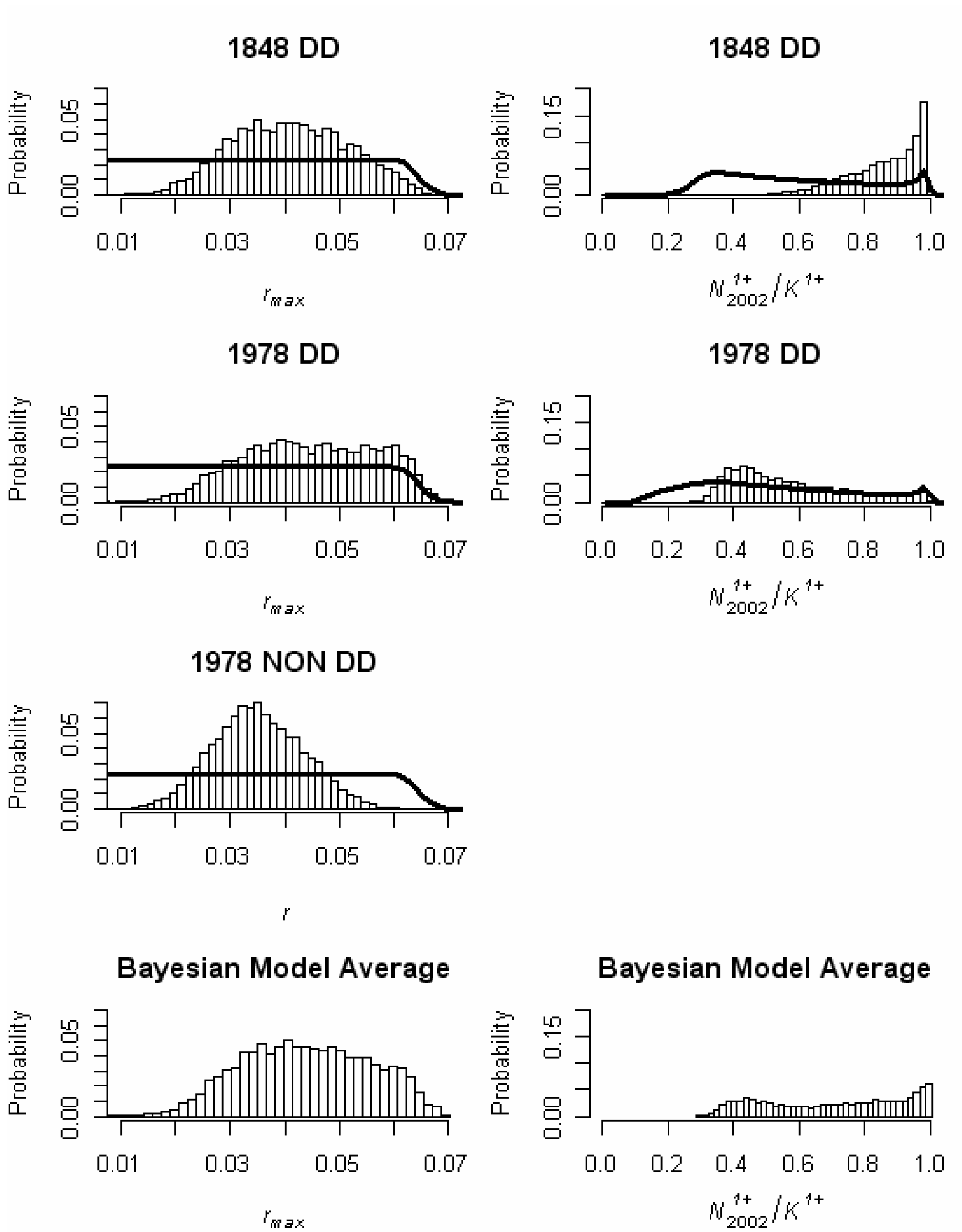

Figure 1.3: Posterior (vertical bars) and post-model-pre-data (solid lines) distributions for intrinsic population growth rate, $r_{\max}$ and r (left panels) and recent depletion in terms of the 1+ component, N^{1+}_{2002} / K^{1+} (right panels). The Bayesian model average is based only on the two models with density dependence.

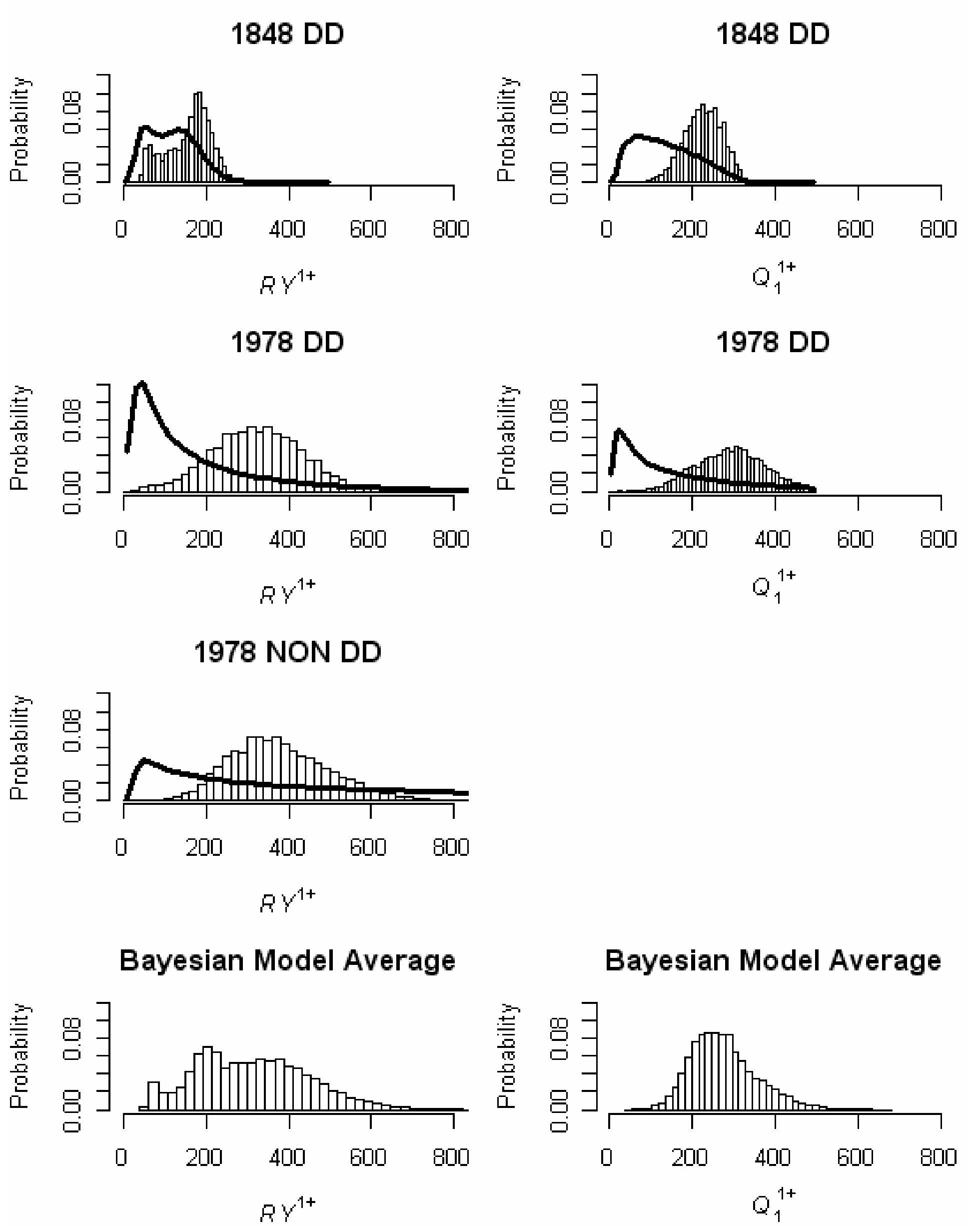

Figure 1.4: Posterior (vertical bars) and post-model-pre-data (solid lines) distributions for replacement yield, RY^{1+} (left panels) and Q_1^{1+} (right panels). Results are shown for only two of the three reference scenarios for Q_1^{1+}, and the Bayesian model average for Q_1^{1+} is based on the results of these two scenarios only.

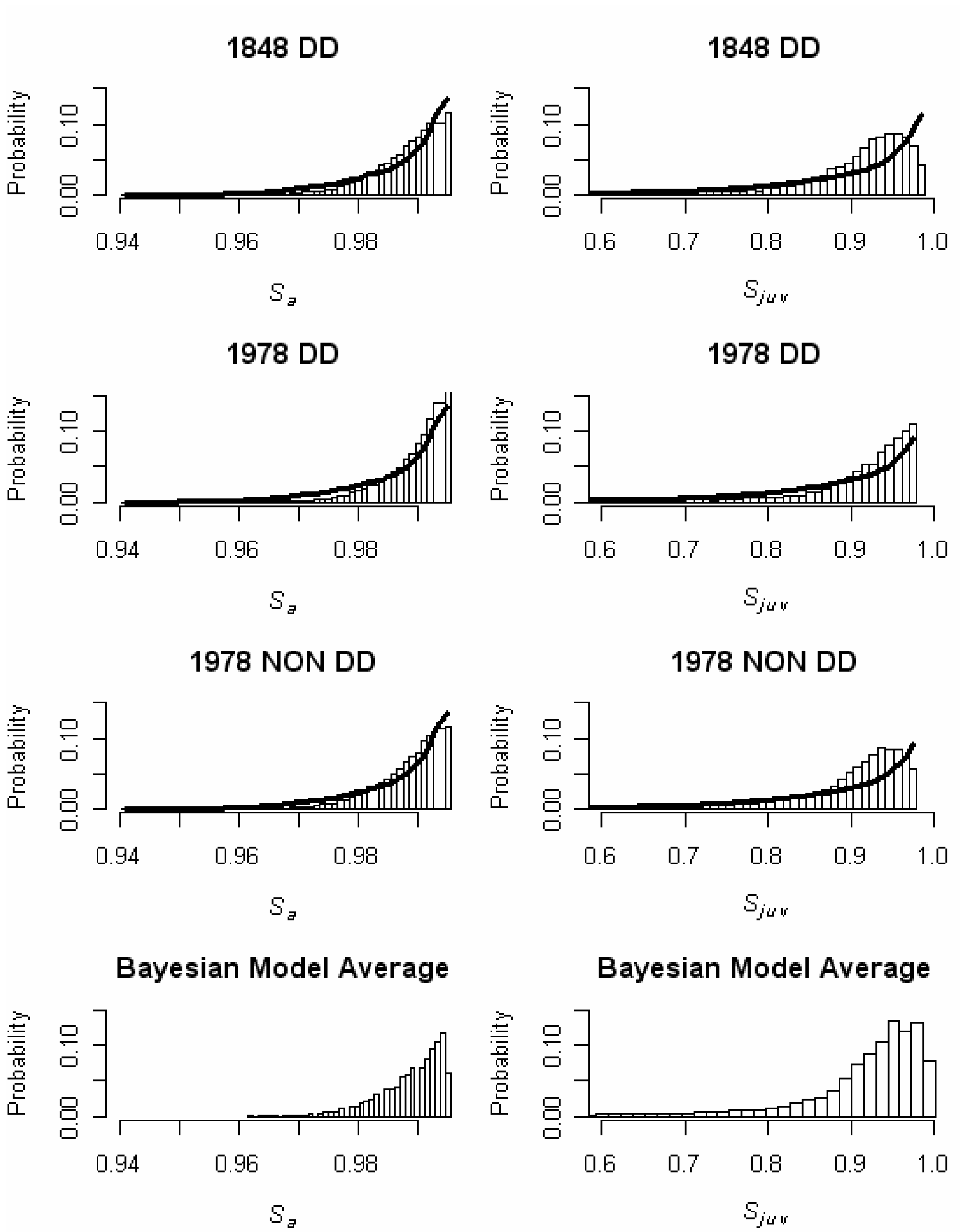

Figure 1.5: Posterior (vertical bars) and post-model-pre-data (solid lines) distributions for adult survival rate, S_a (left panels) and calf and juvenile survival rate, S_{juv} (right panels). Results are shown for the three reference scenarios and for the Bayesian model average.

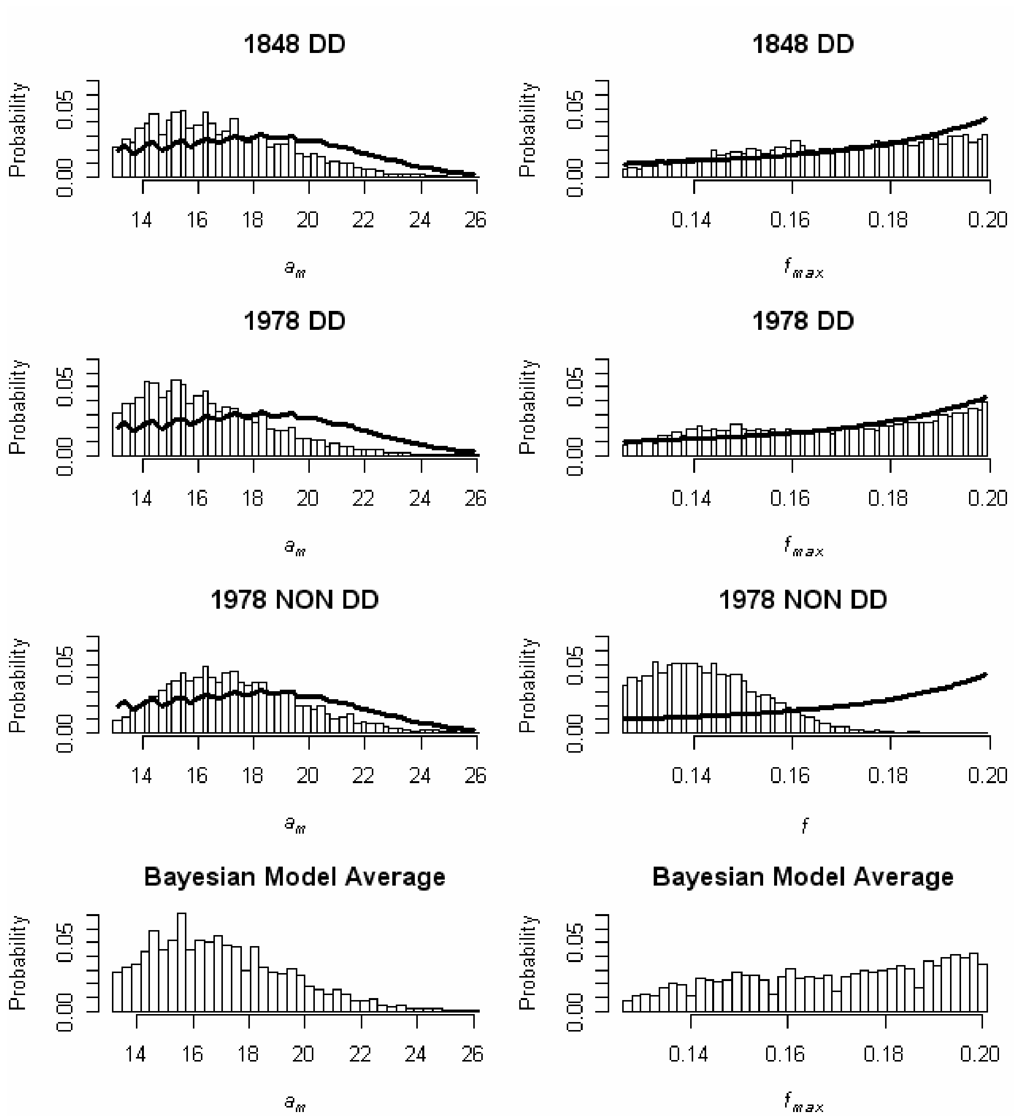

Figure 1.6: Posterior (vertical bars) and post-model-pre-data (solid lines) distributions for the age-at-maturity, a_m (left panels) and fecundity, f_{max} or f (right panels). Results are shown for the three reference scenarios and for the Bayesian model average, which is based only on the two models with density dependence for fecundity.

Chapter 2:

Constructing a coherent joint prior while respecting biological realism: sensitivity of marine mammal stock assessments to recent methods[4]

ABSTRACT

Bayesian estimation methods, employing the Sampling-Importance-Resampling algorithm, are currently used to perform stock assessments for several stocks of marine mammals, including the Bering-Chukchi-Beaufort Seas stock of bowhead whales (*Balaena mysticetus*) and walrus (*Odobenus rosmarus rosmarus*) off Greenland. However, due to the functional relationships among parameters in deterministic age-structured population dynamics models, placing explicit priors on each life-history parameter in addition to the population growth rate parameter results in an incoherent prior distribution (i.e., two different priors on the same parameter). One solution to constructing a coherent joint prior is to solve for juvenile survival analytically, given values generated from the prior distributions for the remaining parameters in the model (including population growth rate). However, certain combinations of parameter values result in solutions for juvenile survival that are larger than adult survival, which is biologically implausible. Therefore, in order to respect biological realism, parameter values must be rejected for some or all of the remaining parameters. This study investigates several alternative resampling schemes for obtaining feasible solutions for juvenile survival. The sensitivity of assessment results is investigated for data-rich (bowhead) and data-poor (walrus) scenarios. The results based on limited data are especially sensitive to the choice of alternative resampling scheme.

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[4] This chapter was published in ICES Journal of Marine Science:

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2.1 INTRODUCTION

Bayesian methods utilizing age-structured population dynamics models (PDMs) have formed the basis for recent stock assessments of several marine mammal populations, including those for Atlantic walrus, *Odobenus rosmarus rosmarus*, in Greenland (Witting and Born, 2005); the Bering-Chukchi-Beaufort Seas (B-C-B) stock of bowhead whales, *Balaena mysticetus* (Brandon and Wade, 2006; Punt, 2006); British grey seals, *Halichoerus grypus* (Buckland *et al.*, 2004; Thomas *et al.*, 2005); the Eastern North Pacific stock of gray whales, *Eschrichtius robustus* (Wade, 2002a; Witting, 2003; Punt *et al.*, 2004); New Zealand sea lions, *Phocarctos hookeri* (Breen et. al., 2003; Breen and Kim, 2006); Northeastern offshore spotted and Eastern spinner dolphins, *Stenella attenuata* and *Stenella longirostris orientalis* (Wade, 1994; Alvarez-Flores, 2002; Hoyle and Maunder, 2004); and Steller sea lions, *Eumetopias jubatus* (Fay, 2004; Fay and Punt, 2006; Winship and Trites, 2006). These assessments use Bayesian estimation methods to calculate posterior probability distributions for model parameters and management-related quantities, and to form the basis for risk analyses to evaluate the implications of potential management actions (Hilborn and Walters, 1992; Ellison, 1996). A brief review is provided below of the developments required for commonly used Bayesian methods when applied to age-structured PDMs for marine mammal stock assessments: the necessity of constructing a coherent joint prior distribution; one solution to this challenge that has been employed in several recent stock assessments; and, finally, the importance of investigating the sensitivity of those results to alternative schemes for constructing a coherent joint prior while respecting biological realism.

Adopting similar approaches to Butterworth *et al.* (1987) and Nakamura *et al.* (1989), Givens (1993), Raftery *et al.* (1995) and Givens *et al.* (1995) developed and influenced the application of Bayesian methods to age-structured PDMs for marine mammal stock assessment. The method developed, ‘Bayesian synthesis,’ was a departure from the ‘standard Bayesian’ approach in that it allowed explicit prior distributions on *both* model inputs *and* model outputs. During the development of these methods, it was shown that Bayesian synthesis (as originally proposed) is inappropriate on theoretical grounds (Wolpert, 1995; Schweder and Hjort, 1996). Givens and Raftery (1997) clarified the concerns by distinguishing two problems: 1) Borel’s paradox (i.e., conditioning on an ill-defined distribution, resulting in this case from explicit priors on both model input and outputs, and ultimately leading to posterior distributions that are not invariant to model parameterization); and, 2) prior incoherence (i.e., the partly implicit presence of two different prior distributions on the same parameter). Bravington (1996) provides illustrative examples of these issues using a simple model of exponential population growth. Borel’s paradox does not apply to a standard Bayesian analysis. However, the issue of prior incoherence is a potential concern for all Bayesian stock assessments. As Givens and Roback (1999) stress, simultaneous and competing prior distributions for the same parameters are common occurrences in Bayesian modeling.

A coherent joint prior must be constructed before inference may be drawn from Bayesian analyses. Punt and Hilborn (1997) advise that care needs to be taken in order to avoid *implicitly* specifying contradictory priors for the same parameter in Bayesian stock assessments. Those authors demonstrate how explicit prior distributions on both unexploited biomass and current depletion (the ratio of current biomass to unexploited biomass) lead to incoherent priors. Such subtleties become more insidious as PDMs (and the functional relationships among parameters therein) increase in complexity. Fortunately, several approaches have been developed to address this issue in the context of age-structured PDMs. However, we postpone consideration of alternative methods at this stage, and instead return to this during the concluding discussion. The sensitivity analyses presented here focus on only one approach for constructing a coherent joint prior while respecting biological realism: the most commonly employed during recent assessments of large whales as outlined below (e.g., Punt and Butterworth, 1999; 2002; Wade, 2002a; Punt *et al.* 2004; Punt, 2006; Brandon and Wade, 2006).

Due to the functional relationships among life-history parameters and the parameter related to population growth rate in a deterministic age-structured PDM (Lotka, 1907; Euler, 1970), placing priors on life history parameters in addition to a prior on the population growth rate would result in effectively placing two (most likely incoherent) priors on the same parameter. Therefore, one option for constructing a coherent joint prior is to place marginal priors on all but one of these parameters, and then solve for the value of the remaining parameter analytically. Given that many of the key model outputs (e.g. the current rate of increase) are almost directly proportional to the population growth rate, having an explicit prior on the latter parameter allows clear consideration of the impact of the priors on these model outputs. For example, placing a uniform prior on the population growth rate, to the extent that it is possible, essentially imposes a non-informative prior on some of the model outputs of interest to management.

There exists very little information on which to base a prior on juvenile survival S_{juv} for the majority of marine mammal populations. Therefore, it has been argued that placing an explicit prior on this life history parameter is unfounded for most species, and that a more appealing approach would be to simply impose some biological bounds instead of a full probability distribution (Butterworth, 1995). Additionally, a common assumption in age-structured PDMs for marine mammals, is that juvenile survival is less than adult survival S_a (e.g. IWC, 1995; Chivers, 1999; Witting and Born, 2005). This assumption is based on observed mammalian mortality patterns, which are typically U-shaped with age (Caughley, 1966; Barlow and Boveng, 1991). Thus, one solution to constructing a coherent joint prior is not to place an explicit prior on S_{juv} (Punt and Butterworth, 1996), but instead to solve for this parameter analytically given the values for the other life history parameters and the population growth rate (Breiwick *et al.*, 1984; Punt, 1999a). Furthermore, the solution for S_{juv} is subject to the constraint, $S_{juv} < S_a$. This approach is appealing because it is a relatively simple, minimizes the influence of priors for life history parameters on key model outputs of interest to management, and results in a coherent joint prior distribution that also respects biological realism.

Sensitivity tests to alternative prior specifications should be conducted during the assessment processes to ensure that inference is robust. Effectively, the constraint $S_{juv} < S_a$ is an element of the joint prior on the life history parameters. However, certain combinations of otherwise reasonable parameter values result in solutions for S_{juv} which seem biologically implausible - if not completely impossible. Specifically, solutions for S_{juv} may result that are larger than those for adult survival (including values larger than 1.0; Figure 2.1). In these cases, it is possible to construct a coherent joint prior in more than one way. For example, in addition to completely ignoring that parameter space which violates the constraint, one could also resample values for different subsets of the life history parameters (effectively re-weighting the marginals) until a feasible solution for S_{juv} is attained. Both of these approaches satisfy the constraint $S_{juv} < S_a$ and both have been applied in marine mammal stock assessments. However, the question of sensitivity to such alternative resampling schemes has not been explored in any detail to date.

The Sampling-Importance-Resampling[5] (SIR) algorithm for approximating Bayesian posterior distributions is employed in this chapter to generate realized prior distributions (also referred to as post-model-pre-data distributions). These distributions represent the actual (implicit) marginal prior distribution for each parameter after the explicit marginal prior distributions have been reconciled (via the model and resampling schemes) into a coherent joint probability distribution. It would be expected that the realized prior distribution will differ under alternative resampling schemes, but little is known about whether and how, if at all, the

[5] 'Resampling' parameters values to find a feasible solution for S_{juv} should not be confused with the 'resampling' step in the SIR algorithm.

posteriors for the quantities of management interest are affected. The results of these interactions are potentially relevant to the calculation of management-related quantities and hence to the provision of management advice.

This chapter therefore explores the sensitivity of Bayesian assessments for marine mammal populations to several alternative resampling schemes used to construct a coherent joint prior, while simultaneously respecting biological realism. Results are provided for two populations that differ in terms of the amount of available data to illustrate the consequences in terms of quantities of management interest. The B-C-B bowhead stock is data-rich in that considerable information is available on abundance and trends in abundance (e.g. Zeh and Punt, 2005); in contrast the walrus off East Greenland (E-G) are data-poor, with only one (fairly imprecise) estimate of abundance on which to base assessments, and hence management advice (Born *et al.*, 1997; Witting and Born, 2005).

2.2. METHODS

To ease subsequent comparison, similar methods are used for the analyses of both the bowhead and walrus data. Hence, unless noted otherwise, the methods described here apply to both populations. Similarly, all parameters related to abundance or catch statistics are reported in terms of the 1+ component of the population (all age groups except calves), except for the trajectories of walrus population size which are plotted on the same scale as the prior for recent abundance (total population size including calves).

Available data

B-C-B bowhead whales

The PDMs utilise three sources of data: 1) abundance estimates from ice-based surveys at Pt. Barrow, Alaska between 1978 and 2001 (Table 2.1); 2) proportion calves/mature animals in the population from 1985 to 1994 (Table 2.2); and 3) annual catches in individuals from 1848 to 2002 (see Punt, 2006 for this catch table).

E-G walrus

A single abundance estimate of 1000 exists for the E-G walrus population. This estimate is based on opportunistic and systematic observations (Born *et al.*, 1997; Witting and Born, 2005) and is assumed to relate to the total population (i.e., including young of the year). Following Witting and Born (2005), the coefficient of variation for this estimate is arbitrarily set to 0.35 to encompass the plausible range for abundance in 1995. This estimate forms the basis for the prior on abundance in 1995 (see below).

Born *et al.* (1997) report, or in some years estimate, catches of walrus off East Greenland during 1889-1999. These catches are treated as known (or estimated without error) in the model. No attempt has been made in this analysis to take into account the potential number of animals struck and lost, or the numbers landed and not reported in a given year (i.e., this corresponds to the "low" catch history analyzed by Witting and Born (2005)). The reader is referred to Born *et al.* (1997) and Witting and Born (2005) for the catch table and a detailed list of sources regarding these catches.

Prior to 1956, there is no information on the sex-ratio of the catch. In 1956, walrus off East Greenland were protected north of ca. 72°N, effectively ending the foreign fishery on this population. After 1956, the sex-ratio in the Greenlandic catch is highly skewed towards males (~90%; Born *et al.*, 1997). Therefore, we follow the methods of Witting and Born (2005), and assume an even sex ratio prior to 1956, and a 9:1 M:F sex-ratio thereafter.

Inflated catches

The implications of higher levels of catch on model outputs are examined by multiplying the catch history by five, for both B-C-B bowheads and E-G walrus.

Population dynamics model

The underlying PDM is an age- and sex- structured Leslie matrix (Leslie, 1945, 1948) projected as:

$$\mathbf{N_{t+1}} = (\mathbf{A_t N_t}) - \mathbf{C_t} \tag{2.1}$$

where:

$\mathbf{N_t}$ is the matrix of population size by sex and age class at the start of year *t* (defined when births and natural mortality occur);

$\mathbf{A_t}$ is the Leslie matrix for year *t*; and

$\mathbf{C_t}$ is the matrix of sex- and age-specific catches during year *t*.

The parameters that define the entries of the Leslie matrix are: 1) S_{juv}, the survival rate of immature animals (assumed identical for calves and juveniles); 2) a_T, the last age with survival rate S_{juv}; 3) S_a, the survival rate of mature animals; 4) a_m, the age at sexual maturity (the last age-class with zero fecundity, i.e., birth occurs at age a_m+1 years, the age at first parturition); 5) $f_{\max}$, the maximum fecundity rate; and 6) $a_{\max}$, the age after which survival becomes zero. Fecundity is assumed to be identical for all mature animals, and is calculated as the number of female calves per mature female. The sex ratio at birth is assumed to be 50:50 male:female. Recruitment to the fishery is assumed to be knife-edged and to occur at age 1, and the catch is hence distributed uniformly over all recruited age-classes.

Density dependence and initial conditions

Density dependence is assumed to affect fecundity according to a Pella-Tomlinson functional relationship based on the depletion of the 1+ component of the population (Pella and Tomlinson, 1969; Allen, 1976):

$$f_t = f_0 + (f_{\max} - f_0)\left[1 - \left(\frac{N_t^{1+}}{K^{1+}}\right)^z\right] \tag{2.2}$$

where:

f_t is the fecundity during year *t*;

N_t^{1+} is the (1+) population size at the start of year *t*;

K^{1+} is the pre-exploitation (1+) population size;

z is the Pella-Tomlinson shape parameter; and

f_0 is the fecundity at carrying capacity.

Given values of the life-history parameters, the value for f_0 is determined from the characteristic equation of the Leslie matrix given equilibrium conditions (Breiwick *et al.*, 1984; Punt, 1999a):

$$f_0 = \frac{1 - S_a}{S_{juv}^{(a_T)} S_a^{(a_m - a_T)} [1 - S_a^{(a_{\max} - a_m - 1)}]} \tag{2.3}$$

The population projections are initialized from a stable age distribution at the start of the year before the first catch is removed, given values for the parameters sampled from the joint prior distribution.

Modeling approaches

B-C-B bowhead whales

The population trajectory is modeled in two ways: 1) a density-dependent model initialized in 1848 (abbreviated: '1848 Bkwd'), and; 2) a density-dependent model initialized in 1978 ('1978 Fwd'). The six life-history parameters of the Leslie model are included in each model. However the approach used to estimate the equilibrium population size, or carrying capacity, *K*, differs between the two modelling approaches. The '1848 Bkwd' model includes a parameter with associated prior for the population size in 1993, N_{1993}, and the 'backwards' method

(Butterworth and Punt, 1995, 1999) is used to back-calculate to the population size in 1848 (assumed to be equal to *K*). Instead of placing a prior on N_{1993}, the '1978 Fwd' model involves placing a prior on the population size in 1978, N_{1978}, and projecting 'forwards' from that initial year (Wade, 2002a). This model includes an additional (explicit) prior on *K*. However, unlike the '1848 Bkwd' model, it does not make the assumption that the catch history is known without error or that *K* has remained unchanged over the last 150 years. Both models include a parameter for the depletion at which *MSY* is achieved (referred to as the 'maximum sustainable yield level' or *MSYL*), and one for the maximum population growth rate in the limit of no density dependence, λ_{max} (the dominant real eigenvalue of the Leslie matrix). These two modeling approaches have been used in recent assessments of the B-C-B bowhead whale (e.g., Brandon and Wade, 2006); it is therefore of interest to include them both in this analysis for the sake of comparison.

E-G walrus

The analyses for this population are based on a density-dependent model initialized in 1899 (corresponding to the model '1848 Bkwd' for B-C-B bowheads)., This model also includes a parameter for the population size in 1995, N_{1995} in addition to the six life-history parameters and *MSYL*. Note that the assumption that harvest selectivity is uniform above age 1 differs from the assumption that selectivity increases with age from age 0 to age 10 made by Witting and Born (2005). However, this difference is inconsequential for the analyses of this chapter.

Model parameters and prior distributions

Calves are defined as young of the year (i.e., age 0) and f_{max} is specified in the standard Leslie matrix formulation as female calves per female per year (e.g., a fecundity rate of *0.125* implies a female calving interval of 8 years, and therefore a total calving interval of 4 years, assuming an equal sex ratio of calves).

B-C-B bowhead whales

'Data-based' prior distributions are assigned to adult survival rate and the age-at-maturity (Table 2.3), and the maximum age in the Leslie matrix is set to 200 years following the results of recent research on ageing (George *et al*, 1999).

E-G walrus

The prior distributions for the life history parameters for walrus are based on various field and modeling studies (Table 2.4). The age at which survival changes from immature to adult is fixed, and set to age 3. The maximum age after which survival becomes zero is set to 60 years.

While we attempt to follow the methods of Witting and Born (2005) in most regards, this study treats juvenile survival rate differently. We choose to follow methods recently employed in stock assessments used by the IWC (e.g., Punt and Butterworth, 1999; Wade, 2002a), i.e. we place a uniform prior from 1.01 to 1.12 on λ_{max}, and do not place a prior on juvenile survival. The details of this treatment are given in the following section (and apply to the bowhead analyses as well).

Alternative resampling schemes

The assumption that juvenile survival must be less than adult survival is followed here. However, as Punt and Butterworth (1999) note, placing an explicit prior on S_{juv} (in addition to priors on the remaining life history parameters, and a prior on the population growth rate) would result in an incoherent prior due to the functional relationships among the life-history parameters. Instead, the value of S_{juv} is calculated analytically by rearranging the characteristic equation of the Leslie matrix given the values for the remaining five life history parameters and λ_{max} (Breiwick *et al.*, 1984):

$$S_{\text{juv}} = \left[\frac{\lambda_{\max}{}^{(a_{\text{m}}+1)} - S_{\text{a}} \lambda_{\max}{}^{(a_{\text{m}})}}{S_{\text{a}}^{(a_{\text{m}}-a_{\text{T}})} f_{\max} \left[1 - (S_{\text{a}} / \lambda_{\max})^{(a_{\max}-a_{\text{m}}-1)} \right]} \right]^{\frac{1}{a_{\text{T}}}} \tag{2.4}$$

The resulting value for S_{juv} is forced to be less than that of S_{a} through one of the alternative resampling schemes below. These schemes involve resampling the following parameters from their prior distributions if $S_{\text{juv}} > S_{\text{a}}$:

1) $f_{\max}$, S_{a} and a_{m};
2) $f_{\max}$ and S_{a}; and,
3) No parameters (abbreviation 'None'), meaning the current vector of life-history values is simply ignored and a completely new set of values is drawn from the marginals (see 'Parameter Estimation').

Values for the parameters are re-sampled until $S_{\text{juv}} < S_{\text{a}}$, or 1000 re-samples occur for resampling schemes 1) and 2). If this maximum is reached, a new value for $\lambda_{\max}$ is selected, and the process is repeated until an acceptable sample from the prior occurs.

Output quantities

Posterior distributions are calculated for several output quantities that are derived from the parameters in Tables 2.3 and 2.4. The maximum sustainable yield rate (*MSYR*) is calculated as (λ_{MSY} - 1) based on the fecundity value, f_{MSY}, associated with *MSYL*. The quantity Q_1, designed to meet the intent of IWC aboriginal whaling management objectives (Wade and Givens 1997), is also calculated. This quantity has the property that the proportion of net production allocated to recovery increases the more depleted a population is assessed to be[6]. Specifically:

$$Q_1 = \min(MSYR * N_t,\ 0.9MSY\ ) \tag{2.5}$$

[6] This definition applies to a population above some minimum level, $P_{\min}$, (assumed here to be $0.1K$), below which catches are set to zero.

where N_t is the population size in 2000 for walrus or 2002 for bowheads.

The realized prior is reported for the parameters. This distribution arises after conditioning the specified priors on the model and the resampling scheme by eliminating combinations of parameters for which: 1) the juvenile survival rate implied by Equation (2.4) exceeds the adult survival rate drawn from the joint prior distribution, and 2) population trajectories that go extinct. Likewise, post-model-pre-data distributions for output quantities are calculated as the distributions for these quantities in the sampled joint prior space.

Parameter estimation

The SIR algorithm (Rubin, 1988; Smith and Gelfand, 1992) is used to generate samples of parameter vectors (and output quantities of interest) from the posterior distribution. This algorithm involves randomly sampling a large number of parameter vectors from the prior distribution. A population trajectory is then calculated for each vector of parameter values, and this trajectory is used to determine the likelihood of the data for each random draw[7]. 10,000 draws (which form a numerical representation of the posterior distribution) are then selected by sampling (with replacement) from the initial samples from the prior, with probability proportional to the likelihood (i.e., the importance function is set equal to the joint prior, so the importance weight is the likelihood). Following Punt and Butterworth (1999) and Raftery *et al.* (1995), the SIR algorithm is considered to have converged if the number of unique parameter vectors in the sample from the posterior is fairly high (>5,000) and if the most frequently re-sampled parameter vector does not occur in the posterior sample more than ten times.

B-C-B bowhead whales

The total negative log-likelihood of a model trajectory, given a vector of parameters and the data, consists of contributions from four data sources: 1) the

[7] The likelihood is 1 for the walrus case because there are no abundance data for this population except for that on which the prior for the abundance in 1995 is based.

estimate of abundance for 1993; 2) the estimates of abundance for the remaining years; 3) the proportion of calves in the population; and 4) the proportion of mature animals in the population. The abundance estimates are assumed to be indices of the 1+ component of the population. The scientific surveys at Pt. Barrow are assumed to have occurred after the aboriginal catch[8], and the likelihood function is calculated accordingly (i.e. catches are removed before calculating the likelihood of the data for a given year). Model-predicted proportions are calculated over the period 1985 to 1994, as the actual stage proportions are based on data for these years.

The estimate of abundance for 1993 is assumed to be independent of the remaining estimates (Punt and Butterworth, 1999), and to have normally rather than log-normally distributed sampling error. The contribution of the abundance estimates to the negative of the log-likelihood function is (ignoring constants independent of model parameters):

$$L_1 = 0.5\frac{(\hat{N}_{1993} - 8293)^2}{626^2} \qquad L_2 = 0.5\sum_{t_1}\sum_{t_2}(\ell \text{n}\hat{N}_{t_1} - \ell \text{n}N_{t_1}^{obs})^{\mathbf{T}}\mathbf{V}_{t_1,t_2}^{-1}(\ell \text{n}\hat{N}_{t_2} - \ell \text{n}N_{t_2}^{obs}) \qquad (2.6)$$

where:

N_t^{obs} is the survey estimate of abundance for year t;

$\hat{N}_t$ is the model estimate of 1+ abundance for year t; and

V is the variance-covariance matrix for the logarithms of the estimates of abundance (excluding 1993).

The estimates of abundance (Table 2.1) are based on combining the data from visual counts at Pt. Barrow, Alaska, and estimates of the proportion of animals that passed within visual range based on acoustic data. Equation (2.6) accounts for the

8 In reality, there are two seasonal (spring and fall) hunts each year, with the survey immediately following the spring hunt. However, as catches are a relatively small proportion of the total population size, the simplification made will hardly affect the quantitative results.

correlation among the non-1993 estimates of abundance that arises because the proportion within visual range is treated as a random effect when constructing the estimates of abundance (Zeh and Punt, 2005).

The contribution of the proportion data to the likelihood function follows Punt (2006), i.e. given the bootstrapping approach adopted to calculate the length-frequency distributions from which the proportion data were calculated (Koski *et al.*, 2006), it is reasonable to assume that the estimates are normally distributed, i.e. ignoring constants independent of model parameters:

$$L_3 = 0.5\frac{(p_{\rm c} - p_{\rm c}^{\rm obs})^2}{(\sigma_{p_{\rm c}})^2} \qquad L_4 = 0.5\frac{(p_{\rm m} - p_{\rm m}^{\rm obs})^2}{(\sigma_{p_{\rm m}})^2} \tag{2.7}$$

where:

$p_{\rm c}^{\rm obs}$ is the observed average fraction of the population that consists of calves between 1985 and 1994;

$\sigma_{p_{\rm c}}$ is the standard deviation of $p_{\rm c}^{\rm obs}$;

$p_{\rm c}$ is the model-estimate of the average fraction of the population that consists of calves between 1985 and 1994;

$p_{\rm m}^{\rm obs}$ is the observed average fraction of the population that consists of mature animals between 1985 and 1994;

$\sigma_{p_{\rm m}}$ is the standard deviation of $p_{\rm m}^{\rm obs}$; and

$p_{\rm m}$ is the model-estimate of the average fraction of the population that consists of mature animals between 1985 and 1994.

Risk analysis

Forward projections are initialized from the posterior distribution corresponding to the status of the stock at the start of 2000 (walrus) or 2002 (bowheads). Following

Witting and Born (2005), the catch during the first five years of the projection period is set equal to that for during the last year of the assessment (e.g., 80 walrus, with a sex ratio 9:1 M:F), and the population is then projected forward under different levels of constant catch *C*, for another 5 years (applying the assumed sex-ratio and selectivity pattern of the current hunt). The management objective, *ob*, used to summarize the results of the decision analysis follows the aboriginal whaling guidelines of the IWC (2000), as interpreted by Witting and Born (2005):

$$ob = \begin{cases} N_{\mathrm{yr+5}} > N_{\mathrm{yr}} & \text{if } N_{\mathrm{yr}} < N_{MSYL} \\ C \leq 0.9MSY & \text{if } N_{\mathrm{yr}} \geq N_{MSYL} \end{cases} \qquad (2.8)$$

N_{yr} is the population size in 2005 for E-G walrus, and 2007 for B-C-B bowheads. The probability of meeting the objective, given a future catch level and one of the alternative re-sampling schemes, is calculated as the proportion of trajectories at the start of $N_{\mathrm{yr+5}}$ that meet the objective. These probabilities are conditioned on reported catch history.

2.3 RESULTS

B-C-B bowhead whales

In general, all three resampling schemes lead to reasonable fits to the data (see, for example, the results for the '1978 Fwd' model in Fig. 2.2). However, there are certain noteworthy differences in the outputs of the models among resampling schemes, especially those from the '1978 Fwd' model. Specifically, resampling f_{max}, S_{a}, and a_{m} consistently leads to higher values for stock productivity, as quantified by λ_{max}, and hence to better fits to the estimate of abundance for 2001. One consequence of this is that resampling f_{max}, S_{a} and a_{m} leads to the largest estimate of 2002 population size for the '1978 Fwd' model (Fig. 2.2; Table 2.5).

As expected from previous research (e.g. Punt and Butterworth, 1999), the '1848 Bkwd' model is relatively insensitive to modifications to the prior. This is likely the result of conditioning the model on the historical catch record from 1848, which is assumed known without error. There are basically no differences between median estimates of current population size among resampling schemes for this model (although the CV of current population size for the first resampling scheme is appreciably smaller). The posterior median for K is slightly lower when f_{max}, S_a and a_m are resampled, resulting in a higher probability that the stock is less depleted according to this resampling scheme (Table 2.5; Fig. 2.3).

It is useful to examine the original (explicit) priors, the realized priors and the posteriors for the model parameters to better understand the reasons for the differences among the three resampling schemes for some of the model outputs. Qualitatively, the results for the age-at-maturity are relatively insensitive to the resampling scheme (Fig. 2.4, left panels) with both the realized prior and posterior distributions being unimodal. Closer inspection of the results reveals, however, that resampling f_{max}, S_a and a_m leads to lower posterior medians than the other schemes. The situation for f_{max} is similar, with this scheme again leading to the most optimistic posterior (Fig. 2.4, right panels). Likewise, the realized priors and posterior distributions assign less probability to the highest values of adult and juvenile survival when none of the parameters are resampled (scheme 'None') (Fig. 2.5).

The realized prior for the maximum rate of increase differs substantially from the explicit prior when no parameters are resampled. Resampling 'None' assigns almost no realized prior probability to high ($\geq$ 1.05) values for λ_{max}, but this is not the case when f_{max} and S_a, and (particularly) when f_{max}, S_a and a_m are resampled (Fig. 2.6).

B-C-B bowheads: sensitivity analysis with inflated catches

Fig. 2.7 compares the posterior distributions for the time-trajectory of 1+ population size given the reported catch history (top panel) with that from the analyses in which the catch history is increased fivefold (bottom panel). The estimates of K are obviously very different between catch histories. However, these estimates are effectively insensitive to the choice of resampling scheme for each catch history (Table 2.5). The estimates of the catch quantity Q_1 are only moderately more sensitive to the choice of resampling scheme than those given the reported catch history (Table 2.5).

B-C-B bowheads: sensitivity of risk analysis

There is essentially no difference between resampling schemes in the probability of meeting the management objective (i.e., all predict ~100% success) for future catches as high as 100 whales (Fig. 2.8, left panel). Regardless of the resampling scheme, the resulting prediction is consistent across a wide range of plausible future catch levels. At higher catch levels, resampling 'None' leads to more conservative results (Fig. 2.8, left panel).

E-G walrus

The results for E-G walrus illustrate how alternative resampling schemes may potentially impact posterior distributions when the data set is uninformative (Table 2.6). Given the reported catches, the population trajectories for E-G walrus show little sensitivity to alternative resampling schemes (Fig. 2.9, top panel). The median and 90% credibility intervals for N_{2000} are nearly identical for all three schemes. This is perhaps not unexpected because the population is estimated to be at a large fraction of K (Table 2.6). As expected from the bowhead analyses, the results of resampling only a subset of the life history parameters are more similar, and differ from those for resampling 'None'. Resampling f_{max} and S_a, and (particularly) f_{max}, S_a and a_m is again more optimistic in terms of management-related quantities such as Q_1. However, unlike the case for the B-C-B bowheads, the impact of the choice of resampling scheme on the management-related quantities can be quite large (e.g. ~50% differences among schemes in the posterior median for Q_1; Table 2.6).

The posterior distributions for some of the management-related quantities are nearly identical among the three resampling schemes. For example, the posterior distribution for *K* is centred around 1000 (slightly higher for 'None') and skewed to the right, that for *MSYL* is very similar to its prior, and the posterior for the catch related quantity Q_1 is skewed to the right and its median differs among resampling schemes (Table 2.6). The sensitivity of the posterior distribution for λ_{max} to the choice of resampling scheme is consistent with that observed for the B-C-B bowheads, although the size of the effect is much larger for E-G walrus (Table 2.6).

E-G walrus: sensitivity analysis with inflated catches

Fig. 2.9 (bottom panel) shows the posterior distributions for the time-trajectory of 0+ population size from the analyses in which the historical catches are increased fivefold. In contrast to the situation for the 'low' catches on which Fig. 2.9 (top panel) was based, the estimates of historical population size are sensitive (i.e., greater than 20% difference in median terms) to the choice of resampling scheme. This sensitivity arises because the catches are now large enough to have reduced the population to well below its carrying capacity; in this situation the stock's current status does depend on how productive the resource is assessed to be which, in turn, depends on λ_{max}, and hence the choice of resampling scheme.

E-G walrus: sensitivity of risk analysis

The diverging population trajectories in recent years among resampling schemes for the analyses based on the higher catches (Fig. 2.9, bottom panel) are noteworthy. This pattern is much more pronounced than that for B-C-B bowheads (Fig. 2.7, bottom panel) and has implications for management advice. Therefore, it is not surprising that the results of the risk analysis (e.g., calculating the probability of achieving a management objective given different levels of catch) are also sensitive to the choice of resampling scheme, even when the analyses are based on the reported (rather than increased) catches. Again, resampling 'None' leads to more conservative results (Fig. 2.8, right panel).

2.4 DISCUSSION

These sensitivity analyses suggest that the choice of resampling scheme when implementing the constraint $S_{juv} < S_a$ can impact the results of stock assessments and hence the scientific management advice arising from such assessments. In particular, resampling f_{max}, S_a, and a_m to achieve a near uniform realized prior distribution for λ_{max} consistently leads to more optimistic results given the ranges of the prior distributions considered here (which are representative of many marine mammal populations). The effect can be marked in cases for which the data are uninformative. This is an example of a well known property of Bayesian analyses: when the information content in the likelihood is low, the prior will dominate the resulting posterior. Alternative resampling schemes correspond to different specifications for the realized joint prior, and therefore results of assessments based on limited data are especially sensitive to this issue.

It is noteworthy that the realized prior distribution for λ_{max} when resampling life history parameters assigns higher prior probability to large values for the intrinsic rate of growth. It is also well-known that there are fewer combinations of parameter values for which $S_{juv} < S_a$ when the intrinsic rate of growth is high (Fig. 2.1; Punt and Butterworth 2000). The scheme ('None') that does not retain the original value drawn from the prior for λ_{max} in order to find a feasible solution for S_{juv} is therefore assigning greater prior probability to low values for the intrinsic rate of growth. This is because the other two resampling schemes continue to resample the life history parameters when the intrinsic rate of growth is high - to sample that part of parameter space that satisfies the constraint on S_{juv} - but are not having to do this when the intrinsic rate of growth is low.

In essence, the resampling schemes are a way of re-weighting the marginal priors. The issue is whether one considers the fact that there is less feasible parameter space for larger values of λ_{max}, means that larger values are less likely. Resampling 'None' accepts with equal weight all points of parameter space which respect biological realism. The other extreme is to resample values for all of the life history parameters, which to the maximum extent possible, maintains the prior on λ_{max}. This approach basically ignores the drop in feasible parameter space for larger values of λ_{max}, and appears (for the cases investigated here) to provide the least conservative outcome.

These schemes (except resampling only f_{max} and S_a) have been employed at one time or another during recent assessments of marine mammals: Punt and Butterworth (1999) based their analyses on resampling 'None', and Wade (2002a) resampled f_{max}, S_a, and a_m. The choice among the resampling schemes depends on several factors. The realized prior distributions for the intrinsic rate of growth are nearly uniform when f_{max}, S_a, and a_m or, f_{max} and S_a are resampled (Fig. 2.6). Such distributions are therefore more consistent with the intended prior for λ_{max}. Choosing a resampling scheme that maintains a near uniform prior on λ_{max} is defensible if it is believed that the resampled life-history parameters are essentially nuisance parameters, recognizing that the status of a population depends critically on the value of the parameter that determines productivity, which is λ_{max} in these models. Such an alternative might be appealing, if, for example, there is limited prior information on life history parameters, and instead, there exist a precise series of abundance estimates over a relatively long time-period. In fact, this approach appears to provide a better fit to recent abundance estimates for the B-C-B bowhead stock (Fig. 2.2).

This study was originally motivated by a desire to ensure that, based on the results of recent stock assessments (e.g., Brandon and Wade, 2006) current aboriginal strike limits for the B-C-B bowhead whale are well-founded and sustainable. We emphasize here that this is certainly the case. However, the B-C-B bowhead whale is one of the most well studied populations of marine mammal in the world, and therefore its stock assessments are exceptionally data-rich. This situation is an exception, not a rule. As we have shown, there are other populations of marine mammals for which these issues are an important consideration.

It is not our intention that the results presented here for E-G walrus are directly comparable with those of Witting and Born (2005). The selectivity ogive assumed here for E-G walrus is probably oversimplified (certainly different), and likewise, we explore a catch series that is five times the reported (or estimated) values, purely to illustrate the potential sensitivity of these results. Although the increase in catches is obviously exaggerated, there is undoubtedly considerable uncertainty in this catch history (e.g., Witting and Born (2005) explore a struck and lost rate of up to 25%). It is noteworthy that the estimates of the quantity Q_1 for bowheads are only moderately sensitive to the inflated catch history (Table 2.5). This result is consistent with previous analyses which showed that, given uncertainty or bias in the historic catch record before 1915, the abundance estimates from survey data are the dominant influence on the posterior distributions for quantities related to management (Givens and Thompson, 1996; Givens, 2005).

We have attempted to consistently apply the methods explored here to both case studies. However, it is not practical to use the 'forwards from recent' modeling approach for E-G walrus. There is insufficient data from which to independently specify a prior on recent abundance for this stock and hence fit a population trajectory. If this technique had been used to estimate management quantities for E-G walrus, the results would have been even more sensitive to the specification of priors than was the case for the backwards method. Another difference between the case-studies is the prior chosen for λ_{max}. However, both are uniform with an upper bound that is chosen to coincide with the realized upper bound dictated by the constraint on S_{juv} (Fig. 2.1). Although different, the upper bounds do not constrain the results, but do make the numerical integration more efficient. The method investigated here is perhaps the most common approach to constructing a coherent prior for marine mammals in recent years, largely based on assessments performed for the IWC. The consistent methodology allows for comparison between a data-rich and data-poor scenario, highlighting the sensitivity of data-poor scenarios to an easily overlooked aspect of constructing a coherent joint prior while respecting biological realism.

The degree of sensitivity between data-rich and data-poor scenarios is well illustrated by the results of the risk analyses, which are based on the reported catch history. A future catch of 100 bowheads (a catch larger than the current catch) would lead one to predict a consistent ~100% chance of meeting the management objective, regardless of the resampling scheme used (Fig. 2.8, left panel). Whereas, there are large differences in the probability of meeting the management objective for E-G walrus, depending on which resampling scheme is used to construct a coherent joint prior while applying the constraint on juvenile survival (Fig. 2.8, right panel). For example, given an annual catch of 15 animals, resampling 'None' indicates that the management objective will be met with only a 60% probability, while resampling f_{max} and S_a (and a_m) would lead one to predict a greater than 90% probability. If the technique examined here - solving for a free parameter – is to be used to construct a coherent joint prior given a biological constraint, we recommend exploring different resampling schemes during the initial phase of the stock assessment to determine the sensitivity of the results to this choice. Given the results of these analyses, it seems that two coherent joint priors that respect biological realism could be constructed and the assessment run twice, resampling 'f_{max}, S_a and a_m' or 'None.' This amounts to a sensitivity analysis to alternative joint priors. These two schemes are likely to bracket intermediately conservative weightings of the marginals. If the results are not consistent between these two schemes, then some consideration should be given to the sensitivity of the assessment results to the priors. We emphasize this recommendation for data poor stock assessments.

Alternative approaches are available to construct a coherent joint prior distribution. For example, a variant of the technique explored here was used by Witting and Born (2005). They imposed a joint prior distribution on (S_{juv}, S_a), with S_{juv} conditional on S_a such that values of S_{juv} greater than S_a were set equal to S_a. Then, given values of the life history parameters from the prior, they solved for the productivity parameter *MSYR* (the population growth rate at *MSYL*). Such an approach (setting population growth rate as the free parameter) is appealing if there is good prior information on life history, but not population growth rate. Indeed, walrus populations are an example of this scenario: there exist reliable measurements of life history parameters (e.g. fecundity and age-at-sexual maturity), but accurate surveys of abundance have proven elusive. Solving for *MSYR* will more closely maintain the explicit priors on life history parameters, for which there is a greater degree of confidence.

Solving for the population growth rate analytically (instead of a life history parameter) does not circumvent biologically impossible solutions (e.g., $\lambda_{max} < 1.0$). Goodman (1984) clearly demonstrated this fact using Monte Carlo simulation with life history parameters for the spotted dolphin, *Stenella attenuata*. Witting and Born (2005) resampled 'None' of the parameters when they arrived at a solution for the maximum population growth rate that was negative. It is just as conceivable to resample only a subset of life history parameters until a feasible solution for population growth rate is obtained. This approach would result in certain realized priors on life history parameters being more consistent with their intended distributions. Choosing to analytically solve for the population growth rate in order to construct a coherent joint prior, instead of a solving for a life history parameter (e.g., S_{juv}), does not circumvent the need to resample (or ignore) values from the priors when parameter combinations result in solutions for population growth rate that violate biological realism.

Obviously, the population growth rate is an extremely influential parameter with regards to model outputs that are important to management. However, if this parameter is solved for analytically to construct a coherent joint prior, it should be recognized that the resulting implicit prior will be sensitive to the limits placed on the priors for the life history parameters. For instance, given uniform priors on all life history parameters, the resulting implicit prior distribution for population growth rate will be bell-shaped with a mean and variance that shifts according to the upper and lower limits of the uniform priors for life history parameters (c.f. Fig. 1 of Goodman, 1984). So, while very little is often known about certain life history parameters, the range for which this "ignorance" is bounded may be more informative than desired. For example, the resulting implicit prior distribution for the intrinsic population growth rate will differ substantially (all else being equal) between priors for S_{juv} ~U[0.70, 0.90] or ~U[0.10, 0.90]. This sensitivity is likely to be unsatisfactory.

If a life history parameter is solved for, then the prior distribution on population growth rate, or at least its upper bounds could be based on a meta-analysis for related species for which there exists trend data from populations recovering from depletion (e.g., Best, 1993). Unfortunately, reliable trend information does not exist for most walrus populations. However, it is worth noting that the constraint on juvenile survival rate, in concert with the ranges of the other life history parameters, is what effectively imposes the upper bound on the realized prior for λ_{max} (Fig. 2.1). Therefore, any uniform prior on λ_{max} will lead to the same results, as long as the upper bound on the explicit prior provides support up to those values for λ_{max} beyond which there is zero realized prior probability. Following the prior distributions for life history parameters used by Witting and Born (2005), we have chosen a suitable upper limit for E-G walrus $\lambda_{max} = 1.12$. It is clear from the values for the upper 95th percentiles of the posteriors for this parameter (Table 2.6), that the upper bound on this prior does not constrain the results for E-G walrus.

Setting one parameter to be calculated, given values from the priors of the remaining parameters potentially ignores information. In certain cases, this might be justifiable (e.g., given a lack of knowledge regarding juvenile survival). However, there are other methods for constructing a coherent joint prior while retaining explicit prior distributions on all inputs (and outputs). Poole and Raftery (2000) extend Bayesian synthesis to include logarithmic pooling of priors (French, 1985; Genest and Zidek, 1986). This technique, termed 'Bayesian melding', provides a coherent joint prior on model inputs and outputs and is not subject to Borel's paradox. To our knowledge, this method has only been applied to an age-aggregated surplus production model for the B-C-B stock of bowhead whale (Givens and Robuck, 1999; Poole and Raftery, 2000). It remains to be seen how a biological constraint like $S_{juv} < S_a$ could be implemented using Bayesian melding with an age-structured PDM. Moreover, it is not obvious how any approach can escape the necessity of resampling (or not) parameter values given that parts of the prior space violate biological realism.

Ideally, whatever method is used to construct a coherent joint prior, an explicit correlation structure between the parameters is involved, given observed and hypothesized relationships among the model parameters (e.g., between fecundity and adult survival). However, completely specifying a joint prior distribution with explicit correlations among the parameters is a complex endeavor for age-structured PDMs. It is interesting to note that implementing the constraint on juvenile survival imposes a correlation structure among the parameters (Fig. 2.10; Punt and Butterworth, 1999), and this is probably an improvement over a naive assumption of independence.

In addition to incorporating correlations among life history parameters, it is desirable that the method used to construct the prior, should change the explicit marginal priors as little as possible. However, it is apparent that resampling (or not) updates the explicit marginal priors, resulting in different realized marginal priors. Further, different resampling schemes change the marginals of the parameters differently. For example, compare the explicit and realized marginals for B-C-B bowhead S_a and λ_{max} (Fig. 2.5 and Fig. 2.6). Radke *et al*. (2002), in an example from another field of natural resource modeling, achieve a coherent joint prior distribution using Bayesian melding (via SIR), while explicitly incorporating rank correlations among input parameters (see Iman and Conover, 1982; Guan, 2000). The method is analogous to a 'normal copula' (e.g., Wang, 2004), which induces a target correlation structure among parameters while retaining the explicit marginal priors. We tested this approach, but it does not appear to be a valid substitution for the constraint on S_{juv} (at least for the cases investigated in these analyses).

It seems certain that the number of assessments using similar Bayesian methods will increase in the future. Our objective is not to advocate a single 'best' approach for constructing a coherent joint prior while respecting biological realism. However, as we have shown, Bayesian inference based on assessment scenarios for which data are limited are likely to be quite sensitive to the issues explored here. Likewise, these issues are also relevant to other long-lived marine taxa, for which similar biological assumptions, PDMs and assessment methodologies are appealing, but time-series of abundance and anthropogenic mortality are likely to be limited and imprecise (e.g., some sea-birds, sharks and sea-turtles).

Table 2.1

Estimates, CVs (actually the standard errors of the log abundance estimates, to which these are approximately equal) and the correlation matrix for the indices of abundance for the B-C-B stock of bowhead whales. Source: Zeh and Punt (2005).

Year	Estimate	CV	Correlation matrix									
1978	4765	0.305	1.000									
1980	3885	0.343	0.118	1.000								
1981	4467	0.273	0.056	0.050	1.000							
1982	7395	0.281	0.094	0.084	0.035	1.000						
1983	6573	0.345	0.117	0.104	0.049	0.084	1.000					
1985	5762	0.253	0.070	0.062	0.020	0.078	0.062	1.000				
1986	8917	0.215	0.072	0.064	0.017	0.092	0.064	0.113	1.000			
1987	5298	0.327	0.124	0.110	0.052	0.088	0.110	0.065	0.067	1.000		
1988	6928	0.120	0.028	0.025	0.013	0.017	0.024	0.009	0.007	0.026	1.000	
2001	10545	0.128	0.008	0.007	0.005	0.001	0.007	-0.004	-0.008	0.008	0.003	1.000

Table 2.2

The average proportion of observed calves (p_c^{obs}) and mature (p_m^{obs}) animals, with associated standard errors, over the years 1985 to 1994. Proportions are given based on ignoring the potentially anomalous data set for 1985. Source: IWC (1999) and Koski *et al*. (2006).

p_c^{obs}	σ_{p_c}	p_m^{obs}	σ_{p_m}
0.0580	0.0062	0.4366	0.0106

Table 2.3

The prior distributions for the B-C-B bowhead whales. Dashes (-) represent prior distributions that are equal to those from the model in the column to the left. 'N/A' indicates a prior that is not required for the model concerned. Fecundity is defined as female calves per mature female. The abbreviations for these distributions are: U ~ Uniform, DU ~ Discrete uniform, and N ~ Normal. Sources are given below.

Parameter		Model Type	
		1848 Bkwd	1978 Fwd
S_a	adult survival	N(0.990, 0.02), truncated at 0.940 and 0.995[a]	-
f_{max}	maximum fecundity	U[0.125, 0.200][b]	-
a_T	age-at-transition to adult survival	DU[1, 9][c]	-
a_m	age-at-sexual maturity	N(20.0, 3.0) truncated at 13.0 and 26.0[d]	-
λ_{max}	intrinsic population growth rate	U[1.005, 1.075][e]	-
N_{1978}	population size in 1978	N/A	U[3000, 9000][f]
N_{1993}	population size in 1993	N(7800, 1200)[g]	N/A
K	carrying capacity	N/A	U[8000, 30000][h]
MSYL	*MSYL* in terms of the 1+ population component	U[0.40, 0.80] [h]	-

a – based on the posterior distribution for adult survival rate obtained by Zeh *et al*. (2002).

b – the prior for the maximum number of calves (of both sexes) per mature female selected by the Scientific Committee of the International Whaling Commission was U[0.25, 0.4] (IWC, 1995). This is the corresponding prior given fecundity has been defined here as female calves per mature female per year.

c – selected by the Scientific Committee of the International Whaling Commission (IWC, 1995) although there is little information on the value of this parameter (Givens *et al*., 1995).

d – based on a best estimate of 20 years and a lower confidence interval for the age at first parturition (age at sexual maturity + 1 year) of 14 years (IWC, 1995).

e – preliminary analyses indicated there was no posterior probability outside this range, which was confirmed in the final analyses. This range was therefore selected to improve the efficiency of the numerical integration while not affecting the results.

f – selected to encompass a plausible range of values for 1+ population size in 1978.

g – selected by the Scientific Committee of the International Whaling Commission (IWC, 1995) based on the prior distribution assumed for the Bayes empirical Bayes estimate of abundance (Raftery and Zeh, 1991).

h – based on the prior selected by the Scientific Committee of the International Whaling Commission (IWC, 1995).

Table 2.4

The prior distributions for E-G walrus. The abbreviations for these distributions are: U ~ Uniform, DU ~ Discrete uniform and LN ~ Log-normal. Sources are given below.

Parameter		Prior
S_a	adult survival	U[0.900, 0.980][a]
f_{max}	Maximum fecundity	U[0.167, 0.250][b]
a_m	age-at-sexual maturity	DU[5, 9][b]
λ_{max}	intrinsic population growth rate	U[1.01, 1.12][c]
N_{1995}	population size in 1995	LN[ln(1000), 0.35^2][d]
MSYL	*MSYL* in terms of the 1+ component	U[0.50, 0.80][e]

a – prior assumed by Witting and Born (2005), with ranges set wide enough to encompass plausible values as no direct evidence is available for this parameter.

b – Mansfield (1958), Fay (1982) and Born (2001). The range of fecundity values used by Witting and Born (2005) has been divided by two because these values are taken here to relate to the number of female calves per mature female per year.

c – preliminary analyses indicated there was no posterior probability outside this range, which was confirmed in the final analyses. This range was therefore selected to improve the efficiency of the numerical integration while not affecting the results.

d – Born *et al.* (1997). This is the abundance estimate used for 1995 by Witting and Born (2005), where the CV is taken to be approximately equal to the standard error of the logarithm.

e – prior assumed by Witting and Born (2005).

Table 2.5

Posterior medians [5th , 95th percentiles] for five management-related quantities for the B-C-B bowhead population for all models and alternative sampling schemes.

	N_{2002}	K	N_{2002} / K	λ_{max}	Q_1
1848 Bkwd					
Reported catches					
f_{max}, S_a, and a_m	9496 [8750, 10180]	10960 [9190, 13950]	0.888 [0.647, 0.985]	1.041 [1.024, 1.059]	228 [149, 296]
f_{max} and S_a	9571 [8030, 10360]	11670 [9252, 15630]	0.826 [0.459 , 0.977]	1.036 [1.014, 1.053]	208 [92, 276]
None	9579 [7974, 10400]	11960 [9562, 16150]	0.809 [0.434, 0.973]	1.034 [1.012, 1.050]	203 [83, 271]
Inflated catches					
f_{max}, S_a, and a_m	10140 [7957, 11840]	56870 [44750, 66170]	0.180 [0.119, 0.245]	1.058 [1.034, 1.067]	330 [215, 506]
f_{max} and S_a	9611 [7457, 11410]	58430 [46240, 70070]	0.166 [0.105, 0.226]	1.050 [1.028, 1.067]	290 [177, 441]
None	9364 [7320, 11180]	57550 [46550, 70760]	0.162 [0.101, 0.222]	1.045 [1.026, 1.060]	282 [167, 436]
1978 Fw.					
f_{max}, S_a, and a_m	10670 [9042, 12410]	20510 [11010, 29120]	0.530 [0.356, 0.925]	1.045 [1.025, 1.063]	295 [160, 439]
f_{max} and S_a	10210 [7989, 12160]	20890 [9403, 29510]	0.498 [0.302, 0.915]	1.037 [1.015, 1.058]	246 [84, 420]
None	10050 [7949, 11930]	20880 [9253, 29500]	0.487 [0.296, 0.912]	1.034 [1.013, 1.051]	232 [73, 402]

Table 2.6

Posterior medians [5th , 95th percentiles] for five management-related quantities for E-G walrus based on reported and inflated catches.

	N_{2000}	K	N_{2000} / K	λ_{max}	Q_1
Reported catches					
f_{max}, S_a, and a_m	1011 [613, 1814]	1067 [661, 1786]	0.98 [0.56, 1.00]	1.059 [1.015, 1.103]	21 [8, 61]
f_{max} and S_a	1022 [619, 1787]	1082 [681, 1779]	0.98 [0.55, 1.00]	1.053 [1.015, 1.096]	19 [8, 55]
None	1036 [624, 1805]	1176 [751, 1838]	0.91 [0.48, 1.00]	1.033 [1.012, 1.073]	14 [6, 38]
Inflated catches					
f_{max}, S_a, and a_m	1335 [715, 2361]	3680 [2503, 5906]	0.31 [0.12, 0.72]	1.059 [1.015, 1.103]	50 [10, 122]
f_{max} and S_a	1312 [701, 2281]	3852 [2627, 5955]	0.29 [0.12, 0.66]	1.053 [1.015, 1.096]	44 [10, 115]
None	1208 [654, 2137]	4575 [3072, 6263]	0.22 [0.10, 0.50]	1.033 [1.012, 1.073]	27 [8, 84]

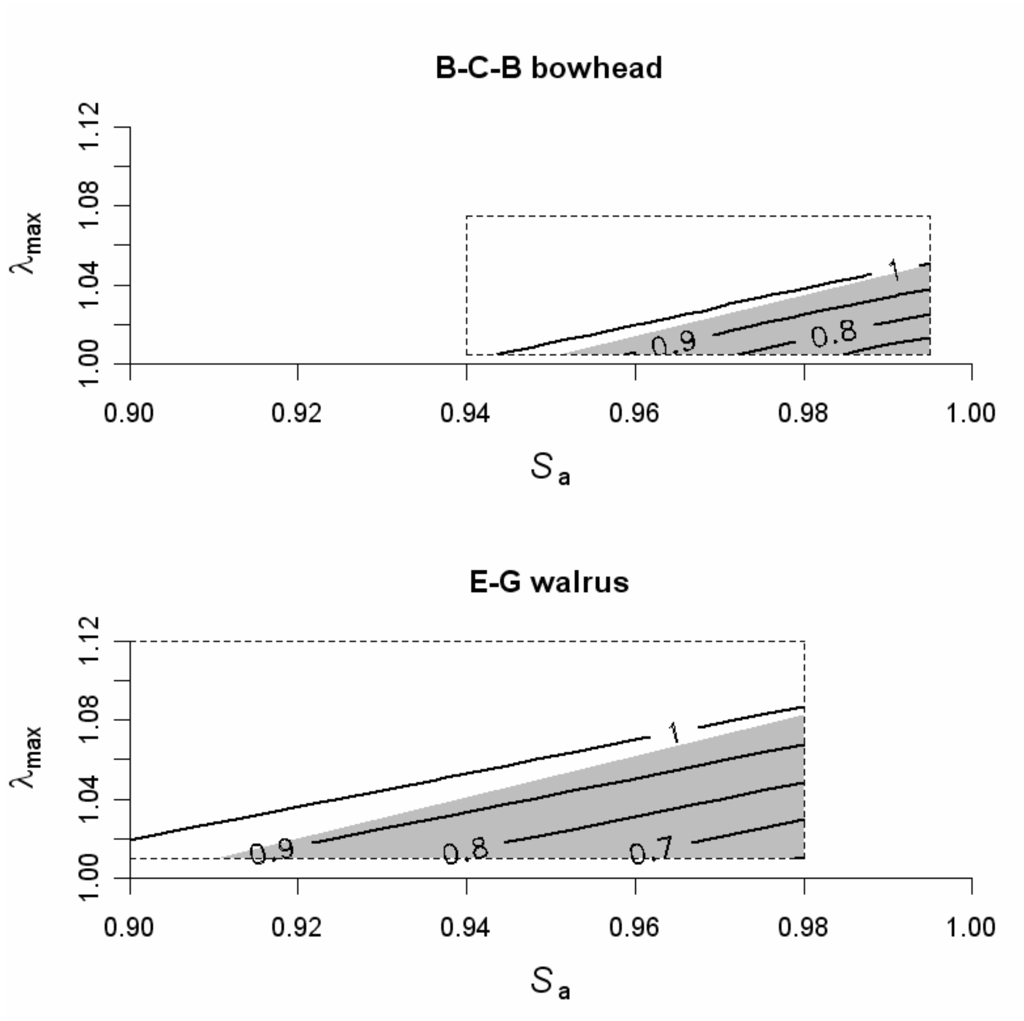

Figure 2.1: Contour plots showing solutions for S_{juv} (from Eqn. 2.4) given a range of values for S_a and λ_{max}. These diagrams are created by setting the remaining life history parameters constant, equal to the expectation of their explicit prior marginal distribution (e.g., a_m = 20 for B-C-B bowheads). The shaded triangular region in the lower right hand corner is the feasible parameter space, subject to the constraint on survival rates. The blank space in the upper left corner represents biologically impossible solutions for S_{juv} which are greater than 1.0. The area between the contour of 1.0 and the shaded region shows the biologically implausible region where $S_{juv} > S_a$. These plots illustrate the fact that there is more parameter space (given the constraint) consistent with smaller population growth rates.

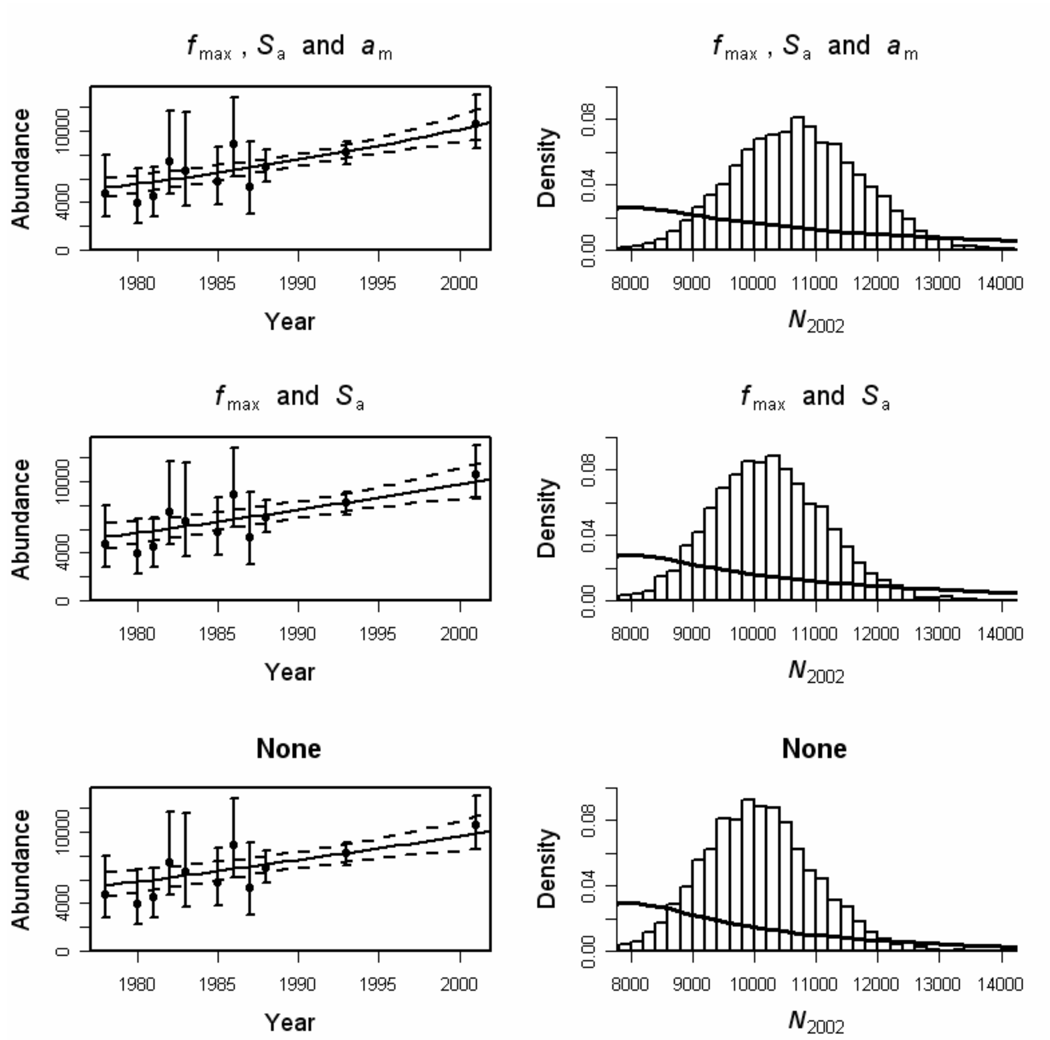

Figure 2.2: Model fits and estimates of recent abundance according to the '1978 Fwd' model for B-C-B bowheads. The left panels show the posterior distributions (medians and 90% credibility intervals) for the time-trajectory of population size. Error bars represent 90% CI's from survey estimates, and are assumed to be log-normally distributed for all abundance estimates except 1993 (second to last), which is assumed to be normally distributed. The commercial catch during the second half of the 19th century was much higher than the current level, which averages 36 whales during the time period shown. The right panels show the posterior distribution of population size in 2002. The solid lines in the right panels are the realized prior distributions and the bars are the posterior probabilities.

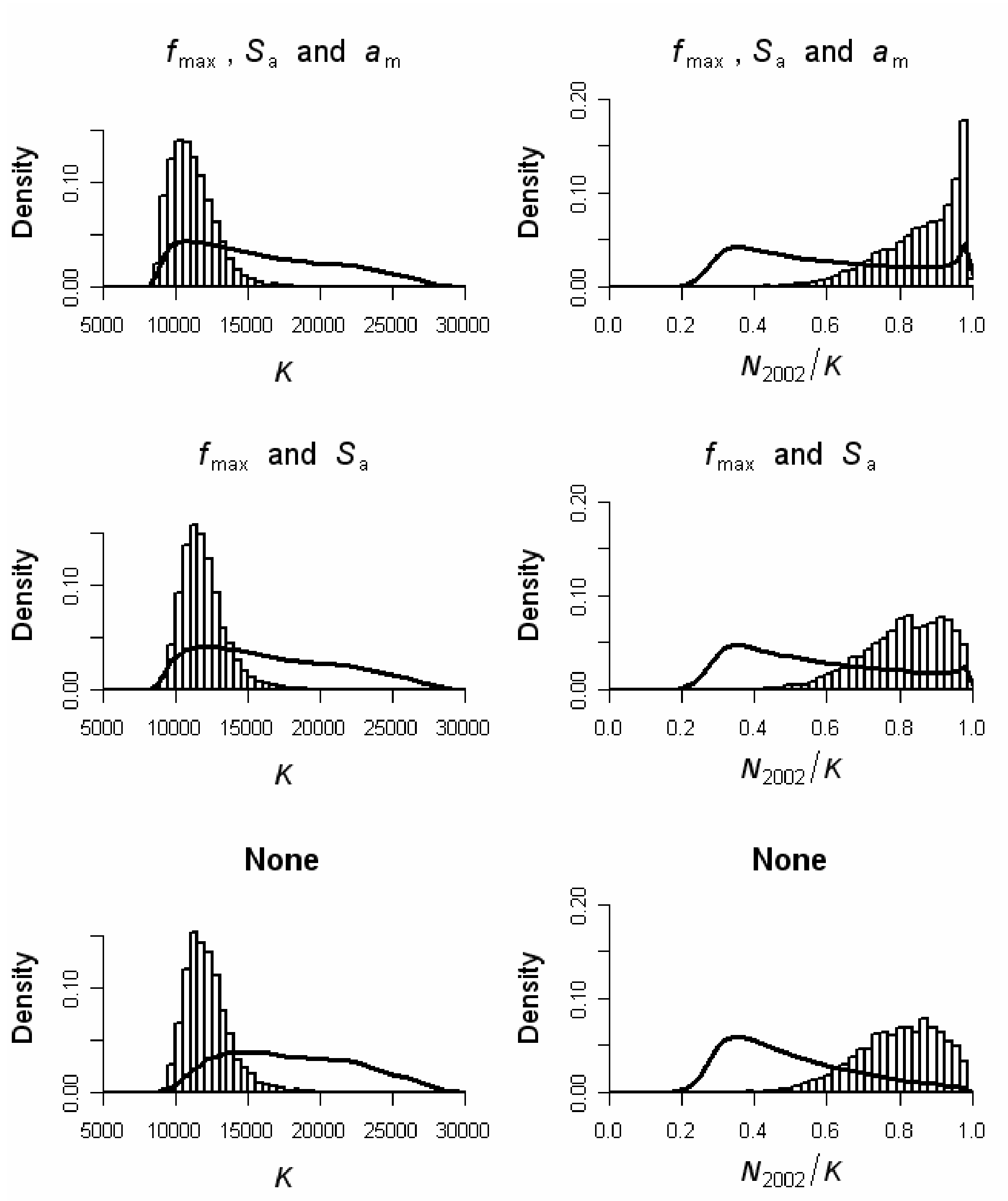

Figure 2.3: Realized prior distributions (solid lines) and posterior distributions (bars) for *K* and depletion in 2002, according to the '1848 Bkwd' model for the B-C-B bowhead population.

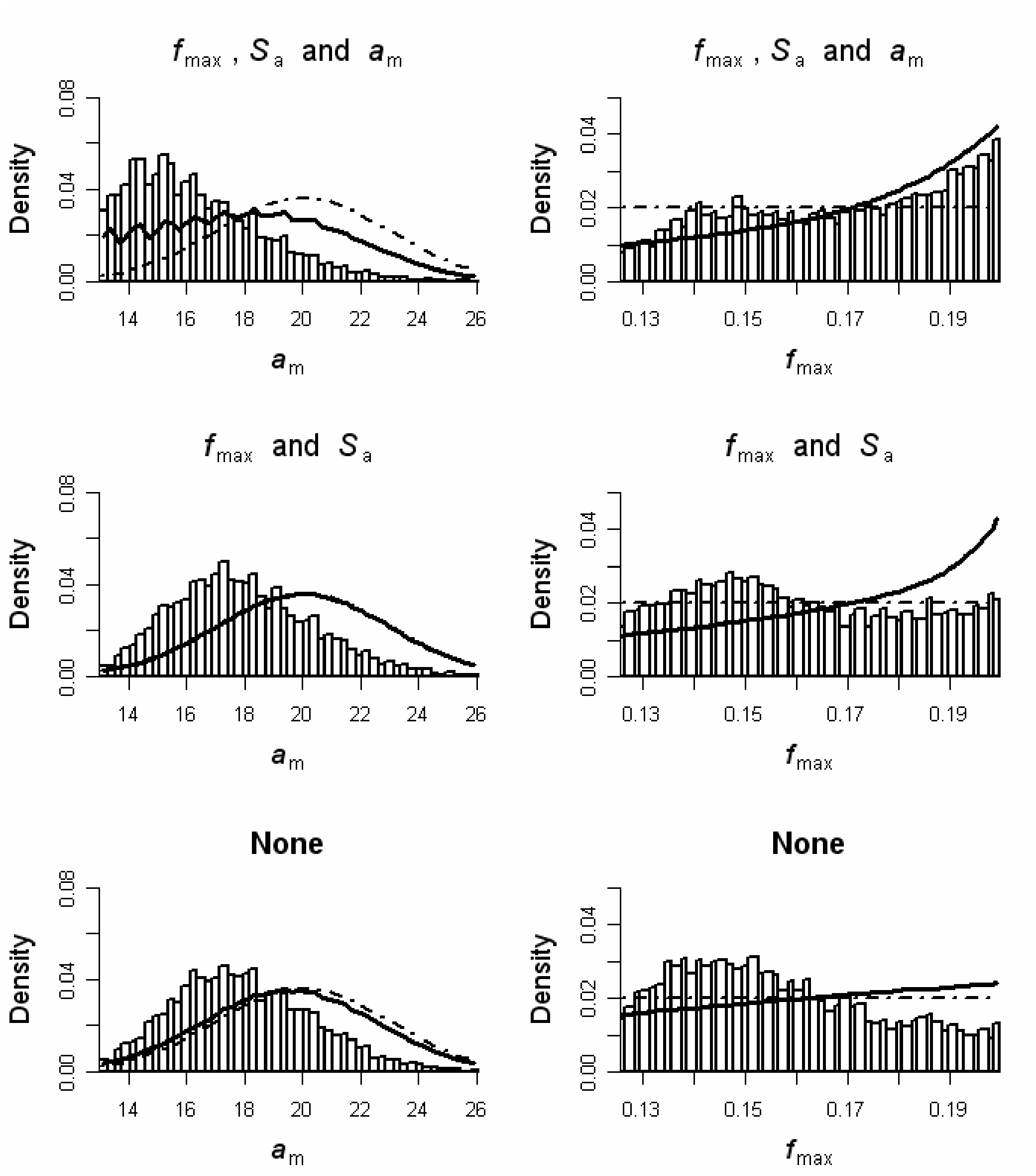

Figure 2.4: Explicit priors (dashed lines), realized priors (solid lines) and posterior distributions (bars) for a_m and f_{max}, according to the '1978 Fwd' model for the B-C-B bowhead population.

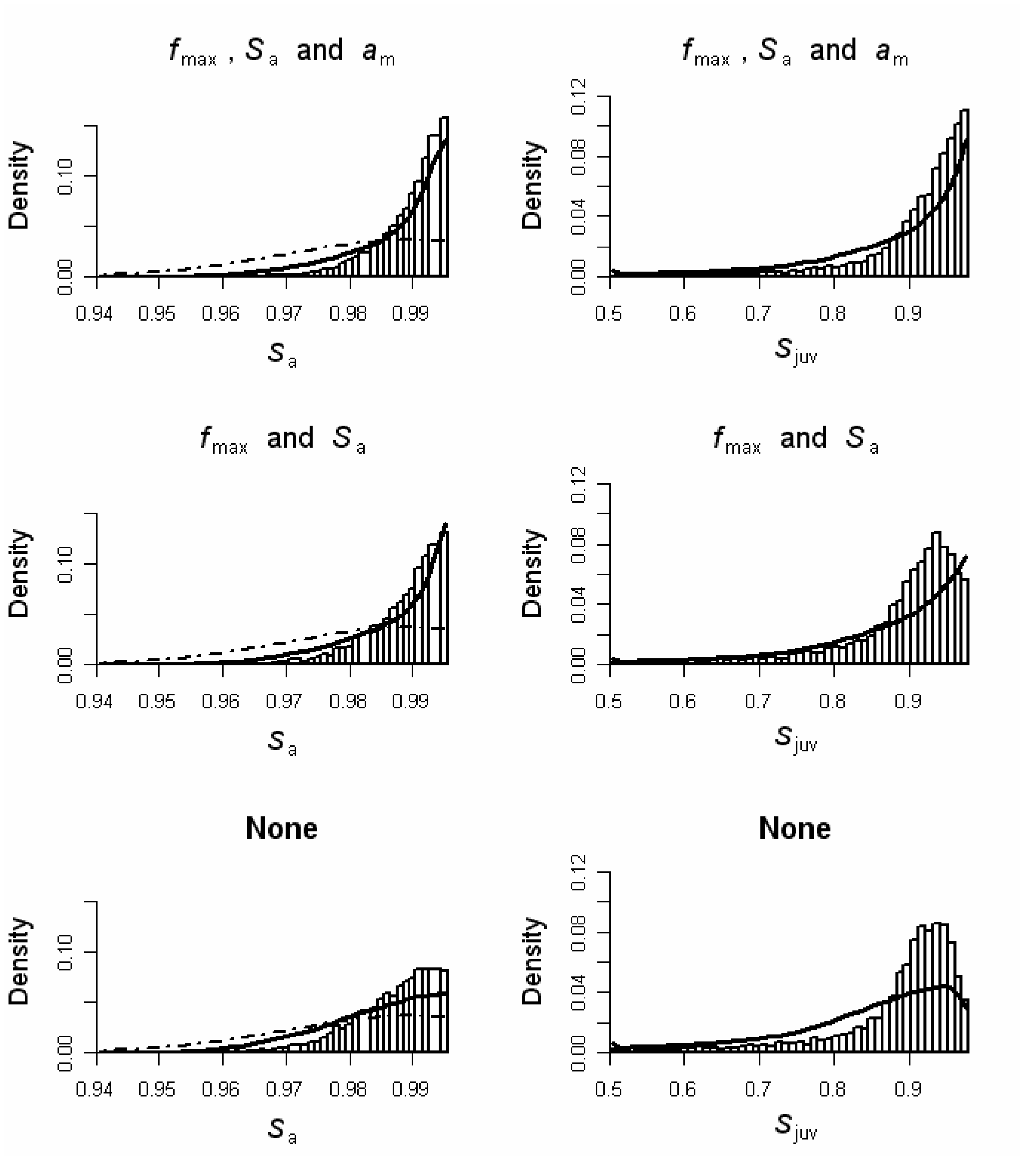

Figure 2.5: Explicit priors (dashed lines – left panels only), realized priors (solid lines) and posterior distributions (bars) for S_a and S_{juv}, according to the '1978 Fwd' model for the B-C-B bowhead population. Note the ranges of the x-axes differ between parameters.

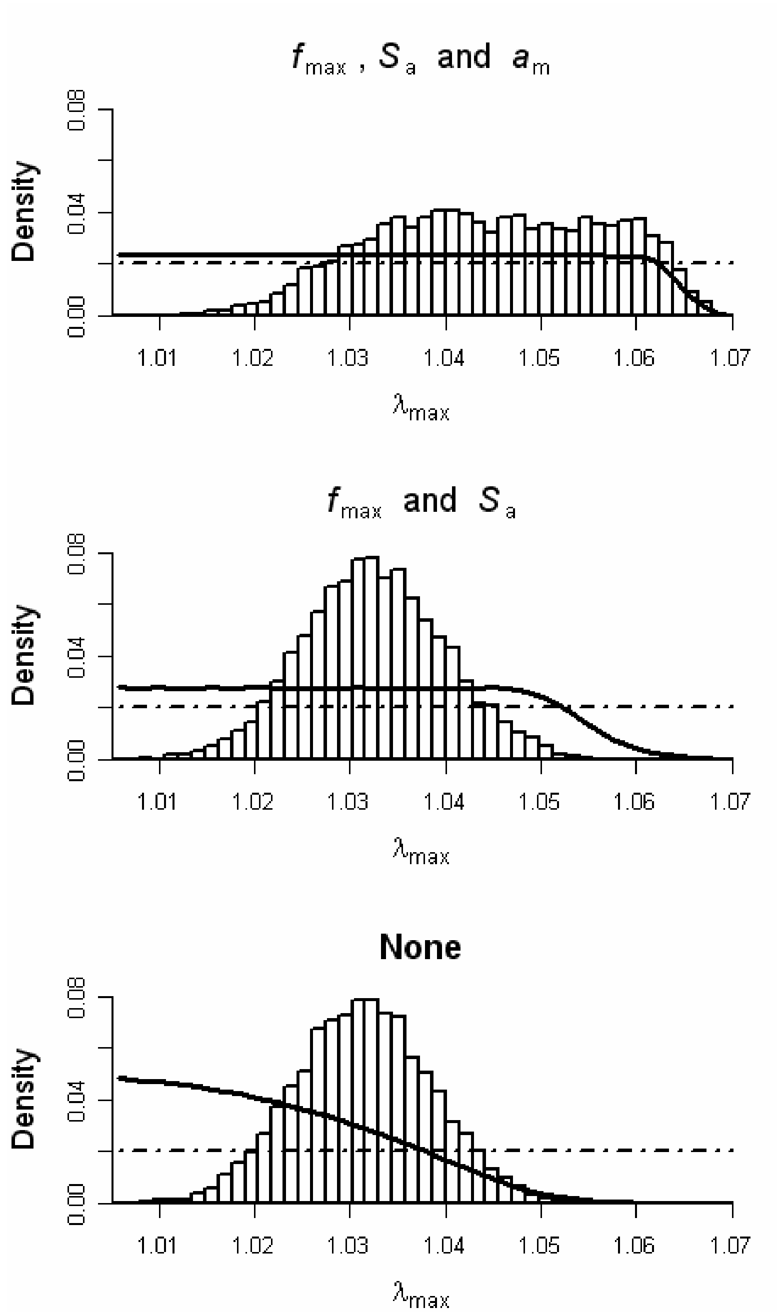

Figure 2.6: Explicit priors (dashed lines), realized priors (solid lines) and posterior distributions (bars) for the intrinsic rate of growth λ_{max}, according to the '1978 Fwd' model for the B-C-B bowhead population.

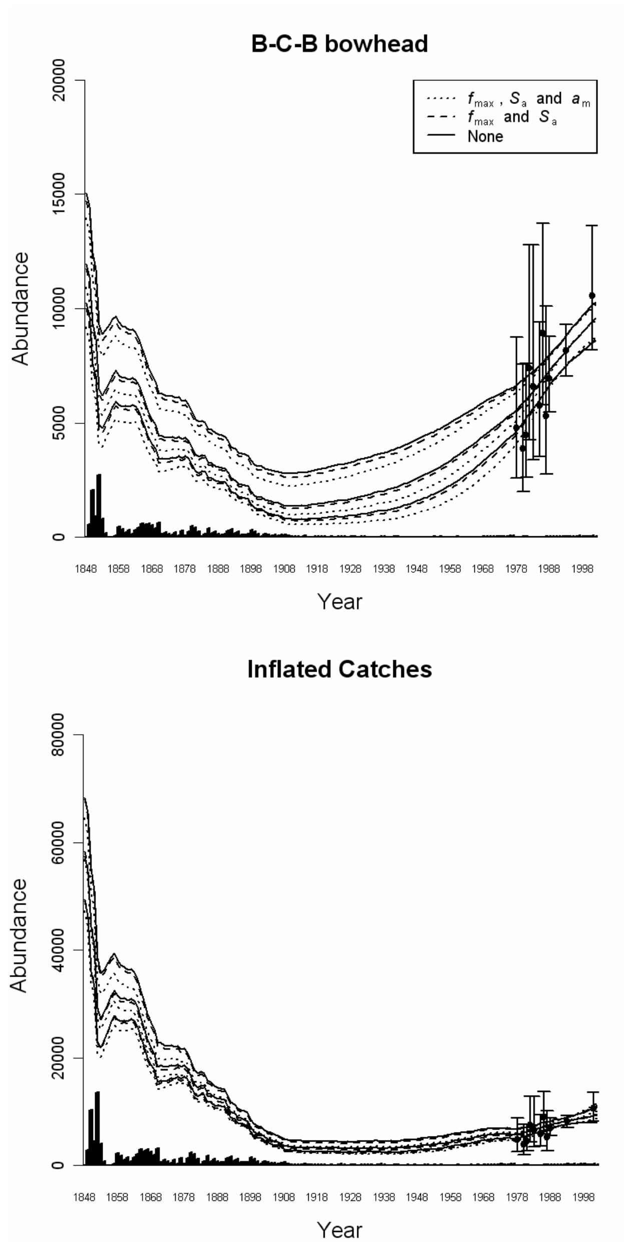

Figure 2.7: Time-trajectories of 1+ abundance (medians and 90% credibility intervals) for the B-C-B bowhead population when the reported catch history is used (top panel) and that when the inflated catch history is used (bottom panel). Note the ranges are different for each y- axis. Catches are plotted along the x-axes. Abundance estimates are shown with error bars representing 90% confidence intervals.

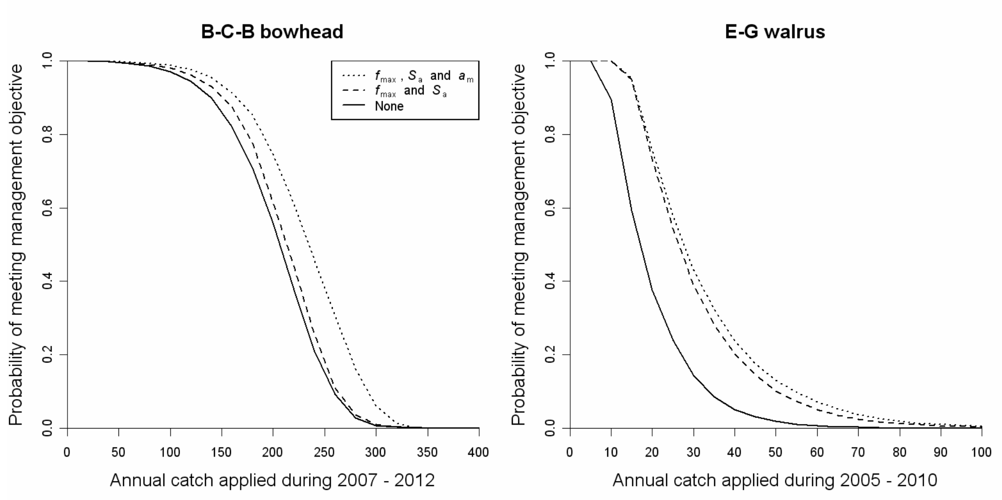

Figure 2.8: The probability of meeting the management objective selected by Witting and Born (2005), for each alternative resampling scheme, as a function of constant future catch for B-C-B bowhead (left panel) and E-G walrus (right panel). Probabilities are shown for each analyses using the reported catch history.

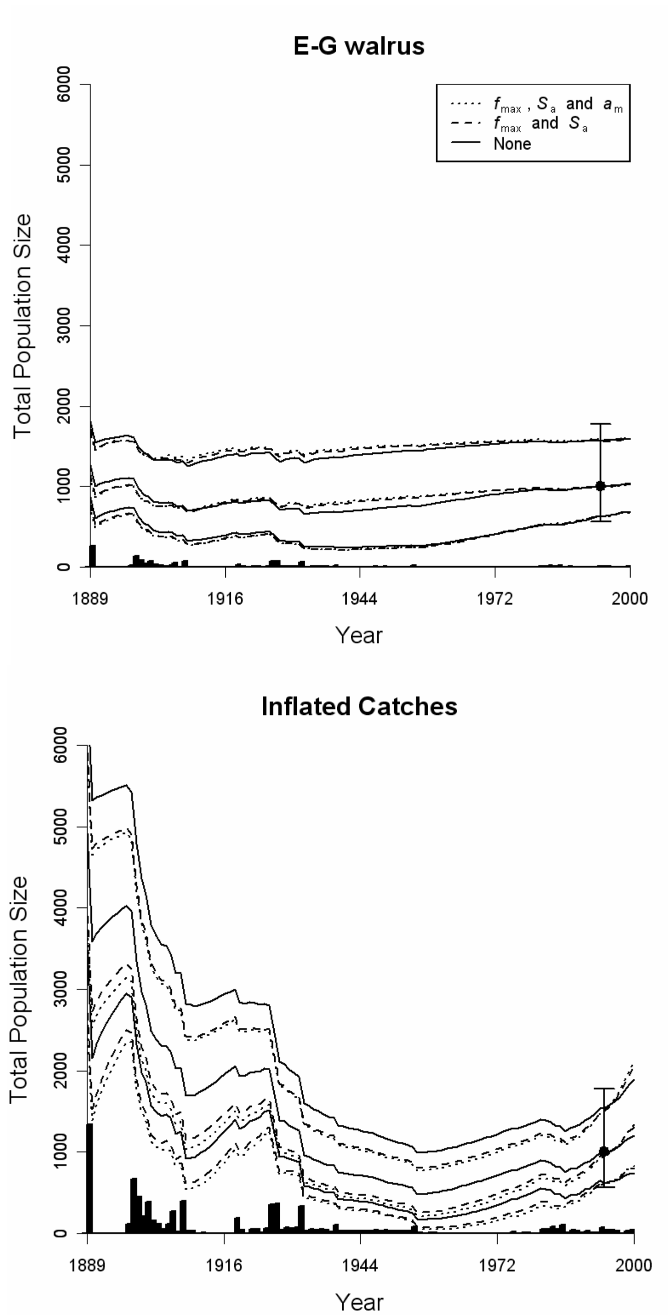

Figure 2.9: Time-trajectories of 0+ population size (medians and 90% credibility intervals) for the E-G walrus population when the reported catch history is used (top panel) and that when the inflated catch history is used (bottom panel). Catches are plotted along the x-axis. The mean of the prior for 1995 abundance (0+) is shown with error bars delimiting the 90th percentiles for the sampling distribution.

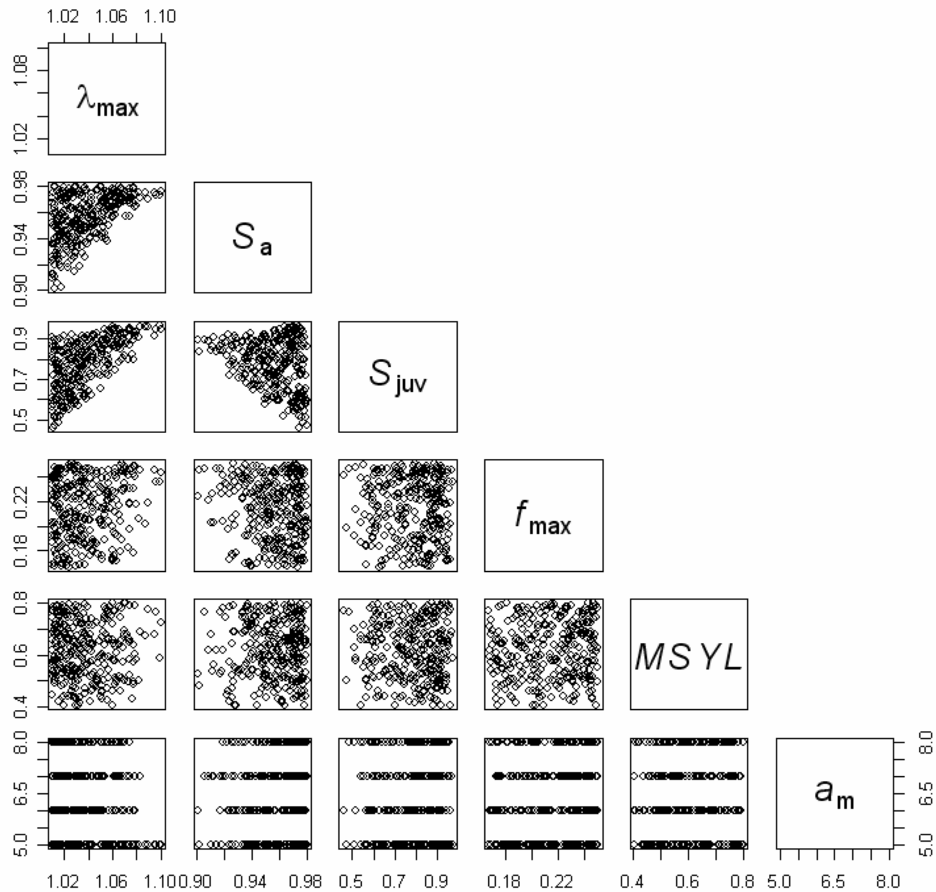

Figure 2.10: Bivariate scatterplots of parameter values from the coherent joint prior achieved by the resampling 'None' for E-G walrus.

Chapter 3:

Assessment of the eastern stock of North Pacific gray whales: incorporating calf production, sea-ice and strandings data

ABSTRACT

A stochastic population dynamics modeling framework that integrated a hypothesized relationship between an environmental variable and process error in life history parameters was developed for the eastern North Pacific stock of gray whales. The case study incorporated an index of sea-ice, which has been hypothesized to regulate calf production in this population. The framework also allowed for stochasticity in both birth and survival rates, and was fit to an index of strandings to capture the dynamics observed during the mortality event of 1999 and 2000. Sensitivity tests were preformed to evaluate the consequences of various assumptions with respect to the extent of stochasticity and data weightings, and the results of this framework were compared to those based on a deterministic model that was only fit to the abundance data. These alternatives were each able to fit the abundance data well and estimated that the population is very close to the carrying capacity of its environment at present. However, those scenarios which accounted for the effect of the mortality event in 1999 and 2000 led to less optimistic estimates of population status during recent decades with concomitant recovery generally attributable to higher survival rates as opposed to higher birth rates. This study represents the first time that the effects of environmental forcing and the mortality event of 1999 and 2000 have been taken into account during a stock assessment of this population. The framework developed here can be used as an operating model with which to test the Gray Whale *SLA*, given climate forecasts and hypotheses regarding environmental impacts on population dynamics.

3.1 INTRODUCTION

Management of cetacean populations involves determining risk-adverse management strategies that account for natural variability in the environment and impacts of climate change on ecosystems (IWC, 1994; Tynan and DeMaster, 1997). Stock assessment methods that incorporate relationships between environmental factors and population processes offer the potential to improve management in several ways: (1) to increase the precision of parameter estimates for population dynamics models and hence catch or by-catch related quotas (Maunder and Watters, 2003); (2) to provide a tool to evaluate the performance of existing and alternative management strategies given forecasts of future climate (e.g. A'mar *et al.*, 2009); (3) to increase the understanding of factors that might affect the recovery of depleted populations; and (4) to identify priorities for future research and management guidelines (IWC, 1997).

The eastern North Pacific (ENP) stock of gray whales is currently subject to aboriginal hunting, with strike limits based on the Gray Whale Strike Limit Algorithm (SLA) under the Aboriginal Whaling Management Procedure (AWMP) of the International Whaling Commission (IWC 2004, 2005a). The life history of this stock follows a typical baleen whale migration between low and high latitudes (Lockyer, 1984). In general, the majority of animals in the population probably derive most of their annual caloric intake from rich benthic prey communities of the northern Bering and southern Chukchi Seas during the summer feeding season. Measurements of weight and girth support the hypothesis that whales on the northbound leg of the migration have lower fat reserves than their counterparts on the southbound migration, due to reduced feeding during the winter migration (Rice and Wolman, 1971; Perryman and Lynn, 2002). Furthermore, observations from individuals killed off California during the 1960's suggest that pregnant females are the first to migrate northward to the feeding grounds after breeding (Rice and Wolman, 1971). Given these factors and the observed variability in calf counts during the northbound migration, it has been hypothesized that the extent of sea-ice covering feeding grounds during the early feeding season might act to dictate calf production by affecting feeding opportunities (Perryman *et al*., 2002).

This chapter provides the first attempt to integrate available estimates of abundance, calf production, strandings and an environmental index that is potentially related to calf production for ENP gray whales in a population dynamics modelling framework. This is one of the most well studied stocks of whales, and therefore provides an ideal candidate to illustrate the results of an assessment method for cetaceans which incorporates an environmental time series. The approach for integrating a relationship between the environmental data and stochastic population dynamics is similar in some respects to that of Maunder and Watters (2003), but differs in that the environmental observations are treated as data and included as a component of the likelihood function (Schirripa *et al*., 2009). This allows an environmental index with missing years to be incorporated in the analysis. The same approach has been used to assess bigeye tuna (*Thunnus obesus*) in the eastern Pacific (Harley and Maunder, 2004) and is currently being adopted for assessment of sablefish (*Anoplopoma fimbria*) off the US west coast (following, Schirripa and Colbert (2006)).

Unlike previous assessments of this stock, the population dynamics model allows for stochastic birth and survival rates and accounts for three female stages: immature, mature receptive (fertile), and mature with calf. Mature females alternate between calving and receptive stages, with the number of calving females in a given year determined by the stochastic birth rate and the number of receptive females that survived the previous year. This underlying population dynamics model is therefore similar to that of Cooke *et al*. (2007), except that it is age-structured rather than being individual-based. The population dynamics model also attempts to take into account the unusual mortality event that occurred during 1999 and 2000, when anomalously high numbers of individuals were reported dead along the west coast of North America (Gulland *et al.*, 2005).

Results from the application of this approach are compared with those from a deterministic version of the same model, which is not fit to calf production and strandings data, and does not take potential environmental forcing into account. The results of alternative scenarios are also presented for the stochastic model. These scenarios correspond to different assumptions regarding the weights assigned to different data sources or different levels of inherent demographic stochasticity, and allow an evaluation of the sensitivity of the results to key assumptions with respect to these concerns.

3.2 METHODS

Population dynamics model

The analyses were based on a sex- and age-based population dynamics model with an annual time-step. The model included stochastic birth and survival rates, and explicitly considered the transition between receptive and calving stages for mature females (Fig. 3.1). The total number of animals in the population was consequently divided into the number of males $N_{a,t}^{male}$ by age and year, the number of immature females by age and year $N_{a,t}^{i}$, the number of cows with calves by year $N_{x,t}^{c}$, and the number of receptive females by year $N_{x,t}^{r}$.

It was not necessary to explicitly track the age-structure of receptive and calving females because the values for their population dynamic parameters, including harvest rate, were the same for all mature ages. Hence, all females that reached the age-at-maturity were lumped into one of the two mature reproductive stages (denoted as age '*x*'). These mature stages are also referred to as the 'plus-groups' hereafter, because they included animals which had reached the age at first parturition, plus all animals older than that age. Mature females transitioned between receptive and calving stages as determined by annual birth rates, with the only exit from these stages through mortality (Fig. 3.1).

Density dependence

Density dependence was assumed to act through the birth rate[9] according to the Pella-Tomlinson model:

$$b_t = \max\left\{0,\ b_{\text{eq}} + (b_{\max} - b_{\text{eq}})\left[1 - \left(\frac{N_{1+,t}}{K_{1+}}\right)^z\right]\right\} \tag{3.1}$$

where:

$b_{\max}$ is the maximum birth rate (in the limit of zero population size);

K_{1+} is the carrying capacity of the 1+ component of the population (all animals aged 1 yr and older);

b_{eq} is the equilibrium birth rate at carrying capacity;

z is the degree of density-dependent compensation (assumed to equal 2.39, which implies maximum sustainable yield at a population density approximately 60% of K_{1+}), and;

$N_{1+,t}$ is the size of the 1+ component of the population (both sexes combined) in year *t*.

Stochastic birth and survival rates

Birth rates varied annually about the deterministic value given by Eqn. 3.1. Since this rate must lie between zero and one, its realization in any one year was calculated using a logistic transformation:

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[9] This is really the rate at which receptive females successfully conceive and then survive with calf to make it past central California on the northbound migration. Therefore, this rate will be less than the true birth rate due to early calf mortality, and even more so less than pregnancy rates due to the combined effects of prenatal mortality. Also note that, a constant birth rate of 1.0 corresponds with roughly 50% of mature females having a calf in any given year, due the nature of the population dynamics model.

$$b_t^* = \left[1 + \exp(-(\Phi^{-1}\left(b_t\right)\sqrt{2.76 + \sigma_\varepsilon^2} + \varepsilon_t + \varepsilon_{\text{add-1},t}))\right]^{-1} \tag{3.2}$$

where:

b_t^* is the realized birth rate during year *t*;

Φ^{-1} is the inverse standard normal cumulative distribution function;

ε_t is the process error deviation during year *t*, such that $\varepsilon_t \sim N(0, \sigma_\varepsilon^2)$;

σ_ε is a measure of the extent of variability in the process error, and;

$\varepsilon_{add-1,t}$ allows for additional process error in the birth rate for 1999 and 2000 (in other years, this parameter was set equal to zero).

This formulation of stochastic birth rates ensured that the expected birth rate in a given year was equal to the deterministic value from Eqn. 3.1 (see Appendix A for the derivation, including an explanation of the number 2.76). This transformation leads to a realized standard deviation (taken across years) for the process error deviations that is less than σ_ε (Punt, 2009). Therefore, the realized standard deviation $`\sigma_\varepsilon$ was also calculated for comparison.

Natural (i.e. non-fishing) survival rates were also allowed to vary annually with the same process error residuals as birth rates (i.e. the deviations in birth and survival rates were assumed to be perfectly correlated). It was assumed that these rates were independent of sex and perfectly correlated among ages in a given year, such that:

$$S_{a,t}^* = \left[1 + \exp(-(\Phi^{-1}\left(S_a\right)\sqrt{2.76 + \sigma_\varepsilon^2} + \varepsilon_t + \varepsilon_{add-2,t}))\right]^{-1} \tag{3.3}$$

where:

$S_{a,t}^*$ is the realized age-specific survival rate during year *t*;

S_a is the deterministic survival rate from age a to a+1, and;

$\varepsilon_{add-2,t}$ is a parameter which allows for additional process error in survival rates in 1999 and 2000 (in other years, this parameter was set equal to zero).

Note, only two natural survival rates were modeled in these analyses: (i) calf survival (S_0) to age 1; and (ii) the survival rate of animals aged 1 year and older (S_{1+}). That is, survival rates were assumed equal for all animals aged 1 and older (i.e., $S_{a>0} = S_{1+}$). Additional details are provided below, under 'Parameterization and scenarios'.

Preliminary analyses indicated that the distributional assumption for the process error deviations did not allow the model to fit the relatively extreme observations of strandings during 1999 and 2000. Thus, ε_{add-1} and ε_{add-2} were introduced into Eqns. 3.2 and 3.3 for those years to try and capture the population dynamics during the mortality event of 1999 and 2000. Two sets of scenarios were run: 1) $\varepsilon_{add-1}=\varepsilon_{add-2}$ (the base-case), and; 2) ε_{add-1} and ε_{add-2} estimated individually (Table 3.1).

Female dynamics

The number of immature females by age depended on the number of births, an assumed 50:50 sex ratio at birth, maturation, and mortality from natural causes and hunting. Maturity was assumed to be knife-edged at age 6 (i.e. all females reached the age at first estrous at age 6). The gestation period was assumed to be one year, so the age at first possible parturition was 7 yr, which is equivalent to the median of the prior distribution for this life history parameter adopted in previous assessments of the ENP gray whales (IWC, 1993; Wade, 2002a). The plus-group age was set equal to the assumed age at first parturition (i.e., x=7 years or older, i.e., 7+), so there was no need to implement a plus-group for the immature stage:

$$N^i_{a,t+1} = \begin{cases} 0.5N^c_{t+1} & \text{if } a = 0 \\ N^i_{a-1,t}S^*_{a-1,t}\left(1 - E^{fem}_t V_{a-1}\right) & \text{if } 1 \le a \le 6 \end{cases} \tag{3.4}$$

where

E^{fem}_t is the exploitation rate during year t on females:

$$E^{fem}_t = C^{fem}_t / \left(N^r_{x,t} + N^c_{x,t} + \sum_a V_a N^i_{a,t} \right) \tag{3.5}$$

V_a is the selectivity on animals of age a, assumed to be constant with regard to sex and time, and uniform on ages 5+, following the approach of previous IWC assessments (IWC, 1993):

$$V_a = \begin{cases} 0 & \text{if } a < 5 \\ 1 & \text{if } a \ge 5 \end{cases} \tag{3.6}$$

C^{fem}_t is the total catch of females during year t.

This formulation assumed that selectivity was the same for all animals of a given age, and was independent of sex, time, and reproductive condition. Hence, the assumed selectivity pattern allowed for cows, but not calves to be killed in the hunt.

The number of receptive females and cows with calves was (given full selectivity on these plus-groups) is given by:

$$N^r_{x,t+1} = S^*_{1+,t}\left[\left(1 - b^*_t\right)\left(N^i_{6,t} + N^r_{x,t}\right) + N^c_{x,t}\right]\left(1 - E^{fem}_t\right) \tag{3.7}$$

$$N^{c}_{x,t+1} = S^{*}_{1+,t} b^{*}_{t} \left(N^{i}_{6,t} + N^{r}_{x,t} \right) \left(1 - E^{fem}_{t} \right) \tag{3.8}$$

Male dynamics

Males were modeled using an age-structured model that ignored maturity because the number of males was assumed not to be a limiting factor for female reproductive success. However, plus-group dynamics (x=7+) were modeled for males because this avoided the assumption that all animals died after a certain age (given full selectivity on the plus-group):

$$N^{male}_{a,t+1} = \begin{cases} 0.5 N^{c}_{t+1} & \text{if } a = 0 \\ N^{male}_{a-1,t} S^{*}_{a-1,t} \left(1 - E^{male}_{t} V_{a-1} \right) & \text{if } 1 \le a < x \\ S^{*}_{1+,t} \left(1 - E^{male}_{t} \right) \left(N^{male}_{6,t} + N^{male}_{x,t} \right) & \text{if } a = x \end{cases} \tag{3.9}$$

where:

E^{male}_{t} is the exploitation rate during year t on males:

$$E^{male}_{t} = C^{male}_{t} / \sum_{a} V_{a} N^{male}_{a,t} \tag{3.10}$$

C^{male}_{t} is the total catch of males during year t.

Initial conditions

Population trajectories were initiated in 1930, under the assumption of a stable-age-distribution given some level of hunting mortality in 1930. A numbers-per-female-calf approach was taken to solve for the numbers-at-age in 1930 given values for the life-history parameters of the model, the relative size of the 1+ component in 1930, and the hunting mortality rate in 1930, E_{init}.The number of females per calf is given by (given full selectivity on the plus-group):

$$NPR_a^{(E)} = \begin{cases} 0.50 & \text{if } a = 0 \\ NPR_{a-1}^{(E)} S_{a-1} \left(1 - E_{\text{init}} V_{a-1}\right) & \text{if } 1 \le a < x \\ NPR_{x-1}^{(E)} S_{1+} \left(1 - E_{\text{init}}\right) \Big/ \left(1 - S_{1+}\left(1 - E_{\text{init}}\right)\right) & \text{if } a = x \end{cases} \tag{3.11}$$

The birth rate at unexploited equilibrium b_{eq} is the inverse of the number of receptive females per-calf which can give birth. Since the maturity ogive was assumed to be knife-edged and the age at first parturition was assumed equal to the age at which individuals entered the plus group, the number of mature females-per-calf was $NPR_x^{(E=0)}$. Given this, b_{eq} is:

$$b_{eq} = \left(NPR_x^{(E=0)} - 1\right)^{-1} \tag{3.12}$$

The numbers-per-recruit approach of Punt (1999a) was modified to take account of hunting mortality in 1930. This involved calculating b_{1930} using Eqn. 3.1 given b_{eq}, $b_{\max}$ and the relative size of the 1+ component in 1930, and using Newton's method (Press *et al.*, 1992) to solve for the value of E_{init} such that:

$$1 = b_{1930}\left(NPR_x^{(E=E_{\text{init}})} - 1\right) \tag{3.13}$$

The age- and sex-structure at the start of the 1930 was then calculated by scaling the numbers-per-calf by the number of calves corresponding to K_{1+}. The numbers-at-age of each sex in 1930 was then the total numbers-at-age divided by two.

Data and likelihood function

Four sources of data were considered when fitting the full model: (1) estimates of population size during 1967-2006 (starting year of survey) from the southbound migration at Granite Canyon, California (Rugh *et al.*, 2005, 2008); (2) estimates of calf production during 1994-2008[10] from the northbound migration at Point Piedras Blancas, California (Perryman *et al.*, 2002; Perryman, *unpublished data*), (3) the number of stranded animals on the coasts of California, Oregon and Washington state, for which a combined annual count was available during 1975-2006 (Brownell Jr. *et al.*, 2007)[11], and; (4) estimated sea-ice area covering the Bering Sea, averaged over March and April during 1953-2006 as calculated by the Hadley Center for their sea-ice and sea surface temperature data set version 1 ('HadSST') (Fig. 3.2, left panel; Rayner *et al.*, 2003).

The HadSST ice index was used here because it represents a good compromise between a shorter high-resolution and a longer less-precise environmental index. It is a compilation of several sources of data including the 'Walsh' charts of sea-ice extent prior to 1978 (Walsh, 1978), and satellite observations for recent decades. Therefore, this index provides a relatively long time series, calibrated by recent satellite observations. It is also worth noting that one of the major goals of these analyses is to use those results to test the Gray Whale *SLA* given predictions of future sea-ice. Since the primary purpose of the HadSST index is to form the basis for forcing atmospheric circulation models during simulations of future climate, and because we plan on using the results from such simulations of future climate when testing the Gray Whale *SLA*, the HadSST is the sea-ice index most consistent with the objectives of this research.

Catches by sex are available from 1930-2006 (Fig. 3.2, right panel). Selectivity-at-age resulting in the observed catches was treated as known. Hence no attempt was made to fit the catch data. Instead, catches were simply subtracted from the population each year according to the assumed selectivity ogive. The catches during 2007 and 2008 were assumed equal to those in 2006.

[10] The two early estimates of calf production during 1980-1981 (Poole, 1984) were not used in these analyses, as they are not currently used when testing the Gray Whale *SLA*.

[11] Data on strandings are collected in other locations (e.g. Mexico and Alaska), but the stranding network effort in California, Oregon and Washington has been more consistent through the years

The total negative of the logarithm of the likelihood function is the sum of the contributions for each data source. In addition, penalties were added to the likelihood function to impose a normal prior with standard deviation σ_ε on the process error deviates and to ensure that trajectories resulting in extinction were assigned zero likelihood. Previous studies using similar, but not identical methods of including process error in the population dynamics have assigned values for σ_ε using an approach which relies on the convergence of the root-mean-squared-error between the logarithms of expected vs. observed recruitment (Methot, 2000). However, that approach is not suitable given the transformation applied here (Equations 3.2 and 3.3). Instead, a default value for σ_ε of 0.50 was used following preliminary analyses which suggested that this value was consistent with observed inter-annual variability in the data. Analyses were also conducted in which σ_ε = 0.30 and 0.70 to assess the sensitivity of the results to the value assumed for σ_ε.

Abundance estimates

The abundance estimates are based on survey seasons which span two calendar years. They are referred to here by the year during which the survey started (e.g., the 1967-68 abundance estimate is referred to as "1967"). In this way, the abundance of the population was considered to be surveyed after births and deaths in a given year. An additional variance term $CV_{\text{add-1}}$ was incorporated into the likelihood component for the abundance estimates following Wade (2002a) and Butterworth *et al*. (1993). The residuals of the fit to the abundance estimates were assumed to be independent between years and log-normally distributed. Moreover, it was assumed that the surveys provided estimates of the number of animals aged 1 and older. These assumptions led to the following component of the negative log-likelihood function[12]:

$$L_1 = \sum_t 0.5\left(\ln\left(\sigma_t^2 + CV_{\text{add-1}}^2\right) + \frac{1}{\sigma_t^2 + CV_{\text{add-1}}^2}\left(\ln N_{1+,t}^{\text{obs}} - \ln N_{1+,t}\right)^2\right) \tag{3.14}$$

where:

$N_{1+,t}^{\text{obs}}$ is the survey estimate of 1+ abundance for year t;

$N_{1+,t}$ is the model estimate of 1+ abundance for year t;

$CV_{\text{add-1}}$ is the extent of additional error about the abundance estimates, and;

σ_t is the standard deviation of the logarithm of $N_{1+,t}^{\text{obs}}$ (approximated by the CV of the untransformed abundance estimate).

Calf estimates

The residuals about the model fit to the calf estimates were also assumed to be independent and identically log-normally distributed. Following previous approaches which fit the calf estimates using a deterministic population dynamics model (Wade, 1997; Wade and Perryman, 2002), the reported observation error about the calf estimates was assumed to be subject to some additional observation error as was the case for the abundance estimates. This approach led to the following component of the negative log-likelihood function:

$$L_2 = \sum_t 0.5\left[\ln\left(\underset{\sim}{\sigma}_t^2 + CV_{\text{add-2}}^2\right) + \frac{1}{\underset{\sim}{\sigma}_t^2 + CV_{\text{add-2}}^2}\left(\ln N_{0,t}^{\text{obs}} - \ln N_{0,t}\right)^2\right] \tag{3.15}$$

where:

$N_{0,t}^{\text{obs}}$ is the survey estimate of calf production in year t;

[12] The likelihood components were calculated ignoring constants independent of the parameters of the model.

$N_{0,t}$ is the model estimate of calf production in year t;

$CV_{\text{add-2}}$ is the extent of additional error about the calf estimates, and;

σ_t is the standard deviation of the logarithm of $N_{0,t}^{\text{obs}}$ (approximated by the CV of the untransformed calf production estimate).

Stranding counts

The residuals about the model fit to the indices of number of stranded animals were assumed to be independent and identically log-normally distributed, leading to the following component of the negative log-likelihood function:

$$L_3 = \sum_t 0.5\left[\ln\left(\sigma_M^2\right) + \frac{1}{\sigma_M^2}\left(\ln M_t^{obs} - \ln(\hat{q}\,\hat{M}_t)\right)^2\right] \tag{3.16}$$

where:

$\hat{q}$ is the constant of proportionality between the indices of stranded animals and $\hat{M}_t$;

M_t^{obs} is the observed number of stranded animals (based on data for California, Oregon and Washington), and;

$\hat{M}_t$ is the model-estimate of the number of animals (for all stages and both sexes) dying due to natural causes:

$$\hat{M}_t = (1 - S_{1+,t}^*)[N_t^r + N_t^c] + \sum_a (1 - S_{a,t}^*)[N_{a,t}^i + N_{a,t}^{male}] \tag{3.17}$$

An empirical estimate for the observation error of the stranding counts does not exist (Brownell Jr. *et al.*, 2007). Therefore, reasonable alternative values were chosen (σ_M = 0.10 or 0.20) to assess the sensitivity of the results to the value assumed for this parameter. A value for σ_M of 0.20 implies that the lower 95% limits for the stranding estimates for 1999/2000 do not overlap with the upper 95%

limits for the strandings estimates for any other years, and it is therefore an upper limit for this parameter which would be consistent with those years representing an unusual mortality event.

The value for $\hat{q}$ was set to its maximum likelihood estimate. This is equivalent to integrating over the prior for this parameter when its prior distribution is uniform in log-space (Walters and Ludwig, 1994). It was reasonable to assume that $\hat{q}$ was less than 1.0, because counts of stranding animals were only made along a portion of the migratory route, and further it seems unlikely that all animals that die will wash ashore or that all of those that do will be counted. In addition, an underlying assumption of this method is that $\hat{q}$ was constant through time. This is unlikely to be strictly true. However, given that gray whales migrate (and die) close to the coast, observation effort has been relatively constant through time for the stranding index considered here and that the mortality event of 1999 and 2000 is believed to have been caused by a substantial decrease in survival (as opposed to a higher fraction of carcasses washing ashore due to a change in wind, ocean currents or the like), minor violations of this assumption were unlikely to be consequential to the results.

Environmental impact on demographic rates

In addition to being subjected to process error, the deviations of birth and survival rates about the deterministic relationship each year were also allowed to be related to an environmental index I_t (in this case, the amount of sea-ice covering the Bering Sea , averaged over March and April). It was assumed that I_t was measured subject to observation error (or there was some error in the relationship between the process error deviations, ε_t, and the environmental index). Consequently, I_t was treated as a state variable, similar to the model prediction of population size. The measurements of the environmental index were therefore treated as data and were consequently included as a component of the likelihood function when the model was fit. The expected environmental index in a given year was assumed to be related to process error residuals for that year, such that the observed index was normally distributed about its expectation:

$$I_t^{obs} = \beta\varepsilon_t + \gamma_t \qquad (3.18)$$

where:

I_t^{obs} is the observed value of the environmental index in year *t*;

β is a scaling parameter for the influence of the environment on the process error residuals;

γ_t the difference between the observed and model-predicted amount of sea ice in year *t*, such that $\gamma_t \sim N(0;\sigma_I^2)$, and;

σ_I is the standard deviation of the residual error for the environmental index:

$$\sigma_I = |\beta|\sigma_I^* \qquad (3.19)$$

This formulation takes a fixed input value for σ_I^* (Table 3.1) and scales the expected standard deviation of the fits to the environmental index by the estimated absolute value for β. It was found through preliminary analyses that, simply fixing σ_I to a given fixed input value (ignoring Eqn. 3.19) led to estimates of the process error deviations ε_t which became increasingly small with smaller assumed values of σ_I. Hence, Eqn. 3.19 leads to the desired effect of the process error deviations being more correlated with the environmental index at smaller values of σ_I.

Perryman *et al.* (2002) investigated two different time lags (corresponding to the potential effect of sea-ice on ovulation or pregnancy rates) and concluded that a relationship between sea-ice during a given year and reproductive success would most likely result from an effect on the pregnancy rates in that year. Therefore, the timing of the potential effect of sea-ice variability in a given year was assumed to be related to deviations from expected birth rates in that year as opposed to the previous year (i.e. a potential effect on ovulation rates). Given the estimation framework here, negative values of β correspond with larger values of the sea-ice index having detrimental affects on birth and survival rates (negative process error deviations).

Given the above assumptions, the contribution of the environmental index to the likelihood function was:

$$L_4 = \sum_t \left[\ln(\sigma_I) + \frac{1}{2\sigma_I^2}\left(I_t^{obs} - I_t\right)^2 \right] \tag{3.20}$$

σ_I^* was assumed to be 0.30 for the base case scenario, because preliminary analyses indicated that this value provided a conservative weight for the environmental index during the model fitting (i.e., it led to a reasonable balance between not over-fitting the environmental index, while still allowing for a relatively strong signal in the process error deviations). Analyses were also conducted with σ_I^*= 0.10 and 1.00 to investigate the sensitivity of the results to alternative values. Likewise, two scenarios were considered in which the model was fit only to data for sea-ice pertaining to those years for which it would have had an effect on recent calf production (1993 – 2008). In these scenarios an alternative index of sea-ice was also fit, based on an updated version of the index used by Perryman *et al.* (2002) (Fig. 3.2, left panel; Perryman, *unpublished data*). This was done to assess the impact of the length of the time-series of environmental data on the results, as well as that given for alternative index of sea-ice.

Parameterization and scenarios

The estimable parameters of the population dynamics model are listed in Table 3.2. Rather than treating all of the survival rates by age as estimable parameters, two survival rates were considered: (i) calf survival S_0 and, (ii) the survival rate for animals aged 1 and older S_{1+}. Moreover, calf survival was not treated as an estimable parameter. Instead, the difference, Δ, between adult and calf survival was estimated. This also allowed the constraint that adult survival cannot be less than calf survival to be enforced. All but one of the scenarios in which the calf data were used to fit the model involved setting the level of additional observation error equal to that for the abundance data (i.e. only one CV_{add} was estimated, such that $CV_{\text{add-2}}$= $CV_{\text{add-1}}$).

Table 3.1 outlines the full set of scenarios. The two base case scenarios were: (i) the stochastic model described above ("Full" in Table 3.1), and; (ii) a deterministic version fit only to abundance data following the approach of previous assessments (e.g., Wade, 2002a) ("Deterministic" in Table 3.1). Several alternative scenarios were considered for the full stochastic model to investigate the affects of certain assumptions and data sources on the results. These alternative scenarios involved estimating the maximum likelihood estimates for the parameters (MLE), while the two base cases involved parameter estimation using maximum likelihood as well as a Bayesian framework. The latter facilitated comparison with previous assessments and forms a basis for evaluating the performance of the Gray Whale *SLA*. A parallel set of scenarios involved estimating separate values for ε_{add-1} and ε_{add-2}. This was done to assess the ability of the model to fit the mortality event when the process error deviations were not assumed to be equal for birth and survival rates during the mortality event.

Parameter estimation

The models were developed using AD Model Builder (ADMB, Otter Research, http://otter-rsch.com/admodel.htm). ADMB uses automatic differentiation (Griewank and Corliss, 1991) to efficiently estimate the variance-covariance matrix of model parameters with respect to the likelihood function. Additionally, it allows for Bayesian estimation by sampling from the posterior distribution using Markov Chain Monte Carlo (MCMC), as implemented by the Metropolis-Hastings algorithm (Hastings, 1970; Gelman *et al.*, 2004). The proposal (or "jump") function used by ADMB for the MCMC algorithm is multivariate normal with a variance-covariance matrix based on that estimated for the model parameters.

The Bayesian Output Analysis Program (BOA) for MCMC was used to diagnose the convergence of the MCMC algorithm (Smith, 2007). The Heidelberger and Welch (1983) stationarity and half-width tests, and the Geweke (1992) and the Raftery and Lewis (1992) convergence diagnostics were inspected for signs of non-convergence and used as guidelines for determining an appropriate burn-in and thinning interval for the chain.

3.2 RESULTS

The MCMC algorithm was run for 50 million iterations, saving every 25,000th sample after a 20% burn-in, leading to a final sample size of 1,601 draws from the posterior. This process resulted in diagnostics for the chain that gave no sign of not having converged, as indicated by Figure 3.3.

The model was able to fit the abundance and calf data reasonably well for all scenarios (see Fig. 3.4 for three examples for calf data; Fig. 3.5 upper panels for abundance data for all scenarios). The results were consistent with this stock being at or near carrying capacity, although estimates of carrying capacity differed among scenarios (Fig. 3.6, left panels; Tables 3.3 and 3.4). The scenarios that did not take the strandings data into account (the 'Deterministic' and 'No Strandings Data' scenarios), or did not place much weight on the strandings data (the σ_M = 0.20 scenario) estimated carrying capacity to be in the low 20,000s, and that the population size has been constant at this level since the late-1980s or early 1990s (Fig. 3.4, upper right panel; Fig. 3.5, lower panels). The inability of certain scenarios to fit the 1999-2000 mortality event is indicated by values of ε_{add-2} that are closer to zero in Tables 3.3 and 3.4. The estimates of maximum birth rate and survival rates were similar among the scenarios that were unable to fit the 1999-2000 mortality event, with higher maximum birth rates and somewhat lower survival rates than for the remaining scenarios (Tables 3.3 and 3.4). The "Full" scenario estimated life history parameters more precisely than the "Deterministic" scenario, and also estimated lower maximum birth rates and higher survival rates (Fig. 3.7).

The scenarios which estimated both $CV_{\text{add-1}}$ (abundance) and $CV_{\text{add-2}}$ (calf) resulted in estimates for $CV_{\text{add-1}}$ which were generally equal to those for the other scenarios. However, $CV_{\text{add-2}}$ was estimated to be equal to zero. The results from estimating this additional parameter were generally similar to those for the Full model (Tables 3.3 and 3.4).

In general, the scenarios investigated here were able to capture at least some of the additional mortality during 1999 and 2000, and estimated that the population has since recovered following that event to numbers that equal or possibly exceed those in 1998, but not necessarily to carrying capacity (Fig. 3.4, left and middle panels). Those scenarios which were able to fit the 1999-2000 mortality event also resulted in less precise (and slightly lower) estimates of current depletion (Fig. 3.6, right panels). There was essentially no support for carrying capacity being greater than 40,000 or that the stock size is currently at less than 70% of carrying capacity for any of the scenarios (Fig. 3.5, lower panels; Fig. 3.6, right panels; Tables 3.3 and 3.4).

The "Full" model was able to capture the variability in the calf production estimates quite well (Fig. 3.4; left panels). Even though the "Deterministic" model was not fitted to the calf estimates, the resulting estimates of calf production were consistent with the average observed calf production in recent years, albeit with much more uncertainty around these estimates than the "Full" model (Fig. 3.4; right panels). None of the scenarios considered were fitted to the 1980 and 1981 calf counts as noted above. However, there are model-predictions corresponding to those counts. In general, the predicted numbers of calves in 1980 and 1981 exceeded the observations, more so for the "Deterministic" model (although the observed values were within the 95% probability intervals for this model) (Fig. 3.4).

The "Full" model fit the data nearly equally well irrespective of whether ε_{add-1} and ε_{add-2} were estimated individually (Fig. 3.4 left and centre panels). However, the estimates of ε_{add-2} were quite different between these scenarios (Tables 3.3 and 3.4, second row last two columns). The scenario which estimated both ε_{add-1} and ε_{add-2} resulted in a larger negative value for ε_{add-2} (lower survival) and was better able to fit the strandings data during the years of the mortality event (Fig. 3.4, middle and bottom rows; Tables 3.3 and 3.4).

The parameter that related the sea-ice index to the process error deviations β was estimated to be negative for all but two scenarios (Tables 3.3 and 3.4). Setting σ_I^*=0.30 allowed the model to fit all but the most extreme years of the sea-ice index (e.g., Fig. 3.4, left and middle panels). Consequently, birth and survival rates were lower (i.e. lower calf production and higher numbers of strandings) than expected during years for which the sea-ice index was large. This result was most evident during those years before the first stranding and calf estimates. For example, calf production and survival were estimated to have been less than otherwise expected during the heavy sea-ice years of the 1970's because of negative process error deviations during those years (Fig. 3.4).

Varying the value of σ_I^* did not greatly affect the ability of the model to fit the data other than the sea-ice index itself. The environmental signal in the process error deviations became more pronounced, especially for those years before the strandings and calf data were available, by giving the sea-ice data more weight (i.e., the σ_I^*=0.10 scenario in Tables 3.3 and 3.4). Likewise, the process error deviations were close to zero prior to there being strandings and calf data when the sea-ice data were substantially down-weighted (i.e., the σ_I^*=1.00 scenarios in Tables 3.3 and 3.4). This scenario led to a positive value for the parameter β. However, the estimated value of β for this scenario was essentially irrelevant because the process error deviates were essentially zero prior to the calf and strandings data and because of the lower weight given to the effect of sea-ice on the model fits.

There was essentially no difference between the results for the two scenarios which only fit to recent sea-ice data from 1993-2008 when the additional process error was assumed equal for birth and survival rates during the mortality event ("Recent Ice" and "Perryman *et al.* Ice" in Tables 3.3). However, the estimated values for ε_{add-1} were more negative for those scenarios which estimated both ε_{add-1} and ε_{add-2}, leading again to better fits to the strandings data and higher estimates of the numbers of animals which died during those years ("Natural Mortality '99 + '00" in Table 3.4). It followed that the estimates of current depletion were lower for those scenarios which were only fit to the recent ice data and also estimated both ε_{add-1} and ε_{add-2} (Table 3.4).

The realized standard deviation of the process error residuals (`σ_ε) was similar across all stochastic scenarios and generally equal to about 0.20; with the notable exceptions of those scenarios for which the input value for σ_ε was varied (Tables 3.3 and 3.4). Not surprisingly, varying the value for σ_ε had a direct result on the realized standard deviations of the process error residuals and, as expected, the realized standard deviations were less than the value for σ_ε. For the Full model with $\varepsilon_{add-1} = \varepsilon_{add-2}$, the point estimates for $`\sigma_\varepsilon$ were 0.07, 0.21 and 0.33, given σ_ε = 0.30, 0.50 and 0.70 respectively. The scenarios with σ_ε =0.30 exhibited fairly deterministic dynamics (with the exception of the impact on the ε_{add-1} during the 1999-2000 mortality event). These scenarios also led to estimated values for $CV_{\text{add-1}}$ = 0.18 and 0.20, which were the largest of any of the scenarios considered in these analyses (Tables 3.3 and 3.4). The estimated value for β was positive when σ_ε =0.30 and both ε_{add-1} and ε_{add-2} were estimated individually, but due to the essentially deterministic dynamics (i.e., very small process error deviates), the estimated value of β for this scenario was inconsequential. In general, the effect of increasing the standard deviation of the process errors was similar to that of decreasing the value for σ_I^* (or similarly, only fitting to the sea-ice data for 1993-2008), and vice-versa. That is, the estimated effects of sea-ice became more exaggerated for higher values of σ_ε or lower values for σ_I^* (or longer time series of sea-ice), especially during those years before calf and strandings data became available.

3.3 DISCUSSION

We incorporated an environmental index into a population dynamics modeling framework, and allowed for a hypothesized relationship between sea-ice and gray whale population dynamics when fitting to observations of abundance, sea-ice, strandings and calf production. The incorporation of such a relationship could potentially improve our understanding of cetacean population dynamics and help to determine whether existing management strategies are robust to climate-induced forcing of the population dynamics. However, it should be noted that the goal of this investigation was not to provide evidence for or against a certain hypothesis about how environmental conditions may affect population dynamics. Rather, the primary aim was to develop a tool by which alternative hypotheses may be explicitly taken into account within a population dynamics modeling framework; ultimately, providing a means through which the robustness of management strategies may be evaluated, given such hypotheses and forecasts of future climate change.

The framework allowed for the deviations in birth and survival rates to be related to an index of sea-ice in the Bering Sea, following a plausible hypothesis about how this environmental index might be related to the population dynamics of ENP gray whales. It would be straightforward to substitute an alternative environmental index (e.g., sea-ice in the Chukchi Sea, El Niño/Southern Oscillation etc…), or some weighted combination of multiple indices into the framework developed here, but such analyses were beyond the scope of this chapter. In this study, the environmental index was used as a proxy measure for the variability in birth and survival rates, while observations of calf production and strandings numbers were taken as direct measures of the underlying variability in those life history parameters. During the years for which calf count, strandings and sea-ice data were all available, the effect of sea-ice on the population dynamics was calibrated. Then, during years when the sea-ice data were available, but prior to direct observations of calf production and strandings (i.e., during the 1960s and 1970s), the expected dynamics in birth and survival rates were extrapolated based on the values of the sea-ice index.

However, something extraordinary clearly occurred during 1999 and 2000 in terms of survival rates, as exemplified by the stranding counts (Fig. 3.4), and the ability of the different model configurations to fit the 1999-2000 mortality event had a large influence on the results. Specifically, the results were more optimistic regarding recent stock size relative to carrying capacity for those scenarios which were not able to fit the strandings data during 1999 and 2000. Furthermore, when the strandings data and mortality event were ignored (e.g., the deterministic model), the recovery of the stock since 1930 was attributed to higher calf production during the period of increasing abundance estimates, as opposed to higher survival rates. In contrast, when the stranding data are taken into account, recovery was explained through higher survival rates and lower calf production.

It was not possible to fit the strandings data for the 1999-2000 mortality event without allowing for some additional process error in the survival rates during those years, given the assumptions made regarding the nature of the process error deviations. This additional process error could be modeled in a few different ways in addition to the approach taken in this chapter. For example, Ward *et al.* (2007) estimate the probability of an unusual or 'catastrophic' event by adopting a mixture distribution approach to process error. That is, they estimate if a given year was a catastrophic year, and, depending on that assessment, draw the process error for that year from one of two (regular and catastrophic) distributions (in effect we have assumed an underlying mixture distribution with a step function for 1999 and 2000, where those years are given probability of 1.0 for catastrophe, and other years assigned zero probability). An estimate of the probability of a mortality event would be of great interest when running future projections and testing the Gray Whale *SLA*, whereas the approach taken here is somewhat limited in its predictive ability of future catastrophic events. However, it is not immediately obvious that available data for ENP gray whales would be sufficient to estimate the additional parameters in a mixed model approach.

Observations of recent variability in calf production and the amount of sea-ice covering the early season feeding grounds supports the hypothesis of a relationship between sea-ice and calf production in gray whales. However, it is possible that this relationship (if it exists) is something that has developed or strengthened within the last two decades. For example, the two early (1980s) calf production estimates are nearly equal (Fig. 3.4), yet occurred during years of disparate ice conditions (Fig. 3.2). Therefore, these early calf production data suggest some non-linearity in the relationship between population dynamics and environmental forcing. We have assumed that the relationship between calf production and sea-ice is stationary (and specifically independent of population density), and one result of this assumption was that the model predicts lower than expected calf production during much of the 1960s and 1970s, when there were higher levels of sea-ice in the Bering Sea. Consequently, the estimates of survival were higher for the stochastic than for the deterministic configurations of the model (Fig. 3.7), which allowed the stochastic model to mimic for the observed trend in the abundance data.

Modeling the interaction between population density and the effects of environmental variability on vital rates, and the probability of mortality events is beyond the scope of this chapter. However, as populations increase in density, the impact of density-independent factors on population dynamics probably become more pronounced (e.g., Durant *et al*., 2005) and accounting for density-dependent mortality events may have implications for management strategies (e.g., Wilcox and Eldred, 2003). Therefore, if the framework presented here is used to test management strategies, a plausible set of scenarios for how such environmental affects and the probability of mortality events might change with population density should be identified. It seems unlikely that it will be possible to estimate such relationships given the amount of data available for most cetacean populations, but the approach taken here could be modified to examine different assumptions along these lines (e.g., modifying σ_I^* as a function of depletion).

The assumption that the birth and survival process errors were perfectly correlated was rather simplistic. In reality, there is likely to be some correlation, but it may be imperfect and non-linear (Eberhardt, 1977; Gaillard *et al.*, 2000). The assumption made here was fairly inconsequential during normal stranding years, because the variability in strandings among years is generally low. However, the consequence of this assumption during the 1999-2000 mortality event was substantial. Estimating both ε_{add-1} and ε_{add-2} provided better fits to the observed strandings during this event. These scenarios illustrated the constraint placed on the ability of the model to simultaneously fit the calf and strandings data during the mortality event, when the additional process error during those years was assumed to the same for birth and survival rates. The differences between the estimates of ε_{add-2} (roughly twice as large when estimated individually) could have implications for projections of population dynamics if future mortality events are conditioned on those estimates of ε_{add-2}.

A forecast of future sea-ice conditions will be needed to perform projections of population dynamics within this framework and hence test the Gray Whale *SLA*. Overland and Wang (2007) have provided one such forecast, based on an ensemble mean from a suite of models considered by the Intergovernmental Panel on Climate Change. We plan on including that forecast as input for population projections in the next stage of this research, using the framework presented here as an operating model while testing the Gray Whale *SLA*.

Future work may extend this framework to other cetacean stocks. Several alternative candidates exist for which a relationship between environmental conditions and cetacean population dynamics has been recognized, for example: northeast Atlantic fin whales (Lockyer, 1986); sperm whales off the Galapagos Islands (Whitehead, 1997), and; north and south Atlantic right whales (Green *et al.*, 2003; Leaper *et al.*, 2006). In addition, recent observations suggest a possible relationship between body condition and sea-ice for animals taken in the aboriginal hunt for the Bering-Chukchi-Beaufort Seas stock of bowhead whales (George *et al.*, 2009). Such information, combined with an index of calf production for this stock (Koski *et al.*, 2008), could eventually be included in a framework similar to that presented here, and then applied to testing of the bowhead *SLA* given relevant climate forecasts.

In conclusion, the framework developed here provides a basis for testing management strategies, given a hypothesis about how environmental factors influence population dynamics and climate forecasts. The results indicated that including the environmental index and fitting to the mortality event lead to somewhat different interpretations of the population dynamics of the ENP gray whale when compared to those provided by a deterministic model. Using this framework to test the Gray Whale *SLA* should help to ensure that management is robust to a plausible range of scenarios for how future climate might impact this, and other cetacean populations.

Table 3.1

The scenarios considered in these analyses. Different data sets, parameter values and estimation techniques are outlined. The scenarios labeled 'Deterministic' and 'Full' refer to the base cases, for which a Bayesian estimation framework was adopted as well as maximum likelihood estimation (MLE). A further set of parallel runs were performed for the Full model, but not fitting the calf estimates from 1999 – 2001. The remaining scenarios are variations of the 'Full' base case. The '=' signs denote that a parameter was not estimated but set to the value of another parameter, and 'NA' signifies a variable that is not applicable to a certain scenario (e.g., σ_I^* is not applicable when the sea-ice data are not considered).

Scenario	Abundance Data	Calf Data	Ice Data	Strandings data	$CV_{\text{add-1}}$ (abundance)	$CV_{\text{add-2}}$ (calf)	σ_ε
Deterministic	Yes	No	No	No	Estimated	NA	NA
Full	Yes	Yes	Yes	Yes	Estimated	$= CV_{\text{add-1}}$	0.50
$\sigma_M = 0.20$	Yes	Yes	Yes	Yes	Estimated	$= CV_{\text{add-1}}$	0.50
Recent Ice	Yes	Yes	'93-'08	Yes	Estimated	$= CV_{\text{add-1}}$	0.50
Perryman *et al*. Ice	Yes	Yes	'93-'08	Yes	Estimated	$= CV_{\text{add-1}}$	0.50
$\sigma_I^* = 0.10$	Yes	Yes	Yes	Yes	Estimated	$= CV_{\text{add-1}}$	0.50
$\sigma_I^* = 1.00$	Yes	Yes	Yes	Yes	Estimated	$= CV_{\text{add-1}}$	0.50
$\sigma_\varepsilon = 0.30$	Yes	Yes	Yes	Yes	Estimated	$= CV_{\text{add-1}}$	0.30
$\sigma_\varepsilon = 0.70$	Yes	Yes	Yes	Yes	Estimated	$= CV_{\text{add-1}}$	0.70
$CV_{\text{add-1}}$ & $CV_{\text{add-2}}$	Yes	Yes	Yes	Yes	Estimated	Estimated	0.50
No Strandings data	Yes	Yes	Yes	No	Estimated	$= CV_{\text{add-1}}$	0.50

Table 3.1 continued

Scenario	σ_M	σ_I^*	$\varepsilon_{add\text{-}1,t}$	$\varepsilon_{add\text{-}2,t}$	$\underline{\varepsilon}_t$	Bayesian or MLE
Deterministic	NA	NA	NA	NA	NA	Both
Full	0.10	0.30	Estimated	$= \varepsilon_{add\text{-}1,t}$	Estimated	Both
$\sigma_M = 0.20$	0.20	0.30	Estimated	$= \varepsilon_{add\text{-}1,t}$	Estimated	MLE
Recent Ice	0.10	0.30	Estimated	$= \varepsilon_{add\text{-}1,t}$	Estimated	MLE
Perryman *et al.* Ice	0.10	0.30	Estimated	$= \varepsilon_{add\text{-}1,t}$	Estimated	MLE
$\sigma_I^* = 0.10$	0.10	0.10	Estimated	$= \varepsilon_{add\text{-}1,t}$	Estimated	MLE
$\sigma_I^* = 1.00$	0.10	1.00	Estimated	$= \varepsilon_{add\text{-}1,t}$	Estimated	MLE
$\sigma_\varepsilon = 0.30$	0.10	0.30	Estimated	$= \varepsilon_{add\text{-}1,t}$	Estimated	MLE
$\sigma_\varepsilon = 0.70$	0.10	0.30	Estimated	$= \varepsilon_{add\text{-}1,t}$	Estimated	MLE
$CV_{\text{add-1}}$ & $CV_{\text{add-2}}$	0.10	0.30	Estimated	$= \varepsilon_{add\text{-}1,t}$	Estimated	MLE
No Strandings data	NA	0.30	Estimated	$= \varepsilon_{add\text{-}1,t}$	Estimated	MLE

Table 3.2

The parameters and their assumed prior distributions. The abbreviations for the prior distributions include: U [uniform] and N [normal]. Footnotes below describe the sources and reasoning behind these parameter values and distributions.

Parameter	Prior distribution
Maximum non-calf survival rate, S_{1+}	U[0.950, 0.999] [a]
Maximum birth rate, $b_{\max}$	U[0.01, 0.99]
Difference between non-calf and calf survival, $\Delta = S_{1+} - S_0$	U[0.01, 0.25] [b]
Carrying capacity, K_{1+}	U[15 000, 70 000] [b]
Relative population size in 1930, $N_{1+,1930} / K_{1+}$	U[0.050, 0.50] [b]
Process error residuals, ε_t	N[0, σ_ε^2]
Additional process error during '99/'00 mortality event, $\varepsilon_{add\text{-}1}$ and $\varepsilon_{add\text{-}2}$	U[-4.0, 4.0] [b]
Influence of sea-ice on calf production, β	U[-400, 400] [b]

a. Equal to the prior distribution used in recent assessments (IWC, 1998).

b. Preliminary analyses provided no evidence of posterior support for values outside this range.

Table 3.3

Results for the scenarios based on the Full model. The estimates correspond to the mode of the posteriors for the Bayesian analyses, and MLEs are shown for the ML analyses: $\tilde{S}$ is the median stochastic survival rate over all years; $`\sigma_\varepsilon$ is the standard deviation of the realized process errors (after the transformation in Eqns. 3.2 and 3.3), and the combined natural mortality during 1999-2000, corresponding to the total number of whales estimated to have died during the mortality event is also shown. The asterisk on $CV_{add\text{-}2}$ (calf) indicates that this parameter was estimated to be zero.

Scenario	$N_{1+,\,2009} / K_{1+}$	K_{1+}	b_{max}	S_{1+}	$\tilde{S}^*_{1+}$	S_0	$\tilde{S}^*_0$	$`\sigma_\varepsilon$
Deterministic	0.981	22,621	0.990	0.964	NA	0.714	NA	NA
Full	0.979	26,773	0.32	0.989	0.981	0.979	0.971	0.21
$\sigma_M = 0.20$	0.996	23,159	0.65	0.978	0.971	0.968	0.961	0.22
Recent Ice	0.938	26,650	0.31	0.989	0.982	0.979	0.972	0.18
Perryman *et al.* Ice	0.940	26,054	0.33	0.988	0.980	0.977	0.969	0.18
$\sigma_I^* = 0.10$	0.980	29,784	0.25	0.995	0.989	0.960	0.954	0.23
$\sigma_I^* = 1.00$	0.941	26,162	0.33	0.988	0.980	0.978	0.970	0.18
$\sigma_\varepsilon = 0.30$	0.941	28,889	0.28	0.994	0.985	0.984	0.975	0.07
$\sigma_\varepsilon = 0.70$	0.962	30,890	0.21	0.997	0.993	0.870	0.866	0.33
$CV_{add\text{-}1}$ & $CV_{add\text{-}2}$	0.988	26,578	0.36	0.987	0.980	0.977	0.970	0.22
No Strandings data	0.992	22,454	0.99	0.980	0.972	0.742	0.735	0.23

Table 3.3 continued

Scenario	β	Natural Mortality '99 + '00	$CV_{\text{add-1}}$ (abundance)	$CV_{\text{add-2}}$ (calf)	$\varepsilon_{add\text{-}1,t}$ (birth)	$\varepsilon_{add\text{-}2,t}$ (survival)
Deterministic	NA	2,414	0.11	NA	NA	NA
Full	-2.32	2,455	0.12	0.12	-1.01	-1.01
$\sigma_M = 0.20$	-2.25	2,072	0.09	0.09	-0.44	-0.44
Recent Ice	-2.28	2,575	0.11	0.11	-0.91	-0.91
Perryman *et al.* Ice	-2.11	2,679	0.09	0.09	-0.66	-0.66
$\sigma_I^* = 0.10$	-3.20	1,996	0.19	0.19	-1.20	-1.20
$\sigma_I^* = 1.00$	-0.93	2,688	0.10	0.10	-1.05	-1.05
$\sigma_\varepsilon = 0.30$	-2.97	2,538	0.18	0.18	-1.19	-1.19
$\sigma_\varepsilon = 0.70$	-1.85	1,314	0.14	0.14	-1.22	-1.22
$CV_{\text{add-1}}$ & $CV_{\text{add-2}}$	-2.30	2,351	0.13	0.00*	-0.87	-0.87
No Strandings data	-2.14	1,468	0.08	0.08	-0.06	-0.06

Table 3.4

As for table 3.3, except that $\varepsilon_{add\text{-}1}$ & $\varepsilon_{add\text{-}2}$ are estimated individually. That is, the 1999/2000 event was not assumed to have an identical impact on birth and survival rates.

Scenario	$N_{1+,\,2009} / K_{1+}$	K_{1+}	b_{max}	S_{1+}	$\tilde{S}^{*}_{1+}$	S_0	$\tilde{S}^{*}_{0}$	\`σ_{ε}
Deterministic	0.981	22,621	0.990	0.964	NA	0.714	NA	NA
Full ($\varepsilon_{add\text{-}1}$ & $\varepsilon_{add\text{-}2}$)	0.940	29,632	0.22	0.999	0.995	0.773	0.770	0.23
$\sigma_M = 0.20$	0.996	22,960	0.705	0.978	0.971	0.968	0.961	0.22
Recent Ice	0.920	27,985	0.268	0.995	0.989	0.869	0.863	0.18
Perryman *et al*. Ice	0.911	27,604	0.277	0.996	0.990	0.803	0.798	0.19
$\sigma^{*}_{I} = 0.10$	0.959	30,835	0.207	0.999	0.995	0.849	0.845	0.24
$\sigma^{*}_{I} = 1.00$	0.711	30,711	0.230	0.996	0.991	0.746	0.741	0.21
$\sigma_{\varepsilon} = 0.30$	0.884	31,209	0.226	0.999	0.995	0.809	0.804	0.05
$\sigma_{\varepsilon} = 0.70$	0.953	29,535	0.213	0.999	0.996	0.749	0.746	0.37
$CV_{add\text{-}1}$ & $CV_{add\text{-}2}$	0.954	29,799	0.233	0.999	0.995	0.773	0.770	0.24
No Strandings data	0.996	22,960	0.705	0.978	0.971	0.968	0.961	0.22

Table 3.4 continued

Scenario	β	Natural Mortality '99 + '00	$CV_{\text{add-1}}$ (abundance)	$CV_{\text{add-2}}$ (calf)	$\varepsilon_{add\text{-}1,t}$ (birth)	$\varepsilon_{add\text{-}2,t}$ (survival)
Deterministic	NA	2,414	0.11	NA	NA	NA
Full ($\varepsilon_{add\text{-}1}$ & $\varepsilon_{add\text{-}2}$)	-2.25	2,620	0.12	0.12	-0.99	-2.24
$\sigma_M = 0.20$	-2.23	2,314	0.09	0.09	-0.56	0.15
Recent Ice	-2.31	2,981	0.11	0.11	-1.45	-0.85
Perryman *et al*. Ice	-2.06	3,414	0.09	0.09	-1.49	-0.55
$\sigma_I^* = 0.10$	-3.08	2,040	0.19	0.19	-1.92	-1.07
$\sigma_I^* = 1.00$	0.94	5,187	0.09	0.09	-2.39	-1.26
$\sigma_\varepsilon = 0.30$	3.07	2,854	0.20	0.20	-2.08	-1.19
$\sigma_\varepsilon = 0.70$	-1.75	2,359	0.13	0.13	-2.38	-0.94
$CV_{\text{add-1}}$ & $CV_{\text{add-2}}$	-2.23	2,549	0.14	0.00*	-2.20	-0.95
No Strandings data	-2.23	2,314	0.09	0.09	-0.56	0.15

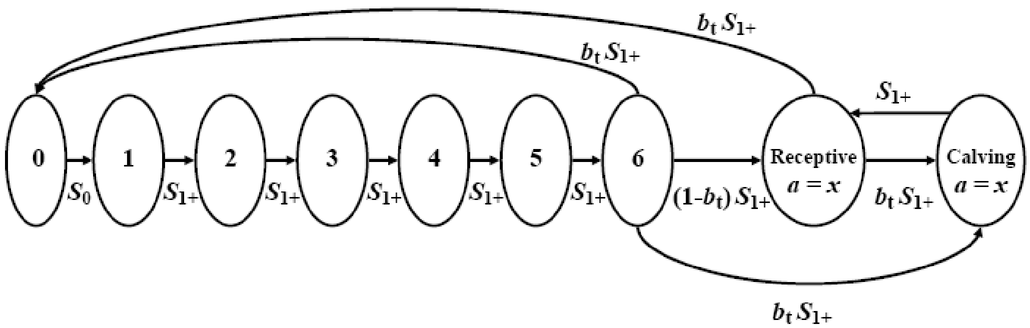

Figure 3.1: Life cycle graph of the model used to track the number of females in each reproductive stage though time. This life cycle refers to the underlying deterministic model, with transition probabilities shown as functions of life history parameters. The survival and birth rates were modified to be stochastic in the all of the analyses presented here (except 'Deterministic'). The arrow from immature to calf arises because some juveniles may mature and give birth (i.e. become pregnant at first estrous) during the projection interval from time *t* to *t*+1.

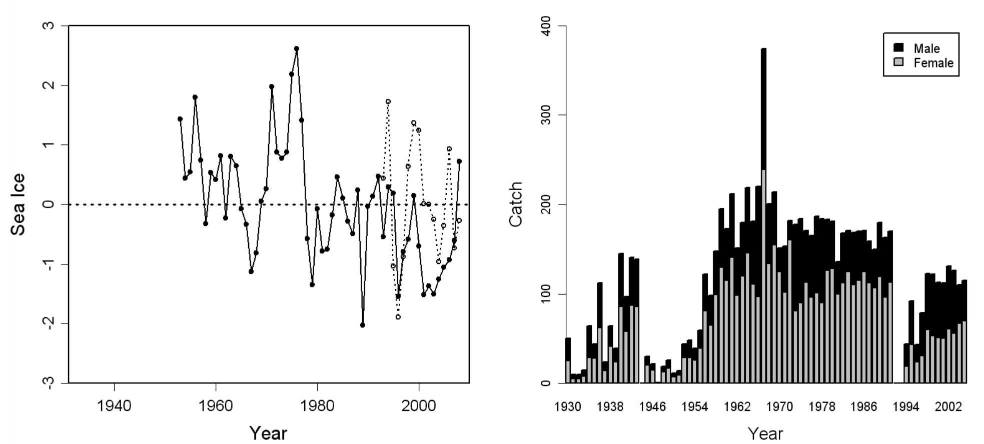

Figure 3.2: (Left panel) The standardized HadSST index for the March-April averaged sea-ice area covering the Bering Sea is shown by the solid line, and the Perryman *et al.* index is shown as the dashed line. Positive values represent years with greater than average spring ice over the time period considered. (Right panel) Catches by individuals and sex: 1930-2006.

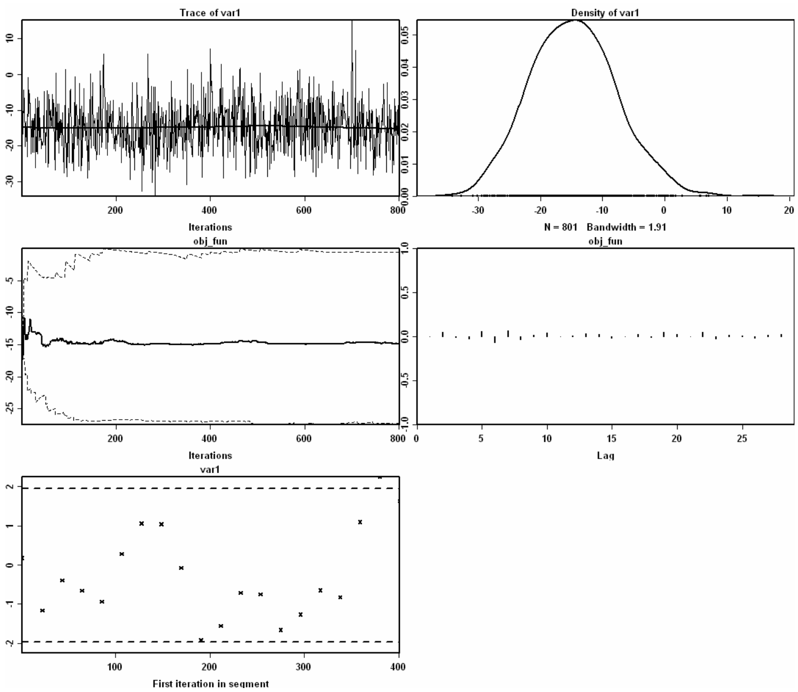

Figure 3.3: Diagnostic plots for the negative log-likelihood function resulting from the MCMC chain for the base-case Full model scenario (all data). Clockwise from upper left: trace, density, autocorrelation, Geweke's z-score, and the cumulative quantile plots showing the evolution of the median (solid line) and 95th percentiles of the chain.

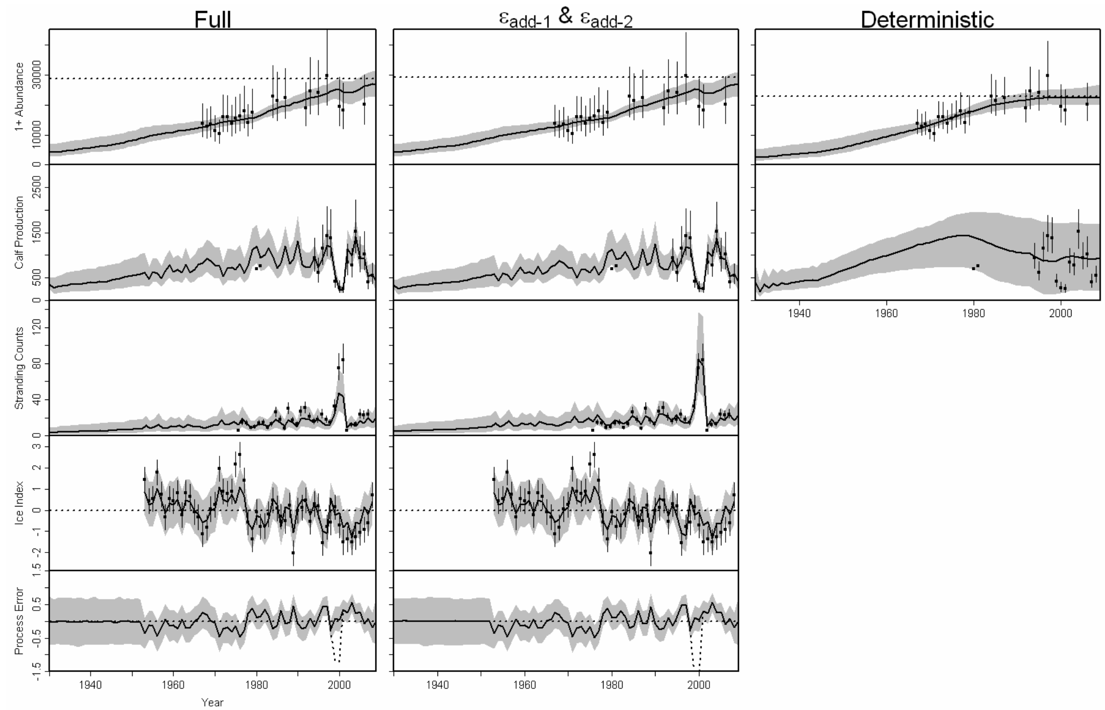

Figure 3.4: Model fits are shown: left column is the Full model; middle column is that model, but estimating ε_{add-1} and ε_{add-2} separately, and; right column is the Deterministic model. From top to bottom: abundance; calf production; strandings; sea-ice, and; estimated process error deviations. The abundance estimates are plotted with the 95% CIs associated with the mode of the posterior distribution for $CV_{\text{add-1}}$. The median of the posterior estimate for carrying capacity is plotted as a horizontal line with the abundance fits. For all plots, the medians and 95% Bayesian credibility intervals are shown as solid lines and shaded areas respectively. The calf estimates for 1980-81 were not fit for the first two scenarios, nor were any of the recent calf estimates fit for the Deterministic model. However, they are plotted for reference. Horizontal dotted lines at zero are plotted in the fits to the sea-ice data and the process error deviation estimates for reference. And the median of the posterior for ε_{add-2} is represented by the more vertical dashed line on the bottom two plots.

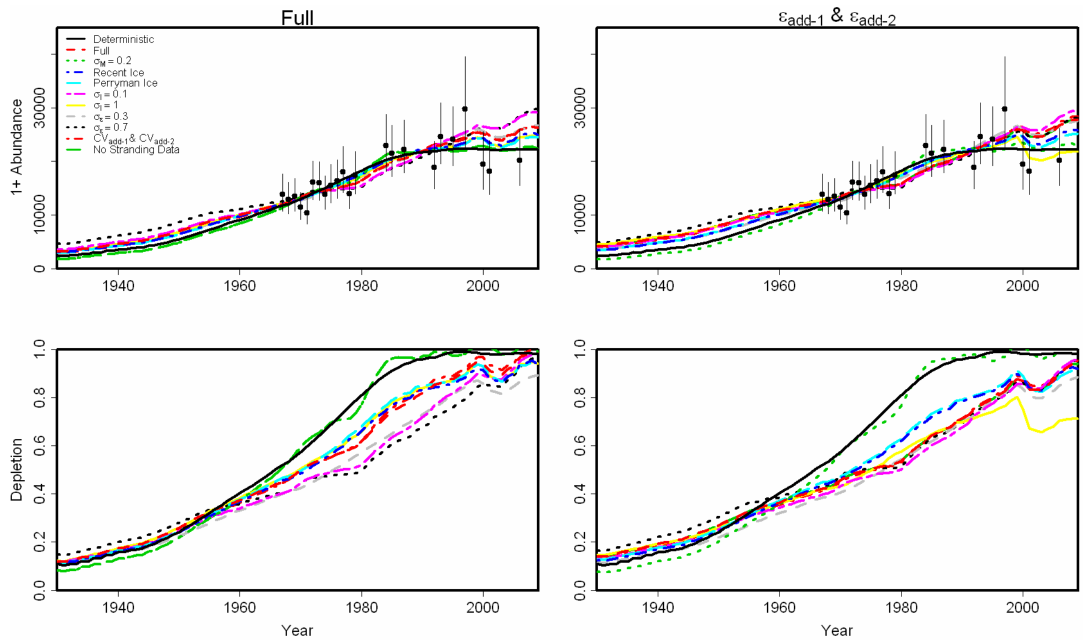

Figure 3.5: Fits to the abundance data based on the maximum likelihood estimates for each scenario (upper panels) and the estimated relative population size ("depletion") through time (bottom panels). The scenarios under the Full model are shown in the left panels, while those that estimated ε_{add-1} and ε_{add-2} are shown in the right panels. The deterministic scenario is plotted as the solid black line. 95% CIs are plotted for the abundance estimates assuming a value for $CV_{\text{add-1}} = 0.10$.

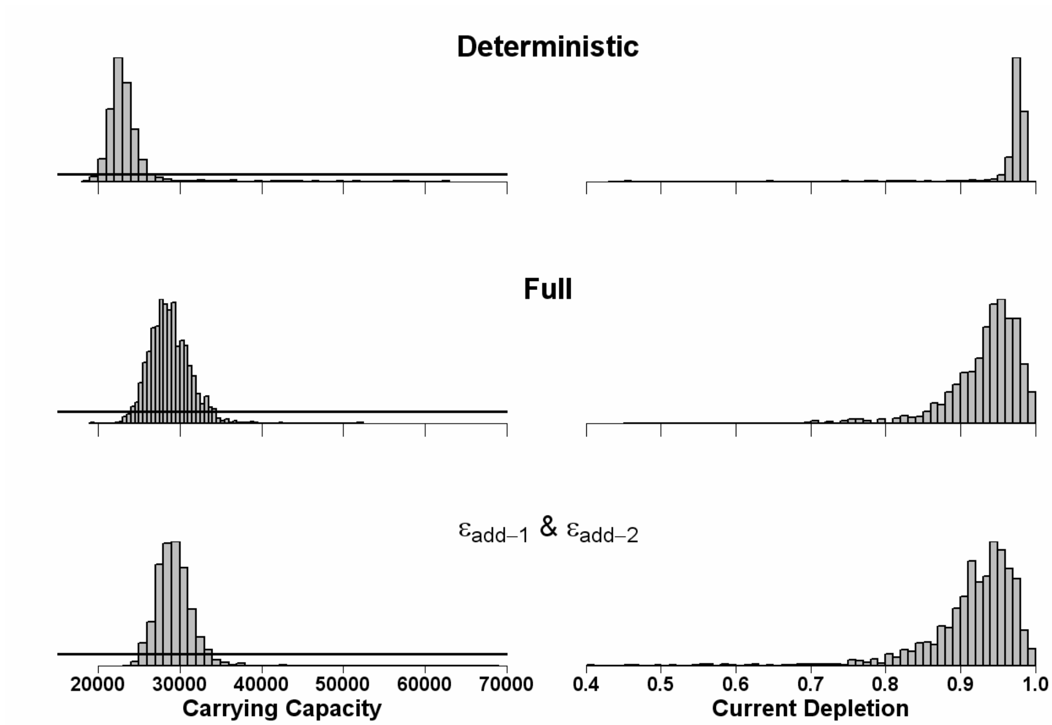

Figure 3.6: Histograms comparing marginal posterior densities (bars). Estimates of carrying capacity (plots on left side) and current depletion (right side) are shown. The upper row shows the samples from the posterior for the deterministic model, the middle rows shows samples from the posteriors for the Full model and the bottom row shows those for the Full model when ε_{add-1} and ε_{add-2} are estimated individually. The uniform prior for carrying capacity is shown as a solid line.

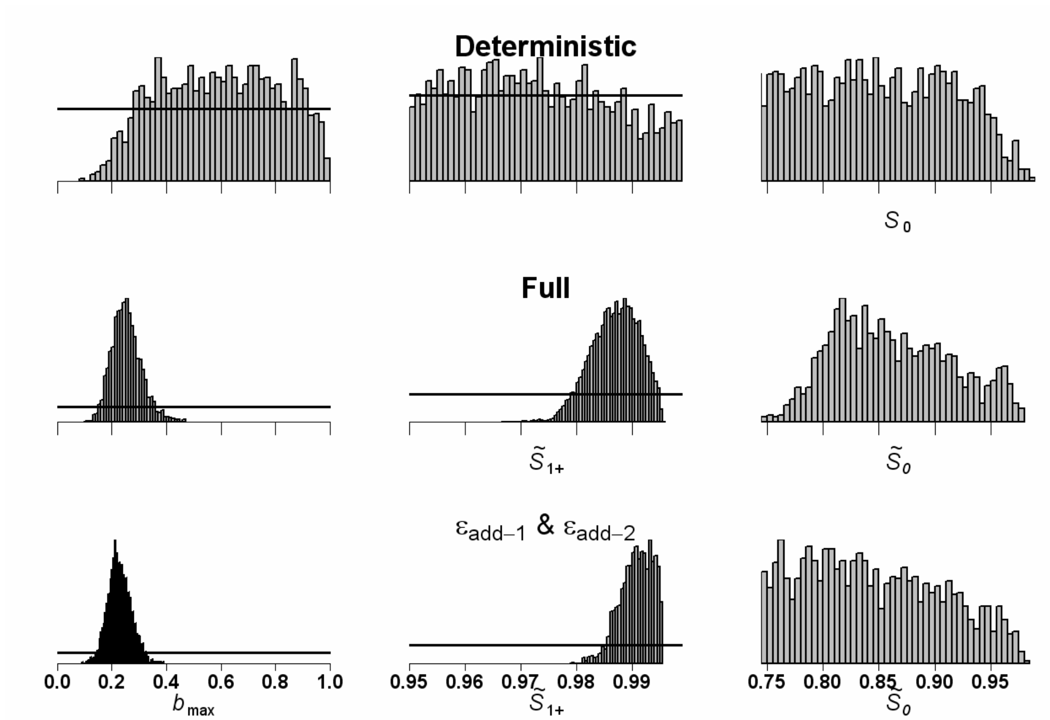

Figure 3.7: Histograms comparing marginal posterior densities (bars). Estimates of the maximum birth rate (in the limit of vanishing population size) (left column), survival rate of non-calves S_{1+} (middle column), and calf survival S_0 (right column) are shown. The upper row shows the samples from the posterior for the deterministic model, the middle rows shows samples from the posteriors for the Full model and the bottom row shows those for the Full model when $\varepsilon_{add\text{-}1}$ and $\varepsilon_{add\text{-}2}$ are estimated individually. The survival rates for the Full model (including those for the $\varepsilon_{add\text{-}1}$ and $\varepsilon_{add\text{-}2}$ scenario) are shown as the medians through time, in order to provide a better comparison with those estimates from the deterministic model. The uniform priors are shown as solid lines.

Chapter 4:

Testing the Gray Whale *SLA*: allowing environmental variability to influence population dynamics

ABSTRACT

The performance of the Gray Whale *SLA* was evaluated based on an operating model which was conditioned on available information, including survey estimates of 1+ abundance, calf counts, strandings data, and the extent of sea-ice in the early season feeding grounds in the Bering Sea. The scenarios considered in the analyses explore the impact of different sources of environmental variation, including scenarios in which future environmental forcing and episodic events are driven by the relationship between extent of sea-ice and reproductive success and survival. A variety of sources of uncertainty are considered, including parameter uncertainty, the uncertainty about the relationship between the extent of sea-ice and population dynamics, and observation error. The impact of these sources of uncertainty on the performance of the Gray Whale *SLA* appears small.

4.1 INTRODUCTION

The eastern North Pacific (ENP) stock of gray whales is currently subject to aboriginal hunting, with recommended strike limits based on the *Gray Whale Strike Limit Algorithm* (*SLA*) under the Aboriginal Subsistence Whaling Management Procedure (AWMP) of the IWC (IWC, 2003). *Implementation Reviews* are scheduled under the AWMP every five years, and that for the Gray Whale *SLA* is currently due. The goal of *Implementation Reviews* is to evaluate new information that has become available since the last *Implementation Review* (or the original *Implementation*) and to determine whether the current state of nature is not outside the realm of plausibility envisioned during the testing of the original *SLA*. If this is the case, additional simulation trials may be conducted to assess whether the performance of the adopted *SLA* remains reasonable, and if not, what changes to the *SLA* are needed.

New or updated sources of information pertaining to the population dynamics of ENP gray whales have become available in recent years and need to be considered during this *Implementation Review*, including: (1) new abundance estimates (Rugh *et al.*, 2008); (2) new estimates of calf production during 1994-2008 from the northbound migration at Point Piedras Blancas, California (Perryman *et al.*, 2002; Perryman, *unpublished data*), and; (3) the number of stranded animals on the coasts of California, Oregon and Washington states, for which a combined annual count is available for 1975-2006 (Brownell Jr. *et al.*, 2007). The latter potentially contains information on the magnitude of the mortality event during 1999/2000 (Gulland *et al.*, 2005). In addition to these data sets, it has been hypothesized that observed variability in the calf counts is a function of the amount of sea-ice covering the early season feeding grounds (Perryman *et al.*, 2002).

Therefore, in this chapter we test the performance of the *SLA* given scenarios for which future population dynamics are subject to environmental forcing and episodic events, using an operating model that integrates these sources of new information and the hypothesis of environmental forcing on the population dynamics (Chapter 3). A forecast of relevant sea-ice conditions based on global climate model output (Overland and Wang, 2007) is used to modify the future stochastic birth and survival rates when testing the *SLA*, given the estimated relationship between observed variations in recent sea-ice (Rayner *et al*., 2003) and calf and strandings data. This approach involves the incorporation of climate-model based forecasts into the operating model; the same basic approach is also is being used to test the performance of alternative management strategies in other fisheries (e.g., Gulf of Alaska walleye Pollock, *Theragra chalcogramma*; A'mar *et al.*, 2009).

Standard summary statistics are provided for the trials investigated here, and these are compared to recent results from the *Evaluation Trials* provided by Punt and Breiwick (2008) to the extent possible. The analyses presented here should help to ensure that the performance of the current *SLA* remains satisfactory (or else provide insight into potential weaknesses), given the new information that has become available since the previous phase of testing and adoption (IWC, 2005a).

4.2 METHODS

Operating model

The population dynamics model developed in Chapter 3 (corresponding to the'Full' scenario) was used as the operating model. This model is sex- and age-based, with an annual time-step. The dynamics includes stochastic birth and survival rates, and explicitly considers the transition between receptive and calving stages for mature females (Fig. 4.1). For consistency, the notation of Chapter 3 is adopted below.

Density dependence was assumed to act through the birth rate according to a Pella-Tomlinson function of 1+ depletion:

$$b_t = \max\left\{0,\ b_{\text{eq}} + (b_{\max} - b_{\text{eq}})\left[1 - \left(\frac{N_{1+,t}}{K_{1+}}\right)^z\right]\right\} \tag{4.1}$$

where:

$b_{\max}$ is the maximum birth rate (in the limit of zero population size);

K_{1+} is the carrying capacity of the 1+ component of the population (all animals aged 1 yr and older);

b_{eq} is the equilibrium birth rate at carrying capacity;

z is the degree of density-dependent compensation (assumed to equal 2.39, which implies maximum sustainable yield at a population size approximately 60% of K_{1+}), and;

$N_{1+,t}$ is the size of the 1+ component of the population (both sexes combined) in year *t*.

Selectivity was assumed to be knife-edged and uniform on ages 5+, and the population trajectories were initialized in 1930.

The operating model was conditioned on available data, including: (1) estimates of population size during 1967-2006 (starting year of survey) from the southbound migration at Granite Canyon, California (Rugh *et al.*, 2005, 2008); (2) estimates of calf production during 1994-2008[13] from the northbound migration at Point Piedras Blancas, California (Perryman *et al.*, 2002; Perryman, *unpublished data*), (3) the number of stranded animals on the coasts of California, Oregon and Washington states, for which a combined annual count is available for 1975-2006 (Brownell Jr. *et al.*, 2007)[14], and; (4) estimated sea-ice area covering the Bering Sea, averaged over March and April during 1953-2008, as calculated by the Hadley Center for their sea ice and sea surface temperature data set version 1 ('HadSST') (Rayner *et al.*, 2003) (Fig. 4.2, left panel).

Deviations from expected birth and survival rates were allowed to be a function of sea-ice variability in the Bering Sea. Thus, the model is an adaptation of the hypothesis that the amount of sea-ice in the Bering Sea early during the feeding season may be related to variability in calf production the following year (Perryman *et al.*, 2002).

[13] The two early estimates of calf production during 1980-1981 (Poole, 1984) were not used in these analyses.
[14] Data on strandings are collected in other locations (e.g. Mexico and Alaska), but the stranding network effort in California, Oregon and Washington has been more consistent through the years.

Future projections

The population was projected forward from the start of 2009. Values for the environmental index were based on an ensemble mean forecast of future sea-ice in the Bering Sea (March-April average) (Overland and Wang, 2007). The trials were based on a 92-year time horizon (*T*=92), because the time series of forecasted sea-ice was only available through 2098. Each simulated trajectory was based on a set of parameter values $\underline{\theta}_i$ (e.g., K_{1+}, $b_{\max}$ etc…) sampled from the joint Bayesian posterior distribution constructed using the MCMC algorithm described in Chapter 3. In a given year, the process error residuals about the expected birth and survival rates were:

$$\varepsilon_t = \left(I_t^{obs} / \beta \right) - \gamma_t \tag{4.2}$$

where:

I_t^{obs} is the forecasted value of the environmental index for year *t* (Fig. 4.2, left panel);

β is a scaling parameter that accounts for the influence of the environment on the process error residuals (sampled from the joint posterior);

γ_t is a generated normal random deviate reflecting error about the sea-ice – process error relationship, such that $\gamma_t \sim N(0; \sigma_I^2)$, and;

σ_I is the standard deviation of the residual error for the environmental index:

$$\sigma_I = |\beta| \sigma_I^* \tag{4.3}$$

This formulation takes a fixed input value for σ_I^* (assumed to be 0.30 for these analyses, corresponding with the 'Full' model described in Chapter 3) and scales the expected standard deviation of the fits to the environmental index by the absolute value sampled from the posterior distribution for β.

Stochastic birth and survival rates

The stochastic survival and birth rates were calculated given the generated process errors for each year. Birth rates were assumed to vary annually about the deterministic value given by Eqn. 4.1. Since this rate must lie between zero and one, its realization in any one year was calculated using a logistic transformation:

$$b_t^* = \left[1 + \exp(-(\Phi^{-1}\left(b_t\right)\sqrt{2.76 + \sigma_\varepsilon^2} + \varepsilon_t + \varepsilon_{\text{add-1},t}))\right]^{-1} \quad (4.4)$$

where:

Φ^{-1} is the inverse standard normal cumulative distribution function;

ε_t is the process error deviation for year t, and;

$\varepsilon_{add-1,t}$ allows for additional process error in the birth rate during years with extraordinary dynamics, such as 1999 and 2000 (in other years, this parameter was set equal to zero).

This formulation of stochastic birth rates ensured that the expected birth rate in a given year was equal to the deterministic value from Eqn. 4.1.

Survival rates were also allowed to vary annually with the same process error residuals as birth rates. It was assumed that these rates were independent of sex and perfectly correlated between ages in a given year, so that:

$$S_{a,t}^* = \left[1 + \exp(-(\Phi^{-1}\left(S_a\right)\sqrt{2.76 + \sigma_\varepsilon^2} + \varepsilon_t + \varepsilon_{add-2,t}))\right]^{-1} \quad (4.5)$$

where:

$S_{a,t}^*$ is the realized age-specific survival rate during year t;

S_a is the expected survival rate from age a to age a+1; and

$\varepsilon_{add-2,t}$ is a parameter which allows for additional process error in survival rates during years with extraordinary dynamics, such as 1999 and 2000 (in other years, this parameter was set equal to zero).

For these analyses, the additional process error in survival rates was assumed to be equal to that for birth rates (i.e., $\varepsilon_{add-1,t} = \varepsilon_{add-2,t} = \varepsilon_{add,t}$).

Data generation

Future abundance estimates were assumed to become available every 10 years. Observation error was assumed to be log-normal:

$$N_{1+,t}^{\text{obs}} = N_{1+,t}\, e^{\phi_t} \tag{4.6}$$

where:

$N_{1+,t}^{\text{obs}}$ is the survey estimate of 1+ abundance for year t;

$N_{1+,t}$ is the 'true' 1+ abundance at the start of year t;

ϕ_t is a normal random deviate ~N(0, σ^2); where $\sigma = \sqrt{\overline{CV}_{est}^2 + CV_{\text{add-1}}^2}$;

$CV_{\text{add-1}}$ is the extent of additional error about the abundance estimates (sampled from the joint posterior), and;

$\overline{CV}_{est}$ is the expected (sampling) standard deviation of the logarithm of $N_{1+,t}^{\text{obs}}$:

$$\overline{CV}_{est} = \sqrt{\frac{1}{Y}\sum_{y=1}^{Y} CV_{\text{y}}^2}, \tag{4.7}$$

where:

y indexes years for which there are survey data up to 2008, and;

Y is the total number of such years.

The estimates of abundance and $\overline{CV}_{est}$ (as opposed to σ) were passed to the *SLA*. No attempt was made to account for further estimation error in the abundance estimates (i.e., mean school size estimation error calculations were ignored).

Need

The annual need Q_t for year *t* was calculated according to the 'need envelope':

$$Q_t = Q_{2009} + \frac{t-2009}{91}\left(Q_{2098} - Q_{2009}\right) \tag{4.8}$$

where:

Q_{2009} (=150) is the present need, and;

Q_{2098} is the final need (in year 2098).

The level of need supplied to the *SLA* was the total (block) need for the 5-year period for which the strike limits were to be set. Two values were assumed for final need (in yr. 2098), corresponding with the 'base case' (Q_{2098}=340) and 'high need' (Q_{2098}=530) trial levels used in previous testing of the *SLA* (IWC, 2003).

Trials

The set of trials is listed in Table 4.1. In addition to the two levels of final need, six scenarios were explored with respect to the future probability (if any) of catastrophic (otherwise known as 'episodic') events and the nature of stochastic (or deterministic) population dynamics: (H0) Deterministic population dynamics with no future catastrophic events[15]; (H1) Environmental stochasticity (as a function of sea-ice) with no future catastrophic events; (H2) Environmental stochasticity (as a function of sea-ice) with probability of future catastrophic events conditioned on the stranding index (corresponding to the percentage of catastrophic years[16] during the time series of stranding counts); (H3) Environmental stochasticity (as a function

[15] The two deterministic trials are most comparable with the base-case operating models in IWC (2004).
[16] The 2 years (1999 and 2000) during the unusual mortality event were considered to be catastrophic.

of sea-ice) with the probability of future catastrophic events p^* conditioned on the percentage of times they occurred during the fitting process when 1+ depletion was greater than 0.40 (Eqn. 4.9; Fig. 4.2 right); (H4) As for H3, but the environmental stochasticity was independent of the sea-ice index, i.e. simply $\varepsilon_t \sim N\left(0, \sigma_\varepsilon^2\right)$, and; (H5) As per H4 but with no future catastrophes.

A depletion of 0.4 represents a level encompassing the full range of trajectories from the posterior (i.e., a small number of those trajectories were estimated to have never recovered to more than 50% of carrying capacity, when carrying capacity was estimated to have been around 50,000 individuals). The probability of future catastrophes p^* conditioned on the percentage of times they occurred during the fitting process when 1+ depletion was greater than 0.40 was then:

$$p^* = 2\left[\left(\sum_{t=1930}^{2008} I(N_{1+,t} / K > 0)\right)^{-1}\right] \tag{4.9}$$

where:

$I()$ is the indicator function.

Performance statistics

The performance statistics were calculated based on future block quotas returned from the standalone version of the 'GUP2' *SLA* (Punt and Breiwick, 2008). All performance statistics were computed in terms of the 1+ component of the population following the standard methods and notation of the AWMP (IWC, 2003). Specifically, four performance statistics were calculated:

1. (D1) Final depletion: $N_{1+,2098} / K_{1+}$;

2. (D8) Rescaled final population size: $N_{1+,2098} / N^*_{1+,2098}$;

where:

$N^*_{1+,2098}$ is the 1+ population size in the final year T, under a scenario of zero future catches.

3. (D10) Relative increase: $N_{1+,2098} / N_{1+,2009}$, and;

4. (N9) Average need satisfaction: $\frac{1}{T}\sum_{t=2009}^{2098}\frac{C_t}{Q_t}$.

where:

C_t is the catch during year *t*, which is determined by the *SLA* through the 5-year block quota system.

4.3 RESULTS

1601 simulations were run for each scenario, corresponding to the number of samples from the posterior provided by the analyses of Chapter 3. In general, the Gray Whale *SLA* was able to satisfy need and maintain a population size near carrying capacity for each of scenarios examined in these analyses. For example, all of the scenarios with base need had an average need satisfaction of 100% and the lowest median final 1+ depletion was 0.874 (Table 4.2). Not surprisingly, those scenarios with higher final need resulted in lower final depletion levels and lower average need satisfaction. However, the differences were not very large (e.g., the lowest median 1+ depletion for the high need scenarios was 0.817). Moreover, none of the scenarios resulted in a lower 5th percentile for the final 1+ depletion less than 0.60. The relative increase statistic (D10) was close to 1 for all scenarios, which indicates stability in the population dynamics. This is, however, not unexpected given the results of Chapter 3, which suggest that this population is close to carrying capacity at present.

The annual probability of future catastrophes for the two 'H2' scenarios was 0.0625, as determined by the number of years for which an episodic event was observed, divided by the total number of years in the strandings index

(2yrs/32yrs)(Brownell *et al.*, 2007). The distribution of probabilities of future catastrophes for the 'H3' and 'H4' scenarios is shown in Fig. 4.2 (right panel). The probability of future catastrophe ranged between 0.025 and 0.222 for those scenarios, with a median of 0.043, which was less than that when conditioned on the stranding index. However, the average difference between these two approaches was relatively small, as evidenced by the nearly identical results between these two assumptions (Table 4.2; Fig. 4.3).

The predicted area of sea-ice on the Bering Sea feeding grounds is forecasted to decrease dramatically, with less than 50% of the average observed area of sea-ice in March-April during future decades (Fig. 4.2, left panel) (Overland and Wang, 2007). The scenarios (H1, H2, and H3) with population dynamics that were a function of this environmental index resulted in the most optimistic outcomes (Table 4.2), with some final depletion levels which were slightly greater than 1.0. On the other hand, the two scenarios that modeled generic environmental stochasticity independent of sea-ice (H4 and H5), resulted in the most pessimistic final depletion levels of any of the scenarios investigated (Table 4.2). Likewise, the trend in process error residuals was very different between these two sets of scenarios. Those scenarios which modeled process error as a function of future sea-ice resulted in an increasing trend in process error deviations, while those scenarios which modeled environmental stochasticity as an independent process resulted in no such trend (Fig. 4.4). However, in terms of the median average need satisfaction, there was essentially no difference between any of the scenarios (Table 4.2).

The results of the "deterministic" trials (H0) were more optimistic than those of the corresponding trials on which the Gray Whale *SLA* was based (GE01 and GE14) (compare table 2 of Punt and Breiwick (2008) with the results for the two H0 trials in table 4.2 of this chapter). However, the differences in the values for the performance statistics are slight, and qualitatively the results of trial H0 and GE01 are identical. The differences in results are attributable to a variety of causes, including differences in the population dynamics models, in the data used to condition the operating model, and in the priors for the parameters of the model.

4.4 DISCUSSION

The analyses incorporated an index of sea-ice variability into an operating model which was used to test the Gray Whale *SLA*, given forecasts for future climate change and a hypothesis regarding the interaction between sea-ice and population dynamics. The trials presented here differ from the standard set designed by the Standing Working Group of the AWMP, in that they were explicitly conditioned on the most recently available data and a hypothesis regarding environmental forcing. For example, deviations in the survival rates during the 1999/2000 mortality event (and resulting population sizes at the start of the future trajectories) were conditioned on observed variability in the strandings data. A set of several alternative trials was also preformed, to compare the results of the environmental forcing scenario to those for which future population dynamics were assumed to be deterministic, or to be subject to random environmental stochasticity (i.e., ignoring sea-ice). For all of the scenarios considered here, the Gray Whale *SLA* was able to maintain stock size and satisfy need at very high levels. Therefore, there is no indication from these analyses that any revisions to the *SLA* are necessary at this time.

It is interesting to note that the assumption that the population dynamics were related to sea-ice led to more optimistic results. This was essentially the result of extrapolating (based on those years for which calf production and strandings data exist) a recent relationship between the environment and population dynamics into the future, under the assumption that such an effect (if it exists) would be constant with respect to time and population density (among other factors). While this is obviously an oversimplification, the framework used here could be modified during the next *Implementation Review* in order to take into account alternative hypotheses with respect to predicted changes in the effect of future environmental variability on population dynamics (e.g., by modifying σ_I^* as a function of depletion).

Table 4.1

The scenarios considered. The trials are denoted by an 'H' followed with the trial number and then 'BN' or 'HN' for base or high final need. Descriptions are given for each scenario in terms of the stochastic or deterministic nature of the population dynamics and the probability of future catastrophes. The extent of future stochasticity σ_ε is equal to 0.50 (for consistency with the 'Full' analyses of Chapter 3) for all except the deterministic scenario.

Trial	Description	σ_ε	Final need	Probability of future catastrophe	Future stochasticity
H0 : BN	Deterministic + no future catastrophes	NA	340	0	None (Deterministic)
H1 : BN	Environmental stochasticity + no future catastrophes	0.5	340	0	Environmental
H2 : BN	Environmental stochasticity + p(future catastrophe)= 0.0625	0.5	340	0.0625	Environmental
H3 : BN	Environmental stochasticity + p(future catastrophe)= *p**	0.5	340	*p** (Eqn. 4.9)	Environmental
H4 : BN	Stochasticity (no sea-ice) + p(future catastrophe)=*p**	0.5	340	*p** (Eqn. 4.9)	Environmental (no sea-ice)
H5 : BN	Stochasticity (no sea-ice) + no future catastrophes	0.5	340	0	Environmental (no sea-ice)
H0 : HN	Deterministic + no future catastrophes	NA	530	0	None (Deterministic)
H1 : HN	Environmental stochasticity + no future catastrophes	0.5	530	0	Environmental
H2 : HN	Environmental stochasticity + p(future catastrophe)= 0.0625	0.5	530	0.0625	Environmental
H3 : HN	Environmental stochasticity + p(future catastrophe)= *p**	0.5	530	*p** (Eqn. 4.9)	Environmental
H4 : HN	Stochasticity (no sea-ice) + p(future catastrophe)= *p**	0.5	530	*p** (Eqn. 4.9)	Environmental (no sea-ice)
H5 : HN	Stochasticity (no sea-ice) + no future catastrophes	0.5	530	0	Environmental (no sea-ice)

Table 4.2

The medians, and upper and lower 5th percentiles of the performance statistics for each scenario. See text for the definitions for each of the performance statistics

Trial	Description	D1: Final 1+ Depletion		
		5%	Median	95%
H0 : BN	Deterministic + no future catastrophes	0.908	0.933	0.950
H1 : BN	Environmental stochasticity + no future catastrophes	0.940	0.981	1.030
H2 : BN	Environmental stochasticity + p(future catastrophe)= 0.0625	0.914	0.974	1.026
H3 : BN	Environmental stochasticity + p(future catastrophe) = *p**	0.922	0.976	1.027
H4 : BN	Stochasticity (no sea-ice) + P(future catastrophe) = *p**	0.745	0.874	0.953
H5 : BN	Stochasticity (no sea-ice) + no future catastrophes	0.802	0.897	0.960
H0 : HN	Deterministic + no future catastrophes	0.855	0.899	0.927
H1 : HN	Environmental stochasticity + no future catastrophes	0.913	0.963	1.017
H2 : HN	Environmental stochasticity + p(future catastrophe)= 0.0625	0.880	0.954	1.011
H3 : HN	Environmental stochasticity + p(future catastrophe) = *p**	0.894	0.957	1.013
H4 : HN	Stochasticity (no sea-ice) + p(future catastrophe) = *p**	0.657	0.817	0.917
H5 : HN	Stochasticity (no sea-ice) + no future catastrophes	0.722	0.847	0.927

Table 4.2 continued

Trial	Description	D8: Rescaled 1+ Depletion 5%	5%	5%
H0 : BN	Deterministic + no future catastrophes	0.875	0.875	0.875
H1 : BN	Environmental stochasticity + no future catastrophes	0.910	0.910	0.910
H2 : BN	Environmental stochasticity + p(future catastrophe)= 0.0625	0.886	0.886	0.886
H3 : BN	Environmental stochasticity + p(future catastrophe) = *p**	0.896	0.896	0.896
H4 : BN	Stochasticity (no sea-ice) + P(future catastrophe) = *p**	0.731	0.731	0.731
H5 : BN	Stochasticity (no sea-ice) + no future catastrophes	0.775	0.775	0.775
H0 : HN	Deterministic + no future catastrophes	0.833	0.833	0.833
H1 : HN	Environmental stochasticity + no future catastrophes	0.889	0.889	0.889
H2 : HN	Environmental stochasticity + p(future catastrophe)= 0.0625	0.858	0.858	0.858
H3 : HN	Environmental stochasticity + p(future catastrophe) = *p**	0.868	0.868	0.868
H4 : HN	Stochasticity (no sea-ice) + p(future catastrophe) = *p**	0.649	0.649	0.649
H5 : HN	Stochasticity (no sea-ice) + no future catastrophes	0.707	0.707	0.707

Table 4.2 continued

Trial	Description	D10: 1+ Relative Increase 5%	5%	5%
H0 : BN	Deterministic + no future catastrophes	0.947	0.947	0.947
H1 : BN	Environmental stochasticity + no future catastrophes	0.973	0.973	0.973
H2 : BN	Environmental stochasticity + p(future catastrophe)= 0.0625	0.954	0.954	0.954
H3 : BN	Environmental stochasticity + p(future catastrophe) = p*	0.960	0.960	0.960
H4 : BN	Stochasticity (no sea-ice) + P(future catastrophe) = p*	0.807	0.807	0.807
H5 : BN	Stochasticity (no sea-ice) + no future catastrophes	0.846	0.846	0.846
H0 : HN	Deterministic + no future catastrophes	0.913	0.913	0.913
H1 : HN	Environmental stochasticity + no future catastrophes	0.951	0.951	0.951
H2 : HN	Environmental stochasticity + p(future catastrophe)= 0.0625	0.927	0.927	0.927
H3 : HN	Environmental stochasticity + p(future catastrophe) = p*	0.932	0.932	0.932
H4 : HN	Stochasticity (no sea-ice) + p(future catastrophe) = p*	0.725	0.725	0.725
H5 : HN	Stochasticity (no sea-ice) + no future catastrophes	0.776	0.776	0.776

Table 4.2 continued

Trial	Description	N9: Avg. Need Satisfaction 5%	5%	5%
H0 : BN	Deterministic + no future catastrophes	1.000	1.000	1.000
H1 : BN	Environmental stochasticity + no future catastrophes	1.000	1.000	1.000
H2 : BN	Environmental stochasticity + p(future catastrophe)= 0.0625	1.000	1.000	1.000
H3 : BN	Environmental stochasticity + p(future catastrophe) = *p**	1.000	1.000	1.000
H4 : BN	Stochasticity (no sea-ice) + P(future catastrophe) = *p**	1.000	1.000	1.000
H5 : BN	Stochasticity (no sea-ice) + no future catastrophes	1.000	1.000	1.000
H0 : HN	Deterministic + no future catastrophes	0.971	0.971	0.971
H1 : HN	Environmental stochasticity + no future catastrophes	0.974	0.974	0.974
H2 : HN	Environmental stochasticity + p(future catastrophe)= 0.0625	0.973	0.973	0.973
H3 : HN	Environmental stochasticity + p(future catastrophe) = *p**	0.973	0.973	0.973
H4 : HN	Stochasticity (no sea-ice) + p(future catastrophe) = *p**	0.959	0.959	0.959
H5 : HN	Stochasticity (no sea-ice) + no future catastrophes	0.964	0.964	0.964

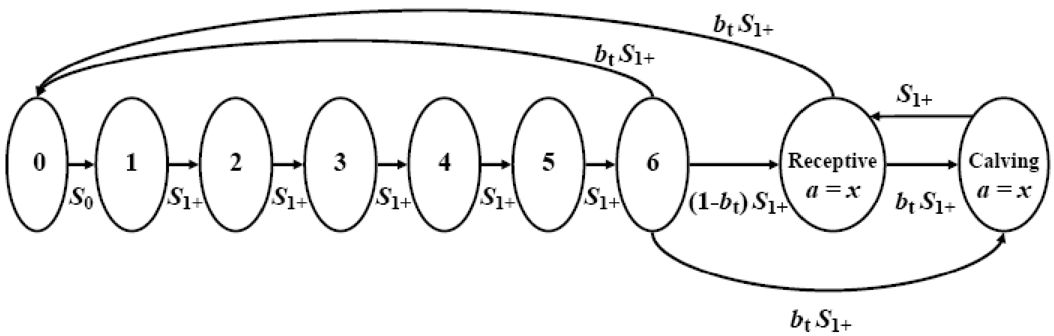

Figure 4.1: Life cycle graph of the model used to track the number of females in each reproductive stage though time. This life cycle refers to the underlying deterministic model, with transition probabilities shown as functions of life history parameters. However, it should be noted that the survival and birth rates were modified to be stochastic in the all analyses except for 'H0'. The arrow from immature to calf arises because some juveniles may mature and give birth (i.e. become pregnant at first estrous) during the projection interval from time t to t+1.

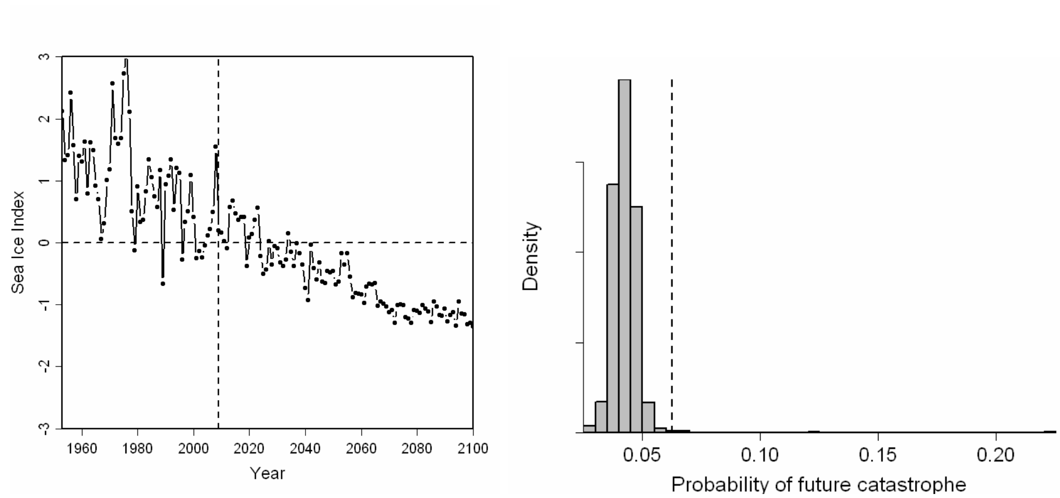

Figure 4.2: (Left panel) The standardized index for the March-April average sea-ice area covering the Bering Sea. The vertical dashed line denotes 2009 and the start of that portion of the time series which is based on the ensemble global climate model mean predictions provided by Overland and Wang (2007). Prior to 2009, the time series is based on the HadSST observations of sea-ice (Rayner *et al.*, 2003). The horizontal dashed line at zero is shown for reference; positive values indicate years with greater than average sea-ice over the entire time period and vice-versa. (Right panel) The distribution for the probability of future catastrophe. This distribution is conditioned on the number of years for which the depletion of each trajectory is greater 0.40 during 1930-2008, divided by 2 (the number of years with observed catastrophes, corresponding to 1999 and 2000). The dashed vertical line denotes the probability as calculated from the strandings index (Brownell *et al.*, 2007)

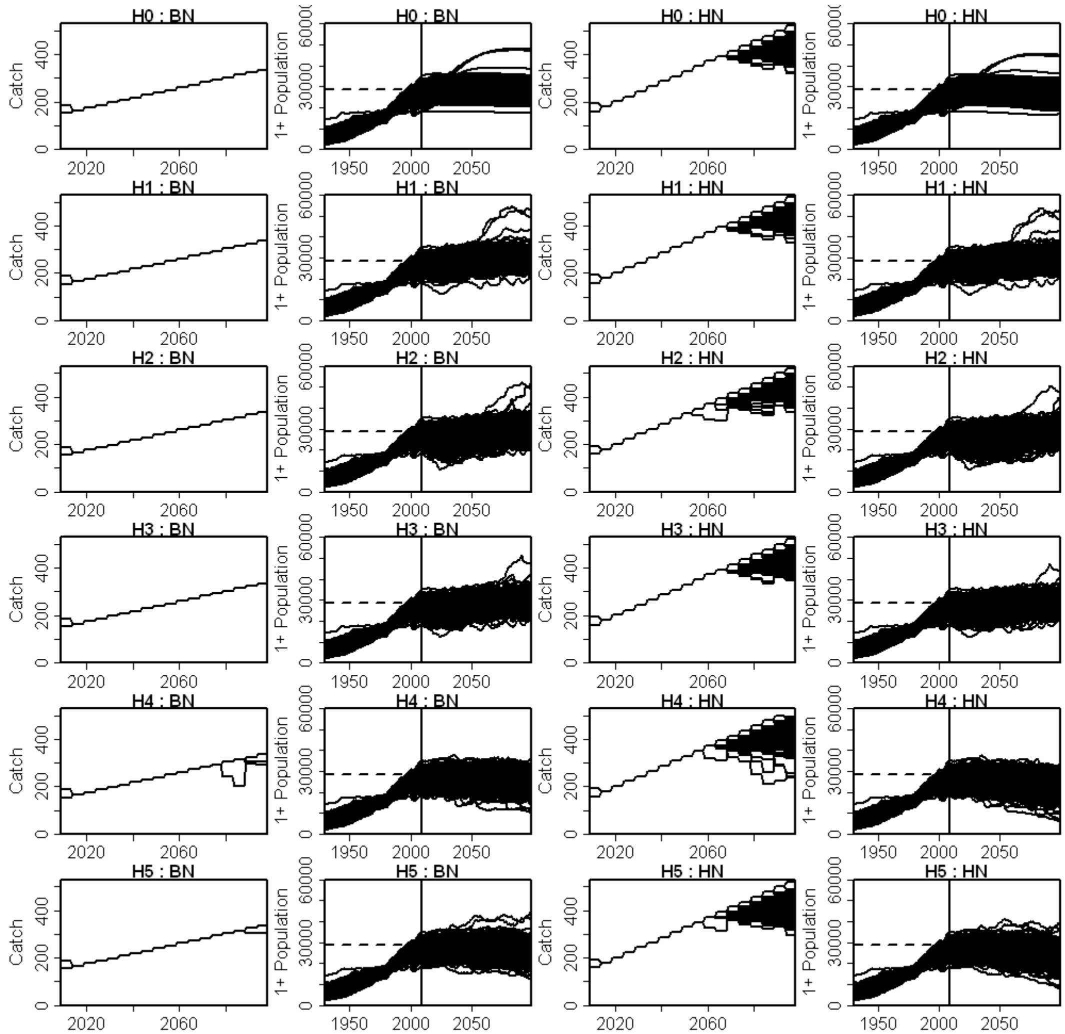

Figure 4.3: Time-trajectories of future catches (first and third columns) and population trajectories from 1930-2098 (second and fourth columns) for the twelve scenarios (Table 4.1). The left and right two columns are respectively for a final need levels of 340 and 530 whales per year. The results for each simulation are plotted as an individual line (e.g., a single visible line for catches represents a series of years where future catches were identical across scenarios).

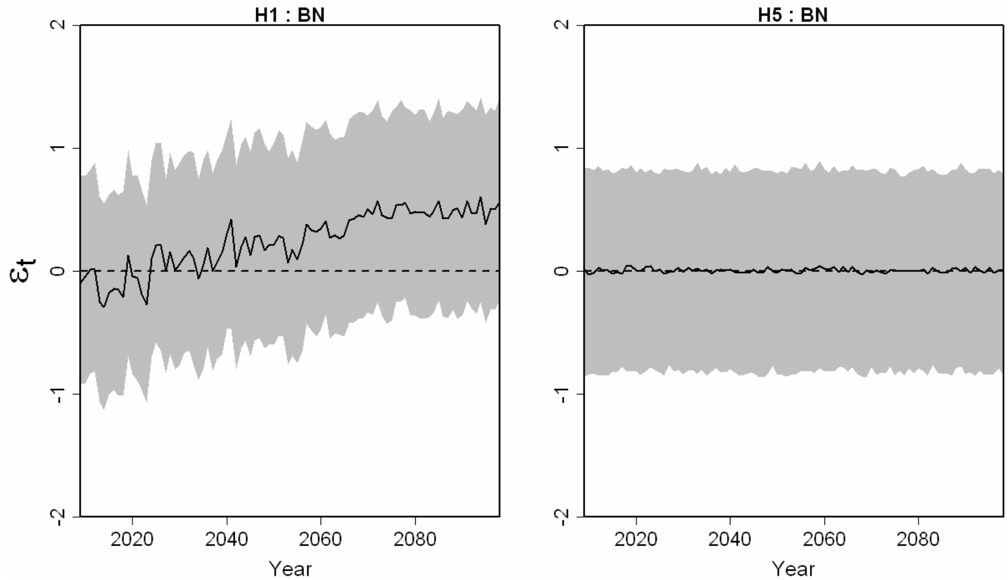

Figure 4.4: The time-trajectories of future process error residuals ε_t for a case where these residuals are a function of future sea-ice (H1:BN; left panel) and where they are independent of the sea-ice index (H5: BN; right panel). The annual median is plotted as the solid line, the 5th and 95th percentiles are shaded in gray and the horizontal dashed line at zero is shown for reference.

CONCLUSIONS

The preceding chapters quantify several key aspects of uncertainty in the context of marine mammal stock assessments. A Bayesian estimation framework was used for each example, which allowed the various dimensions of uncertainty to be integrated in the analyses and provided a logical foundation for calculating the probability that management strategies can achieve their desired objectives. Several case studies were examined, and it was found that existing management strategies are likely to be quite robust to the uncertainties considered when relatively a long time series of abundance estimates is available (i.e., BCB bowheads and ENP gray whales). On the other hand, the results of risk assessments were sensitive to how uncertainty was treated when constructing a coherent joint prior distribution that respects biological realism if abundance data are scarce (EG walrus).

A population dynamics model represents a working hypothesis with respect to the mechanisms that lead to changes in abundance. In common with all hypotheses, these models are based on underlying assumptions about the processes that drive the dynamics of the population. Therefore, model uncertainty can be thought of as uncertainty in which processes are most important in determining the population dynamics. Model selection methods are analogous to hypothesis testing; certain models may be rejected if they are not consistent with observations. However, given the relatively low growth rates of marine mammal populations and the inherent difficulties in estimating abundance for most populations of marine mammals, it is likely that a range of plausible models and assumptions will be consistent with the observed data. That is, available data may not provide much power to reject alternative hypotheses about the population dynamics. In Chapter 1, the assessment of the BCB stock of bowhead whales represented a situation for which alternative models were able to fit the data nearly equally well, but resulted in quite different estimates of stock status and sustainable catch levels. Each model represented a variation on an underlying set of assumptions with respect to the historical catch record, carrying capacity and density dependence. Given available data, there was no evidence for rejecting the different assumptions underlying each model. Therefore, Bayesian model averaging was used to take this uncertainty into account, while also integrating parameter uncertainty and providing a weighted average of the model results based on their respective abilities to fit the data.

By using Bayesian model averaging, the assessment results presented in this case were able to incorporate uncertainty regarding assumptions such as the historical catch history is known without error and that the carrying capacity of the environment has remained unchanged since the middle of the 19^{th} century for BCB bowheads. While taking into account the uncertainty in these assumptions is likely an improvement over previous approaches for this assessment which ignored such uncertainty, care must be given when considering the set of alternative models which are considered. If the candidate models are not biologically plausible or otherwise inappropriate, then the resulting estimates of management quantities may also be misleading, even if model uncertainty is taken into account. Munch *et al*. (2005) address this concern and provide a promising development in the treatment of model uncertainty based on Bayesian nonparametric modeling and using fishery stock-recruitment models as an example. This approach is similar to Bayesian model averaging in that alternative models are weighted by their ability to fit available data, but provides a framework which integrates model uncertainty over a continuous range of models spanning the biologically plausible stock-recruitment model space. This approach could potentially be incorporated into stock assessment frameworks to take into account model uncertainty (e.g., uncertainty in the assumed form of density dependence) while also accounting for parameter and observation uncertainty. Further, as fisheries management continues to move towards an ecosystem approach based on inherently complex models, the need to account for model uncertainty is likely to become increasingly important (Hill *et al.*, 2007).

Bayesian methods have become progressively more popular in fishery science because they provide a natural framework for integrating and quantifying multiple sources of uncertainty. As discussed above, model uncertainty is one potentially important level in this hierarchy. Another fundamental level of uncertainty is expressed by the joint prior distribution for model parameters, which represents the uncertainty in those quantities prior to observing available data. Chapter 2 explored a subtle, but potentially important, aspect of constructing a coherent joint prior distribution, given an imposed constraint which ensured biological realism for the functionally related parameters in age-structured population dynamics models. It is evident from the results of this research that uncertainties resulting from alternative approaches for constructing the joint prior are unlikely to affect the results of assessments when informative time series of abundance estimates are available. In contrast, the results of a risk assessment for a data-poor stock were shown to be sensitive to the alternative approaches for creating the joint prior distribution. Unfortunately, there are no objective criteria on which to base a recommendation for adopting one approach to constructing a coherent joint prior over another. However, the results of Chapter 2 serve as a reminder that, when information on the trend in abundance is lacking (as is the case for many stocks of marine mammals), age-structured models are not necessarily the best approach for providing management advice. Instead, alternative methods should be considered for calculating sustainable limits of human-caused mortality. For example, the 'Potential Biological Removal' (PBR) rule adopted by the U.S. National Marine Fisheries Service (Wade, 1998) may be a better candidate than data-intensive age-structured models for determining precautionary catch limits for EG walrus. Indeed, the lack of sufficient data to inform more complex models for many stocks of marine mammals was exactly the motivation that led to the development of the

PBR as a simple, yet robust, method for assessing the appropriateness of removal levels (Taylor *et al.*, 2000).

Constructing coherent joint prior distributions which respect biological realism is a challenge that is not unique to marine mammal stock assessments. For example, Punt and Hilborn (1997) provide an example of how an incoherent distribution results from placing priors on both unexploited biomass and depletion (the ratio of current to unexploited biomass) in a biomass dynamics model for the western stock of New Zealand hoki (*Macruronus novaezelandiae*). Indeed, specifying contradictory priors is a potential pitfall during the development of any Bayesian analysis. While care must be taken in constructing a coherent joint prior, the real challenge is more likely to involve the necessary imposition of constraints on parameter space to ensure biologically realistic parameter values. This is a challenge which extends beyond marine mammal stock assessments and even the broader realm of fisheries models. It is a consideration for any application in the general arena of natural resource modeling whenever biological constraints on parameter values form part of the prior knowledge about the system in question.

Although walrus and many other marine mammals are extremely difficult to survey because they are distributed widely over large areas in relatively inaccessible habitats, some populations have been successfully monitored for long time periods e.g. the ENP gray whale. In Chapter 3, a modeling framework was developed for this stock, which allowed for the incorporation of a hypothesized relationship between sea-ice and population dynamics while also taking into account the mortality event in 1999 and 2000. This research represented the first time that the extent of this mortality event was quantified and integrated into a stock assessment. In this case, given the uncertainty in the magnitude of the mortality event and the availability of relevant data on fluctuations in birth and death rates (i.e., calf production and strandings data), the stochastic modeling framework developed in Chapter 3 is an appropriate and necessary approach for providing estimates of stock status, because failure to take the mortality event into account is likely to lead to overly optimistic estimates of stock status. Therefore, the framework developed in Chapter 3 should be considered in addition to standard deterministic models during future assessments of this population.

The role of environmental variability on population dynamics is an area of special concern for management of marine mammals which are found in the Arctic, because forecasted climate change and anticipated changes in sea-ice are expected to be dramatic in this region. In Chapter 4, the modeling framework developed in Chapter 3 was used as an operating model in order to test the Gray Whale *SLA* of the IWC, given future predictions of annual sea-ice area on the Bering Sea feeding grounds. The estimated relationship between sea-ice and calf production was used to extrapolate future population dynamics based on the forecasted decrease in sea-ice. Future catches were determined by the *SLA* under different levels of future aboriginal subsistence need and account was taken of observation error in future estimates of abundance as generated using the operating model. While the *SLA* performed very well under the scenarios considered in these analyses, there is still much uncertainty about how changes in sea-ice (or other environmental conditions) will affect future population dynamics. At present, the level of information about the affects of environmental variability on population dynamics is largely correlative in nature. That is, the underlying mechanisms responsible for fluctuations in birth and survival rates are not well understood. Although a plausible explanation has been hypothesized (i.e., that sea-ice may act as a physical barrier to prime feeding habitat), it is not straightforward to predict how other likely changes in the environment resulting from reductions in sea-ice will interact with the mechanisms that are currently in force. Therefore, while the results of Chapter 4 indicate that the Gray Whale *SLA* is robust to predicted changes in arctic sea-ice, this conclusion must be tempered by uncertainty in the underlying assumption that current ecological processes will remain unchanged in the future, especially when so many other fundamental changes in ecosystems are expected as a result of climate change.

As continuing research provides more insight into the mechanisms underlying the impacts of environmental variability on population dynamics of ENP gray whales, the modeling framework developed here will provide a good basis for integrating such information into assessments and management strategy evaluations. One of the appealing attributes of this framework for incorporating environmental data is its flexibility. For example, it is simple to substitute alternative environmental data during the model fitting process. Likewise, this framework can be applied to other stocks for which environmental fluctuations are hypothesized to be an important determinant of variability in population dynamics or behavior, and could prove to be useful in modeling changes in the availability of animals with respect to surveys or fishery catches. Additionally, it would be relatively straightforward to take into account hypothesized changes in the interaction between environmental variability and population dynamics in future projections (e.g., a loss of sea-ice might be beneficial for the ENP gray whales until the point at which the loss of sea-ice might result in negative effects owing to other impacts on the ecosystem).

Such considerations bring the research presented here full-circle. That is, the underlying uncertainty in the assumption that a certain index of environmental conditions is related to population dynamics and that if such a relationship exists, that current processes will remain unchanged in the future, are really manifestations of model uncertainty. Further, instead of assuming that current relationships will persist independently of other ecological changes, it may be preferable to enforce constraints on the degree to which future environmental conditions may affect population dynamics to respect biological realism. Explicitly accounting for this last point is beyond the scope of this dissertation, but does illustrate how the various issues dealt with in this research are potentially inter-related in the broader context of providing management advice in the face of scientific uncertainty.

In summary, this dissertation explores several notable categories of uncertainty in marine mammal stock assessments. This research serves to improve the current understanding of population dynamics by incorporating and quantifying these various sources of uncertainty, and hence it also aims to ensure that resulting management advice is robust to these issues. In addition, the methods developed for incorporating environmental variability as well as the issues of model uncertainty and constructing coherent joint prior distributions which respect biological realism, are matters likely relevant to a large range of ecological modeling efforts. Therefore, the methods applied here are broadly applicable, and also serve as a basis for providing the best available management advice for marine mammals as well as other exploited natural resources.

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Appendix A:
DERIVATION OF EQNS. 3.2 AND 3.3

In a given year, the realized stochastic birth rate can be written as a logistic function of a parameter related to the expected birth rate μ_t and process error ε_t that year:

$$b_t^* = \left[1+\exp(-(\mu_t+\varepsilon_t))\right]^{-1} \qquad \text{where:} \qquad \varepsilon_t \sim N(0,\sigma_\varepsilon^2) \qquad \text{A.1}$$

Further, let $\mu_t^* = \mu_t + \varepsilon_t$ where $\mu_t^* \sim N(\mu_t, \sigma_\varepsilon^2)$. Now, given a random variable generated from some underlying distribution $X \sim f(x)$ and a function of this random variable $Z = h(X)$, the expectation of the function can be written:

$$E[Z] = \int_{-\infty}^{\infty} h(x) f(x) dx \qquad \text{A.2}$$

It is necessary to define the expectation of the stochastic birth rates as equal to the deterministic value from the Pella-Tomlinson model (Eqn. 3.1), i.e. $E[b_t^*] = b_t$ to model density dependence acting solely through the stochastic birth rate. Proceeding from the form of the expectation above, while noting that $b_t^* = h(\mu_t^*) = \left[1+\exp(-\mu_t^*)\right]^{-1}$ and likewise, given its additive nature, that $\mu_t^* \sim N(\mu_t, \sigma_\varepsilon^2)$, substitute for *h(x)* and *f(x)* in equation A.2 and write the analytical expectation of the stochastic birth rates (Punt, 2008):

$$E[b_t^*] = \int_{-\infty}^{\infty} \left[1+\exp(-\mu_t^*)\right]^{-1} \left[\frac{1}{\sigma_\varepsilon\sqrt{2\pi}} \exp\left(\frac{-\left(\mu_t^* - \mu_t\right)^2}{2\sigma_\varepsilon^2}\right)\right] d\mu_t^* \qquad \text{A.3}$$

It was found through numerical methods that, the integral on the right side is well approximated by:

$$\approx \Phi\left(\frac{\mu_t}{\sqrt{2.76+\sigma_\varepsilon^2}}\right) \qquad \text{A.4}$$

where:

Φ is the standard normal cumulative distribution function; and
2.76 is a value found through numerical minimization, which approximates this expectation.

Setting the expectation of the stochastic birth rates equal to the deterministic density dependent rate:

$$\Phi\left(\frac{\mu_t}{\sqrt{2.76+\sigma_\varepsilon^2}}\right)=b_t \qquad \text{A.5}$$

And finally, rearranging to solve this equation for μ_t and substituting back into equation A.1 yields Eqns. 3.2 and 3.3. Of course, for those years with added process error, the stochastic expectation will not necessarily be equal to the deterministic value.

VITA

John was born in Sacramento, California in 1976. He was raised in Davis with his younger brother, Patrick. His parents, John and Dorothy, introduced him to science through their respective involvements in the entomology and botany departments at UC Davis. He graduated from Davis High School in 1994. In 1998 he received his B.S. in Biology from UC San Diego, where he also captained the men's soccer team and spent the off-season in the ocean, surfing. He was hired during his senior year by Dr. Tim Gerrodette at the SWFSC of the NMFS, to assist in research of dolphin populations and the eastern tropical Pacific tuna fishery. During his 3 years as an employee of the SWFSC he became increasingly interested in the application of quantitative methods in conservation biology, and was also introduced to marine mammal surveys through field work in the eastern tropical Pacific and various locations along the west coast of the U.S. After traveling around the world by himself for a year, to surf and fly-fish in the southern hemisphere, he moved to Seattle for graduate school to study quantitative fisheries methods. Before enrolling at the UW, he worked as a marine mammal observer on aerial and ship-based surveys in the Arctic, and in the Aleutian Islands. Since that time, he has also been a marine mammal observer on surveys in the western Atlantic and the Yangtze River in China. Much of his dissertation research has been conducted for the International Whaling Commission, where John has been an Invited Participant during recent Scientific Committee meetings. He received his Ph.D. from the University of Washington, School of Aquatic and Fishery Sciences in 2009.

Testing the *Gray Whale* Strike Limit Algorithm (*SLA*): allowing environmental variability to influence population dynamics

JOHN R. BRANDON AND ANDRÉ E. PUNT

School of Aquatic and Fisheries Sciences, Box 35020, University of Washington, Seattle, WA 98195-5020, USA

Contact e-mail: jbrandon@u.washington.edu

ABSTRACT

The performance of the *Gray Whale SLA* is evaluated based on an operating model conditioned on available information for the eastern North Pacific stock of gray whales including: survey estimates of 1+ abundance; calf counts; strandings data; and the extent of sea-ice in the feeding grounds in the Bering Sea in the early season. Multiple scenarios are considered in the analyses to explore the impact of different sources of environmental variation, including scenarios in which future environmental forcing and episodic events are driven by the relationships between reproductive success and survival to sea ice. A variety of sources of uncertainty are considered, including parameter uncertainty, the uncertainty about the relationship between the extent of sea-ice and population dynamics, and observation error. The impact of these sources of uncertainty on the performance of the *Gray Whale SLA* is small. For all scenarios considered in the simulations, application of the *SLA* results in the stock being at or near carrying capacity at the end of a 92 year projection period for which sea-ice cover forecasts are available, while still satisfying the needs of aboriginal whalers.

KEYWORDS: BIRTH RATE; CLIMATE CHANGE; ICE; MANAGEMENT PROCEDURE; MODELLING; MORTALITY RATE; WHALING–ABORIGINAL; GRAY WHALE

INTRODUCTION

The IWC has established a procedure (an '*Implementation*') to provide scientific advice on catch limits for different whale stocks (e.g. IWC, 2012). The eastern North Pacific (ENP) population of gray whales is currently subject to aboriginal hunting, with recommended strike limits based on the *Gray Whale Strike Limit Algorithm* (*Gray Whale SLA*) under the Aboriginal Subsistence Whaling Management Procedure (AWMP) of the IWC (IWC, 2003). *Implementation Reviews* are scheduled under the AWMP every five years. The goal of *Implementation Reviews* is to evaluate new information that has become available since the last *Implementation Review* (or the original *Implementation*), *inter alia* to determine whether the current state of nature is outside the realm of plausibility envisioned during the simulation testing of the original *SLA*. If this is the case, additional simulation trials may be conducted to assess whether the anticipated performance of the *SLA* adopted remains reasonable, and if not, what changes to the *SLA* are needed.

New or updated sources of information pertaining to the population dynamics of ENP gray whales have become available in recent years, including: (1) new abundance estimates (Rugh *et. al.,* 2008); (2) new estimates of calf production during 1994–2008 from the northbound migration at Point Piedras Blancas, California (Perryman *et al.*, 2002; Perryman, unpublished data); and (3) the number of stranded animals on the coasts of California, Oregon and Washington states, for which a combined annual count is available for 1975–2006 (Brownell *et al.*, 2007). The last data source potentially contains information on the magnitude of the mortality event during 1999/2000 (Gulland *et al.*, 2005). In addition to these data sets, it has been hypothesised that observed variability in the calf counts is a function of the amount of sea-ice covering the feeding grounds in the Bering Sea in the early season (Perryman *et al.*, 2002).

Accordingly, in this paper the performance of the *Gray Whale SLA* is tested given scenarios when future population dynamics are subject to environmental forcing and episodic events, using an operating model that integrates these sources of new information and the hypothesis of environmental forcing on the population dynamics (Brandon and Punt, 2009). A forecast of relevant sea-ice conditions based on global climate model output (Overland and Wang, 2007) is used to modify the future stochastic birth and survival rates generated when testing the *SLA*, given the estimated relationships of calf production and strandings data to observed variations in recent sea-ice. This technique involves the incorporation of climate-model-based forecasts into the operating model. The same basic framework is also being used to test the performance of alternative management approaches in other fisheries (e.g. Gulf of Alaska and Eastern Bering Sea walleye pollock, *Theragra chalcogramma*; A'mar *et al.*, 2009; Ianelli *et al.*, 2011).

Standard summary statistics are provided for the trials investigated here, and these are compared to results from the *Evaluation Trials* provided by Punt and Breiwick (2008) to the extent possible. The analyses presented here should help to ensure that the anticipated performance of the current *Gray Whale SLA* remains satisfactory (or else provide insight into potential weaknesses), given the new information that has become available since the phase of testing and adoption reported in IWC (2005a).

METHODS

Operating model

The population dynamics model developed by Brandon and Punt (2009) (corresponding to their 'Full' scenario) was used as the operating model. This model is sex- and age-based,

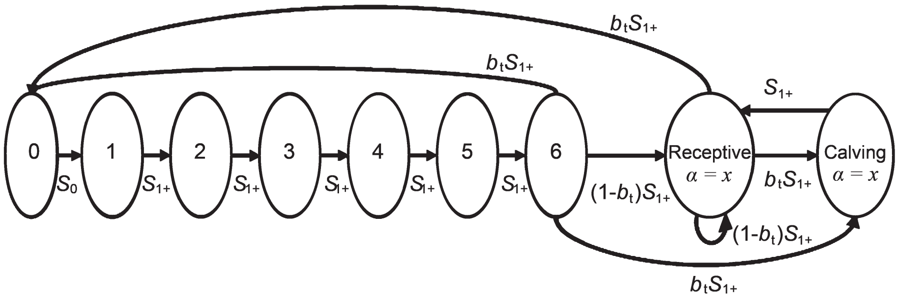

Fig. 1. Life cycle graph of the model used to track the number of females in each reproductive stage though time. This life cycle refers to the underlying deterministic model, with transition probabilities shown as functions of life history parameters. However, it should be noted that the birth and survival rates were modified to be stochastic in the all analyses except for 'H0'. The arrow from immature to calf arises because some immatures may mature and give birth (i.e. become pregnant at first estrous) during the projection interval from time *t* to *t*+1.

with an annual time-step. The dynamics include stochastic birth and survival rates, and explicitly consider the transition between receptive and calving stages for mature females (Fig. 1). For consistency, the notation of Brandon and Punt (2009) is adopted below.

Density dependence was assumed to act through the birth rate according to a Pella-Tomlinson function of 1+ depletion:

$$b_t = max\left\{0,\ b_{eq} + (b_{max} - b_{eq})\left[1 - \left(\frac{N_{1+,t}}{K_{1+}}\right)^{z}\right]\right\} N_{1+,t} \quad (1)$$

where b_{max} is the maximum birth rate (in the limit of zero population size); K_1 is the carrying capacity in terms of the 1+ component of the population (all animals aged 1 year and older)[1]; b_{eq} is the equilibrium birth rate at carrying capacity; z is the degree of density-dependent compensation (assumed to equal 2.39, which implies maximum sustainable yield at a population size approximately 60% of K_1, the conventional value for MSYL assumed for whale populations, e.g. IWC, 2005a); and $N_{1+,t}$ is the size of the 1+ component of the population (both sexes combined) at the start of year *t*.

Selectivity was assumed to be knife-edged and uniform for ages 5+, catches were assumed to be taken at the start of the year, before natural mortality, and the population trajectories were initialised in 1930, under the assumption of a stable-age-distribution given some level of hunting mortality in 1930 (as in Brandon and Punt, 2009). Process error after 1930 ensures that the age-structure by the time data are available is non-equilibrium.

Deviations from expected birth and survival rates were allowed to be functions of sea-ice variability in the Bering Sea. Thus, the operating model is an adaptation of the hypothesis that the variability in calf production the following year may be related to the amount of sea-ice in the Bering Sea early during the feeding season (Perryman *et al.*, 2002). Birth rates were assumed to vary annually about the deterministic value given by Equation (1). Since this rate must lie between zero and one, its realisation in any one year was calculated using a logistic transformation:

[1] Strictly, K_{1+} is only the carrying capacity in the deterministic case (no fluctuations in birth rate and no catastrophic events). It should be interpreted here as a parameter which relates to stochastic carrying capacity. The latter could be defined as the average long-term population size in the absence of catches.

$$b_t^* = \left[1 + \exp(-(\Phi^{-1}\left(b_t\right)\sqrt{2.76+\sigma_\varepsilon^2} + \varepsilon_t + \varepsilon_{add}))\right]^{-1} \quad (2)$$

Where Φ^{-1} is the inverse standard normal cumulative distribution function; ε_t is the process error deviation for year t, $\varepsilon_t \sim N(0;\sigma_\varepsilon^2)$, σ_ε is a measure of the extent of variability in process error and; allows for additional process error in the birth (and survival) rate during years with extraordinary dynamics, such as 1999 and 2000 (in other years before 2009, this parameter was set equal to zero; see below for how future catastrophic events are generated). This formulation of stochastic birth rates (e.g. the 2.76 factor) ensures that the expected birth rate in a given year equals the deterministic value from Equation (1) (see Appendix A of Brandon and Punt, 2009). The form of Equation (2) (and (3)) is such that 'positive' catastrophic events can lead to very high survival and birth rates (where the maximum birth rate is bounded by 0.99). However, it should be noted that Equation (2) only applies to receptive females and that a high birth rate in one year will result in a decrease in receptive females and hence a lower pregnancy rate the following year (Fig. 1).

Survival rates were also allowed to vary annually with the same process error deviations as birth rates to reflect the assumption that survival and birth rate covary. The effects of process error on survival and birth rate are assumed to be the same in the absence of data to distinguish these sources of process error. It was assumed that process error in survival rates were independent of sex and perfectly correlated between ages in a given year, so that:

$$S_{a,t}^* = \left[1 + \exp(-(\Phi^{-1}\left(S_a\right)\sqrt{2.76+\sigma_\varepsilon^2} + \varepsilon_t + \varepsilon_{add}))\right]^{-1} \quad (3)$$

where $S_{a,t}^*$ is the realised age-specific survival rate during year t; and S_a is the expected survival rate from age a to age a+1.

Conditioning

The operating model was conditioned on available data, including: (1) estimates of population size during 1967–2006 (covering the years of surveys) from the southbound migration at Granite Canyon, California (Rugh *et al.*, 2005; 2008); (2) estimates of calf production during 1994–2008[2] from the northbound migration at Point Piedras Blancas,

[2] The two early estimates of calf production during 1980–1981 (Poole, 1984) were not used in these analyses.

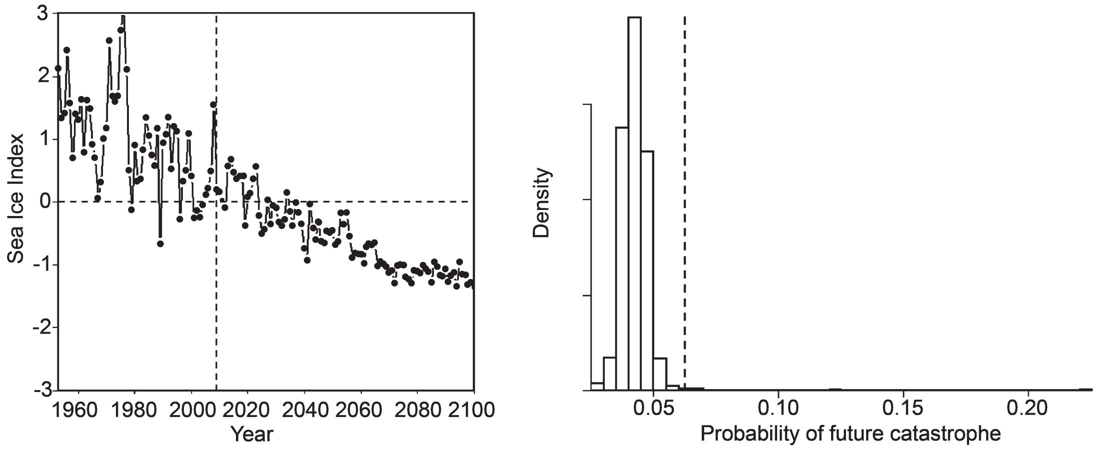

Fig. 2. Left panel: The standardised index for the March–April average sea-ice area covering the Bering Sea. The vertical dashed line denotes 2009 and the start of that portion of the time series which is based on the ensemble global climate model mean predictions provided by Overland and Wang (2007). Prior to 2009, the time series is based on the HadSST observations of sea-ice (Rayner *et al*., 2003). The horizontal dashed line at zero is shown for reference; positive values indicate years with greater than average sea-ice over the entire time period and *vice versa*. Right panel: The distribution for the probability of a future catastrophe in any one year. This distribution is conditioned on the number of years for which the depletion of each trajectory is greater 0.40 during 1930–2008, divided by 2 (the number of years with observed catastrophes, corresponding to 1999 and 2000) (Brandon and Punt, 2009). The dashed vertical line denotes the probability as calculated from the strandings index (Brownell, *et al*., 2007).

California (Perryman *et al*., 2002; Perryman, unpublished data); (3) the number of stranded animals on the coasts of California, Oregon and Washington states, for which a combined annual count is available for 1975–2006 (Brownell *et al*., 2007)[3]; and (4) estimated sea-ice area cover in the Bering Sea, averaged over March and April during 1953–2008, as calculated by the Hadley Center for their sea ice and sea surface temperature data set version 1 (‘HadSST’) (Rayner *et al*., 2003) (see Fig. 2, left panel). The conditioning process involves fitting the operating model to the data and estimating posterior distributions from the basis for probabilistic projections of future population dynamics.

The deviations of birth and survival rates about the deterministic relationship each year were allowed to be related to an environmental index I_t (the amount of sea-ice covering the Bering Sea) during the conditioning. It was assumed that I_t was measured subject to observation error (or there was some error in the relationship between the process error deviations and the environmental index). Consequently, I_t was a state variable, like the model prediction of population size. Hence, the measurements of the environmental index were treated as data and were consequently included as a component of the likelihood function when the model was fit. The expected environmental index in a given year was assumed to be related to process error residuals for that year, such that the observed index was normally distributed about its expectation:

$$I_t^{obs} = \beta \varepsilon_t + \gamma_t \tag{4}$$

where I_t^{obs} is the observed value of the environmental index in year t; β is a scaling parameter for the influence of the environment on the process error residuals; γ_t the difference between the observed and model-predicted amount of sea ice in year t, such that $\gamma_t \sim N(0;\sigma_I^2)$; and σ_I is the standard deviation of the residual error for the environmental index:

$$\sigma_I = |\beta| \sigma_I^* \tag{5}$$

This formulation takes a fixed input value for (assumed to be 0.30 for these analyses, corresponding to the ‘Full’ model of Brandon and Punt, 2009) and scales the expected standard deviation of the fits to the environmental index by the estimated absolute value for β.

Future projections

Once the operating model was conditioned on the available data, it was possible to project simulated population trajectories into the future. Each forward projection was initialised in 2009, based on the estimated status of the simulated population and the parameter values (e.g. K_{1+}, b_{max} etc…) for a given trajectory from the joint Bayesian posterior distribution. The posterior was constructed using the MCMC algorithm during the conditioning phase (Brandon and Punt, 2009).

Future values for the sea-ice index were based on an ensemble mean forecast of sea-ice in the Bering Sea (March–April average) (Overland and Wang, 2007). The trials were based on a 92-year time horizon (T = 92), because the time series of forecasted sea-ice was only available until 2098. In a given year, the process error deviations about the expected birth and survival rates were a function of forecasted sea-ice according to:

$$\varepsilon_t = \left(I_t^{obs} / \beta \right) - \gamma_t \tag{6}$$

where I_t^{obs} is the forecasted value of the sea-ice index for year t (Fig. 2, left panel); and $\gamma_t \sim N(0;\sigma_I^2)$

Future abundance estimates were assumed to become available every 10 years. Observation error was assumed to be log-normal:

$$N_{1+,t}^{\text{obs}} = N_{1+,t} \, e^{\phi_t} \tag{7}$$

[3] Data on strandings are collected in other locations (e.g. Mexico and Alaska), but the stranding network effort in California, Oregon and Washington has been more consistent over time.

where $I^{obs}_{1+,t}$ is the survey estimate of 1+ abundance for year t; $N_{1+,t}$ is the 'true' 1+ abundance at the start of year t; $\phi_t \sim N(0;\sigma^2)$; where $\sigma = \sqrt{\overline{CV}^2_{est} + CV^2_{addA}}$; CV_{addA} is the extent of additional error about the abundance estimates (sampled from the joint posterior), and; $\overline{CV}_{est}$ is the expected (sampling) standard deviation of the logarithm of $N^{obs}_{1+,t}$:

$$\overline{CV}_{est} = \sqrt{\tfrac{1}{Y}\sum_{y=1}^{Y} CV_y^2} \tag{8}$$

where y indexes years for which there are survey data up to 2008; CV_y is the sampling CV associated with the abundance estimate for year y; and Y is the total number of years with past surveys. The estimates of abundance and $\overline{CV}_{est}$ (as distinct from σ) were passed to the *SLA*. No attempt was made to account for further estimation error in the abundance estimates (i.e. mean school size estimation error calculations were ignored).

Need[4]

The annual need Q_t for year t was calculated according to the 'need envelope':

$$Q_t = Q_{2009} + \frac{t-2009}{91}\left(Q_{2098} - Q_{2009}\right) \tag{9}$$

where Q_{2009} (= 150) is the present need; and Q_{2098} is the final need (in year 2098). The level of need supplied to the *SLA* was the total (block) need for the 5-year period for which the strike limits were to be set. Two values were assumed for final need (in year 2098), corresponding to the 'base case' (Q_{2098} = 340) and 'high need' (Q_{2098} = 530) trial levels used in previous testing of the *SLA* (IWC, 2003).

Trials

The set of trials is listed in Table 1. In addition to the two levels of final need, six scenarios were explored with respect to p^*, the future probability (if any) of catastrophic (otherwise known as 'episodic') events, and the nature of stochastic (or deterministic) population dynamics.

(1) (H0) Deterministic population dynamics with no future catastrophic events[5];

(2) (H1) Environmental stochasticity (as a function of sea-ice) with no future catastrophic events;

(3) (H2) Environmental stochasticity (as a function of sea-ice), with probability of future catastrophic events conditioned on the stranding index (0.0625, the proportion of years for which an episodic event was observed, divided by the total number of years in the strandings index (2yr/32yr) (Brownell *et al.*, 2007));

(4) (H3) Environmental stochasticity (as a function of sea-ice) with the probability of future catastrophic events conditioned on the percentage of times they occurred during the fitting process when 1+ depletion was greater than 0.40 (Eqn. 9; Fig. 2 right);

(5) (H4) As for H3, but the environmental stochasticity was independent of the sea-ice index, i.e. simply $\varepsilon_t \sim N(0,\sigma^2_\varepsilon)$; and

(6) (H5) As for H4 but with no future catastrophes.

A depletion level of 0.40 during the conditioning phase was used for calculating the probability of future episodic events for scenarios H3 and H4 because the population almost always recovers to 40% of carrying capacity by when the catastrophes occur. The probability of future catastrophes p^* conditioned on the percentage of times they occurred during the fitting process when 1+ depletion was greater than 0.40 was then:

$$p^* = 2\left[\left(\sum_{t=1930}^{2008} I(N_{1+,t}/K > 0.4)\right)^{-1}\right] \tag{10}$$

where $I()$ is the indicator function. Hence, a future year was determined to be either normal ($\varepsilon_{add} = 0$) or catastrophic by drawing a random variate from a Bernoulli distribution with probability p^* for these scenarios if the 1+ depletion was greater than 0.40. Future catastrophic years were modelled through the inclusion of the estimated ε_{add} parameter into Eqn. 2 and 3 for birth and survival rates during those years (Fig. 2, right).

No attempt was made to model correlation between years with catastrophes, i.e. the probability of a catastrophe occurring did not depend on the whether or not there was one the previous year.

Performance statistics

The performance statistics were calculated based on future block quotas returned from the standalone version of the 'GUP2' *SLA* (IWC, 2005b; Punt and Breiwick, 2008). All performance statistics were computed in terms of the age 1+ component of the population following the standard methods and notation of the AWMP (IWC, 2003). Specifically, four performance statistics were calculated:

(1) (D1) Final depletion: $N_{1+,2098}/K_{1+}$;

(2) (D8) Rescaled final population size: $N_{1+,2098}/N^*_{1+,2098}$, where $N_{1+,2098}$ is the 1+ population size in 2098, under a scenario of zero future catches;

(3) (D10) Relative increase: $N_{1+,2098}/N_{1+,2009}$; and

(4) (N9) Average need satisfaction: $\frac{1}{T}\sum_{t=2009}^{2098}\frac{C_t}{Q_t}$

where T is the number of years in the projection period; and C_t is the catch during year t, which is determined by the *SLA* through the 5-year block quota system.

RESULTS

1,601 simulations were run for each scenario, corresponding to the number of samples from the posterior provided by Brandon and Punt (2009). In general, the *Gray Whale SLA* was able to satisfy need and maintain a population size near carrying capacity for all of scenarios examined in these analyses. For example, all of the scenarios with base need had an average need satisfaction of 100% and the lowest median final 1+ depletion was 0.874 (Table 2). Not

[4] This is the number of whales a country or the Commission specifies is required to satisfy cultural and subsistence 'needs' before taking the conservation situation into account

[5] The two deterministic trials are most comparable with the base case operating models in IWC (2004).

Table 1

The scenarios considered. The trials are denoted by an 'H' followed with the trial number and then 'BN' or 'HN' for base or high final need. Descriptions are given for each scenario in terms of the stochastic or deterministic nature of the population dynamics and the probability of future catastrophes.

Trial	Description	σ_ε	Final need	Probability of future catastrophe	Future stochasticity
H0:BN	Deterministic + no future catastrophes	N/A	340	0	None (deterministic)
H1:BN	Environmental stochasticity + no future catastrophes	0.5	340	0	Environmental
H2:BN	Environmental stochasticity + *p*(future catastrophe) = 0.0625	0.5	340	0.0625	Environmental
H3:BN	Environmental stochasticity + *p*(future catastrophe) = *p**	0.5	340	*p** (Eqn. 10)	Environmental
H4:BN	Stochasticity (no sea-ice) + *p*(future catastrophe) = *p**	0.5	340	*p** (Eqn. 10)	Environmental (no sea-ice)
H5:BN	Stochasticity (no sea-ice) + no future catastrophes	0.5	340	0	Environmental (no sea-ice)
H0:HN	Deterministic + no future catastrophes	N/A	530	0	None (deterministic)
H1:HN	Environmental stochasticity + no future catastrophes	0.5	530	0	Environmental
H2:HN	Environmental stochasticity + *p*(future catastrophe) = 0.0625	0.5	530	0.0625	Environmental
H3:HN	Environmental stochasticity + *p*(future catastrophe) = *p**	0.5	530	*p** (Eqn. 10)	Environmental
H4:HN	Stochasticity (no sea-ice) + *p*(future catastrophe) = *p**	0.5	530	*p** (Eqn. 10)	Environmental (no sea-ice)
H5:HN	Stochasticity (no sea-ice) + no future catastrophes	0.5	530	0	Environmental (no sea-ice)

surprisingly, those scenarios based on higher final need resulted in lower final depletion levels and lower average need satisfaction. However, the differences were not large (e.g. the lowest median 1+ depletion for the high need scenarios was 0.817). Moreover, none of the scenarios resulted in a lower 5th percentile for the final 1+ depletion less than 0.60. The relative increase statistic (D10) was close to 1 for all scenarios. The increase in population size is somewhat constrained because even under decreases in ice cover, Eqn. 1 still imposes an upper bound on abundance.

The distribution of probabilities of future catastrophes for the 'H3' and 'H4' scenarios is shown in Fig. 2 (right panel). The probability of future catastrophe ranged between 0.025 and 0.222 for those scenarios, with a median of 0.043, which was less than that when conditioned on the stranding index. However, the average difference between these two approaches was relatively small, as evidenced by the nearly identical results for these two assumptions (Table 2; Fig. 3).

The predicted area of sea-ice on the Bering Sea feeding grounds is forecast to decrease dramatically, with less than 50% of the average observed area of sea-ice in March–April during future decades (Fig. 2, left panel; Overland and Wang, 2007). The scenarios H1, H2, and H3 with population dynamics that are a function of this sea-ice index resulted in the most optimistic outcomes (Table 2), with some final depletion levels slightly greater than 1.0. On the other hand, the two scenarios that modelled generic environmental stochasticity independent of sea-ice (H4 and H5) resulted in the most pessimistic final depletion levels of any of the scenarios investigated (Table 2). Likewise, the trend in process error deviations was very different between these two sets of scenarios. Those scenarios which modelled

Table 2

The medians, and upper and lower 5th percentiles of the performance statistics for each scenario. See text for the definitions for each of the performance statistics.

		D1: Final 1+ depletion			D8: Rescaled 1+ depletion			D10: 1+ relative increase			N9: Avg. need satisfaction		
Trial	Description	5%	Median	95%	5%	Median	95%	5%	Median	95%	5%	Median	95%
H0:BN	Deterministic + no future catastrophes	0.908	0.933	0.950	0.875	0.918	0.948	0.947	0.986	1.095	1.000	1.000	1.000
H1:BN	Environmental stochasticity + no future catastrophes	0.940	0.981	1.030	0.910	0.965	1.019	0.973	1.041	1.179	1.000	1.000	1.000
H2:BN	Environmental stochasticity + p(future catastrophe) = 0.0625	0.914	0.974	1.026	0.886	0.959	1.016	0.954	1.032	1.158	1.000	1.000	1.000
H3:BN	Environmental stochasticity + p(future catastrophe) = *p**	0.922	0.976	1.027	0.896	0.961	1.017	0.960	1.034	1.167	1.000	1.000	1.000
H4:BN	Stochasticity (no sea-ice) + *p*(future catastrophe) = *p**	0.745	0.874	0.953	0.731	0.861	0.945	0.807	0.932	1.050	1.000	1.000	1.000
H5:BN	Stochasticity (no sea-ice) + no future catastrophes	0.802	0.897	0.960	0.775	0.883	0.954	0.846	0.952	1.066	1.000	1.000	1.000
H0:HN	Deterministic + no future catastrophes	0.855	0.899	0.927	0.833	0.884	0.921	0.913	0.950	1.038	0.971	0.980	0.988
H1:HN	Environmental stochasticity + no future catastrophes	0.913	0.963	1.017	0.889	0.946	1.006	0.951	1.022	1.156	0.974	0.981	0.988
H2:HN	Environmental stochasticity + *p*(future catastrophe) = 0.0625	0.880	0.954	1.011	0.858	0.937	1.001	0.927	1.011	1.132	0.973	0.981	0.988
H3:HN	Environmental stochasticity + *p*(future catastrophe) = *p**	0.894	0.957	1.013	0.868	0.941	1.002	0.932	1.015	1.138	0.973	0.981	0.988
H4:HN	Stochasticity (no sea-ice) + *p*(future catastrophe) = *p**	0.657	0.817	0.917	0.649	0.805	0.909	0.725	0.873	0.989	0.959	0.979	0.987
H5:HN	Stochasticity (no sea-ice) + no future catastrophes	0.722	0.847	0.927	0.707	0.834	0.921	0.776	0.901	1.013	0.964	0.980	0.988

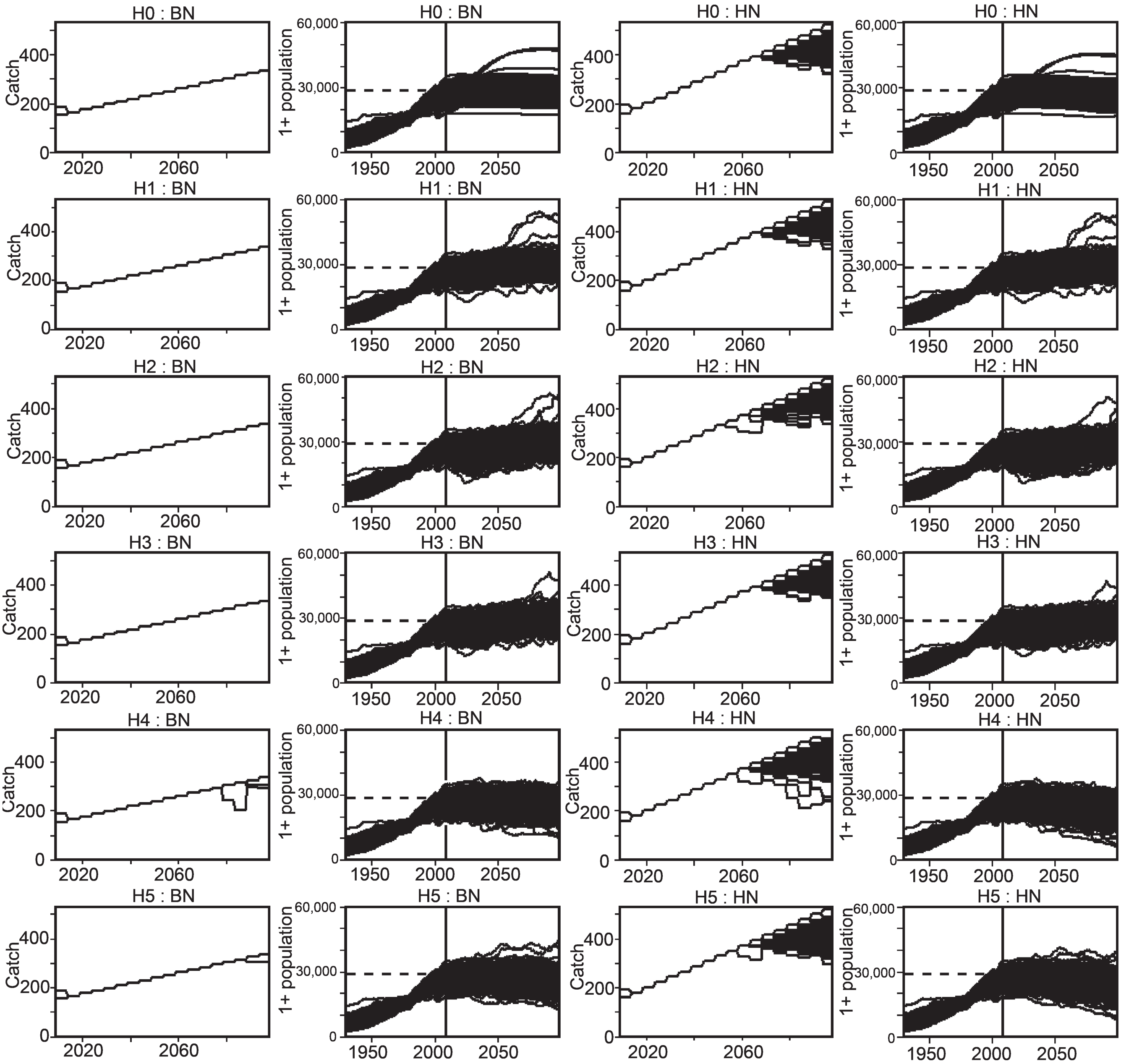

Fig. 3. Time-trajectories of future catches (first and third columns) and population trajectories from 1930–2098 (second and fourth columns) for the twelve scenarios (Table 1). The left and right pairs of columns are respectively for a final need levels of 340 and 530 whales per year. The results for each simulation are plotted as an individual line (thus a single visible line for catches represents a series of years where future catches were identical across scenarios).

process error as a function of future sea-ice resulted in an increasing trend in the size of process error deviations, while those scenarios which modelled environmental stochasticity as an independent process led to no such trend (Fig. 4). However, in terms of the median average need satisfaction, there was essentially no difference amongst all the scenarios; the *SLA* was able to achieve high need satisfaction for all of those examined here (Table 2).

The results of the 'deterministic' trials (H0) were more optimistic than those of the corresponding trials on which the *Gray Whale SLA* was based (GE01 and GE14) (compare table 2 of Breiwick *et al.* (2009) with the results for the two H0 trials in Table 2 of this paper). However, the differences in the values for the performance statistics are slight, and qualitatively the results of trial H0 and GE01 are identical. The differences in results are attributable to a variety of causes, including differences in the population dynamics models, in the data used to condition the operating model, and in the priors for the parameters of that model.

DISCUSSION

The approach taken here allows a forecast for an index of environmental variability to be incorporated into an operating model, which can be used to test management approaches given hypothesized interactions between the environment and population dynamics. These trials differ slightly from the standard set designed by the Standing Working Group of the AWMP during the original *Implementation* of the *Gray Whale SLA* (IWC, 2005a) in that they are conditioned on updated and newly available data, as well as a hypothesis regarding the effect of sea-ice on deviations in demographic rates. Hence, these analyses serve

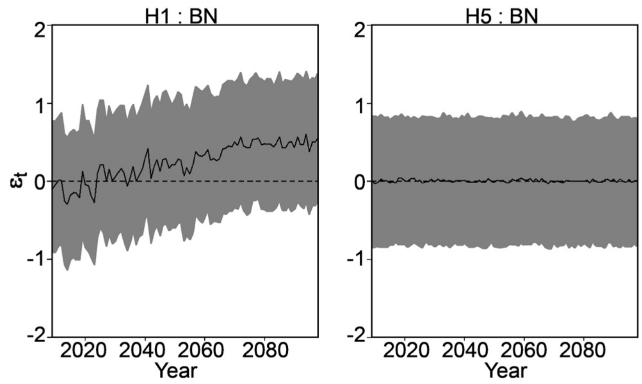

Fig. 4. The time-trajectories of future process error deviations for a case where these deviations are a function of future sea-ice (H1:BN; left panel) and where they are independent of the sea-ice index (H5: BN; right panel). The annual median is plotted as the solid line, the 90% probability interval envelope is shaded in gray, and the horizontal dashed line at zero is shown for reference.

to take account of new information that has become available since the original *Implementation*. The results provide evidence that the current state of nature is not outside the realm of plausibility envisioned during the simulation testing of the original *SLA*.

The magnitude of future additional mortality events was assigned in an *ad hoc* manner during the original *Implementation* of the *Gray Whale SLA*, i.e. future events were assumed to result in 20% declines in abundance (a likely large value, chosen to test the robustness of the *SLA*). In these analyses however, the operating model is conditioned in part on the strandings data, which allows the deviations in survival rates during the 1999/2000 mortality event and the resulting population size at the start of the future trajectories to be estimated directly. Likewise, the observed frequency and magnitude of those mortality events determined when conditioning are used to model the potential impact of future events. A set of several alternative trials was also preformed, to compare the results of the environmental forcing scenario to those for which future population dynamics were assumed to be deterministic, or to be subject to random environmental stochasticity (i.e. ignoring possible sea-ice impacts). For all of the scenarios considered here, the *Gray Whale SLA* was able to maintain stock size and satisfy need at higher levels. Therefore, there is no indication from these analyses that any revisions to the *SLA* are necessary.

While the *SLA* performed well under the scenarios considered in these analyses, there is still considerable uncertainty about how changes in sea-ice (or other environmental conditions) will affect future population dynamics. At present, the available information about the affects of environmental variability on cetacean population dynamics is largely correlative in nature, with the underlying mechanisms responsible for fluctuations in birth and survival rates not well understood. Although a plausible explanation has been hypothesised for ENP gray whales (i.e. that sea-ice may act as a physical barrier to prime feeding habitat), it is not straightforward to predict how other changes resulting from reductions in sea-ice will interact with the mechanisms that are currently influencing the dynamics of this population. Therefore, the conclusion that the *Gray Whale SLA* is robust to predicted changes in sea-ice should be tempered by uncertainty regarding the underlying assumption that current ecological processes will remain unchanged in the future, especially when so many other fundamental changes in ecosystems are expected as a result of climate change. Indeed, this one is one of the reasons *Implementation Reviews* are mandatory.

The assumption that the population dynamics were related to sea-ice led to more optimistic results. This was essentially the result of extrapolating (based on those years for which calf production and strandings data exist) a recent relationship between the environment and population dynamics into the future, under the assumption that such an effect (if it exists) would be invariant over time and independent of population density, among other factors. While more optimistic results would have been expected given the nature of the relationship between calf production and sea-ice cover, the magnitude of the effect could not be determined *a priori*. In addition, it was possible that the impact of trends in birth rate and survival could have 'confused' the *SLA* and led to poorer performance (e.g. the models underlying the *SLA*s could have concluded that the stock was depleted rather than close to carrying capacity) and reduced the strike limit.

The operating model used here could be modified to take into account alternative hypotheses with respect to predicted changes in the relationship between future environmental variability and population dynamics. For example, it would be relatively straightforward to model a change-point in the relationship between deviations in demographic rates and sea-ice, such that a loss of sea-ice might be beneficial up to some future time, after which the continued loss of sea-ice results in negative effects on population dynamics (e.g. by changing the sign of β after some future year). The operating model could then be used to test the performance of the *SLA* under such scenarios. A disadvantage of this approach would be that there are no data to determine the magnitude of negative effects, so any results would be speculative.

One of the appealing attributes of the framework for incorporating environmental data is its flexibility. As continuing research provides more insight into the mechanisms underlying the impacts of environmental variability on the population dynamics of ENP gray whales, the basic operating model used here can provide a basis for integrating this new information into assessments and evaluating alternative management approaches. For example, alternative environmental data (e.g. an index of El Niño/Southern Oscillation, a sea-ice index on the Chukchi Seas feeding grounds, or some weighted combination of different indices) could be substituted during the model fitting process to take alternative hypothesised relationships between environmental variability and population dynamics into account. Likewise, the framework could, with some modification, be applied to other populations of cetaceans for which environmental fluctuations are hypothesised to be an important determinant of population dynamics. Therefore, this framework should help to ensure that management strategies are robust to hypothesised impacts of future environmental variability on cetacean population dynamics.

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Original Article

Toward a tier system approach for calculating limits on human-caused mortality of marine mammals

John R. Brandon[1]*, André E. Punt[2], Paula Moreno[3] and Randall R. Reeves[4]

[1]Independent Consultant, Pacifica, California, USA
[2]University of Washington, School of Aquatic and Fishery Sciences, Seattle, Washington, USA
[3]University of Southern Mississippi, Gulf Coast Research Laboratory, Ocean Springs, Mississippi, USA
[4]Okapi Wildlife Associates, Hudson, Quebec, Canada

*Corresponding author: tel: +1 206 9196541; e-mail: jbrandon@gmail.com

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The Potential Biological Removal (PBR) management strategy is used for the assessment, relative to management objectives, of human-caused mortality of marine mammal stocks. PBR has been used to provide scientific advice on limits on human-caused mortality of marine mammals as well as other long-lived marine vertebrates worldwide. Current values for the parameters of this reference limit were obtained using a Management Strategy Evaluation (MSE) approach, where computer simulation is used to model a range of scenarios representing different scientific uncertainties. An assumption underlying the current management strategy, as originally evaluated, is that only the single most recent estimate of abundance is used to calculate PBR. We extend the original MSE and introduce a tiered hierarchy of data availability, from data-rich to data-poor. Alternative approaches for deriving values used to calculate PBR in each tier (e.g. incorporating multiple abundance estimates for data-rich stocks) are evaluated relative to the management objectives of the United States Marine Mammal Protection Act. A PBR tier system would allow the best available information to be used for each stock, recognizing the different types and levels of uncertainty that exist among stocks. It is shown that if the sex ratio of human caused mortality is not one, PBR may not perform as expected. Likewise, an alternative value for the N_{MIN} percentile could be adopted when survey estimates are imprecise and multiple abundance estimates are available. The standard approach, using only a single abundance estimate, is less flexible in this regard. Additionally, incorporating multiple abundance estimates for data-rich stocks can lead to increased stability of calculated values for PBR through time. Reduction in variability could reduce regulatory uncertainty that may be associated with some human activities managed according to PBR. Therefore, including multiple abundance estimates, when possible, into the calculation of PBR may prove desirable.

Keywords: marine mammals, management strategy evaluation, population dynamics, potential biological removal, tier system.

Introduction

Marine mammals are typically highly mobile and range over large areas. This can lead to estimates of abundance that are imprecise or incomplete, limiting the ability to detect trends and assess population characteristics relative to management reference points. The 1994 amendments to the US Marine Mammal Protection Act (MMPA, originally enacted in 1972) contain provisions intended to limit annual levels of human-caused mortality and serious injury experienced by stocks of marine mammals (note that hereafter human-caused "mortality" is understood to encompass both outright deaths and serious injuries). Although assessment reports for some US marine mammal stocks include information on and estimates of human-caused mortality from sources other than commercial fisheries (e.g. ship strikes, subsistence harvest), most of the information and estimates pertain to mortality in fisheries, which is the only sector for which PBR is applied in management.

Specifically, as part of the stock assessment framework, the MMPA prescribes that a "Potential Biological Removal" (PBR) limit to human-caused mortality be set for each stock. Further, the MMPA mandates that this limit be calculated using a harvest control rule (or in this context a removal control rule) that is the product of three values: (i) a minimum estimate of abundance that "provides reasonable assurance that the stock size is equal to or greater than the estimate"; (ii) one-half of the maximum intrinsic rate of population growth; and (iii) a recovery factor between 0.1 and 1.0. PBR can therefore be written as the equation:

$$\text{PBR} = N_{\text{MIN}} 0.50 R_{\text{MAX}} F_{\text{R}} \quad (1)$$

One of the primary management objectives of the MMPA is to allow stocks of marine mammals to be maintained at or above their "optimum sustainable population" (OSP) level (MMPA, 1972). OSP is defined by the US National Marine Fisheries Service (NMFS) as a level between the maximum net productivity level (MNPL) of the population and its carrying capacity (Wade, 1998; Taylor *et al.*, 2000). MNPL is the population level relative to carrying capacity that corresponds to the maximum net rate of population growth. MNPL is thought to occur between 50 and 85% of carrying capacity for marine mammals (e.g. Taylor and DeMaster, 1993).

The PBR approach to managing human-caused mortality has been shown through performance testing to be fit for its designed purpose. Alternative approaches for setting limits to human-caused mortality have been debated (e.g. IWC, 2003, 2005; Lonergan, 2011; Cooke *et al.*, 2012), and the PBR management scheme has limitations when stock-level abundance data are lacking (e.g. Robards *et al.*, 2009). Nevertheless, PBR is well established within the U.S. regulatory context where it has been applied for more than 20 years. Additionally, the basic principles of PBR have been used to provide scientific advice on limits of human-caused mortality of marine mammals as well as other long-lived marine vertebrates in other countries. For example, reference limits based on PBR have been considered for seals in Canada (e.g. Hammill and Stenson, 2007; Stenson *et al.*, 2012) and the United Kingdom (Butler *et al.*, 2008); pilot whales (*Globicephala macrorhynchus*) in Japan (Kanaji *et al.*, 2011); dugongs (*Dugong dugon*) in Torres Strait, between Australia and Papua New Guinea (Marsh *et al.*, 2004); and sea-birds (Dillingham and Fletcher, 2011), sea-lions (*Phocarctos hookeri;* Maunder *et al.*, 2000), and dolphins (*Cephalorhynchus hectori*) in New Zealand (Slooten and Dawson, 2008; Slooten, 2013). A generalization of the PBR framework has also been developed to estimate the combined direct and indirect effects of fishing on cetaceans in US waters (Moore, 2013). Among the features that make PBR appealing to managers is that it is easily understood, inherently precautionary, and simple to apply.

The amount of data (number, frequency, and precision of estimates of abundance) differs among marine mammal populations, making some species or populations "data-rich" while others can be considered "data-poor". However, the PBR formula as evaluated by Wade (1998) makes use of only the most recent estimate of abundance, irrespective of its precision or the number of estimates available. Stocks with different amounts of data are common in fisheries. One solution to this problem, apart from collecting more data for the data-poor stocks, which is often impractical or infeasible, is to develop tier systems of harvest control rules. Such tier systems assign species or populations to different tiers based on the availability and quality of data or on the quality of the assessments that use the data (Dichmont *et al.*, in press).

No formal tier system currently exists for marine mammal stocks in the United States. However, for stocks with multiple abundance estimates (e.g. the California/Oregon/Washington stocks of Dall's porpoise and Pacific white-sided dolphins; Carretta *et al.*, 2015), the US NMFS has provided guidelines for calculating N_{MIN} as an arithmetic average, within an eight-year window, weighted by the precision of each estimate (NMFS, 2005). Wade and DeMaster (1999) demonstrated that averaging abundance (and mortality) estimates using this method can lead to a lower rate of classifying human-caused mortality as greater than PBR when it is not (i.e. averaging can lower the rate of false positives—the rate of classifying situations as in need of management measures when such measures are not actually warranted). That analysis did not quantitatively explore how combining multiple estimates of abundance might affect the value used to calculate N_{MIN}.

Ultimately, a tier system approach would enable better use of all available data. We therefore investigate one alternative tier system that could help move toward this goal following an MSE approach. Various aspects of the PBR calculation could be considered for a tier system. We focus on the availability of abundance estimates and the calculation of N_{MIN} as a case study for how a tier system might be implemented. This article provides a comparison between the standard PBR approach (single estimate of abundance) and two alternative approaches for combining multiple abundance estimates, depending on data availability (e.g. survey frequency). As the amount of information available to calculate N_{MIN} increases, it might be expected that the precision of the minimum abundance estimate would increase as well. Additionally, we provide an evaluation of alternative approaches across multiple performance metrics, e.g. meeting the OSP management objective of the MMPA while simultaneously reducing temporal variability in PBR. This could make the overall management process more stable without compromising its conservation effectiveness.

Brief history of development and testing of PBR decision rules

Although the MMPA stipulates that PBR must be calculated as the product of three terms, it does not provide explicit values for those terms. Rules for setting the values have been established largely based on the results of a management strategy evaluation (MSE) conducted by Wade (1998), who expanded on a previous simulation study (Taylor, 1993). MSE is the use of simulation modelling to evaluate the performance of candidate management strategies, where a management strategy relates to specifications for the data to be collected and how those data are used in a feedback loop involving management actions (in the case of US marine mammal stocks, the PBR). MSE has been used extensively to evaluate the ability of potential management strategies related to commercial and aboriginal subsistence whaling to satisfy the management objectives of the International Whaling Commission (IWC) (Punt and Donovan, 2007). MSE involves several steps: (i) developing a model of the system, which represents the "truth" for the purposes of simulation (the "operating model"); (ii) specifying the range of uncertainties to be considered and thereby which "trials" will be undertaken; (iii) defining performance metrics that quantify the management objectives; (iv) selecting the candidate management strategies; (v) conducting projections of each management strategy for each operating model; and (vi) providing the results to decision makers (Punt *et al.*, in press). The trials conducted by Wade (1998) and here capture uncertainties about the "true" state of nature (e.g. uncertainties in the actual underlying abundance or human-caused mortality levels).

In common with many MSEs, Wade (1998) defined a set of "base case" trials, along with a set of robustness trials. Wade's (1998) base-case trials involved estimates of abundance that were unbiased, albeit with two different levels of precision, to find the percentile of the sampling distribution for the most recent abundance estimate (i.e. N_{MIN}) that results in meeting the OSP management objective of the MMPA when F_R is set equal to 1, i.e. after 100 years, 95% of the simulations lead to population sizes greater than MNPL (Figure 1). The assumptions of the "base case" trials include: R_{MAX} is 0.04 for cetaceans and 0.12 for pinnipeds; MNPL is 50% of carrying capacity (K); and the initial population size is 30% of K. Under those scenarios, the value of N_{MIN} is the lower 20th percentile of the sampling distribution for the most recent abundance estimate (Wade, 1998).

Wade (1998) then set N_{MIN} to the lower 20th percentile of the most recent abundance estimate and found the value of F_R that results in at least 95% of the simulations meeting the OSP objective for the remaining trials (Figure 1). The results of Wade's simulation testing form the basis for the parameter values currently used by the US NMFS to calculate PBR for stocks of marine mammals (NMFS, 2005).

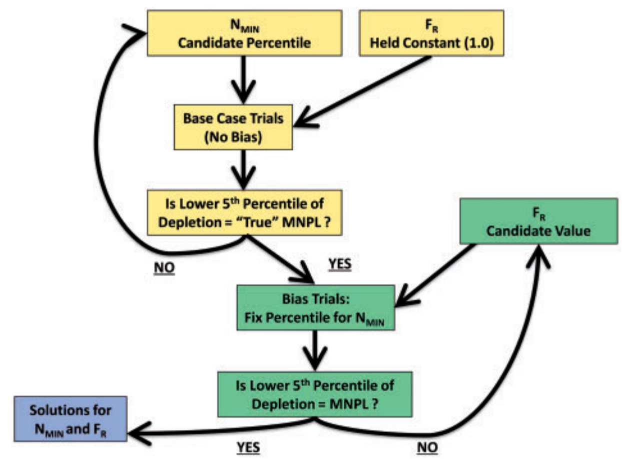

Figure 1. Flow diagram of Wade's (1998) procedure for solving for values of N_{MIN} and F_R that meet the OSP management objective of the MMPA.

Methods

The model for the underlying population dynamics and data generation for the simulations (i.e. the operating model) is provided in Appendix A (The Fortran code for the operating model and calculating PBR for the data tiers is free, open-source, and available from: https://github.com/John-Brandon/PBR-Tier-System. R code to analyse and visualize output is available in the same repository.). The operating model of the Appendix differs from that of previous simulation studies of PBR (Taylor, 1993; Wade, 1998; Wade and DeMaster, 1999), which were based on an age-aggregated population dynamics model. An age-structured model allows the performance of PBR to be evaluated over a wider range of uncertainties (e.g. different patterns of vulnerability to human-caused mortality across sexes and ages).

Parameterization and trials

Values for life history parameters were assumed to be: adult survival (S_{adult}) = 0.95; maximum birth rate (b_{max}) = 0.5; age at transition to adult survival (a_T) = age at first partuition (a_p) = the age from which life history parameters remain constant (age x) = 11 years (Appendix A). These values were chosen to approximate the life-history pattern of humpback whales *Megaptera novaeangliae* (e.g. Zerbini *et al.*, 2010). In order to make the results comparable with previous PBR simulation research, the trials were identical to those performed by Wade (1998) (Table 1).

Selectivity-at-age was assumed to be uniform across all ages and the sex ratio of human-caused mortality was assumed to be 50:50. The sensitivity of the results to the assumption of uniform selectivity-at-age was explored by running the base case trials (Table 1; $CV_N = 0.2$) with selectivity-at-age being knife edged on the plus group (age x); Appendix A). The age x-plus group corresponded with the reproductive component of the population, given the assumed life history. The relative vulnerability of females to males with respect to human-caused mortality was allowed to vary in sensitivity evaluations at the increments: 0.001, 0.01, 0.1, 0.5, 1, 2, 10, 100, and 1000. A value of 0.5 means that females are half as vulnerable to human-caused mortality as males, a value of 1 represents equal vulnerabilities of the sexes, and a value of 2 means that females are twice as vulnerable as males (Equation A.8). The sensitivity trials for relative vulnerability by sex were also run for the base case specifications with $CV_N = 0.2$ (Table 1). In common with previous evaluations of PBR, no attempt is made here to specify the source(s) of human-caused mortality. However, it is assumed that the mortality of interest can be constrained by management. Therefore, the evaluations in this article pertain most closely to the PBR approach as applied in the United States to marine mammal stocks subject to mortality in commercial fisheries.

A PBR tier system

Three alternative tiers for calculating PBR were investigated:

Tier 1: Using only the most recent estimate of abundance, and setting N_{MIN} to the 20th percentile of a log-normal distribution, following Wade (1998);

Tier 2: Using a weighted arithmetic mean and variance of available abundance estimates over the last eight years (NMFS, 2005). The weights (w_s) were equal to the inverse of the variances of the abundance estimates, such that:

$$\bar{N}' = \sum_s w_s \hat{N}_s; \quad w_s = \frac{1/\mathrm{var}\left(\hat{N}_s\right)}{\sum_s 1/\mathrm{var}\left(N_s\right)}; \qquad \mathrm{CV}(\bar{N}) = \frac{\sqrt{\sum_s w_s^2 var\left(\hat{N}_s\right)}}{\bar{N}} \tag{2}$$

where $\bar{N}'$ is the weighted arithmetic mean abundance, $\mathrm{CV}(\bar{N})$ is the coefficient of variation of the weighted arithmetic mean, and s denotes a survey year. The summations are taken over available survey estimates within the last 8 years, following the US.NMFS guidelines (NMFS, 2005).

Table 1. Trials considered in evaluating the performance of alternative approaches to incorporating abundance estimates in the calculation of PBR.

Trial	Description	R_{MAX}	CV_N	CV_M	Abundance Bias	Initial Depletion	Mortality ~ Normal (μ, σ^2)	Abundance survey interval (years)	θ
0A	Base Case	0.04	0.20	0.30	1	0.30	μ = PBR, σ = CV_M *PBR	4	1.0
0B		–	0.80	–	–	–	–	–	–
1A	Biased mortality	–	0.20	–	–	–	**μ = 2 * PBR**	–	–
1B		–	0.80	–	–	–	**μ = 2 * PBR**	–	–
2A	Biased abundance	–	0.20	–	**2.00**	–	–	–	–
2B		–	0.80	–	**2.00**	–	–	–	–
3A	Biased R_{MAX}	**0.02**	0.20	–	–	–	–	–	–
3B		**0.02**	0.80	–	–	–	–	–	–
4A	Bias in CV_N	–	**0.80**	–	–	–	–	–	–
4B		–	**1.60**	–	–	–	–	–	–
5A	Bias in CV_M	–	0.20	**1.20**	–	–	–	–	–
5B		–	0.80	**1.20**	–	–	–	–	–
6A	Survey every 8 years	–	0.20	–	–	–	–	**8**	–
6B		–	0.80	–	–	–	–	**8**	–
7A	MNPL = 0.45 * K	–	0.20	–	–	–	–	–	**0.53**
7B		–	0.80	–	–	–	–	–	**0.53**
8A	Biased mortality and MNPL = 0.70 * K	–	0.20	–	–	–	**μ = 2 * PBR**	–	**5.04**
8B		–	0.80	–	–	–	**μ = 2 * PBR**	–	**5.04**

These trials follow those considered by Wade (1998). The default R_{MAX} for cetaceans is shown. Dashes represent parameter values that are the same as those for the base-case scenario. Parameter values that differ from the base-case scenario are denoted in bold. CV_N and CV_M are the coefficients of variation about the estimates of abundance and mortality respectively. "~" denotes "distributed as", and θ is the shape parameter for density dependence (Equation A.5). A value of 1.0 under "Abundance Bias" means the abundance estimates are unbiased, whereas a value of 0.50 means that true abundance is one-half of the estimated value. All animals irrespective of age and sex are equally vulnerable to being killed.

Tier 3: A weighted average by time and precision. This approach has been investigated by the Scientific Committee of the IWC for calculating strike limits for aboriginal subsistence whaling (e.g. Brandão and Butterworth, 2014):

$$\bar{N}' = \exp\left[\sum_s \frac{\gamma^{t_s}\ln(N_s)}{CV_s^2} \left(\sum_s \frac{\gamma^{t_s}}{CV_s^2}\right)^{-1}\right]; \qquad CV(\bar{N}') = \sqrt{\sum_s \frac{\gamma^{2t_s}}{CV_s^2} \Big/ \sum_s \frac{\gamma^{t_s}}{CV_s^2}}; \tag{3}$$

where $\bar{N}'$ is the weighted average abundance by time and precision, $CV(\bar{N}')$ is the coefficient of variation of the weighted average by time and precision, and t_s is the number of years between year s and the year for which an estimate of abundance is needed. Abundance estimates were weighted by time through the γ parameter, which was set equal to 0.9 in this case. This value allows for the majority of the weight to be placed on the most recent estimates, while still allowing for some weight to be placed on older estimates as well.

The minimum abundance estimate for each approach was calculated following the assumption of log-normal sampling error:

$$N_{MIN} = \frac{N'}{\exp\left(z\sqrt{\ln\left(1 + CV(N')^2\right)}\right)}$$

where $\bar{N}'$ is either the most recent estimate of abundance $\hat{N}_t$, or the estimate of abundance resulting from one of the averaging approaches (N′ from Eqn 2 or 3), and z is a standard normal variate (e.g. $z = 0.842$ corresponds with the 20th percentile of the log-normally distributed abundance estimate).

Performance metrics

Two thousand simulations were run for each trial. Preliminary analyses indicated that this number of simulations was sufficient to achieve stable results. Two performance metrics were calculated for the MSE: (1) the fifth percentile across simulations of depletion (N_{1+}/K_{1+}) at the end of 100 years, and (2) variation in the calculated values for PBR through time. Variation in PBR was calculated as a performance metric because, all else being equal, lower variation in PBR should equate with a more robust management scheme, i.e. one that simultaneously reduces the probability of conservation risk (under-protection) and the economic loss to stakeholders through unnecessary regulation of human activities (over-protection). The value for PBR was updated after every new survey. The average inter-survey variation (AISV) statistic was used to measure the average absolute difference in PBR between surveys:

$$AISV = \sum_{ts=1}^{T} |PBR_{ts+1} - PBR_{ts}| \Big/ \sum_{ts=1}^{T} PBR_{ts} \tag{4}$$

where ts indexes each time the PBR is calculated and T is the final survey year in the simulated time series.

Depletion (the number of 1+ animals relative to carrying capacity) after 100 years was the main performance metric investigated by Wade (1998) and was used in this study to determine whether the OSP management objective of the MMPA had been met.

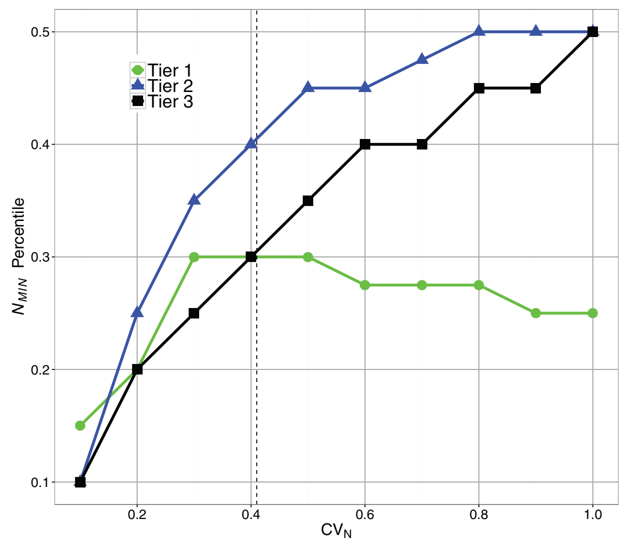

Figure 2. The percentile used to calculate N_{MIN} that meets the OSP management objective of the MMPA, given CV_N for each data availability tier and approach to calculating N_{MIN}. The dashed vertical line represents the median CV_N across stocks in the 2014 US assessment reports (http://www.nmfs.noaa.gov/pr/sars/region.htm).

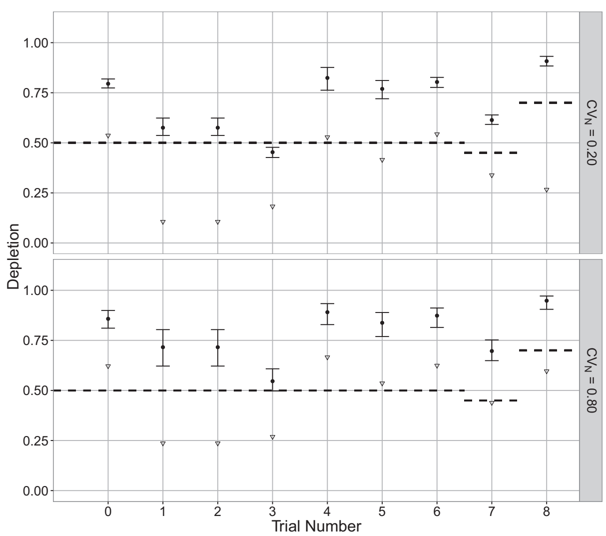

Figure 3. Final depletion when $F_R = 0.50$, and the Tier 3 approach is used to calculate the PBR. Median values are plotted as dots, and error bars represent the inner 90% of the simulations (i.e. the range between the 5th and 95th percentiles). The horizontal dashed lines represent MNPL for a given trial. Triangles show the fifth percentile for simulations when $F_R = 1.0$. The results for the other two approaches to calculating PBR follow the same pattern as shown here (albeit with the N_{MIN} percentile held constant at 0.25 for the Tier 2 approach).

Results

Specifying the value of N_{MIN}

The age-structured operating model was able to mimic the results of the age-aggregated model used by Wade (1998) given the assumption that all animals were equally vulnerable to human-caused mortality. For example, the 20th percentile of the abundance estimates used to calculate N_{MIN} resulted in the lower fifth percentile of simulations being at MNPL under the base case trial with $CV_N = 0.20$ (Figure 2). The NMFS (2005) approach for averaging abundance estimates (Tier 2) resulted in a slightly higher value (0.25) for the N_{MIN} percentile given the OSP management objective (Figure 2). The N_{MIN} percentile for the weighted by time and precision approach (Tier 3) was ~0.20, conditional on the assumption that CV_N for the abundance estimates was not any greater than 0.20 (Figure 2). When abundance estimates are relatively precise (e.g. $CV_N = 0.2$), the percentiles across data tiers are similar (0.2–0.25). As the uncertainty in abundance estimates (CV_N) increases, the percentiles between data tiers diverge. For the standard approach to calculating PBR (Tier 1), the percentile for N_{MIN} only varies between 0.2 and 0.3 (Figure 2). The approach using only the single most recent abundance estimate is hence less affected by the precision of the survey estimates than are the alternative approaches that incorporate more information.

The N_{MIN} percentile was held constant at 0.20 for the standard single abundance estimate and the weighted average approaches, and at 0.25 for the arithmetic averaging approach in subsequent analyses.

Selecting the value for F_R

Setting the N_{MIN} percentile equal to 0.20 (Tier 1 standard approach; Tier 3 weighted by time and precision) or 0.25 (Tier 2 arithmetic averaging approach), and running the remaining trials (Table 1), resulted in a value for $F_R = 0.50$ that met the management objective of depletion only to a level at or above MNPL after 100 years (Figure 3 shows the results for Tier 3). The one exception was trial 3, which involved a bias in R_{MAX} (i.e. true R_{MAX} was 0.02, but the default value of 0.04 was assumed when calculating PBR; in other words, population growth was overestimated). The results of this trial were less satisfactory than those reported by Wade (1998). Those results were based on the assumption that the true R_{MAX} for this trial was equal to the default value (e.g. 0.04), whereas the value assumed to calculate PBR was twice the true value (e.g. 0.08) (P. Wade, NMFS, *pers comm.*). The assumption made here is that the value used to calculate PBR is the default (e.g. 0.04), and the true value is one-half of that (e.g. 0.02). The difference between assumptions made by Wade (1998) and the assumptions made here regarding the true R_{MAX} values explains the discrepancy in the results for final depletion. This trial failed to meet the OSP management objective for the approaches to calculating PBR examined here (Supplementary Figures S.1 and S.2 show the results for Tier 1 and 2, respectively).

The fifth percentile of depletion for each trial was generally consistent between tiers when abundance estimates were relatively precise ($CV_N = 0.2$); however, when abundance estimates were less precise ($CV_N = 0.8$), the lower fifth percentiles of depletion were higher for those tiers that calculated PBR using multiple abundance estimates compared with Tier 1 (e.g. compare the lower panels of Supplementary Figure S.1 and S.2).

Variability in PBR

The AISV was noticeably lower for Tiers 2 and 3. Averaging across abundance estimates resulted in fewer years with more extreme values for PBR than the standard approach of using only

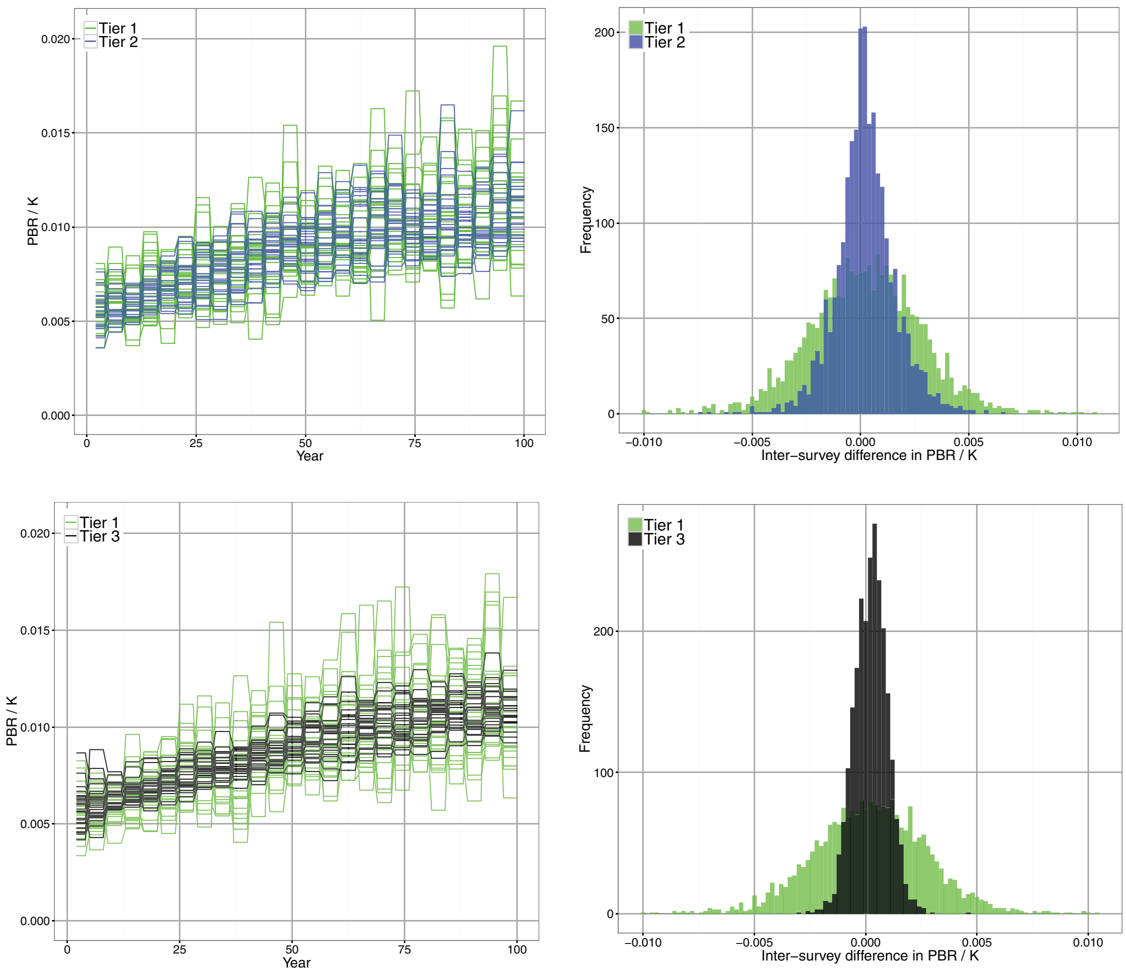

Figure 4. Time series of PBR values (relative to carrying capacity K) for the Tier 1 (Wade, 1998) and Tier 2 (NMFS, 2005) approaches (upper left panel). 30 randomly selected simulations are shown for each tier. The upper right panel shows the distributions of the AISV statistic (relative to carrying capacity *K*) for the Tier 1 approach and for the Tier 2 approach. The bottom two panels show the same comparisons between Tiers 1 and 3. Results are shown for the base-case trial where $CV_N = 0.2$.

Table 2. Results for the AISV in PBR are shown for the three approaches evaluated given a $CV_N = 0.2$ (results are shown for $CV_N = 0.8$ in parentheses).

BASE CASE: $N_{MIN} = 0.2$; $F_R = 1$			**BIAS TRIALS: N_{MIN} selected; $F_R = 0.5$**		
	Lower fifth percentile of of final depletion	**AISV**	**Lower percentile for N_{MIN}**	**MIN lower fifth percentile of final depletion**	**MAX AISV across trials**
Tier 1	0.5	0.22 (0.77)	0.2	0.43	0.76 (1.13)
			% Difference from Tier 1		
Tier 2	104	50 (54)	125	100	53 (57)
Tier 3	99	32 (29)	100	98	29 (31)

The percentage difference under Tiers 2 and 3 is equal to the value for those tiers divided by the value for Tier 1.

the most recent estimate of abundance (Figure 4). This result was consistent across all trials in Table 1. For the base case trial, Tier 2 resulted in an AISV that was roughly one-half (50% for $CV_N = 0.2$; 54% for $CV_N = 0.8$) of that for the Tier 1 approach. This variability was even further reduced under Tier 3; the AISV was roughly one-third of that for the Tier 1 approach (32% for $CV_N = 0.2$; 29% for $CV_N = 0.8$; Table 2).

For the robustness trials, the maximum AISV across trials was used for comparison. The trial with a survey interval of 8 years was excluded from this comparison because Tier 2 performs exactly as Tier 1 in this case, i.e. only one estimate of abundance is available within an 8-year window, and hence averaging is not an option. The Tier 2 and 3 approaches resulted in AISVs for the robustness trials, relative to those from Tier 1, which compared

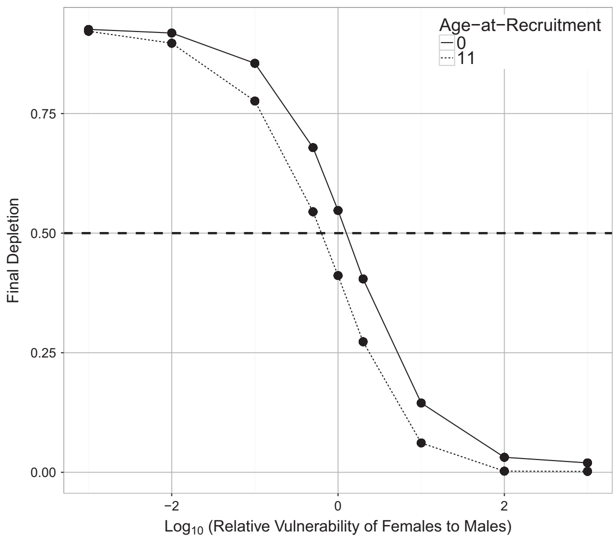

Figure 5. The fifth percentiles of final depletion (circles) as a function of the relative vulnerability of females to males for the Tier 1 base-case trial with $CV_N = 0.2$. The solid line represents a scenario where all animals are equally vulnerable. The relative vulnerability is plotted in Log_{10} space, i.e. a value of 0 represents equal vulnerability, a value of 1 represents a case where females are 10 times more vulnerable than males, etc. The dotted line represents a scenario where only the reproductively mature component of the population is subject to human-caused mortality. The dashed horizontal line represents the OSP management objective of the US MMPA.

favourably with the results of the base case trial. Tier 2 resulted in a maximum AISV across robustness trials that was roughly one-half (53% for $CV_N = 0.2$; 57% for $CV_N = 0.8$) of that from the Tier 1 approach. Again, this variability was even further reduced under Tier 3; the AISV was roughly one-third of that from the Tier 1 approach (29% for $CV_N = 0.2$; 31% for $CV_N = 0.8$; Table 2).

Reduction in temporal variability in PBR limits did not come at the expense of increasing the conservation risk, i.e. the lower fifth percentiles of final depletion were nearly equal across Tiers (Table 2). For example, for the base case trial, Tier 3 resulted in a fifth percentile for final depletion that was 99% of that from Tier 1 (0.495 vs. 0.5).

Selectivity-at-age and sex

The relative vulnerability of females, in contrast to the age at which animals become vulnerable to human-caused mortality, had a large effect on whether or not the PBR approach met the OSP management objective of the US MMPA. This pattern was similar across tiers (Figure 5 shows the base case for Tier 1). In general, the results were more optimistic with respect to meeting the OSP management objective when females were less vulnerable than males. In the case where females were twice as vulnerable to human-caused mortality as males, the fifth percentile of final depletion indicated that stocks would be depleted to below the OSP management objective after 100 years (Figure 5). This analysis also indicated that PBR might be overly conservative (i.e. overly risk-averse or precautionary) if human-caused mortality was predominately males.

Discussion

Data on population age structure and sex structure are important when providing management advice (Figure 5). If selectivity is skewed with respect to age or sex, our results indicate that the performance the PBR management approach (Wade, 1998) may over- or under-protect stocks, depending on the nature of the skew in selectivity. If human-caused mortality consists predominately of young animals and/or of males, PBR will likely be overly conservative. Conversely, PBR may not be sufficiently precautionary if human-caused mortality consists predominately of mature females (Figure 5) or if R_{MAX} is over-estimated (Figure 3).

Empirical estimates of R_{MAX} are generally limited to stocks that have been monitored during recovery from exploitation (e.g. Punt and Wade, 2012). The majority of stocks in the United States have been assigned default values for this parameter (0.04 for cetaceans, 0.12 for pinnipeds). If the default value for this parameter is not accurate, PBR may be biased and management objectives may not be met (Figure 3; Trial 3). Alternative methods for estimating R_{MAX}, based on allometric and life table models, have been developed for other marine vertebrates (e.g. Dillingham *et al.*, 2016), and could provide a complimentary approach to assigning values to this important parameter for marine mammals.

The implications of biased sex ratios have been recognized in the past. Consequently, e.g. IWC catch limits are reduced when females are more vulnerable to capture than males (IWC, 2012). Information on the age and sex structure of fishery bycatch should be collected, when possible, to investigate if selectivity is non-uniform. Quantitative approaches to adjusting F_R for such cases (e.g. when the sex ratio is not one) could be assessed through a future MSE.

The results of this study also highlight two effects that the incorporation of multiple estimates of abundance can have on the calculation of PBR. The first involves the value for the N_{MIN} percentile that meets the OSP management objective of the MMPA. If abundance estimates are relatively precise (e.g. $CV_N \leq 0.2$), the difference between N_{MIN} percentiles is small across the data tiers investigated here. Additionally, for the standard approach (Tier 1), the solution for the N_{MIN} percentile is relatively insensitive to the precision of the abundance estimate. Over a range of CVs from 0.2 to 1.0, the N_{MIN} percentile for Tier 1 only varies between 0.2 and 0.3 (Figure 2).

The value for the N_{MIN} percentile increases as the precision of the estimates of abundance decreases when multiple estimates are used to calculate PBR (Tiers 2 and 3). For these tiers, if the precision of the abundance estimates is low, the 20th percentile of the resulting confidence limit results in a value for PBR that is more conservative (i.e. lower) than would be necessary to meet the OSP management objective of the MMPA. The results from these simulations indicate that for $CV_N \geq 0.6$, the 40th percentile of the confidence limit for either Tier 2 or Tier 3 would be appropriate (Figure 2).

To understand how this difference influences the calculated value of PBR, consider a scenario where the survey interval is 4 years, estimates of abundance have a $CV_N = 0.6$, and the point estimates are assumed to be equal between the last two surveys. Under Tier 2 (NMFS, 2005), there would be a 38% increase in the calculated value of PBR if the 40th percentile of the confidence limit were used, relative to PBR based on the standard 20th percentile. For this hypothetical scenario, averaging two point estimates of 1500 individuals would result in a PBR of 13.0 (N_{MIN} = 40th percentile) vs. 9.4 (N_{MIN} = 20th percentile). The management implications for such differences are likely to be stock-specific, and may be limited to those stocks for which estimates of human-caused mortality are nearly equal to the calculated value of PBR based on the standard approach (Tier 1).

The second effect of incorporating multiple abundance estimates in the calculation of PBR is a reduction in the temporal variability of calculated PBR values. Including only a single estimate of abundance in the calculation of PBR results in variability at least two times greater than that resulting from the approaches where multiple estimates are averaged (Figure 4; Table 2). The reduction in variability from incorporating multiple abundance estimates does not come at the expense of increasing the conservation risk (Table 2). Given this risk equivalency, strategies that decrease the variability in the calculated value for PBR may be worth considering. For example, temporal variability in the calculated PBR value can cause economic uncertainty for commercial fisheries that have interactions with marine mammals. Incorporating multiple abundance estimates in the calculation of PBR could lessen unnecessary impacts on human activities while still meeting conservation objectives, e.g. the OSP management objective of the MMPA. Such an approach would be consistent with MMPA recommendations to consider economic factors in implementing regulations with respect to the taking of marine mammals (MMPA, 1972).

The PBR tier system evaluated here represents an extension of the current US management scheme. This tier system could be considered for calculating PBR under a management scheme that has the same objective as the US MMPA. Stocks could be assigned to a tier based on the number of available abundance estimates. Nevertheless, there are several assumptions that should be considered before any such tier system was put into practice, including (but not limited to): (i) The set of trials adequately spans the range of plausible uncertainties; (ii) The value used for R_{MAX} is not biased, and; (iii) Selectivity is not skewed disproportionally towards females. Additionally, different guidelines may be in effect in different jurisdictions (e.g. whether older abundance estimates age out of consideration, or not). Therefore, a tier system like this one may be appropriate in one instance but not another. Likewise, reference limits and management objectives in different jurisdictions are not always identical. Hence future MSEs in such cases would need to be adjusted accordingly.

Advancements have been made recently in analytical approaches to calculating abundance and trends for marine mammal populations using relatively long time series. For example, Moore and Barlow (2014) used hierarchical Bayesian modelling to estimate trends in abundance and N_{MIN} from six abundance estimates of eastern North Pacific sperm whales *Physeter macrocephalus* based on surveys during 1991–2008. Similar methods have been applied to fin whales *Balaenoptera physalus* and beaked whales (family Ziphiidae) (Moore and Barlow, 2011, 2013). A MSE incorporating more sophisticated model fitting of abundance data is outside the scope of this research, although in principle it would be possible. Additionally, future MSEs could investigate methods for incorporating trend estimates into the calculation of PBR. For example, quantitative approaches could be evaluated for calculating F_R as a function of the estimated rate of change in abundance and its standard error (perhaps contingent on the stock's status, e.g. listed as endangered, threatened, etc.). Methods to incorporate trend information have been evaluated by the IWC for aboriginal subsistence whaling strike limits (e.g. Brandão and Butterworth, 2014), and these could form the basis for evaluations of a PBR tier management scheme for stocks with multiple estimates of abundance.

Abundance estimates are imprecise for many stocks of marine mammals (e.g. Taylor *et al.*, 2007). The median CV estimates across stocks in the 2014 US marine mammal stock assessment reports was 0.41 (Carretta *et al.*, 2015). If survey estimates are imprecise, and a stock falls within either Tier 2 or Tier 3, an alternative value for the N_{MIN} percentile could be adopted from the results presented here (Figure 2). Incorporating multiple abundance estimates for data-rich stocks can lead to more stability through time for calculated values of PBR, while simultaneously meeting conservation objectives such as the OSP objective of the MMPA. Therefore, including multiple abundance estimates into the calculation of PBR, when possible, may prove desirable.

Supplementary data

Supplementary material is available at the *ICESJMS* online version of the article.

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APPENDIX A

The operating model and data generation

The basic population dynamics were:

$$N^s_{t+1,a} = \begin{cases} 0.5b_{t+1}P_{t+1} & \text{if } a = 0 \\ (N^s_{t,a-1} - M^s_{t,a-1})S_{a-1} & \text{if } 1 \leq a < x \\ (N^s_{t,x} - M^s_{t,x})S_x + (N^s_{t,x-1} - M^s_{t,x-1})S_{x-1} & \text{if } a = x \end{cases} \quad \text{(A.1)}$$

where $N^s_{t,a}$ is the number of animals of age a and sex s (m/f), at the start of year t, b_t is the birth rate (the proportion of females that have reached parturition and given birth) in year t (Equation A.5), P_t is the number of females that have reached the age of first parturition (a_p) at the start of year t:

$$P_t = \sum_{a'=a_p}^{x} N^f_{t,a'} \quad \text{(A.2)}$$

S_a is the annual survival rate of animals of age a, determined by the age at transition to adult survival (a_T):

$$S_a = \begin{cases} S_{juv} & \text{if } a < a_T \\ S_{adult} & \text{if } a \geq a_T \end{cases} \quad \text{(A.3)}$$

$M^s_{t,a}$ is the human-caused (anthropogenic) mortality of animals of age a and sex s, during year t.

It was assumed that the values for the population dynamics parameters, including human-caused mortality rates, were the same from a certain age onwards (denoted as age "x"). Age x was assumed equal for males and females. Senescence in birth and mortality rates was not modelled. Males were assumed to be a non-limiting factor in reproduction.

Initial conditions

A numbers-per-recruit approach is taken to initialize the age-structure in the first year of the projections. This is represented by a stable age distribution, in year $t = 0$, given a fixed initial anthropogenic exploitation rate denoted E:

$$\tilde{N}^s_a = \begin{cases} 0.5 & \text{if } a = 0 \\ [\tilde{N}^s_{a-1}(E)]S_{a-1}(1 - V^s_{a-1}E) & \text{if } 1 \leq a < x \\ [\tilde{N}^s_{x-1}(E)]S_{x-1}(1 - V^s_{x-1}E)/ & \\ \quad [1 - S_x(1 - V^s_x E)] & \text{if } a = x \end{cases} \quad \text{(A.4)}$$

where E is the anthropogenic exploitation rate prior to implementation of the PBR management strategy, V^s_a is the relative vulnerability of animals of age a and sex s to anthropogenic mortality (assumed for most analyses to be 1 for all ages and both sexes), $\tilde{N}^s_a(E)$ is the number of animals of age a and sex s, as a function of a fixed anthropogenic exploitation rate (E). The subscript for time t is dropped in Equation (A.4) for clarity. The value for E that resulted in a given depletion level with a stable age structure is solved for using Brent's method (Brent, 1973; Press *et al.*, 1992). The numbers per female recruit were rescaled so that abundance at the start of the first year corresponded to the initial depletion level in terms of the age 1+ component (ages one year and older).

Intrinsic rate of population growth (R_{MAX})

The intrinsic rate of population growth, or maximum net recruitment rate, for an age-structured population dynamics model can be solved for from the characteristic equation of the projection matrix (e.g. Punt, 1999; Caswell, 2001). The projection matrix corresponds to Eqn A.1, where maximum fecundity (female calves per female) is substituted for the birth rate (i.e. maximum fecundity $= 0.5b_{max}$, assuming a 50:50 sex ratio at birth). b_{max} is the maximum birth rate, which corresponds with R_{MAX}, i.e. the birth rate in the absence of any density dependence.

The base-case R_{MAX} is set to 0.04 for cetaceans to make the results comparable to those of Wade (1998). This is implemented by solving for the juvenile survival rate S_{juv} that resulted in a projection matrix with a dominant real eigenvalue $\lambda_{MAX} = R_{MAX} + 1$. λ_{MAX} was calculated numerically using the Fortran 90 LAPACK (Linear Algebra PACKage) libraries (Available from: www.netlib.org.) (Anderson *et al.*, 1999). Brent's method (Brent, 1973; Press *et al.*, 1992) was used to solve for the juvenile survival rate S_{juv} that resulted in the target value for R_{MAX}.

Density dependence

Density dependence was assumed to act through the birth rate, according to the Pella-Tomlinson model:

$$b_t = \max\{0, b_{eq} + (b_{max} - b_{eq})[1 - (N_{t,1+}/K_{1+})^\theta]\} \quad \text{(A.5)}$$

where θ is the shape parameter, assumed for the base-case trials to equal 1.0 (or MNPL of ~50% of K_{1+}, the carrying capacity in terms of the component of the stock that is age 1 year and older). Likewise $N_{t,1+} = \sum_{s'}\sum_{a'=1}^{x} N^{s'}_{t,a'}$.

For an age-structured model, if the carrying capacity is modelled in terms of the total population (including calves), the resulting system of equations becomes essentially intractable. Hence, carrying capacity is modelled in terms of age 1+ abundance.

The equilibrium birth rate b_{eq}(i.e. the birth rate at carrying capacity in the absence of anthropogenic mortality) is given by:

$$b_{eq} = \left(\sum_{a'=a_p}^{x} \tilde{N}^f_{a'}(E = 0)\right)^{-1} \quad \text{(A.6)}$$

Data generation

The sampling error about the survey estimates was assumed to be log-normal.

$$\hat{N}_t = \beta \exp\left[\ln\left(\frac{N_t}{\sqrt{1+CV_N^2}}\right) + x\sqrt{\ln\left(1+CV_N^2\right)}\right] \quad (A.7)$$

where N_t is the true underlying abundance, and β is the extent of bias in the abundance estimate. If the abundance estimates are unbiased then $\beta = 1.0$. Values of $\beta > 1.0$ represent abundance estimates that are positively biased (i.e., surveys over-estimate true abundance on average). CV_N is the coefficient of variation about the true abundance, and, x is a standard normal random variate (mean = 0, variance = 1).

The total human-caused mortality each year is: $M_t = \sum_{s'} \sum_{a'=0}^{x} M_{t,a'}^{s'}$ where

$$M_{t,a}^{s} = M_t \delta^s V_a^s N_{t,a}^s / \sum_{s'} \sum_{a'=0}^{x} \delta^{s'} V_{a'}^{s'} N_{t,a'}^{s'} \quad (A.8)$$

where δ^{female} is the relative vulnerability of females relative to males, given $\delta^{male} = 1$. M_t was assumed to be normally distributed, with an expectation equal to PBR, and a pre-specified coefficient of variation CV_M (base-case value 0.3). M_t was set to zero if the generated human-caused mortality was less than zero. These assumptions about the estimated human-caused mortality were made to be consistent with the approach taken by Wade (1998).

Additional *SLA* variants to further evaluate the proposed Makah hunt

John R. Brandon* and Jonathan Scordino#
Contact email: jonathan.scordino@makah.com

ABSTRACT
At the 2012 Annual Scientific Committee meeting, the Implementation Review for eastern North Pacific gray whales with a focus on the proposed Makah hunt and the Pacific Coast Feeding Group (PCFG) was completed. Two variants of the proposed hunt (one with research provisions) were agreed by the Committee to meet the conservation objectives of the Commission. However, the Committee also noted that neither of these variants exactly mimicked the proposed hunt and expressed concern that the actual conservation outcome of the proposed hunt had not been tested. The reason that an exact variant was not tested was because there is a temporal rule in the proposed hunt, such that all struck and lost whales from December through April are not counted against the Allowable PCFG Limit (APL), whereas any struck and lost whales in May are counted against the APL. There are insufficient data however, to determine the proportion of strikes that would occur in May or prior to May, and hence the two variants of the hunt were developed to bracket the range of possible strikes by month. Following the Committee's request for an exact evaluation of the proposed hunt management plan, six additional variants were identified intersessionally. In combination, these eight variants span the full range of possible strikes that could occur in May or prior to May, and hence provide a means of more precise evaluation. A broad comparison is provided here of this set of variants across all evaluation and robustness trials, and more detailed results are presented for trials identified as of interest during the Implementation Review. Perhaps not surprisingly, the conservation performance of the six additional variants is found to be in-between the two previously evaluated variants. The central questions remaining for management advice would then seem to pertain to whether the photo-ID research provision might be required for any (or all) of the additional variants presented here, and moreover, whether the research provision should apply to the proposed hunt management plan as a whole.

KEYWORDS: ABORIGINAL WHALING; MANAGEMENT PROCEDURE; NORTH PACIFIC; GRAY WHALES

INTRODUCTION

During the 2012 Scientific Committee meeting, the Implementation Review for eastern North Pacific gray whales was completed (IWC/64/Rep1 Annex E). The focus of that Implementation Review was on the proposed Makah hunt and the Pacific Coast Feeding Group (PCFG) of gray whales. Several variants of the proposed Makah hunt were examined (see SC/64/Rep3 Annex D), and the Scientific Committee agreed that two of these variants (one with research provisions – see below) performed acceptably in terms of meeting the aboriginal subsistence and conservation objectives of the Commission.

However, the Scientific Committee also noted that these two variants did not exactly mimic the proposed Makah hunt, and agreed that the Standing Working Group of the AWMP should develop and test an exact variant intersessionally, in order for the Scientific Committee to evaluate the results at this year's meeting.

During the AWMP intersessional meeting, the Standing Working Group reviewed a set of six

* *Greeneridge Sciences, Inc., San Francisco, California, USA*
# *Makah Fisheries Management, Makah Tribe, Neah Bay, Washington, USA*

additional variants suggested by Brandon and Scordino (2012), and agreed these were appropriate and sufficient to achieve the Scientific Committee's goal (SC/65a/Rep02).

Background and rationale for why a set of variants (rather than a single management variant) has been suggested in order to satisfy the Scientific Committee's request is outlined below. As described in the Scientific Committee's report (IWC/64/Rep1):

> *"In order to minimise the risk of taking PCFG whales, the management plan developed by the Makah Tribe restricts the hunt both temporally (to the migratory season for gray whales i.e. 1 December – 31 May) and geographically (to the Pacific Ocean region i.e. the Makah U&A[1] except the Strait of Juan de Fuca). Some PCFG whales are present during the migratory season and thus the plan proposes an allowable PCFG limit (APL) during hunts that are targeting eastern North Pacific migrating whales with the aim of ensuring that accidental takes of PCFG whales do not deplete the PCFG. Whales struck in May might have a higher probability of being PCFG whales since they feed in this area in June. The management plan thus proposes an additional requirement that all animals struck-and lost in May are assumed to be PCFG whales (i.e. count against the APL), whereas whales struck between December and April are not.*
>
> *Weather conditions and availability of whales makes it likely that most hunting will occur in May. However, there are insufficient data to assess the number of strikes by month. Thus, it is not possible to reliably estimate the proportion of struck-and-lost whales that would count towards the APL. Given this uncertainty about how the plan would respond to failing to take into account struck-and-lost PCFG whales, the Tribe had proposed two SLA variants (1 and 2) spanning the options as to when the hunt might occur.*
>
> *SLA variant 1 proposes that struck-and-lost whales do not count towards the APL i.e., there is no management response to PCFG whales struck but not landed. SLA variant 2 proposes that all struck-and-lost whales count to the APL irrespective of hunting month. i.e., the number of whales counted towards the APL may exceed the actual number of PCFG whales struck."*

Hence, the two agreed acceptable *SLA* variants (1 and 2) differ in their categorical assignment of struck and lost whales to the APL, and therefore each variant corresponds to the hunt taking place during two different time periods.

Variant 1 was agreed to have performed acceptably for all trials deemed most plausible[2] during the Implementation Review, except that is, for two related trials where it was deemed to have marginal performance. Those two trials in question assume that the PCFG $MSYR_{1+}$ = 2% and further that the probability of striking a PCFG whale is double the observed proportion of PCFG whales in the available photo-identification studies during the proposed hunting season. Because the ratio of PCFG whales to migratory whales can be monitored through photo-identification studies during the proposed hunting season, variant 1 was agreed to meet the Commission's conservation objectives under the provision that annual photo-identification research be undertaken and results reported to the Scientific Committee for evaluation. Given the assumption that no struck and lost whales belong to the PCFG, variant 1 corresponds to the proposed hunt occurring entirely during Dec – Apr.

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[1] Usual and accustomed fishing grounds

[2] Generally, the most challenging trials were agreed by the Committee to have low plausibility (*e.g.,* see the discussion regarding MSYR = 1% being at the lower bound of plausibility in IWC/64/Rep1 Annex E), and hence if a variant did not meet conservation criteria for those challenging lower plausibility trials, it was not judged that the variant performed unacceptably.

Variant 2, on the other hand, assumes all struck and lost whales belong to the PCFG, and as such counts all struck and lost whales against the APL. This variant performed acceptably for all trials deemed most plausible by the Scientific Committee (*i.e.*, it was agreed acceptable with no such research provision). Under the proposed hunting rules outlined above, variant 2 corresponds to hunting during May only.

Essentially then, the aspect of the proposed hunt that was not evaluated during the Implementation Review is the interaction between the actual number of strikes-per-month over the entire hunting season (Dec – May) and the time-varying assumption of whether a struck and lost whale belongs to the PCFG (*i.e.*, counts against the APL).

At present, there is no reliable way to predict the exact number (or model the probability) of strikes that may occur during a given month. However, one strategy to address this challenge is to evaluate a variant for each possible outcome of the number of strikes by month. To simplify this approach, months can be divided into two categories (May, or prior to May), given the assumption of whether or not struck and lost whales are counted against the APL during those time periods. This leads to the six additional variants suggested by Brandon and Scordino (2012). Variants 1 (all strikes prior to May) and 2 (all strikes in May) are logical bounds on the range of possible strikes by time period. Following the recommendation of the Scientific Committee, a comparison of the results of all eight variants (including *SLA* variants 1 and 2) is presented here to further evaluate the proposed Makah hunt management plan.

METHODS

The additional variants are labeled alphabetically (A-F) to avoid confusion with previously evaluated variants that were assigned numbers during the 2012 Implementation Review. The full range of variants considered in these analyses, including variants 1 and 2, is shown in Table 1. Note that the maximum strike limit per year in the proposed Makah hunt management plan is seven (SC/64/Rep3).

Table 1

Variant *SLAs* covering the range of possible strikes by time period (prior to May or during May), given the categorical assignment of struck and lost whales to the APL in the proposed Makah hunt management plan. Accordingly, the proposed management plan assumes that all whales struck and lost prior to May are migrants belonging to the greater northern feeding group, whereas it assumes that all whales struck and lost in May belong to the PCFG.

Variant	Description
1.	All strikes prior to May.
A.	Allow up to six strikes prior to May.
B.	“ ” five strikes prior to May.
C.	“ ” four strikes prior to May.
D.	“ ” three strikes prior to May.
E.	“ ” two strikes prior to May.
F.	“ ” one strike prior to May.
2.	All strikes in May.

Allocation of strikes by month

Variants D – F are outlined below as examples illustrating how the set of additional variants is modeled. Note that there are additional rules in the proposed management plan that could preclude hunting, even if the APL for a given year has not been reached (*i.e.*, the limit of 20 whales landed per five year quota, the maximum of five whales landed in any calendar year, and the maximum of three struck and lost whales in any calendar year; SC/64/Rep3). For the purposes of these illustrative examples, those additional rules are not included in the outline below but they are nevertheless an active component of the simulated hunt (exactly as they were during the Implementation Review).

Variant D: Allow up to 3 strikes prior to May, remaining (max of 4) strikes in May
1. Compute the APL.
2. If hunting is allowed under the APL, the first strike of the season occurs prior to May.
3. If the first whale is struck and lost, it does not count against the APL.
4. If a second strike is allowed under the APL, the second strike occurs prior to May.
5. If the second whale is struck and lost, it does not count against the APL.
6. If a third strike is allowed under the APL, the third strike occurs prior to May.
7. If the third whale is struck and lost, it does not count against the APL.
8. If subsequent strikes are allowed under the APL, they occur in May. If any of these are struck and lost, they are assumed to be PCFG whales and those strikes apply to the APL.

Variant E: Allow up to 2 strikes prior to May, remaining (max of 5) strikes in May
1. Compute the APL.
2. If hunting is allowed under the APL, the first strike of the season occurs prior to May.
3. If the first whale is struck and lost, it does not count against the APL.
4. If a subsequent strike is allowed under the APL, the second strike occurs prior to May.
5. If the second whale is struck and lost, it does not count against the APL.
6. If subsequent strikes are allowed under the APL, they occur in May. If any of these are struck and lost, they are assumed to be PCFG whales and those strikes apply to the APL.

Variant F: Allow up to 1 strike prior to May, remaining (max of 6) strikes in May
1. Compute the APL.
2. If hunting is allowed under the APL, the first strike of the season occurs prior to May.
3. If the whale is struck and lost, it does not count against the APL.
4. If any subsequent strikes are allowed under the APL, they occur in May. If any of these are struck and lost, they are assumed to be PCFG whales and those strikes apply to the APL.

Variants A-C proceed accordingly, and all other parameters of the operating model and trials are identical to those used during the Implementation Review (SC/64/Rep3 Annex F).

Further, as recommended by the Standing Working Group (SC/65a/Rep02), all of the additional variants were run across all of the evaluation and robustness trials examined during the 2012 Implementation Review, and the results compared with *SLA* variants 1 and 2.

RESULTS

Figure 1 shows the lower 5^{th} percentile (5%ile) of (a) final PCFG (age 1+) depletion, and; (b) rescaled (age 1+) PCFG depletion for all evaluation and robustness trials given the range of possible maximum strikes prior to May (including *SLAs* 1 and 2 for comparison).

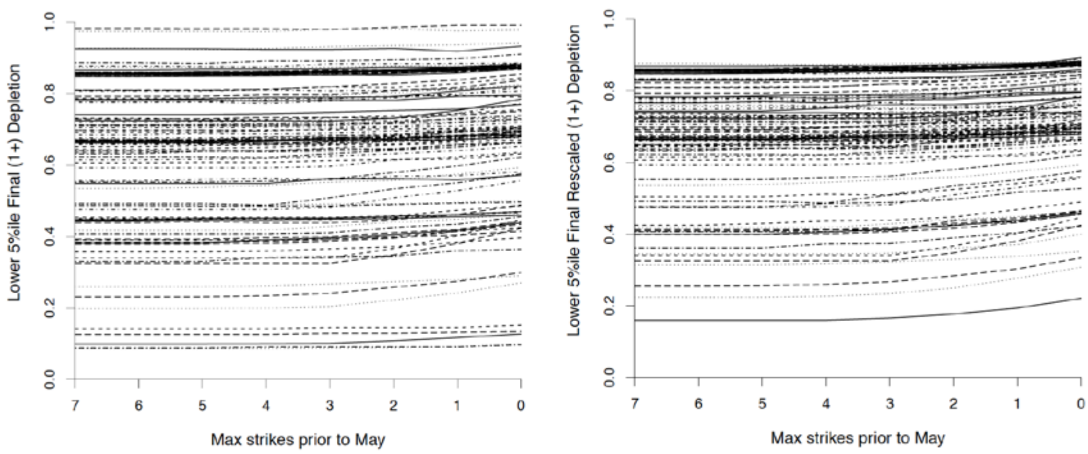

Fig. 1. The lower 5th percentile (5%ile) of PCFG final depletion (left panel) and rescaled (1+) depletion (right panel) are shown as a function of the maximum number of strikes prior to May for all evaluation and robustness trials. The lines connect the results for a single trial across variants. *SLA* variant 1 corresponds to all (maximum of seven) strikes prior May, *SLA* variant 2 corresponds to zero strikes prior to May (*i.e.*, all strikes occur in May), and variants A-F correspond with the intermediate number of (maximum) strikes prior to May (Table 1).

There are several note-worthy patterns that emerge from these results across all trials: (1) the additional variants (A-F) have intermediate conservation performance between *SLAs* 1 and 2; (2) any trend that exists in conservation performance between variants for a given trial is best described as a monotonically increasing function of the number of strikes that occur during May (*i.e.*, there is no pattern of convexity or concavity in conservation performance across variants), and; (3) there appears to be a saturation point (dependent on the trial), after which the number of allowable strikes prior to May does not lead to a decrease in conservation performance.

We did also investigate the output for the other conservation statistics of interest for all trials (e.g. minimum number of mature females) and found the same patterns hold true as shown in Fig. 1. Due to considerations of space, we have not presented results for every performance statistic for each trial across all variants, but these have been provided to the Secretariat and are on file for reference.

Given the fundamental result that variants A-F are intermediate in conservation performance across all evaluation and robustness trials, only the subset of trials identified as having questionable conservation performance during the 2012 Implementation Review is considered further here. The lower 5th percentile and median of the final and rescaled final depletion statistics are shown in Table 2 for those trials.

In the more detailed presentation of results across variants provided in Table 2, variants A through F can again be seen to result in conservation performance that is in-between variants 1 and 2 (excepting the rare cases of apparent monte-carlo sampling error in the third decimal). Likewise, as the number of strikes prior to May decreases, conservation performance can also be seen to increase.

Of the set of trials in Table 2, GB10B and GP10B are of particular interest because the conservation performance of *SLA* 1 was found to have been marginal for these two trials during the Implementation Review. The Zeh plots for these two trials are provided in Fig. 2 across all eight variants. These plots display the trade-off between conservation performance and need satisfaction across the range of possible strikes by month.

Table 2

Final and rescaled final depletion statistics for the eight *SLA* variants for the trials with $MSYR_{1+}$=1% and the trials with $MSYR_{1+}$=2% for which conservation performance might be considered to be questionable given the results of the 2012 Implementation Review.

	Final Dep (1+)		**Rescaled Final Dep**		**Final Dep (1+)**		**Rescaled Final Dep**	
SLA Variant	**Low 5%**	**Median**	**Low 5%**	**Median**	**Low 5%**	**Median**	**Low 5%**	**Median**
	Trial GB01C				**Trial GB08B**			
SLA 1 (7 strikes before May)	0.259	0.343	0.314	0.383	0.357	0.458	0.505	0.594
6 strikes before May	0.259	0.343	0.314	0.383	0.357	0.458	0.505	0.594
5 strikes before May	0.259	0.342	0.314	0.383	0.357	0.460	0.505	0.596
4 strikes before May	0.262	0.344	0.317	0.383	0.359	0.462	0.512	0.598
3 strikes before May	0.267	0.346	0.323	0.386	0.365	0.463	0.509	0.601
2 strikes before May	0.273	0.349	0.330	0.394	0.371	0.468	0.525	0.611
1 strikes before May	0.280	0.356	0.338	0.403	0.384	0.484	0.542	0.628
SLA 2 (7 strikes in May)	0.290	0.365	0.352	0.414	0.396	0.504	0.560	0.656
	Trial GP01C				**Trial GB10B**			
SLA 1 (7 strikes before May)	0.382	0.461	0.400	0.472	0.492	0.556	0.492	0.557
6 strikes before May	0.382	0.461	0.400	0.472	0.492	0.556	0.492	0.557
5 strikes before May	0.382	0.460	0.400	0.472	0.492	0.556	0.492	0.557
4 strikes before May	0.390	0.464	0.406	0.476	0.487	0.560	0.487	0.562
3 strikes before May	0.396	0.468	0.414	0.479	0.508	0.566	0.510	0.567
2 strikes before May	0.405	0.476	0.424	0.488	0.533	0.584	0.535	0.584
1 strikes before May	0.417	0.494	0.439	0.509	0.550	0.604	0.552	0.606
SLA 2 (7 strikes in May)	0.438	0.515	0.460	0.528	0.575	0.633	0.576	0.635
	Trial GP02C				**Trial GP08B**			
SLA 1 (7 strikes before May)	0.231	0.272	0.255	0.295	0.330	0.442	0.475	0.578
6 strikes before May	0.231	0.272	0.255	0.295	0.330	0.442	0.475	0.578
5 strikes before May	0.231	0.272	0.256	0.295	0.330	0.442	0.475	0.582
4 strikes before May	0.234	0.276	0.260	0.299	0.341	0.441	0.486	0.579
3 strikes before May	0.241	0.281	0.267	0.304	0.343	0.443	0.489	0.582
2 strikes before May	0.258	0.297	0.284	0.319	0.345	0.451	0.497	0.595
1 strikes before May	0.274	0.320	0.303	0.345	0.360	0.466	0.517	0.610
SLA 2 (7 strikes in May)	0.299	0.347	0.334	0.372	0.364	0.482	0.528	0.635
	Trial GI01C				**Trial GP10B**			
SLA 1 (7 strikes before May)	0.378	0.446	0.399	0.459	0.475	0.536	0.476	0.538
6 strikes before May	0.378	0.446	0.399	0.459	0.475	0.536	0.476	0.538
5 strikes before May	0.378	0.449	0.399	0.460	0.475	0.537	0.476	0.538
4 strikes before May	0.381	0.451	0.401	0.465	0.475	0.542	0.476	0.543
3 strikes before May	0.387	0.455	0.407	0.469	0.482	0.549	0.483	0.549
2 strikes before May	0.395	0.465	0.416	0.478	0.508	0.566	0.510	0.567
1 strikes before May	0.414	0.477	0.433	0.491	0.528	0.587	0.530	0.588
SLA 2 (7 strikes in May)	0.434	0.497	0.457	0.513	0.556	0.619	0.557	0.621

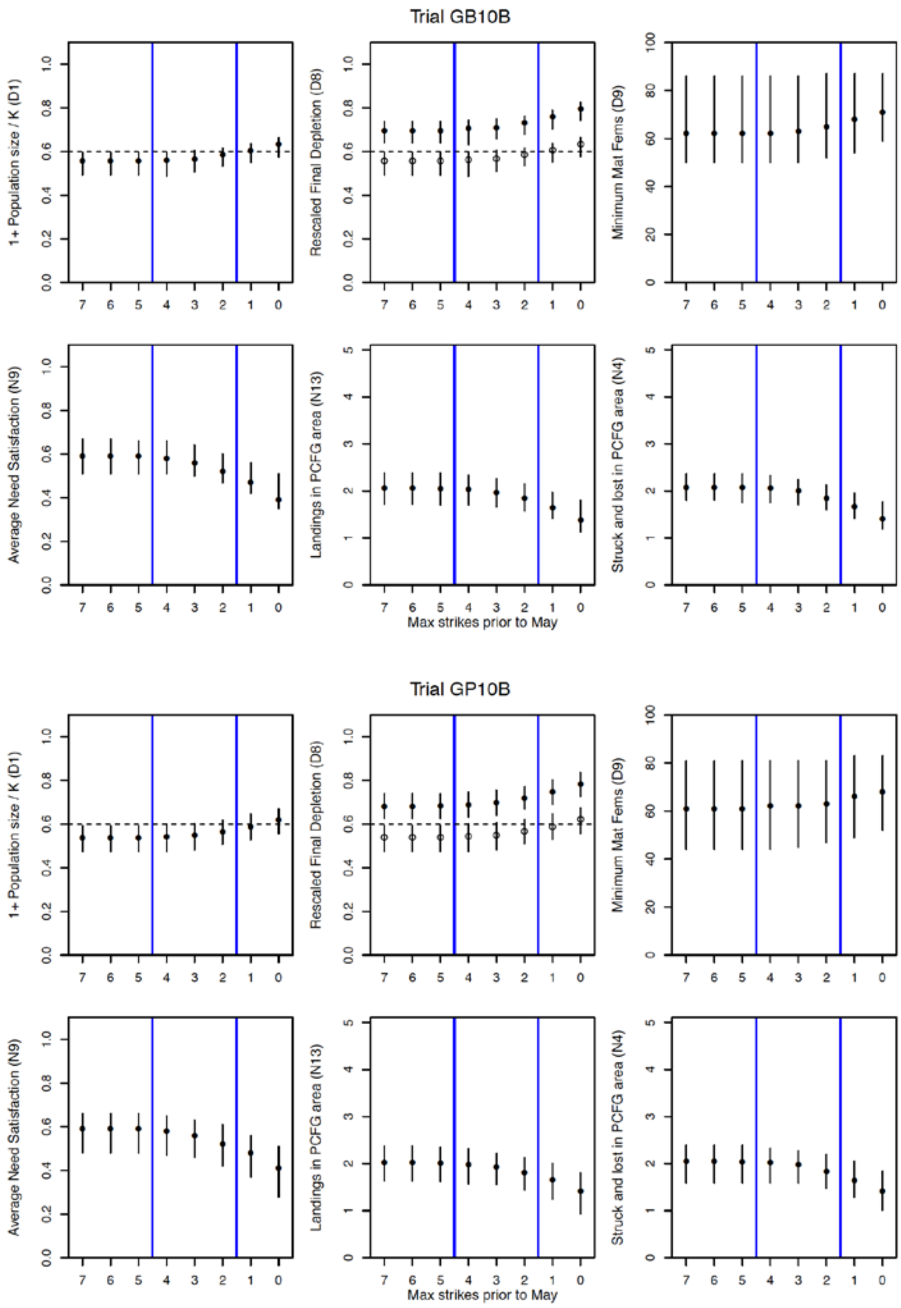

Fig. 2. Zeh plots for the two trials (GB10B upper panel, and GP10B lower panel) that assume that PCFG $MSYR_{1+}$ = 2% and that the probability of striking a PCFG whale is double the proportion of PCFG whales observed in the photo-ID data during the proposed hunting season. The conservation performance for variant 1 (all strikes prior to May) was found to be marginal for these trials during the Implementation Review. The maximum number of strikes that could occur prior to May for each variant is indicated along the x-axis, and the depletion plots (upper left two panels for each trial) are shown with a dashed horizontal line at 0.60 for reference.

DISCUSSION

The result that variants A - F achieve conservation performance that is intermediate between variants 1 and 2 is perhaps not surprising, given the original design that variants 1 and 2 should bracket the expected performance of the proposed Makah whaling management plan.

Variant 1 is less conservative with respect to the resource than variant 2 because it does not make the assumption that struck and lost whales belong to the PCFG. In other words, if a struck and lost whale is indeed a PCFG whale, variant 1 does not count this strike against the APL, and it is therefore possible under variant 1 to strike more PCFG whales before the hunt would be stopped (*e.g.*, because the APL was reached) than it is under variant 2.

Mechanically, variants A-F are bounded by variants 1 and 2 in terms of conservation performance because the percentage of strikes assumed to be PCFG can not be less than none (variant 1) or greater than all (variant 2). This logically leads to a transitive relationship of inequality with respect to conservation performance under the APL. In other words, variants A-F can only perform equal to or greater than variant 1 (and no better than variant 2). This relationship is evident in Figs. 1 and 2, and Table 2.

Given the relationship across these variants (*i.e.*, the number of strikes allotted by monthly time period), if variant 1 performed acceptably for a certain trial during the Implementation Review, then variants A-F (and variant 2) would be expected to perform acceptably for that trial as well. Hence, we propose that it is redundant to re-visit in detail the results of variants A-F for any trials except those for which variant 1 was deemed to have performed unacceptably.

The trials in Table 2 were identified during the Implementation Review as those for which either variants 1 or 2 had questionable performance. However, of those trials, only the results from GB10B and GP10B were considered further. The associated marginal conservation performance of variant 1 for GB10B and GP10B lead to the recommended research provision to hedge against the risk identified in those two trials. The other trials in Table 2 were deemed to have low plausibility.

Given the recommendations from the 2012 Implementation Review with respect to the two extremes of when strikes might occur (variants 1 and 2) -- and the results of the additional variants presented here which provide a finer resolution on this issue -- it seems that the central questions remaining for management advice pertain to whether the photo-ID research provision might be required for any (or all) of the additional variants (A-F), and moreover whether the research provision should apply for the proposed hunt management plan as a whole.

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TRENDS IN ABUNDANCE AND CURRENT STATUS OF HARBOR SEALS IN OREGON: 1977–2003

ROBIN F. BROWN
BRYAN E. WRIGHT
Marine Mammal Research Program,
Oregon Department of Fish and Wildlife,
7118 NE Vandenberg Avenue, Corvallis, Oregon 97330, U.S.A.
E-mail: robin.f.brown@state.or.us

SUSAN D. RIEMER
Marine Mammal Research Program,
Oregon Department of Fish and Wildlife,
P. O. Box 642, Gold Beach, Oregon 97444, U.S.A.

JEFFREY LAAKE
National Marine Mammal Laboratory,
Alaska Fisheries Science Center,
National Marine Fisheries Service,
7600 Sand Point Way, NE, Seattle, Washington 98115, U.S.A.

ABSTRACT

The distribution and abundance of harbor seals (*Phoca vitulina richardii*) in Oregon were monitored from 1977 to 2003 by aerial photographic surveys. Harbor seals on shore were counted each year during the reproductive period. Mean annual counts of non-pups (adults and subadults) were used as an index of population size and the trend in the counts was modeled using exponential (density-independent) and generalized logistic (density-dependent) growth models. Models were fit using maximum likelihood and evaluated using Akaike's Information Criterion. The population dynamics of harbor seals in Oregon were best described by the generalized logistic model. The population grew following protection under the Marine Mammal Protection Act of 1972 until stabilizing in the early 1990s. The estimated absolute abundance of harbor seals (all age classes) during the 2002 reproductive period was 10,087 individuals (95% confidence interval was 8,445–12,046 individuals). The current predicted population size for harbor seals in Oregon is above its estimated maximum net productivity level and hence within its optimum sustainable population range. We speculate that recent increases in ocean productivity in the eastern Pacific Ocean may lead to an increase in carrying capacity and renewed growth in Oregon's harbor seal population.

Key words: harbor seal, *Phoca vitulina*, Oregon, generalized logistic, optimum sustainable population, maximum net productivity level, carrying capacity, trend, status.

Trends in the abundance of Pacific harbor seals (*Phoca vitulina richardii*) along much of the west coast of North America suggest that harbor seal numbers may be approaching, or may have reached, current carrying capacity. Research suggesting that harbor seals populations have undergone density-dependent growth includes work from southern (Stewart and Yochem 1994) and central (Sydeman and Allen 1999) California, coastal and inland Washington (Jeffries *et al.* 2003), and British Columbia (Olesiuk 1999). However, in Alaska trends have been more varied; evidence there suggests that while some populations have increased or stabilized (Small *et al.* 2003), others may have declined (Pitcher 1990, Frost *et al.* 1999).

In Oregon, harbor seals are currently the most abundant and ubiquitous pinniped species found in coastal marine and estuarine waters. They can be found year-round on nearshore reefs and islands, along shore, and on tidally exposed sand and mud flats in most estuaries. Throughout the early 1900s harbor seals were viewed as significant predators of marine fishery resources and were subject to indiscriminate killing through state-funded bounty programs. No estimates of abundance are available for this period. By the late 1960s, Pearson and Verts (1970) estimated that fewer than 500 seals existed in Oregon's coastal waters and perhaps less than 100 in the Columbia River. Although it is not clear if they visited many of the areas where harbor seals are found today, they did note that seals only "occasionally entered estuaries for short periods."

Shortly after implementation of the Marine Mammal Protection Act (MMPA; 16 U.S.C. 1361) in 1972, harbor seals began to occupy many of Oregon's estuaries and the population size appeared to increase. This was most likely in response to the protection provided under the federal law (cessation of hunting and harassment), as well as increased pup survival and access to prey in newly available estuarine habitat. Harvey *et al.* (1990) first reported this increased use of estuaries concurrent with an increase in seal numbers. They found that harbor seal counts at 14 major trend sites statewide increased at an average annual rate of 8.1%, and the proportion of seals found in estuaries increased from 47% of the total count in 1975 to 61% in 1983.

The recovery of a depressed population such as harbor seals in Oregon could be considered a primary objective of the MMPA since it was intended that marine mammal populations should reach and be maintained within their optimum sustainable population (OSP) range. As defined, OSP is the range of population sizes between the maximum net productivity level (MNPL) and the carrying capacity of the species' environment (Federal Register, 21 December 1976, 41FR55536).

This paper presents an analysis of aerial survey counts of harbor seals in Oregon from 1977–2003. Our objectives were to: (1) model the trend in harbor seal survey counts; (2) determine whether or not seals in Oregon were within their OSP range; and (3) estimate the absolute size of the current population.

Methods

Aerial Surveys

We conducted annual aerial surveys along the Oregon coast during the mid-May to mid-June reproductive period. The coast was divided into two survey regions (Fig. 1), each of which could be flown during a 4-h survey. Haul-outs south of Hunters Island (42.31°N) were not included in the trend analysis because surveys did not occur there until 1984. We attempted to count each haul-out at least two times per year (*i.e.,* two replicates per region per year). The first and second survey windows typically occurred in late May and early June, respectively.

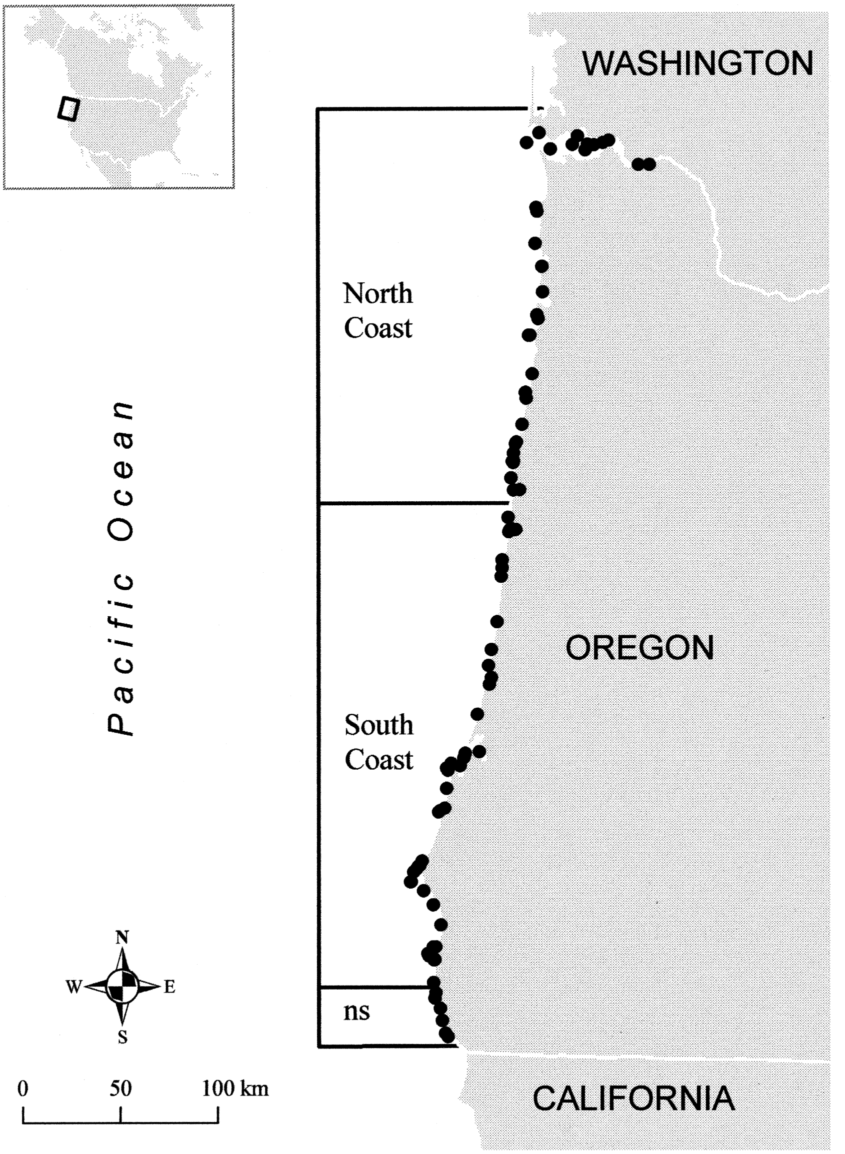

Figure 1. Map of harbor seal haul-out sites and survey regions in Oregon. Haul-outs on the southernmost coast were not surveyed (ns) prior to 1984 and were therefore not included in the trend analysis; counts from these haul-outs, however, were included when estimating absolute abundance for the 2002 reproductive period.

We conducted surveys from a single-engine, high-wing aircraft at altitudes of between 180 and 300 m. Surveys were flown within 2 h of the predicted morning low tide under good visibility and weather conditions (no fog, little or no precipitation, 300 m minimum ceiling). Data collected during surveys included date, time, location, weather conditions, and an estimate of the number of harbor seals at each site. Photographs of animals were taken obliquely through a side window of the aircraft using a hand-held 35-mm SLR camera, with a 70–210 mm zoom lens, and high speed (400 ASA) color slide film. These photographs were projected onto a white surface and the image of each animal was marked with a pen to prevent overcounting or undercounting. During the last two survey years (2002 and 2003), we used a digital SLR camera in conjunction with a GIS system to obtain harbor seal counts. Seals in the water were not counted. Although we counted both pups and non-pups, only the latter were used in the trend analysis.

Surveys were often cancelled due to poor weather (primarily fog), which resulted in some years having only one survey per region. In addition, some surveys were considered incomplete if either photographs or accurate counts could not be obtained for one or more haul-outs within the region. The two most common reasons for an incomplete survey were fog and human disturbance. Surveys with more than one missing haul-out were discarded; if only one haul-out was missing, the count was estimated either from field notes or by using the mean count from replicate surveys from the same year. In the case of the Columbia River, some missing counts were obtained from the Washington Department of Fish and Wildlife (Jeffries, unpublished data).[1]

Population Growth Models

We analyzed our aerial survey count data based on the methods in Jeffries *et al.* (2003) (also see Wade 1999). Our approach assumed that the average proportion of seals hauled out and counted during a survey was constant over space and time. The following statistical model was used to represent the count data:

$$C_{t_{ij}} = N_{t_{ij}} + \varepsilon_{t_{ij}}, \tag{1}$$

where $C_{t_{ij}}$ is the observed count of non-pup harbor seals ashore during survey i, in region j and year t; $N_{t_{ij}}$ is the estimated non-pup population size ashore as predicted by a population growth model; and $\varepsilon_{t_{ij}}$ are independent and normally distributed errors with an expectation of zero and a constant coefficient of variation.

Population growth was modeled using exponential and generalized logistic difference equations. These are non-age and non-sex-structured, deterministic, discrete-time models where the annual time-step represents the pupping season. The exponential model assumes density-independent growth at an annually constant rate ($R_{\max}$):

$$N_{t_{ij}} = N_{t_{ij}-1} + N_{t_{ij}-1} R_{\max}. \tag{2}$$

The generalized logistic model assumes density-dependent growth where the rate of increase depends on the population size relative to the carrying capacity K:

$$N_{t_{ij}} = N_{t_{ij}-1} + N_{t_{ij}-1}\left[1 - \left(\frac{N_{t_{ij}-1}}{K}\right)^{z}\right]. \tag{3}$$

The shape parameter z determines the inflection point of the growth curve and hence the timing of the density-dependent effect relative to K. The intercept in both growth models is the abundance N_0 at an arbitrary starting time $t = 0$ (we chose 1968 since

[1] Personal communication from S. Jeffries, Washington Department of Fish and Wildlife, 7801 Phillips Road S.W., Tacoma, WA 98498, U.S.A., January, 2004.

estimates of statewide harbor seal abundance were available from the literature for that year).

Model Selection

Following Jeffries *et al.* (2003), we fit a total of six versions of the above models to our data: two exponential growth models and four generalized logistic growth models. The two exponential models differed by whether the parameter $R_{\max}$ was allowed to vary by region. Similarly, the four generalized logistic models differed by whether $R_{\max}$ and z varied by region. (N_0 and K were both assumed to vary by region.)

We used information-theoretic methods to evaluate our candidate models (Burnham and Anderson 1998). We first ranked our models according to the small sample version of Akaike's Information Criterion:

$$\mathrm{AIC}_{c_i} = -2\log(L_i) + 2m_i + \frac{2m_i(m_i+1)}{(n-m_i-1)}. \tag{4}$$

where L_i is the likelihood of model i, m is the number of parameters in the model (including the nuisance parameter), and n is the total number of surveys. We rescaled AIC_c values by subtracting the minimum from each value:

$$\Delta_i = \mathrm{AIC}_{c_i} - \min\mathrm{AIC}_c. \tag{5}$$

These rescaled values provided a ranking from best to worst where the larger the difference, the less plausible the model. Lastly, we calculated normalized Akaike weights for each of the M models, which can be interpreted as the "weight of evidence" in favor of model i:

$$w_i = \frac{\exp\left(-\frac{1}{2}\Delta_i\right)}{\sum_{i=1}^{M}\exp\left(-\frac{1}{2}\Delta_i\right)}. \tag{6}$$

Goodness of fit of the global model (generalized logistic with regionally varying $R_{\max}$ and z) was tested using a Kolmogorov-Smirnov (KS) test to assess whether the standardized residuals were normally distributed.

Parameter Estimation

Parameter estimates for N_0, $R_{\max}$, K, and z were obtained by maximum likelihood (Jeffries *et al.* 2003). This was carried out using an optimization search algorithm in a Fortran program. The optimization was constrained such that the predicted population size was not allowed to exceed K (*i.e.,* over-shooting and oscillation about K was considered noise) and $z \geq 1$ (*i.e.,* density-dependence was restricted to occur at or above $K/2$).

We based our inferences on the single "best" approximating model as identified by the Akaike weights. We estimated the conditional variance of model parameters *via* parametric bootstrapping (Efron and Tibshirani 1993, Jeffries *et al.* 2003). Parametric bootstraps were generated using the maximum likelihood estimates from the best model to generate a "true" population growth curve. Noise was then added to the data in the form of normally distributed residuals from the assumed statistical model. The model was then refit to this new data and a set of new maximum likelihood estimates were generated and stored. We did this 10,000 times and computed the mean, standard error and percentile confidence limits for the 2.5 and 97.5 percentiles for each parameter (*i.e.,* N_0, R_{max}, K, and z).

OSP Determination

We determined whether harbor seals were within their OSP range by comparing the most recent predicted index of population size ($\hat{N}_{2003}$) with MNPL (Gerrodette and DeMaster 1990), where MNPL was estimated based on an approximation in Polachek (1982):

$$\text{MNPL} \approx K(z+1)^{(-1/z)}. \qquad (7)$$

For each parametric bootstrap we computed the ratio $\hat{N}_{2003}$/MNPL. If the lower bound of the 95% confidence interval for the ratio did not include one, then we concluded the population was within its OSP range.

Absolute Abundance Estimation

We estimated the absolute abundance of the 2002 statewide harbor seal population in Oregon by multiplying the mean harbor seal count for that year by a correction factor of 1.53 (Huber *et al.* 2001). The correction factor, developed from aerial surveys of radio-tagged seals in Oregon and Washington, adjusts the observed count of seals upwards to account for animals in the water. We included pups in our mean count since the correction factor is based on an assumed sex and age distribution that included pups. Furthermore, since we wanted a statewide estimate, we included all known haul-outs in our count, not just those used for the trend analysis described above. (The 2002 surveys were used instead of the 2003 survey because fog prevented counts of some of the southernmost haul-outs in 2003.)

Results

Trends in Relative Abundance

From 1977 to 2003 observed counts of non-pup harbor seals ashore nearly doubled in the southern survey region and increased by a factor of four in the north (Table 1, Fig. 2). Of the two types of growth models considered, the generalized logistic models clearly approximated the observed count data better than the exponential models ($\Delta_i \geq 41.78$; Table 2), thus providing evidence for density-dependent growth. Although AIC_c values for all four generalized logistic models suggested they were plausible ($\Delta_i \leq 2.12$; Table 2), we based our inferences on the single best approximating model ($w_i = 0.457$; Table 2). This model suggested that maximum growth rates differed between regions but the inflection points of the growth curves were equal (Table 3). We found no evidence of a lack of fit for our global model ($KS = 0.06$, $P = 0.5$).

OSP Determination

Given that the best approximating model suggested that z was constant between regions, we pooled our regional estimates of K to compute MNPL (as well as other

Table 1. Average annual counts of non-pup harbor seals ashore for two survey regions in Oregon, 1977–2003.

	Average count (n surveys)		
Year	North coast	South coast	Total
1977	616 (1)		
1978		1,749 (1)	
1979			
1980			
1981			
1982	764 (1)	1,946 (1)	2,710
1983	999 (3)	2,409 (2)	3,407
1984	1,009 (1)		
1985	1,115 (2)	2,641 (2)	3,756
1986	991 (3)	2,341 (1)	3,332
1987	1,463 (1)	2,523 (2)	3,986
1988	1,564 (2)	2,916 (2)	4,480
1989	1,907 (2)	3,137 (3)	5,044
1990	1,880 (1)	2,945 (1)	4,825
1991	1,676 (1)	2,917 (2)	4,593
1992	2,501 (2)	3,007 (4)	5,508
1993	2,330 (1)	2,872 (1)	5,202
1994	2,185 (1)	2,496 (1)	4,681
1995	1,907 (1)	2,338 (1)	4,245
1996	2,159 (3)	2,471 (3)	4,630
1997		2,849 (1)	
1998	2,513 (1)	2,816 (1)	5,329
1999	1,780 (1)	2,627 (2)	4,407
2000	1,644 (1)	2,916 (1)	4,560
2001	1,652 (2)	2,827 (2)	4,479
2002	2,155 (2)	3,103 (2)	5,258
2003	2,436 (2)	3,055 (2)	5,491

parameters) (Table 4). None of the bootstrap replicates for $\hat{N}_{2003}$ were below MNPL which is consistent with the hypothesis that harbor seals in Oregon, as indexed by non-pups counted ashore, were within their OSP range. Harbor seals were estimated to be nearly at their estimated carrying capacity (99% of K, Table 4).

Absolute Abundance

The mean coastwide count of harbor seals (pups and non-pups) in Oregon during May–June 2002 was 6,607 animals (SE = 295.7; 5,505 non-pups and 1,102 pups). Multiplying the mean count by the correction factor of 1.53 (SE = 0.1; Huber *et al.* 2001) to account for the number of seals in the water yielded an estimated total of 10,087 animals (95% CI: 8,445–12,046).

Discussion

While the Pacific harbor seal is distributed from Baja California, Mexico, northward to Alaska, for management purposes the U.S. National Marine Fisheries

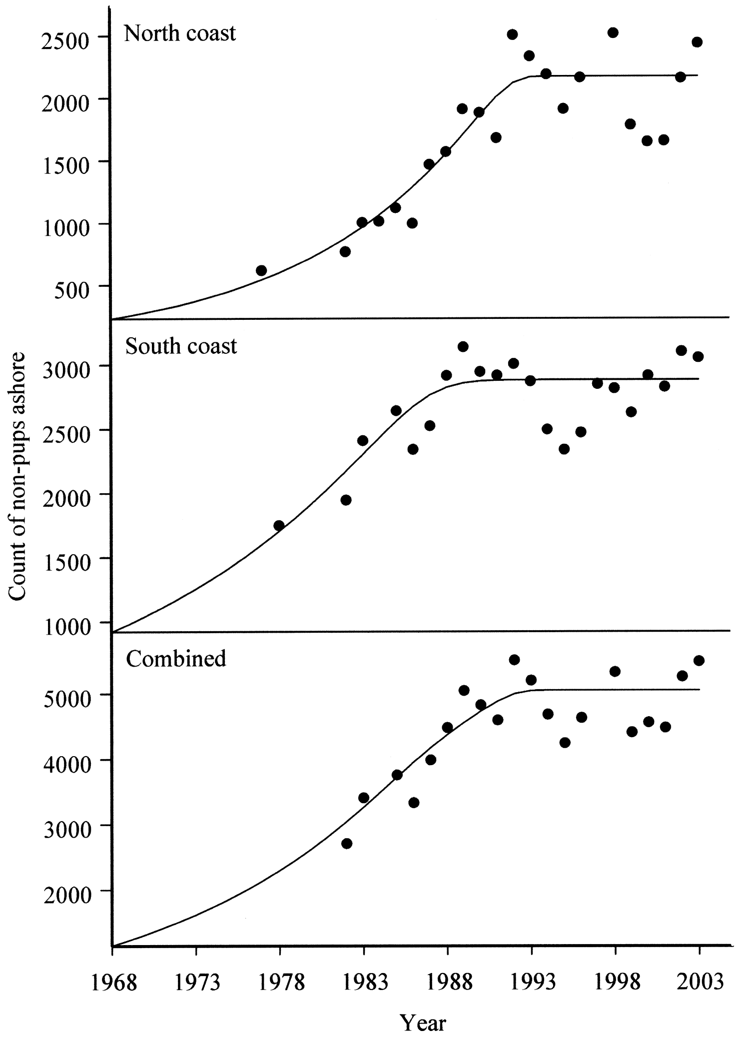

Figure 2. Average (circles) and predicted (line) counts of non-pup harbor seals ashore for two survey regions in Oregon. The combined total represents the sum of the regional averages and predicted values.

Service (NMFS) divides the population into different stocks based on various criteria including genetics, movements, pupping dates, and fishery interactions (Angliss and Lodge 2004, Carretta *et al.* 2004). Harbor seals in Oregon are considered to be part of the Oregon/Washington coast stock, which extends from the California-Oregon border north to Cape Flattery, Washington. While there is strong evidence for separation between the Washington inland waters stock and the Oregon/Washington coast stock, the separation between the Oregon/Washington coast stock and the California stock is largely a "political/jurisdictional convenience" (Carretta *et al.* 2004). Additional information (*e.g.*, new genetic

Table 2. Model selection results for exponential and generalized logistic growth models fit to counts of non-pup harbor seals ashore in Oregon, 1977–2003.

Model	R_{max}	z	Log L	m	AIC_c	Δ_i	w_i
Generalized logistic	Regional	Constant	24.44	9	−28.04	0	0.457
Generalized logistic	Constant	Regional	23.67	9	−26.49	1.54	0.211
Generalized logistic	Constant	Constant	22.18	8	−26.11	1.92	0.174
Generalized logistic	Regional	Regional	24.73	10	−25.92	2.12	0.158
Exponential	Regional	NA	−0.23	6	13.74	41.78	0
Exponential	Constant	NA	−7.75	5	26.39	54.44	0

analyses) will be needed to more appropriately characterize harbor seal stock structure in the southern Oregon and northern California region. Nonetheless, we believe that the results of our trend analysis, when considered with those of Jeffries *et al.* (2003), provide evidence that the Oregon/Washington coast stock is currently above its MNPL and within its OSP range. This conclusion, however, rests upon at least several other considerations which are discussed below.

Trend Counts

Environmental covariates such as tide (Terhune and Almon 1983), time of day (Thompson and Harwood 1990), weather (Watts 1992), and date (Frost *et al.* 1999) have been shown to affect the number of seals hauled out at given times and locations. Harbor seal monitoring programs have sought to control for these environmental factors either before data are collected through study design (Jeffries *et al*. 2003) and/or after data are collected through analysis (Frost *et al.* 1999, Boveng *et al.* 2003, Small *et al.* 2003). We chose the former approach.

In the model formulation we used, it was assumed that the average proportion of the population that was hauled out during our surveys was constant. Conceptually, this proportion represents a detection probability (p) which can be thought of more

Table 3. Parameter estimates from generalized logistic growth model with regional growth rates (R_{max}) and a constant shape parameter (z). Point estimates are maximum likelihood estimates (MLE); standard errors and percentile confidence intervals (10,000 replicates) are from parametric bootstraps based on MLEs from the selected model.

Parameter	Region	Estimate	SE	95% confidence interval: Lower	95% confidence interval: Upper
N_{1968}	North	229	58.5	90	295
	South	920	295.4	203	1,280
K	North	2,171	157.3	2,104	2,682
	South	2,882	70.1	2,828	3,109
R_{max}	North	0.101	0.037	0.086	0.20
	South	0.064	0.070	0.046	0.27
z	Both	10.10	3.83	1.06	11.49
CV[a]	North	0.147			
	South	0.097			

[a] Estimated coefficient variation of the errors (ε).

Table 4. Parameter estimates for OSP determination for harbor seals in Oregon. Point estimates, standard errors, and percentile confidence interals (10,000 replicates) are from parametric bootstraps based on MLEs from the generalized logistic growth model with regional growth rates (R_{max}) and a constant shape parameter (z).

Parameter	Region	Estimate	SE	95% confidence interval	
				Lower	Upper
$\hat{N}_{2003}$	Combined	5,241	124.5	5,009	5,500
MNPL	Combined	3,184	586	2,617	4,185
$\hat{N}_{2003}$/MNPL	Combined	1,703	0.297	1.245	1.955
$\hat{N}_{2003}/K$	Combined	0.991	0.0114	0.967	1
MNPL/K	Combined	0.603	0.122	0.505	0.803

broadly as all the factors influencing the probability of whether an animal is encountered or detected (Buckland *et al.* 2001). If p varied randomly among surveys, then this could be expected to manifest itself in an increased variation in counts and increased variance in the parameter estimates. If p changed systematically over time, then this would result in a biased estimate of population trend.

Sources of variation in p include observer effects, environmental conditions, and attributes of the animal itself (Anderson 2001, Buckland *et al.* 2001). Observers, for example, may differ in their ability to detect animals (while flying and/or counting) based on their training, experience, interest, and fatigue. Likewise, environmental conditions such as season, time of day, tide, and weather may affect whether a seal is hauled out and hence available for detection. Finally, attributes such as the size and coloration of an animal that might make it more or less conspicuous than other individuals may affect its detectability. We sought to minimize these sources of variation by (1) having the majority of the surveys flown (and photographs counted) by the same people, (2) only flying under a specific set of environmental conditions (see methods), and (3) only including non-pups in our trend analysis (which we believed had a more constant probability of detection than pups).

Despite our efforts, survey counts were likely affected to some degree by uncontrolled sources of variation. We were not overly concerned, however, since the effect size we were measuring was large (2–4 fold observed increases), our time series was long (27 yr), and our study design held many covariates relatively constant (*e.g.,* observers, tidal stage, time of day). Frost *et al.* (1999) noted that under this set of circumstances, it may be possible to evaluate population trends without concern for covariate effects. We acknowledge, however, that the precision of our estimates might be increased by using a covariate adjustment approach, as well as by increasing the number of replicate flights flown per year.

More worrisome than random variation in p would be a case in which there was a systematic trend in p over time (Anderson 2001). In this situation, an apparent trend in abundance would be confounded with a trend in detectability. Jeffries *et al.* (2003) noted that one plausible scenario for a time-trending p would be if there was an inverse relationship between seal population density and time spent ashore due to increased intraspecific competition for food resources. They examined this scenario by comparing the proportion of seals ashore in Oregon and Washington in 1991–1992 *versus* those ashore in 1999–2000 (Washington only) and found that while some small decreases in p did occur, they were not inconsistent with their conclusions that seal numbers in Washington had stabilized. We did not conduct a similar comparison and therefore must assume that, as in Washington, no trend in the proportion of seals hauled out occurred in Oregon during our time series.

Population Dynamics

One axiom of population biology is that populations do not increase indefinitely (Williams *et al.* 2002). For large mammals, a basic assumption has been that their populations increase until they are in equilibrium with the environment, and that this equilibrium is achieved through a density-dependent response in population growth that occurs near carrying capacity (Fowler 1981, 1987). This assumption was inherent in the MMPA and in the definitions of OSP and MNPL (Taylor and DeMaster 1993, Ragen 1995, Wade 1998, Taylor *et al.* 2000). In reality, however, it is unlikely that populations have a fixed equilibrium point (Wolda 1989, Harwood and Rohani 1996; but also see Koetsier *et al.* 1990, Turchin 1995). Instead, population regulation and limitation processes likely produce a "stationary distribution of population densities" (Dennis and Taper 1994). Furthermore, there are likely to be multiple "densities" at which a population moves between as environmental conditions and limiting factors change (Williams *et al.* 2002). For example, Hucke-Gaete *et al.* (2004) studied the recovery of Antarctic fur seals (*Arctocephalus gazella*) in the South Shetland Archipelago and proposed that the carrying capacity had declined by an order of magnitude over the past two centuries. Small *et al.* (2003) suggested that the carrying capacity for pinnipeds in the Gulf of Alaska had declined following a climate-regime shift in 1977. In contrast, Bowen *et al.* (2003) reported on the sustained exponential growth of Sable Island (Nova Scotia) grey seal pup production over nearly 40 years in spite of considerable environmental variability.

Gerrodette and DeMaster (1990) noted the implications to the MMPA of changes to carrying capacity when they stated: "whether current or historical carrying capacity is to be used when making an OSP determination is presently an unresolved issue in marine mammal management [in the U.S.]." While we do not know what historic carrying capacity for harbor seals in Oregon might have been, we speculate that carrying capacity may have recently increased as a result of a reversal in the Pacific Decadal Oscillation. This reversal marked a shift in coastal ocean conditions off the west coast of the contiguous United States from a warmer, inhibited productivity period (Pearcy 1992, Hare and Mantua 2000) to a colder, enhanced productivity period (Emmett 2002, Peterson and Schwing 2003). Interestingly, much of the observed increase in harbor seal abundance reported here occurred during the warmer, inhibited productivity period (perhaps as a result of initial low abundance). In Oregon, improved ocean conditions have resulted in increased salmonid (*Oncorhynchus* spp.) survival and increased densities of zooplankton (Peterson and Schwing 2003) and forage fishes (Emmett 2002, Emmett[2]).

Although the harbor seal population in Oregon appeared to stabilize in the 1990s, we do not know the underlying regulatory mechanisms that limited its continued growth. However, since no evidence of unusual disease-related mortality was observed, and many additional areas with apparently suitable habitat remained unused, we suspect that one limiting factor may have been food supply. If so, the

[2] Personal communication from R. Emmett, National Marine Fisheries Service, Hatfield Marine Science Center, Newport, OR 97365, U.S.A., March, 2004.

recently improved ocean conditions may remove food as a limiting factor and hence result in an increase in carrying capacity for seals in this region. Whether this turns out to be the case or not, we nonetheless conclude that, when viewed within the existing MMPA framework, our results support the conclusion that the Oregon/ Washington coast stock is currently above its MNPL and within its OSP range.

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Why a management procedure approach? Some positives and negatives

Doug S. Butterworth

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The origin of the management procedure (MP) approach (sometimes termed management strategy evaluation), with its simulation testing of feedback-control algorithms as a necessary and structured basis for dealing with the inevitable uncertainties associated with fisheries assessments, is briefly reviewed. Also discussed are the advantages that overcome some of the difficulties of the "traditional" approach of coupling an annual "best" assessment to some harvest control rule, such as a failure to consider longer-term trade-offs properly. The MP approach does, however, also have disadvantages, such as the length of time typically required for its development and an argued inflexibility after implementation. Solutions that have been developed to overcome some of these difficulties are discussed.

Keywords: assessment, management procedure, operating model, precautionary approach, risk, simulation testing, trade-offs, uncertainty.

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D. S. Butterworth: Marine Resources Assessment and Management Group, Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch 7701, South Africa. tel: +27 21 6502343; fax: +27 21 6502334; e-mail: doug.butterworth@uct.ac.za

Introduction

This topic is most readily addressed by comparing the management procedure (MP) approach with what might be termed the "traditional" approach (TA) to the provision of scientific recommendations for management measures [such as total allowable catches (TACs) or allowable effort levels] for fishing marine resources.

Typically, the TA involves developing a "best assessment" of the resource, i.e. a mathematical evaluation that integrates all available data for and understanding of the resource to provide estimates of, in particular, past and present resource abundance and productivity. This is then augmented in some manner to translate these results into, say, a TAC recommendation, e.g. by the application of a reference-point-based harvest control rule or consideration of resource trends predicted under future alternative constant-catch scenarios. In many cases, this process is repeated as frequently as annually.

An MP is formally a formula to provide, say, a TAC recommendation, where the inputs to the formula (essentially resource monitoring data) have been pre-specified. To that extent, it seems no different from the TA. However, the core difference is that this formula has been tested by simulation to confirm that it can be expected to get reasonably close to concurrently achieving appropriate trade-offs among the mutually conflicting objectives of maximizing catches, minimizing interannual catch variability in the interests of industrial stability, and minimizing the risk of substantial depletion of the population that could put future use of the resource in jeopardy. Importantly, though, it must also be shown to be able to achieve this even if the current best assessment of the resource is in error (at least to a degree that is within the bounds of plausibility). Therefore, it is by design compatible with the precautionary approach (PA), by making appropriate allowance for scientific uncertainties. Crucially, it relies on the mechanism of feedback control to adjust for inevitable errors in current perceptions about the resource (the "uncertainties").

The MP approach was first developed by the Scientific Committee of the International Whaling Commission (IWC) during the late 1980s. In 1974, the "New Management Procedure" (NMP) had been adopted as a basis to provide advice on catch limits (IWC, 1976; Punt and Donovan, 2007), a typical example of the TA. However, a decade later, the approach was seen to have failed for two main reasons: (i) the NMP proved unable to meet its intended role of facilitating scientific agreement on catch-limit recommendations, because debate simply moved from what might be an appropriate catch-control law to arguments about parameter (such as maximum sustainable yield (MSY)) values, when implementing that law for a particular case, and (ii) even if agreement could have been reached about the best estimates of those parameters, arguments then developed about how the inevitable scientific uncertainty about those values should be taken into account. The process of developing the IWC "Revised Management Procedure" (RMP) (IWC, 1989; Kirkwood, 1992), initiated by the pioneering work of de la Mare (1986) and with its eventual product accepted by the IWC Scientific Committee in 1991 (IWC, 1992), deliberately focused on resolving these two problems and did so by the process set out above, which is now taken to define an MP.

At about that same time, the desirability of adopting a PA in the management of renewable natural resources was gaining general acceptance, following broad statements to this end adopted by UNCED in Rio de Janeiro in 1992, but it was unclear how to put the PA into effect operationally. The FAO (1995) Technical Consultation on the Precautionary Approach to Capture Fisheries, held in Lysekil, was organized to address this very point. The report of that meeting implicitly endorsed the MP approach developed by IWC by expressing the need for "management plans" involving "decision rules" to be developed, in conjunction with a directive that "a management plan should not be accepted until it has been shown to perform effectively in terms of its ability to avoid undesirable outcomes". Note that the evaluation of such "performance" necessarily implies some simulation testing.

After summarizing major difficulties (primarily in implementation) with the TA in fisheries management, the main advantages of the MP approach are listed below, emphasizing how they resolve those TA problems. However, the MP approach introduces some new difficulties, and I conclude by explaining those and suggesting how they can be addressed. The presentation is framed in terms of providing advice on TACs, but the comments made would apply similarly to management under effort limitation.

Difficulties with the TA

Variability in "best assessments" from year to year, and hence in associated TAC recommendations

This type of variability can arise for three reasons: new data becoming available, primarily from resource-monitoring sources such as surveys and commercial catch per unit effort (cpue); modified methods to refine such data for inputs into stock assessment (e.g. standardization through generalized linear modelling of cpue series); and (supposed) improvements to the assessment methodology. As a consequence, the recommended TAC can vary independently of the true population dynamic processes, for example, as a result of estimation error in the first case or even change in the opposite direction to trends in resource indices in the other two cases.

Inability to consider longer-term trade-offs properly

An evaluation of the trade-off between long-term catches and risk to the resource is fundamental to sound fisheries management. However, risk can be properly evaluated only based on simulating repeated application of a decision rule because, except for short-lived species, no immediate threat to the resource arises from taking catches somewhat in excess of sustainable levels. The common TA of making catch projections based on a best assessment (even if taking account of estimation error and uncertainty about future recruitment) can overestimate risk appreciably, because the management responses that would follow given future resource monitoring data are not considered. For example, if these provided firm evidence of deteriorating stock status, a recommendation to reduce the TAC would undoubtedly follow and adjust the risk downwards.

Lengthy haggling

Even in nominally objective scientific gatherings, discussions during the process of selecting a singular TAC recommendation can become wastefully protracted through attempts (perhaps linked to interest-group agendas) to squeeze agreement to small changes (up or down). These may be based on argued improvements that would arise from minor modifications to data choices or methods used. Generally, however, such changes reflect only noise, rather than improved detection of resource trends from noisy data, and they add no real value to the advice generated.

What if the "best assessment" is wrong?

The TA does not include any formal basis to make proper allowance for uncertainties, which means that the best assessment at any particular time could be considerably in error. Simple approaches to address such uncertainties, such as basing decisions on the most conservative assessment alone (see critique in Butterworth *et al.*, 1996) or on a lower 95% confidence bound on an estimated TAC, can be wasteful of the resource by setting catches much lower than is needed to avoid real risks of unintended depletion of the population.

Default decisions of "no change"

In the numerous instances of assessment uncertainty that occur in practice, management agencies frequently fall back on the default decision of no change as the easiest path to take. In international fora, where change requires a consensus among participating parties, this problem is particularly acute. The ensuant procrastination usually results in whatever action is eventually taken as being too little, too late.

Advantages of the MP approach

Less time spent haggling to little long-term benefit

The flaw in the IWC's NMP was that it stopped with the specification of the catch-control law. A true MP also needs pre-specification of the data to be used, together with a pre-specified estimation method. The latter transforms the input data into the information required for the computation of a TAC in accordance with the control law. This pre-specification (i.e. before any implementation) of both the formule used and their inputs eliminates room to discuss and modify these each year, which can save considerable time. A classic example of this benefit has been provided by the experiences of the South African Rock Lobster Scientific Working Group when converting from a TA to an MP approach: the total of 40 meetings needed in the previous year to finalize the TAC recommendation was reduced to only four in 1997 when an MP was first implemented for the fishery for *Jasus lalandii*.

Haggling time saved can be put to better use

An important byproduct of the MP development process is the identification of those scientific uncertainties that cause the greatest difficulties in meeting risk-related performance criteria. This in turn clarifies the focus areas for longer-term research to help resolve such uncertainties, and perhaps thereby allow for enhanced harvests with the same perceived risk. Reducing haggling time, and the pressure to address short-term issues, creates the opportunity to focus more on longer-term research efforts designed to resolve these more important uncertainties in assessments.

Proper evaluation of risk

Using medium-term projections, the simulation testing framework provides the appropriate basis for an evaluation of risk. Importantly, it generates new resource-monitoring data for each new year, then re-applies the MP formula, so that allowance is made for feedback effects primarily using the updated trend information to self-correct (at least to some extent) for earlier errors made in TAC recommendations.

Providing a sound basis to put limits on interannual TAC variability

Orderly industrial development requires fairly steady TACs. Under the TA, it is impossible to judge what externally imposed constraint on the extent to which the TAC can be allowed to vary from year to year might be set without jeopardizing resource status. In contrast, evaluation of the implications of alternative levels for such constraints is readily achieved through the MP-testing framework. For the short-lived pelagic species dominating the South African purse-seine fishery, the capability to address this desirable feature for management of the fishery in an objective way has proved particularly advantageous, with industry showing particular interest in plots showing the trade-off between bigger catches and lesser TAC stability. This trade-off arises because, if limitations are set on the rate at which a TAC may be reduced, the TAC cannot be allowed to increase to too high a level either; otherwise, it may become impossible to reduce the TAC fast enough to counter drops in abundance arising, perhaps, from some years of environmentally driven poor recruitment.

Consistency with the PA

As the MP simulation testing framework includes not only the best assessment, but also robustness tests to reflect the scientific uncertainties of this assessment, consistency with the PA is ensured.

Providing a framework for interactions with stakeholders, particularly regarding objectives

The MP approach enforces consideration of the long-term as well as the short-term developments. Because many of the objectives of sound management pertain to the former, this prompts clearer thinking among stakeholders. Moreover, the process of scientists neutrally reporting the range of trade-offs available, from within which it is for stakeholders to make the choice, facilitates enhanced interactions among all players. This in turn promotes those players' buy-in to the MP selected and to the TAC recommendations, which it subsequently provides.

Providing a default

Some haggling may nevertheless be unavoidable, particularly in international settings where member states tend to accord primary priority to maintaining their recent catches. In national situations, the state, which ultimately decides the TAC, is distinct from the potential beneficiaries of that decision (the fishing companies), so the decision may reflect broader objectives than the typical emphasis on shorter-term priorities of such companies. However, in international settings, the states become the beneficiaries while still remaining the decision-makers, which in turn creates additional pressure for a no change decision as the only one that can achieve consensus. An important role for an MP in this situation is to output a "default" TAC calculation as the fall-back position, to replace the current no change default that may expose the harvested population to undue risk.

Disadvantages of the MP approach and how they can be addressed

Lengthy development time

The development and review of an MP for a fishery requires more time (at least a number of months) than TA assessments to arrive at a TAC recommendation (typically in 1 or 2 weeks in scientific committees of regional organizations). However, once the MP is in place, non-productive scientific and political haggling time in later years is greatly diminished. Experience has emphasized the importance of avoiding "backtracking" during the extended development/review process, i.e. once a certain stage of the process has been reached, such as specification of the set of models of resource dynamics for simulation testing, the next stage must be undertaken without allowing new hypotheses or information to be placed on the table to take the process back towards its beginning in a potentially infinite loop. As elaborated in Punt and Donovan (2007), the IWC (2005a) set down a schedule to complete the development or review process for selecting which variant of its RMP to apply to a specific species and region over five meetings within a 2-y time frame. This was not to abort new insights developed after such deadlines; rather the place for their consideration was accepted to be the next MP review. Reviews are planned at intervals of 5 y in the IWC framework, but for shorter-lived species, shorter intervals may prove more appropriate.

An overly rigid framework

Decision-makers sometimes desire flexibility to have the "wriggle" room required by the political process, which may have to take heed of the socio-economic realities of the moment. This can be addressed by designing MPs which output a range of TAC options, rather than a single number. The simplest version of such an approach is a "block quota" awarded for a number of years, with a specified maximum amount (somewhat higher than the annual average for the period) that can be taken each year if the block quota is not exceeded over the full period. However, such extensions require that the MP evaluation process include a model of how the choice within the available range is to be made each year. Necessary robustness to possible choices that lead to more negative impacts on the population introduces a cost to such flexibility. This is likely by way of either lower future TACs on average or higher interannual TAC variability, if the perceived risk is to be kept unchanged. As discussed below, the MP review process also provides a mechanism that allows participants to address argued needs for flexibility.

Trusting an autopilot?

An MP is analogous to an autopilot, with the associated advantages. However, this does not mean that the aircraft should be left without a pilot. The pilot must remain on board to look out for unexpected major course deviations that may not have been factored into the design, including appreciable changes in scientific perceptions concerning the resource. Therefore, the MP under consideration for southern bluefin tuna (*Thunnus maccoyii*) includes provisions for updated assessments at regular intervals to ensure that the resource has not moved outside the range over which the MP was designed to operate (CCSBT, 2005). Similar provisions are being adopted for South African fisheries managed under MPs (MCM, 2006). If compelling evidence becomes available, planned reviews at wider time intervals can be brought forward.

Such reviews also provide the opportunity to assess whether the objectives originally chosen, and which the control parameters of the selected MP were "tuned" to achieve, remain appropriate under possibly changed socio-economic circumstances. Importantly, though, decisions to change objectives, or to bring reviews forward, must first ensure that the rationale offered is indeed compelling. Otherwise, such mechanisms can degenerate into surrogates to tinker with outputs each year in a manner that frustrates the advantages that the MP approach seeks to achieve—genuinely appreciable changes in scientific perceptions about a resource are typically not annual events.

Non-availability of, or "poor", data inputs

Care needs to be taken in designing MPs that the future monitoring data assumed to become available for input to the TAC-computing algorithm are indeed likely to eventuate. Nevertheless, the design process needs to consider the possibility that such data either are occasionally not collected or are deemed inadequate for use (e.g. because a small sample size raises questions of whether such data are representative). Simple ways of dealing with occasional gaps in data (e.g. use the same value as for the previous year) need to be pre-specified, with their adequate performance confirmed in robustness trials. If such gaps develop more regularly, however, it may become necessary to consider bringing the regular MP review forward (see provisions in MCM, 2006). Another possible mechanism to consider would be an appropriate adaptation of the IWC RMP, which stipulates a period over which a TAC is phased down to zero, if an abundance survey anticipated in the testing process within a certain period fails to materialize (IWC, 1994). This provides an incentive to encourage continuation of the necessary resource monitoring.

Reference case selection

Evaluation of the achievement of specified quantitative objectives, such as resource recovery by a certain amount within a specified time frame, is dependent on, and can be quite sensitive to, the choice of the "reference case" operating model (or plausibility-weighted "reference set" of such models over which performance statistics are integrated; Plagányi *et al.*, 2007; Rademeyer *et al.*, 2007) that is used for such computations in the testing and tuning process. In other words, the MP approach does not fully escape, in its fullest sense, the difficulties of selecting a best assessment. Naturally, the TA has exactly this same problem, but the MP approach has the advantage of having tested for the adequacy of feedback to correct for any errors, which can to some extent compensate for a poor initial choice of a reference case.

A related problem can arise if such a quantitative, risk-related objective is framed in terms of the probability of not having abundance decrease below a certain level. Even if it is agreed that "low" plausibility scenarios be excluded from consideration (IWC, 2004), arguments can ensue about whether or not certain hypotheses are sufficiently plausible to merit retention, particularly if they are perceived to influence the conclusion as to whether the objective is met. Hypotheses about more complex stock structure in particular tend to raise difficulties because of Type II error problems: the absence of significant evidence from, for example, genetic data to support such hypotheses is not necessarily sufficient to classify them as implausible. Punt and Donovan (2007) outline an innovative "research-conditional" approach adopted by the IWC Scientific Committee to address this problem (Donovan and Hammond, 2004; IWC, 2005b).

Conclusion

The MP approach can solve most, though not all, of the problems of the traditional "best assessment + control rule" approach. Although it does introduce additional difficulties, these can largely be resolved by operating in accordance with sound protocols (IWC, 2005a; MCM, 2006). The greatest advantages are probably: (i) a sound basis to limit the extent of future TAC variations without compromising resource status and (ii) the proper way of addressing concerns about scientific uncertainty through simulation testing to ensure that feedback secures reasonably robust performance across a range of plausible alternative resource dynamics.

As an afterthought, three decades ago, the major issue in global fisheries management was the collapse of several large fisheries for small pelagic species (e.g. Peruvian anchoveta, *Engraulis ringens*; Namibian sardine, *Sardinops sagax*), primarily as a result of over-exploitation to which the management response had come too late. The primary lesson from these events was summarized by Alec MacCall in a speech around 1980 (subsequently reflected in MacCall, 1996) as: "agree beforehand what remedial action to take if negative signals are forthcoming from the resource, rather than risk socio-economic arguments being advanced to delay action in tandem with wishful thinking that the situation will rectify itself." MacCall's invocation is no more than the theme underlying the MP approach: all stakeholders (industry, conservationists, scientists, and managers) need to agree the rules before a fisheries management game is played.

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Abundance and population structure of seasonal gray whales in the Pacific Northwest, 1998-2008

(SC/62/BRG32)

John Calambokidis, Jeffrey L. Laake, Amber Klimek

Abstract

The existence of a small number of eastern North Pacific gray whales that spend the spring, summer and fall feeding in coastal waters of the Pacific Northwest has been known for some time and localized and short-term studies have examined aspects of the natural history of these animals. We report the results of an 11-year (1998-2008) collaborative study examining the abundance and the population structure of these animals conducted over a number of regions from Northern California to British Columbia using photographic identification. Some 12,679 identifications representing 872 unique gray whales were obtained. Gray whales seen after 1 June (after the northward migration) were more likely to be seen repeatedly and in multiple regions and years and 1 June was used as the seasonal start date for the data included in the abundance estimates. Gray whales using the Pacific Northwest in summer and fall include two groups: 1) whales that return frequently and account for the majority of the sightings and 2) apparent stragglers from the migration seen in only one year, generally for shorter periods and in more limited areas. Abundance estimates for whales present in summer and fall using three different methods and different geographic scales revealed the abundance of animals to be at most a few hundred individuals. The proportion of calves documented was generally low but varied dramatically among years and may have been biased downward by weaning of calves prior to much of the seasonal effort. Observations of calves returning to the Pacific Northwest in subsequent years documents one possible mechanism for recruitment. The results we present will be valuable in assessing the impacts of potential resumption of a gray whale hunt by the Makah Tribe, currently proposed to target migrating whales by hunting prior to 1 June.

1 Introduction

Although most gray whales in the Eastern North Pacific stock migrate each spring from calving lagoons in Baja Mexico to feeding grounds in the arctic, the existence of gray whales that spend the spring, summer and fall feeding in coastal waters of the Pacific Northwest has been known for some time. Starting in the 1970s, photographic identification demonstrated that some whales returned regularly to feed off the west coast of Vancouver Island (Darling 1984). The proximity of these whales to the traditional whale hunting grounds of the Makah Tribe coupled with the Tribe's interest in resuming gray whale hunts in the 1990s made determination of the status and number of these whales of greater importance to management.

Beginning in 1998, a collaborative effort among a number of research groups was initiated to conduct a range-wide photographic identification study of gray whales in the Pacific Northwest (Calambokidis et al. 2000, 002b). An initial publication of findings from 1998 demonstrated there was considerable movement of individual whales among sub-areas from northern California to southeastern Alaska (which we broadly refer to as the Pacific Northwest) and also provided initial estimates of the abundance of whales within that geographical area (Calambokidis et al. 002a). The ability to look at movements and employ more sophisticated capture-recapture models, however, was restricted by the lack of multiple years of data with broad geographic coverage. A subsequent report by Calambokidis et al. (2004) characterized the group of whales feeding in these survey areas during the summer-fall period as a "Pacific Coast Feeding Aggregation" (PCFA). They proposed that a smaller area within the PCFA survey areas – from Oregon to Southern Vancouver Island (OR-SVI) – was the most appropriate area for abundance estimation for managing a Makah gray whale hunt (Calambokidis et al. 2004).

The collaborative effort to collect photographic identifications of gray whales from California to Alaska has continued since 1998 and these data now cover 11 years (1998-2008) and span fifteen survey regions along the coast from Southern California to Kodiak, Alaska (Figure 1). We provide estimates of abundance for the summer-fall seasons (1 June to 30 November) for survey regions comprising different combinations of subareas within this range.

2 Methods

Gray whales were photographed during small boat surveys conducted from California to Alaska by Cascadia Research, National Marine Mammal Laboratory and collaborating researchers between 1998 and 2008. Gray whale identifications were divided into the following regions (Figure 1): 1) SCA: Southern California, 2) CCA: Central California, 3) NCA: Northern California, 4) SOR: Southern Oregon, 5) OR: central Oregon, 6) GH+: Gray's Harbor and the surrounding coastal waters, 7) NWA: Northern Washington coast, 8) SJF: Strait of Juan de Fuca, 9) NPS: Northern Puget Sound, 10) PS: which includes southern Puget Sound, Hood Canal (HC), Boundary Bay (BB) and San Juan Islands (SJ), 11) SVI: Southern Vancouver Island, 12) WVI: West Vancouver Island, 13) NBC: Northern Vancouver Island and coastal areas of British Columbia, 14) SEAK: Southeast Alaska, and 15) KAK: Kodiak, Alaska. The NWA and SJF survey areas together make up the Makah Usual and Accustomed grounds (MUA). With some exceptions, research groups work primarily in one or two regions. Details of identifications obtained by the different research groups are briefly summarized below and are listed in Tables 1-2.

o National Marine Mammal Laboratory: NMML obtained identification photographs of 1159 gray whales representing 336 unique individuals sampling all years from 1998 to 2008 (except for 2004) from a variety of locations from northern California to Kodiak, Alaska. Identification photographs were mostly taken while conducting dedicated surveys for gray whales.

o Cascadia Research Collective: Cascadia obtained identifications photographs of gray whales on 1306 occasions representing 372 unique individuals. Surveys were conducted in all years using 5.3 m rigid hull inflatable boat at a wide range of locations from California to Southeast Alaska.

o Humboldt State University: HSU conducted surveys primarily off northern California from 1998 to 2002 and in 2008 and obtained 360 identifications of 156 unique whales.

o Brian Gisborne, Juan de Fuca Express: Brian Gisborne obtained identification photographs every year from 1998 to 2008 primarily along the West Coast trail of southern Vancouver Island during daily trips of this region. He obtained 5318 identifications of 297 unique whales.

o Jim Darling, West Coast Whale Research Foundation: Jim Darling provided identification photographs obtained during surveys along the west coast of Vancouver Island primarily from Clayoquot Sound to Barkley Sound in 1998, 2001, and 2002. These yielded 99 identifications of 59 unique whales.

o Coastal Ecosystems Research Foundation: CERF conducted regular surveys from 1998 to 2008 off British Columbia north of Vancouver Island primarily in the vicinity of Cape Caution. Identification photographs were obtained on 2289 occasions representing 107 unique individuals.

o University of Victoria: UVIC obtained identifications photographs from Clayoquot Sound north along the west side of Vancouver Island every year from 1998 to 2002 except 2001. Identification photographs were obtained on 760 occasions of 137 unique individuals.

o Volker Deecke, independent researcher: Obtained identification photographs of gray whales from 1998 to 2001 and 2006 off British Columbia and in Southeast Alaska including 170 photographs of 74 unique animals.

o Wendy Szanislo, independent researcher: Wendy Szanislo obtained identification photographs of gray whales from 2005 to 2008 along the west coast of Vancouver Island. She obtained 407 identification photographs of 101 unique whales.

o Makah: Makah tribal biologists conducted surveys along the coast of Northern Washington and into the Strait of Juan de Fuca from 2004 to 2008. They obtained 575 photos of 121 unique individuals.

o Other: Various independent researchers that have contributed photographs and related information.

Each year from 1998 to 2008, between 545 and 1490 identifications were obtained of gray whales totaling 12679 photos of 872 unique gray whales for the entire period (Table 1). These were conducted from March through November with most effort from June to September. Surveys were most numerous in British Columbia, along the south and west coasts of Vancouver Island and just north of Vancouver Island (Table 2).

2.1 Photographic Identification Procedures

Procedures during surveys by different groups varied somewhat but were similar in identification procedures. When a gray whale was found, the time, position, number of animals, and behaviors were recorded. Whales were generally approached to within 40-100 m and followed through several dive sequences until suitable identification photographs could be obtained.

For photographic identification of gray whales, both left and right sides of the dorsal region around the dorsal hump were photographed when possible. Most identification photographs were obtained with 35mm cameras most often with large 300mm lenses. We also photographed the ventral surface of the flukes for identification when possible. The latter method was not as reliable as the sides of the whale because the gray whales did not always raise their flukes out of the water. Markings used to distinguish whales included pigmentation of the skin, mottling, and scarring, which varied among individuals. These markings have provided a reliable means of identifying gray whales (Darling 1984). We also identified gray whales using the relative spacing between the knuckles along the ridge of the back behind the dorsal hump. The size and spacing of these bumps varies among whales and does not change over the years we have tracked whales. Figure 2 shows typical photographs and features used in making gray whale identifications.

Comparisons of whale photographs were made in a series of steps. All photographs of gray whales were examined and the best photograph of the right and left sides of each whale (for each sighting) were selected and printed (7 x 2.5 inch). To determine the number of whales seen during the year, the prints were then compared to one another to identify whales seen multiple days. Finally a comparison was made to the CRC catalog of whales seen in past years. Whale photographs that were deemed of suitable quality but did not match our existing catalog (compared by two independent persons) were considered "unique" identifications and assigned a new identification number and added to the catalog.

2.2 Data Analysis

The abundance of gray whales was estimated with open and closed population models for four nested spatial scales consisting of contiguous survey regions (Figure 1; Table3) 1) NCA-SEAK: the survey regions from Northern California (NCA) through Southeast Alaska (SEAK), 2) OR-NBC: survey regions from southern Oregon through Northern Vancouver Island/British Columbia (NBC), 3) OR-SVI: survey regions from southern Oregon through Southern Vancouver Island (SVI), and 4) MUA-SVI: the survey regions from MUA which includes Northern Washington coast (NWA) and Strait of Juan de Fuca (SJF) and SVI . The proposed hunt by the Makah Tribe would be in NWA. Gray whales photographed and identified anytime during the period between 1 June and 30 November (hereafter referred to as the "sampling period") within the defined region were considered to be "captured" or "recaptured". For each unique gray whale photographed, a capture history was constructed using the eleven years of data from 1998-2008. For example, the capture history 01001001000 could represent a gray whale photographed in 1999, 2002 and 2005 in the PCFA. The same gray whale may have had a capture history 01001000000 for a smaller spatial scale such as OR-SVI or may not have been seen at all (00000000000) and would not be used for the smaller spatial scale.

Multiple "detections" of a single whale within the sampling period were not treated differently than a single detection. A "1" in the capture history meant that it was detected on at least one day during the sampling period. However, multiple detections in the same year were used to construct an observed minimum tenure (MT) for each whale. MT was defined as the number of days between the earliest and latest date the whale was photographed with a minimum of one day for any whale seen.

2.2.1 Abundance using closed population models

Closed models for capture-recapture assume that the population is both geographically and demographically closed with no losses or gains. Due to births/immigration and mortality/emigration, closure would not be a reasonable assumption for the 11 year period but previous analysis has assumed closure for two consecutive years (e.g., Calambokidis et al. 2004). For those abundance estimates, a Lincoln-Petersen (LP) estimator (Seber 1982) was used in which each of the consecutive years (June-November) was a sampling occasion. Thus, it was assumed that all whales that were available to be photographed from June-November, 1998 were also available to be photographed from June-November 1999 and vice versa. If new whales joined in 1999 or whales from 1998 did not return in 1999, the closure assumption would be violated. A sequence of abundance estimates can be constructed using each consecutive pair of years (e.g., 1998-1999,1999-2000, etc). It is well known that the LP estimator can be unbiased even if there are losses or gains (Seber 1982) but not both (Kendall 1999) except for a completely random movement model. A completely random movement model is unlikely in this case because with more than 20,000 whales there would be few if any matches between years if movement in and out of the area was completely random.

The losses and gains each year are primarily from “transient” whales that are seen in one of the years and are never seen again in any other year. To remove this source of bias, we developed the following ad-hoc approach to remove the transients. For each pair of years in the computation of abundance with the LP estimator, we only used whales that were seen in one or more years other than the years being considered. For example, in computing an abundance estimate for 1999-2000 we only used whales that were also seen in 1998 or at least one year after 2000. This removed any transients that would have only been seen in either 1999 or 2000. It also removes those seen only in both years; while these are technically not transients their removal was unavoidable using this approach. This was done for each year pairing and we have called this estimation method “Limited LP”.

2.2.2 Abundance using open population models

In addition to the closed models, we fitted open population models to the 11 year time series of capture history data for each spatial scale to estimate abundance and survival. Open models allow gains due to births/immigration and losses due to deaths/emigration. Using the RMark interface (Laake and Rexstad 2008) to program MARK (White and Burnham 1999), we fitted a range of models to the data using the POPAN model structure. The POPAN model structure (Schwarz and Arnason 1996) provides a robust parametrization of the Jolly-Seber (JS) model structure in terms of a super population size (N), probability of entry parameters (immigration), capture probability (p), and survival/permanent emigration (φ).

It is essential to consider the population structure and its dynamics to build adequate models. In particular, we know from previous analysis of a subset of these data (Calambokidis et al. 2004) that some whales were seen in only one year between June-November and were never seen again. Transient behavior is a well-known problem in capture-recapture models and it is often addressed using a robust design which involves coordinated multiple capture occasions within each year and typically assumes closure within the sampling period (June-November). Region-wide coordinated surveys may be possible but would be difficult with variation in weather conditions. Also, the closure assumption within the year would be suspect due to variable timing of whales arrivals and departures into the PCFA. We also know from prior analysis that whales newly seen in year (y) were less likely to return (i.e., seen at some year >y) than previously seen whales but also newly seen whales that stayed longer (i.e., longer MT) in the PCFA were more likely to return. Likewise, previously seen whales were more likely to be seen in the following year (y+1), if they stayed longer in year y. Calambokidis et al. (2004) postulated that these observations were consistent with whale behavior that was determined by foraging success/failure.

Transient behavior in which an animal is seen only once can be modeled by including a different "first year" survival (Pradel et al. 1997) for the newly seen animals. Survival in the time interval after being first seen is dominated by permanent emigration rather than true mortality. Survival in subsequent time intervals represents true survival under the assumption that animals do not permanently emigrate except in their first year. To accommodate the "transient" effect, the whales were divided into cohorts based on the year in which they were first seen. Each cohort's first year survival was allowed to vary from subsequent survivals. "Newly seen" is not a particularly useful concept for the first year of the study (1998), because all whales are being seen for the first time. Thus, we also considered a model that allowed for a different first year survival and effect of MT for 1998 than for 1999-2007 and another model in which each cohort had a different first year survival. We also considered models that allowed a different first-year survival for whales identified as calves under the presumption that their true survival might be lower but that there probability of returning to the PCFA might be higher. In total we considered 8 models for survival (Table 5).

A cohort-specific super-population size was estimated for each cohort. These sizes were estimates of the number of whales that used the PCFA (or subset) during the sampling period for their first time. The estimated population size will be as large or larger than the number of whales newly seen during the year. This was a departure from Calambokidis et al. (2004) who assumed that all whales that were in the PCFA (or subset) were never missed and that capture probability reflected temporary emigration. In effect, Calambokidis et al. (2004) assumed each cohort super-population size was the number that were observed. The accidental discovery of a large number of whales in an area far offshore of Oregon in 2007 (Oleson et al. 2009; Calambokidis et al. 009b) made it particularly clear that this was a poor assumption. Thus, here we have not made this restrictive assumption and have chosen to use the standard assumption in JS models that newly seen whales have the same capture probability as previously seen whales. Lacking broad-scale data from a prior year, to estimate a cohort size for 1998 we had to assume that detection probability in 1998 was the same as in 1999 to make the former parameter estimable. We fitted 3 models for capture probability that varied by time (year) and/or varied by MT in the previous year (Table 5).

We used the individual covariate MT which was both whale and time-specific but we don't know those values for whales that were not caught. Thus, to fit these models we assumed that the covariate values for missed whales was the same as the average covariate value of captured whales. This was accommodated by centering the covariate values in each year such that the median was 0. Missed whales ("0" in the capture history) were assigned a value MT=0 and abundance estimation for each year was based on the median MT (centered 0 value).

We used Test 2 and Test 3 results from the Cormack-Jolly-Seber structure (Lebreton et al. 1992) as a general goodness of fit for the global model and as a measure of possible over-dispersion creating the lack of fit. We fitted each combination of models for S (survival) and p (capture probability) and used AICc (Burnham and Anderson 2002) to select the most parsimonious model of the 18 fitted models. Model averaging was used for all 18 models to compute estimates and unconditional standard errors and confidence intervals.

3 Results

The database from all eleven years (1998-2008) contains 12679 records; however 1930 are replicate identifications of whales on the same day. The database contains photographs of 872 unique whales seen from Southern California to Kodiak, Alaska with an average of 12.3 sightings/whale (range: 1- 202) where a "sighting" is one or more photographs on a day. Only 51.9% of the whales were seen on more than one day but many of these identifications are from early in the season during the migration as well as from peripheral areas such as Kodiak, Alaska (Table 6).

3.1 Seasonality

Whales have been photographed in every month of the year (Table 6) but with very few during December-February when most of the whales are in or migrating to Mexico and survey effort is reduced. Previous analysis of these data have always used 1 June - 30 November as the sampling period to describe the whales in the PCFA because whales seen prior to 1 June are more likely to be whales that are migrating through the region. The separation between May and June is clearly supported by the data. For example, of the 872 unique whales, 204 whales were only seen before 1 June and 84.3% of those were only sighted once. In comparison, of the 668 whales sighted between June and November, 40% were only sighted once. If sightings in Alaska are excluded, then only 32.7% of the 566 were seen only once.

The break between May and June is apparent in various measures such as proportion of whales sighted more than once, sighted in more than one region, and sighted in more than one year (Figure 3). However, the break is more apparent if the identifications are divided into subsets of survey regions (Figure 4). In particular, the difference across months is not as strong for regions such as the inland waters of Washington and British Columbia (NPS, SJF) because these are whales that have diverted from the migration and are either more likely to remain after 1 June or demonstrate high year-to-year fidelity during spring such as with NPS. The pattern across months is also weaker for Southern Vancouver Island

(SVI) which is in the main migration corridor; however, that is due to sampling efforts being focused on the spring herring spawn in Barkley Sound (effectively an inland waterway) and therefore undersampling passing migrant whales (Brian Gisborne, pers. comm.). The break between May and June is much more apparent for NWA and the other areas in the migration corridor. These observations are consistent with the northbound migration of gray whales proceeding past Washington through May. Resighting rates of whales seen after 1 June remained high through November.

The proposed Makah gray whale hunt will occur in NWA after 30 November and prior to 1 June. There have been 74 whale sightings in NWA prior to 1 June of which 20.3% (15) were of whales that were seen in the PCFA after 1 June at some time. All of those whales were sighted after 1 June in SVI and over 80% (12 whales) were seen in MUA (Figure 5). Of those 12 whales, 11 were seen in NWA, 9 were seen in SJF and only 1 whale was seen in SJF that was not seen in NWA. In comparison, 23 whale sightings were in SJF prior to 1 June of which 82.6% (19) were of whales that were seen in the PCFA after 1 June at sometime, emphasizing the importance of restricting a hunt to coastal waters of the MUA (i.e., the NWA) to limit the take of whales from the PCFA. Therefore, with a proposed hunt in the winter/spring in NWA, an assessment of impact on whales in the PCFA needs to consider a target population of whales contained in MUA and SVI after 1 June because all or most of the whales seen in the NWA before 1 June and seen after 1 June in the PCFA are likely to be found in the MUA and SVI.

3.2 Regional Sighting Patterns

There is considerable variation in the annual regional distribution of numbers of whales photographed during the sampling period (Table 7) which is in part due to variation in effort. Although not a true measure of effort, the number of days whales were seen (Table 8) does reflect the amount of effort as well as abundance of whales. In particular, in comparison to other regions, the large number of sightings in SVI partly reflects large numbers of sampling days by Brian Gisborne who has routinely sampled SVI 2-3 days a week. On the other hand, the decline in sightings in SVI during 2007 was not due to reduced effort but to the distribution of whales with many of the whales having moved to waters off Oregon and Washington (Calambokidis et al. 009b).

Whales were sighted across various survey regions and the interchange of whales (Table 9) between survey regions during 1 June - 30 November depends on proximity of the regions (Calambokidis et al. 2004). Of the whales sighted in regions from SOR to NBC, depending on the region, from 57-73% of the whales were seen at some point within MUA-SVI (Figure 6). However, whales seen in California or Alaska were much less likely to be seen in MUA-SVI.

If we look at latitudes of sightings of individual whales across the 11 years using whales that have been sighted on at least 6 different days (Figure 7), we see that sightings of some whales are highly clustered; whereas, sightings of other whales are highly dispersed across several regions. We defined each whales primary range by the 75% inner quantile which is the middle of the range that includes 75% of the locations. The length of the 75% inner quantile in nautical miles exceeded 60 nautical miles (or 1 degree of latitude) for 40% of the whales (Figure 8) and it was more than 180 nautical miles for more than 15% of the whales. Thus, it makes little sense to compute an estimate of abundance for any region that spans less than a degree of latitude.

There was a large variation in the frequency of sightings for whales (Table 10). Most whales that were seen during June-November 1998-2008 in the PCFA (NCA to NBC) were only seen in one year and the whales that were seen in more years were sighted more often each year and therefore represented a large proportion of the sightings (Figure 9). Likewise, examination of MT in the first sighting year demonstrates that whales who stay longer in their first year were more likely to be seen in a following year (Figure 10). Whales "first" seen in 1998 includes some whales that were truly new to the PCFA in that year but many were only "new" because it was the first year of the study. This is evident (Figure 10) in the much higher proportions for 1998 than for the other years. These relationships are important in capture-recapture models for abundance estimation. For example, in an open population model, whales that do not return after their first year (a large percentage in this analysis) would appeared to have not survived because they have permanently emigrated (with a small fraction that died).

3.3 Mothers and calves

While a relatively low proportion of calves have been sighted from the summer and fall sightings of gray whales, 33 different gray whales identified as PCFA whales were seen as definite or probable mothers with calves representing 41 likely births, six whales were seen with calves multiple seasons (two or three) (Table 11). Two individuals were sighted with calves in three years, the most we documented, however, in both cases one of these calves was documented outside the 1998 to 2008 primary study period. One individual (ID#81) was observed with a calf in 2001, 2003, and 2009 (not all data from 2009 has been analyzed) and the other individual (ID#67) was seen with a calf in 1995, 2002 and 2004.

Four of the 41 calves occurred outside our primary study period, three prior to 1998 and one known female who was known to have a calf in 2009, leaving 37 or just over three per year during our primary study period 1998-2008 (Table 12). These likely represent a minimum estimate of the births occurring because: 1) collaborators did not always note the presence or absence of calves, 2) as described below, calves weaned from their mothers, making them unidentifiable as calves, as early as June and July. Both these factors would tend to result in underestimates of the presence of calves.

The number of mothers of calves seen varied dramatically by year from 0 to 9 and was concentrated in a four-year period (2001-2004) which accounted for 28 of the 41 sightings. During this 4-year period an average of 7 calves were seen while an average of just over one calf per year was seen in the other seven years (9 calves in 7 years). Even among these known or suspected mothers, the proportion of years they were seen where they had a calf average only 14% although it was 39% and 36% during the peak years of 2001 and 2002, which would be closer to what would be expected if females were getting pregnant almost every other year.

In 18 cases, a calf was seen associated with its mother early in the season and then either the mother or the calf was resighted later in the season apart, suggesting weaning had occurred. The latest a mother was seen associated with its calf was 6 September (CRC 67 with calf CRC 698 in 2002) and there were indications of separation of calves from their mothers as early as June. In two cases either the mother or calf was seen separated in June, however, in neither case was the calf resighted in the future year (although the mother was) suggesting these calves may not have survived. In at least seven cases the weaning had occurred prior to a July sighting (and possibly earlier).

Of the 33 likely mothers documented, 20 had been seen four or more years in the study area (13 had been seen only 1, 2, or 3 years). Even those animals with long sighting histories were seen with calves in only a small proportion of the years but as shown in Table 11, often the initial sighting of these animals was in late August or later, past the period when weaning may have occurred.

Some of these whales commonly seen in the Pacific Northwest were sighted with calves outside of this region and the somewhat atypical locations may suggest they may behave differently in years they have a calf. One mother (ID#281) was regularly sighted in the PCFA area including every years from 1999 to 2007. In only one of those years was she with a calf (2002). In 2008, however, she was seen on 19 April off Santa Barbara, Southern California apparently in the migration with a small calf but neither of them were seen that year in any of our effort farther north from Northern California to Southeast Alaska. Another case not included in our summary because the calf was never seen in the our study area and also there was uncertainty of who was the mother, was an apparent calf (ID 962) sighted off San Miguel Island on 27 July 2006 but which was accompanied by two adults (ID 359 and 718) both of whom were seen in most years from 2002 to 2008 in the Pacific Northwest (Northern California to Southeast Alaska), but not in 2006. Both the mothers and calves from these two sightings were not seen in the Pacific Northwest in their birth year (despite the mothers being seen most other years) and were only opportunistically sighted outside the region, suggesting there may be other calves born to animals that use the Pacific Northwest that perhaps do not come into sampled areas (either within or outside the Pacific Northwest) in their birth year. This would negatively bias estimates of the number of calves born to these animals.

One important question in evaluating the population structure of the gray whales using the Pacific Northwest feeding areas is how animals are recruited to this group. We examined the sighting histories of the identified calves to determine if they tended to be seen in future years. Animals that were not seen in future years could reflect either mortality in the first year of life or animals that did not continue to feed in the Pacific Northwest in future years. There were 39 calves or suspected calves identified with their mothers through 2008 in the study area. Just under half of these (18) had been seen only in the year they were calves and 21 (54%) had been resighted in years after they were calves. Using only the 30 calves seen through 2004 (to allow a follow up period to resight animals, 19 (63%) have been resighted in a later year. The 37% not seen in a following year could be the result of: 1) the calf dying, 2) the calf not returning to the area or not yet resighted during its return, or 3) the calf not being recognized by photo-ID since calves can undergo changes in markings rapidly especially if not seen for several years. Given all these factors the resighting rate of calves does suggest a high proportion of surviving calves appear to become part of the small feeding aggregation that uses the Pacific Northwest.

3.4 Open Population Capture-Recapture Models

If the yearly cohorts were pooled, Test2+Test3 statistics indicated a significant lack of fit for the PCFA and subsets (Table 13) primarily resulting from Test 3. This was expected due to the different "survival" rates of previously seen whales (true survival) and newly seen whales of which many never returned (i.e., permanently emigrated) (Table 14) . By separating the cohorts, survival for each cohort was time-varying and thus each cohort has a separate first year survival. In this case, the goodness of fit test (Test 2 only) did not demonstrate a lack of fit except for OR-NBC and NCA-SEAK. For those regions, we estimated over-dispersion values of $\widehat{c}$=2.11 and $\widehat{c}$=2.28 respectively, to adjust AICc and estimated standard errors. The lack of fit for OR-NBC and NCA-SEAK is probably related to the inclusion of NCA, WVI and NBC which are at the fringes of the PCFA. Effort in NCA and WVI has been less regular than the other survey regions and whales in NBC have a higher degree of interchange with Alaska.

The best fitted model (Table 15) was always model 2 for p. For φ the best model depended on the spatial scale. For MUA-SVI and OR-SVI, model 7 was best with some support for model 8. For OR-NBC and NCA-SEAK, simpler models for φ with fewer parameters were supported due to the assumed over-dispersion. As shown in Calambokidis et al. (2004), the analysis demonstated strong support for the effect of MT on first year survival (Figure 11-12) and capture probability (Figure 13) in the following year for all spatial scales. First year survival estimates were dominated by permanent emigration. For MUA-SVI, the estimates varied from 0.18 to 0.47 for non-calf whales with MT=1 in their first year and from 0.63 to 0.93 for MT>80 in their first year (Figure 11). For calves, they were more variable but generally higher presumably because they were more likely to return in a following year. Survival subsequent to the first year was assumed to be constant and represent true survival assuming there was little permanent emigration after the first year. Those estimates were 0.951 (se=0.0112), 0.95 (se=0.0098), 0.948 (se=0.0123) and 0.945 (se=0.0118)for MUA-SVI, OR-SVI, OR-NBC, NCA-SEAK respectively. For the analysis of MUA-SVI, there was large year to year variation in capture probability from 0.18 to 0.94 depending on the year and value of MT (Figure 13). The lowest values were from 2007 which reflects the temporary emigration of whales from MUA and SVI to waters offshore of Oregon in that year.

3.5 Abundance and Recruitment

For MUA-SVI, OR-SVI, OR-NBC, and NCA-SEAK annual estimates of abundance were constructed with LP, Limited LP and model averaged values for the POPAN models (Figure 14, Tables 16-21). Estimates are only shown for 1999-2008 because with the closed models only 10 estimates can be constructed with the 11 years of data. In general, the estimates from the POPAN models are intermediate between the higher estimates from LP and lower estimates of Limited LP. This was expected because Limited LP estimates the abundance of whales excluding transient whales; whereas, LP attempts to estimate a total abundance which includes transient whales except that it is positively biased because there are losses and gains in each set of years. The POPAN models allow for gains and losses and the estimate of abundance each year includes the estimate of the new whales that entered that year and the number that have survived (i.e., lived and did not permanently emigrate) from whales seen in previous cohorts. The annual abundance estimate from the POPAN models includes some transient "new" whales that will permanently emigrate and thus should be higher than the Limited LP estimate which excludes transients. The abundance estimates from Limited LP for 2008 are biased low because new whales that enter that year have no chance to be re-sighted and thus they excluded even though some may return in the ensuing years. To a lesser degree, the estimates of 2007 and possibly 2006 are influenced in a similar manner because the whales may have been simply not seen yet even though they are returning.

Excluding the LP estimator which will be biased high and the Limited LP estimates for 2008 which will be biased low, the most recent N_{min}values range from 109 (Table 18) to 211 (Table 21) across the four spatial scales. To gain a sense for how these values might be relevant to estimating a possible level of removal (e.g., due to harvest) we ran calculations using the MMPA's Potential Biological Removal (PBR) formula (typically reserved for stock-level assessments). Using the PBR formula, with a default Rmax of 4% and a recovery factor of 1, the PBR for this group of whales would be 2.2 to 4.3. For the smallest region considered (MUA-SVI), the PBR would range from 2.2 to 2.5 whales for the 2007 limited LP (Table 18) and 2008 POPAN estimates (Table 20).

New whales have continually appeared annually and many of these new whales have subsequently returned and been re-sighted (Table 14). In MUA-SVI from 1999-2008, an average of 22.7 (range: 5.0, 56.0) new whales were seen each year. Of these new whales, on average 10.1 (range: 1.0, 19.0) whales returned and were seen in subsequent years. While these numbers vary annually there has been sufficient numbers of newly seen whales to replace a removal of at least 2 whales annually.

4 Discussion

The population structure of gray whales using the Pacific Northwest in summer and fall is complicated and involves two elements. One group of whales return frequently and account for the majority of the sightings in the Pacific Northwest during summer and fall. This group is certainly not homogeneous and even within this group, there is some degree of preference for certain subareas. Despite widespread movement and interchange among areas, some of these gray whales are more likely to be seen returning to the same areas they were seen before. The second group of whales are apparent stragglers encountered in this region after the migration. These animals are seen in only one year, tend to be seen for shorter periods that year, and in more limited areas.

The existence of these two groups in the study area and their dynamics complicate estimating abundance. The various methods we used here for estimating abundance try to deal with this in different ways. The estimates from the unadjusted Lincoln Petersen incorporate whales from both of these groups and the inclusion of the stragglers violates the closure assumption and creates a positive bias. This explains the higher estimate obtained with this method. The Limited Lincoln Petersen estimate specifically excludes the stragglers and only estimates the abundance of whales that return after the year of the initial sighting. It is useful except for the last year in which new whales that may return are excluded because they have not had a chance to return. The Limited Lincoln Petersen estimates were similar or slightly less than the estimates from the Open models because the latter include stragglers that were present in each year. However, the Open models are not biased like the unadjusted Lincoln-Petersen because they include a first year "survival" that is lower for those whales because they are less likely to return. The Open models should provide a better estimate of the annual number of whales that are present.

Despite extensive interchange among subregions in our study area, whales do not move randomly among areas. Abundance estimates were lower when using more limited geographic ranges but these more limited areas do not reflect closed populations. While the use of geographically stratified models can be useful in cases where populations have geographic strata they use (see for example Hilborn 1990), this would be difficult in our case because of the frequent sightings of animals in multiple regions within the same season and these models typically only allow an animal to be sighted in one strata per period. This could be dealt with by assigning animals to only a single region per season but this would be forcing the data into a somewhat inaccurate construct.

Several studies have considered the question of gray whale population structure. There is widespread agreement that at least two populations of gray whales in the North Pacific exist, a western North Pacific population (also called the Korean population) and an eastern North Pacific (ENP) population (sometimes called the California population) (Swartz et al. 2006; Angliss and Outlaw 2008; Rugh et al. 1999). The population structure of the gray whales feeding in the Pacific Northwest has remained in question and only a few studies have examined this. Steeves et al. (2001) did not find mtDNA differences in a preliminary comparison of gray whales from the summer off Vancouver Island and those from the larger ENP population. Ramakrishnan et al. (2001) did not find evidence that the Pacific Northwest whales represented a maternal genetic isolate, although even very low levels of recruitment from the larger overall population would prevent genetic drift. More recently, Frasier et al. (in prep.) have examined mtDNA differences in a larger sample of gray whales from Vancouver Island than tested by Steeves et al. (2001) and found significant differences in the haplotype frequencies between that sample and data reported for the breeding lagoons off Mexico. The Frasier et al. (in prep) study has had some limitations including samples taken from a single primary location off Vancouver Island, comparison to the breeding lagoons (where genetic differences in the lagoons have also been reported), and no verification by microsatelite analysis that whales have not been duplicated. However, Frasier et al. (in prep) provides the strongest evidence to date that the Pacific Northwest whales might be sufficiently isolated to allow maternally inherited mtDNA to differ from the overall ENP population.

Population structure in other large whales has been the subject of recent inquiry and has revealed diverse results for different species. Clapham et al. (2008) examined 11 subpopulations of whales subjected to whaling that were extirpated possibly due to the loss of the cultural memory of that habitat and concluded subpopulations often exist on a smaller spatial scale than had been recognized. Studies of other baleen whales, particularly humpback whales, have shown evidence of maternally directed site fidelity to specific feeding grounds based on photographic identification studies (Calambokidis et al. 1996, 2001, 2008). This high degree of fidelity to specific feeding areas is often discernible genetically. In the North Pacific strong mtDNA differences were found among feeding areas even when there was evidence of low level of interchange from photo-ID (Baker et al. 2008). Similar findings were documented for humpback whales in the North Atlantic which feed in different areas but interbreed primarily on a single breeding ground (Palsboll et al. 1995) like ENP gray whales. In the North Pacific the differences for humpback whales were often dramatic. For example, humpback whales that feed off California have almost no overlap in mtDNA haplotypes with humpback whales feeding in Southeast Alaska (Baker et al. 1990, 1998, 2008). One difference between humpback and gray whales is the coastal migration route of gray whales which means gray whales going to arctic waters to feed would migrate right through the feeding areas to the south. Other species of large whales have not shown as strong site fidelity to specific feeding grounds. Blue whales have undergone an apparent shift in their feeding distribution in the North Pacific apparently due to shifting oceanographic conditions (Calambokidis et al. 009a). Fin whales in the North Pacific have long migrations and while there do not appear to be multiple distinct feeding areas as was the case for humpback whales, there were some distinct and isolated apparently non-migratory populations (Mizroch et al. 2009; Berube et al. 2004).

Even though the population structure of gray whales off the Pacific Northwest remains unresolved, there is a consistent group of animals that use this area and we provide several estimates of their abundance. Different abundance methods and geographic scopes yield varied results but all suggest the annual abundance of animals using the Pacific Northwest for feeding through the summer is at most a few hundred animals depending on the estimating method and how broadly the region is defined geographically.

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Table 1: Contributions of numbers of photos and resulting number of uniquely identified whales by reseach group for 1998-2008. Totals for whales are unique whales across all research groups.

	Photos	Whales	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
B. Gisborne	5318	297	371	343	779	585	435	882	325	429	527	117	525
CERF	2289	107	101	145	243	456	290	173	779	11	42	11	38
CRC	1306	372	168	230	118	79	135	112	172	33	62	102	95
HSU	360	156	21	89	60	75	71	0	0	0	0	0	44
J. Darling	99	59	50	0	0	35	14	0	0	0	0	0	0
MAKAH	575	121	0	0	0	0	0	0	44	58	142	84	247
NMML	1159	336	132	194	133	128	88	76	0	133	93	39	143
Other	236	118	4	12	1	1	0	7	0	1	42	120	48
UVIC	760	137	351	159	128	0	121	0	0	0	0	1	0
V. Deecke	170	74	39	42	28	11	0	0	0	0	50	0	0
W. Szanislo	407	101	0	0	0	0	0	0	0	125	67	71	144
Photo Totals	12679	1878	1237	1214	1490	1370	1154	1250	1320	790	1025	545	1284
Whale Totals		872	156	248	176	198	253	178	195	205	185	157	222

Table 2: Regional distribution of numbers of photos and resulting number of uniquely identified whales by reseach group for 1998-2008. Totals for whales are unique whales across all research groups. NPS is northern Puget Sound and PS includes southern Puget Sound, San Juan Islands, Hood Canal and Boundary Bay.

	CA	NCA	SOR	OR	GH+	NWA	SJF	PS	NPS	SVI	WVI	NBC	SEAK	KAK
B. Gisborne	0	0	0	0	0	0	0	1	0	5155	160	2	0	0
CERF	0	0	0	0	0	0	0	0	0	0	0	2289	0	0
CRC	19	85	185	138	201	86	23	66	343	33	0	120	7	0
HSU	0	323	0	37	0	0	0	0	0	0	0	0	0	0
J. Darling	0	0	0	0	0	0	0	0	0	6	93	0	0	0
MAKAH	0	0	0	0	0	153	422	0	0	0	0	0	0	0
NMML	0	4	34	0	0	267	275	0	22	196	177	13	0	171
Other	13	1	0	118	0	1	8	11	35	4	0	4	16	25
UVIC	0	0	0	0	0	0	0	0	0	1	759	0	0	0
V. Deecke	0	0	0	0	0	0	0	1	0	122	0	43	4	0
W. Szanislo	0	0	0	0	0	0	0	0	0	214	193	0	0	0
Photo Totals	32	413	219	293	201	507	728	79	400	5731	1382	2471	27	196
Whale Totals	24	159	79	92	91	170	110	32	43	294	209	114	21	108

Table 3: Survey regions and region subsets used for abundance estimation. Numbers refer to locations on the map in Figure 1.

Survey Region	Region Description	NCA-SEAK	OR-NBC	OR-SVI	MUA-SVI
(1) SCA = Southern California					
(2) CCA = Central California					
(3) NCA = Northern California	Eureka to Oregon border; mostly from Patricks Pt. and Pt. St George	x			
(4) SOR = Southern Oregon		x	x	x	
(5) OR = Oregon Coast	Primarily central coast near Depoe Bay and Newport, OR	x	x	x	
(6) GH+ = Gray's Harbor	Waters inside Grays Harbor and coastal waters along the S Washington coast	x	x	x	
(7) NWA = Northern Washington	Northern outer coast waters with most effort from Cape Alava to Cape Flattery	x	x	x	x
(8) SJF = Strait of Juan de Fuca	US waters east of Cape Flattery extending to Admiralty Inlet (entrance to Puget Sound)	x	x	x	x
(9) NPS = Northern Puget Sound	Inside waters and embayments from Edmonds to the Canadian border				
(10) PS = Puget Sound	Central and southern Puget Sound (S of Edmonds), including Hood Canal, Boundary Bay, and the San Juan Islands				
(11) SVI = Southern Vancouver Island	Canadian waters of the Strait of Juan de Fuca along Vancouver Island from Victoria to Barkley Sound, along West Coast Trail	x	x	x	x
(12) WVI = West Vancouver Island		x	x		
(13) NBC = Northern British Columbia	British Columbia waters north of Vancouver Island, with principal effort around Cape Caution	x	x		
(14) SEAK = Southeast Alaska	Waters of southeastern Alaska with the only effort in the vicinity of Sitka	x			
(15) KAK = Kodiak, Alaska					

Table 5: Model specifications for survival (φ) and capture probability (p) parameters in POPAN models for gray whale photo-identification data. Fy is 1 if it is year the whale was first seen and 0 otherwise. Fc is 1 for 1998 cohort and 0 otherwise. C is 1 if identified as a calf in its first year and 0 otherwise. MT is minimum tenure (centered so median is 0 each year) of a whale in its first year and 0 otherwise. $\beta_{Fy,1999}$ is for cohorts 1999-2007 and $\beta_{Fy,C}$ represents 9 cohort specific parameters for 1999-2007 (for the first year survival). β_{CF} is an adjustment for calf first year survival andβ_{CM} is an adjustment for calves to the slope of MT for survival. For the capture probability models, β_t has 9 levels for t=2000,...2008 and β_0 represents 1998 and 1999 value. Each POPAN model includes 11 parameters for the initial sizes of the 11 year cohorts.

Model	Parameter Logit Formula	Number of parameters
φ		
1	$\beta_0 + \beta_{Fy} Fy$	2
2	$\beta_0 + \beta_{Fy} Fy + \beta_M MT\, Fy$	3
3	$\beta_0 + \beta_{Fy,1998} Fy + \beta_{Fy,1999}(1 - Fc) Fy$	3
4	$\beta_0 + \beta_{Fy,1998} Fy + \beta_{Fy,1999}(1 - Fc) Fy + \beta_M MT\, Fy$	4
5	$\beta_0 + \beta_{Fy,1998}\, Fy + \beta_{Fy,1999}(1 - Fc)\, Fy + \beta_{M,1998} MT\, Fy + \beta_{M,1999}(1 - Fc)\, MT\, Fy$	5
6	$\beta_0 + \beta_{Fy,1998} Fy + \beta_{Fy,C} Fy\,(1 - Fc) + \beta_M MT\, Fy$	12
7	$\beta_0 + \beta_{Fy,1998} Fy + \beta_{Fy,C} Fy\,(1 - Fc) + \beta_M MT\, Fy + \beta_{CF} C\, F_y$	13
8	$\beta_0 + \beta_{Fy,1998} Fy + \beta_{Fy,C} Fy\,(1 - Fc) + \beta_M MT\, Fy + \beta_{CF} C\, F_y + \beta_{CM} C\, MT$	14
p		
1	$\beta_0 + \beta_t$	10
2	$\beta_0 + \beta_t + \beta_M MT$	11
3	$\beta_0 + \beta_M MT$	2

Table 6: Regional distribution of numbers of whales seen by month for 1998-2008.

	1	2	3	4	5	6	7	8	9	10	11	12
CA	0	0	0	7	4	0	6	6	1	0	0	0
NCA	0	0	0	0	2	38	83	31	13	56	15	0
SOR	0	0	0	2	0	0	22	22	48	25	0	0
OR	0	0	0	0	2	7	30	47	41	34	0	0
GH+	2	0	10	39	14	15	2	0	27	1	0	0
NWA	0	0	4	6	63	18	44	68	49	28	4	0
SJF	0	0	2	9	8	11	21	26	46	68	44	11
PS-HC-BB-SJ	0	1	3	15	6	6	5	2	1	1	2	0
NPS	0	0	15	23	28	10	0	0	0	0	0	0
SVI	1	0	50	24	70	164	198	152	115	34	3	2
WVI	0	1	1	5	0	38	133	125	85	15	0	0
NBC	0	0	0	0	2	24	75	100	80	0	0	0
SEAK	0	0	0	0	0	12	4	1	3	0	5	0
KAK	0	0	0	0	0	0	23	52	44	0	0	0

Table 7: Regional distribution of numbers of whales seen during June-November for 1998-2008.

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
CA	0	1	0	5	0	0	4	0	3	0	0
NCA	15	38	27	32	37	15	3	0	0	1	47
SOR	0	0	0	2	46	24	13	1	0	23	15
OR	17	31	8	15	0	0	16	4	9	38	6
GH+	0	1	1	1	0	0	1	0	0	38	0
NWA	21	7	10	31	8	19	0	19	44	13	27
SJF	15	4	4	2	1	9	21	18	20	14	49
PS-HC-BB-SJ	3	8	4	0	0	0	0	1	0	0	0
NPS	0	0	10	0	0	0	0	0	0	0	0
SVI	60	45	52	102	66	90	86	91	70	34	77
WVI	57	66	53	29	85	9	0	54	40	13	23
NBC	23	26	23	40	44	51	91	12	21	5	21
SEAK	5	6	0	1	0	6	0	1	2	3	0
KAK	0	0	0	0	42	4	0	48	0	0	23

Table 8: Number of days in which whales were seen for each region and year from 1998-2008 from 1 June - 30 November.

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
CA	0	1	0	2	0	0	2	0	1	0	0
NCA	7	8	20	13	20	2	2	0	0	2	9
SOR	0	0	0	1	4	1	1	1	0	3	1
OR	6	9	5	7	0	0	1	1	7	38	1
GH+	0	1	1	1	0	0	1	0	0	3	0
NWA	22	10	7	11	4	9	0	12	13	7	11
SJF	15	9	8	4	1	15	5	14	17	25	34
PS-HC-BB-SJ	3	11	4	0	0	0	0	2	0	0	0
NPS	0	0	1	0	0	0	0	0	0	0	0
SVI	91	87	82	55	68	66	48	73	59	36	72
WVI	54	46	28	7	10	3	0	6	14	27	31
NBC	39	50	53	43	34	29	53	11	16	9	13
SEAK	2	3	0	1	0	3	0	1	2	2	0
KAK	0	0	0	0	4	2	0	7	0	0	5

Table 9: Interchange of whales across regions for all years (1998-2008) for June-November. The diagonal is the number of unique whales seen in that region over the 11 year time span. Here PS includes NPS and CA represents SCA and CCA.

	CA	NCA	SOR	OR	GH+	NWA	SJF	PS	SVI	WVI	NBC	SEAK	KAK
CA	13												
NCA	0	158											
SOR	3	33	77										
OR	1	34	39	91									
GH+	1	7	7	10	40								
NWA	0	24	32	42	16	108							
SJF	0	9	8	19	13	44	99						
PS	0	0	0	0	0	1	1	24					
SVI	4	40	39	54	29	91	61	1	250				
WVI	2	29	28	45	23	68	52	1	140	203			
NBC	2	8	9	21	14	28	25	1	73	70	112		
SEAK	0	1	1	1	1	2	3	0	7	8	10	21	
KAK	0	4	1	3	0	1	0	0	7	6	6	1	108

Table 10: Number of photographs by month in all regions and years(1998-2008)for a sample of whale IDs.

	1	2	3	4	5	6	7	8	9	10	11	12
6	0	0	0	0	2	1	1	4	3	2	0	0
73	0	0	0	0	0	0	5	3	0	0	0	0
123	0	0	0	0	0	22	54	18	6	1	0	0
175	0	0	0	0	4	21	35	35	19	4	1	0
226	0	0	0	0	1	10	29	20	12	1	0	0
252	0	0	0	0	0	0	0	0	0	0	1	0
273	0	0	1	6	1	0	0	0	0	0	0	0
300	0	0	0	0	2	14	42	22	12	2	0	0
322	0	0	0	0	0	3	19	10	8	2	0	0
362	0	0	0	0	0	0	0	1	0	0	0	0
383	0	0	5	22	2	0	0	0	0	0	0	0
405	0	0	0	0	2	0	0	0	0	0	0	0
428	0	0	0	0	0	0	1	0	0	0	0	0
451	0	0	0	0	0	0	1	2	2	0	0	0
476	0	0	0	0	0	0	2	0	0	0	0	0
507	0	0	0	0	0	0	4	8	10	1	0	0
529	0	0	0	0	0	7	18	13	11	2	0	0
553	0	0	0	0	0	0	1	0	0	0	0	0
574	0	0	0	0	0	3	3	0	0	0	0	0
595	0	0	0	0	0	3	0	0	0	0	0	0
618	0	0	0	0	0	0	0	0	1	0	0	0
639	0	0	0	0	0	0	1	2	0	1	0	0
664	0	0	0	0	0	0	0	1	0	0	0	0
691	0	0	0	0	0	5	3	6	2	0	0	0
713	0	0	0	0	0	0	0	0	1	0	0	0
734	0	0	0	0	0	0	0	3	0	0	0	0
755	0	0	0	0	0	0	0	1	0	0	0	0
776	0	0	0	0	0	1	0	0	0	0	0	0
802	0	0	0	0	0	0	1	0	0	0	0	0
823	0	0	0	0	0	0	5	3	6	1	0	0
848	0	0	0	1	0	0	0	0	0	0	0	0
869	0	0	0	0	0	0	0	1	0	0	0	0
892	0	0	0	0	0	0	0	0	4	0	0	0
917	0	0	0	0	0	0	0	0	1	0	0	0
941	0	0	1	0	0	0	0	0	0	0	0	0
963	0	0	0	0	0	1	1	0	0	0	0	0
984	0	0	0	0	0	0	0	0	1	0	0	0
1007	0	0	1	0	0	0	0	0	0	0	0	0
1029	0	0	0	0	0	0	1	0	0	0	0	0
1051	0	0	0	0	0	0	1	0	4	4	0	0
1072	0	0	0	0	0	0	1	0	0	2	0	0
1094	0	0	0	0	0	0	1	0	0	0	0	0

Table 11: History of mothers seen with calves during study. Each year a whale was seen, the first confirmed sighting date is shown for that year. Years where a calf was documented are shown in bold with an asterisk. Total years seen includes 9 sightings of whales during 1984,1988, 1990-1992 that are not shown but no calves were seen in those few cases.

Mother ID	Calves	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Years seen
43	2	21-Jul	**9-Jul***	22-Jul	15-Jul	9-Aug	11-Jul	16-Jul	19-Jun	**18-Jul***	12-Jul	24-Jun	4-Jul		7-Jul				16
67	3			**19-Jul***	2-Jul	6-Jul		10-Aug			**7-Aug***		**4-Jun***	3-Aug	4-May				9
80	2	14-Jul	25-Aug	23-Jun	8-Aug		8-Jun	27-Jun	3-Jul	7-May	**22-May***	27-Apr	25-Jun	**18-Jun***					12
81	3	14-Jul		19-Aug		23-Sep	14-Jun	21-Jun	29-Jul	**20-Jun***	24-Jun	**28-Jul***	23-Jul	3-Jul	4-Jul	16-Jun		**NA***	13
91	1	1-Aug					23-Jun		22-Jul	15-Aug	**5-Jul***	17-Jun		23-Jun		11-Jul	18-Jun		9
92	1	1-Aug			27-Jul	9-Aug	4-May	30-Jun	29-Jul	9-Jul	4-Aug	27-Jul	11-Jul	**27-Jun***	18-Jun	8-Jun	22-May		14
93	1	1-Aug			17-Jul	23-Sep	14-Jun	22-Jun	12-Aug	21-Jun	16-Jul	2-Aug	**30-Jun***		4-Jul		18-Jun		13
94	1	31-Jul	4-Aug				27-Jun	6-Jul	24-Jul	7-Jul	15-Jul	23-Jul	5-Aug	13-Jul	18-Mar	**8-Jul***	8-Jul		13
101	1		22-Jun	6-Sep	5-Sep		11-Jun	8-Jul	29-Jul	8-Jun	9-Jul	9-Aug	**15-Jun***	1-Aug	7-Jun	8-Jun	28-Jun		17
105	1		**9-Jul***				17-Jun	9-Jun	20-Jul	22-Jun	3-Jul	2-Aug	23-Jul	24-Jul	28-Jul	22-Jun			11
120	1									**13-Jun***	11-Jun		2-Jun						3
143	1						27-Jun	29-Jun	1-May	6-Jul	**29-Jul***	17-Aug		5-Sep	12-Mar	24-Mar	22-Jun		10
144	1						11-Jul	13-Aug	6-Sep	6-Jul	**5-Jul***	30-Mar	19-Jun	26-May	4-Jul	31-Mar	25-May		11
175	1			22-Jul	13-Jun	27-Jun	26-May	9-Jun	29-May	15-Jun	3-Jul	**12-May***	30-Jun	21-Jul	4-Jul	15-Jul			13
216	1					27-Jun	23-Aug	30-Jul	29-Jun	15-Jun	15-Jul	**26-Jul***	4-Jun	9-Jun					9
232	2						6-Jul		30-Jul	**5-Jul***	15-Aug	**9-Jun***							5
237	1						23-Jul	25-Jul	4-Jul	5-Jul	1-Jul	**29-Apr***	19-Jul						7
281	2							20-Jul	15-Jul	21-Jun	**17-Aug***	5-Sep	19-Jul	13-Aug	7-Jul	14-Sep	**19-Apr***		11
291	1						1-Oct	12-Jul	24-Aug	**8-Jun***	4-Aug	25-Jun	24-Jul	21-Jul	5-Jul		20-Oct		10
312	1						**12-Jun***			7-Jul									2
321	1						**25-Jun***												1
372	1							26-Jun	9-May		4-Aug	15-Jul	**25-Jun***	7-Jul	3-Jul	1-Sep			8
575	1									**5-Jun***									1
581	1									**5-Jun***					4-Jul	30-Jun			3
596	1									**26-Jun***	3-Jul								2
612	1								23-Jun	**1-Aug***	1-Jul	5-Jun	1-Jul	18-Jul	5-Nov				7
683	1										**25-Jul***		27-Oct	18-Jun					3
684	1										**4-Jul***	11-Aug							2
717	1										**3-Jul***								1
801	1											7-Jul	2-Aug	**3-May***					3
815	1												**19-Jun***				14-Jul		2
973	1															**14-Sep***			1
993	1														1-May	**14-Aug***			2
Calves	41	0	2	1	0	0	2	0	0	9	9	5	5	3	0	3	1	1	

Table 12: Sighting histories of calves identified in the study area. First separate date represents sighting of either the calf or mother alone.

Calf ID	Mother ID	First date w/ mother	Last date w/ mother	First separate date	1994	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Yrs
104	105	9-Jul-94	9-Jul-94		1														1
107	43	9-Jul-94	4-Aug-94		2	1	2	7	1	34	10	1	15	11	9	10	3	12	14
169	67	19-Jul-95	23-Jul-95			4					3	5	10	5	3	7	2	5	9
246		11-Aug-98	17-Aug-98					3											1
307	312	28-Jun-98	9-Jul-98					2											1
310	321	25-Jun-98	4-Jul-98	6-Jul-98				3	1										2
583	581	5-Jun-01	4-Oct-01								5	1	6		6	2	12	13	7
584	81	20-Jun-01	18-Jul-01	22-Jul-01							3	1		27	3	4	2		6
595	596	26-Jun-01	29-Jun-01								3								1
611	43	18-Jul-01	31-Jul-01	28-Oct-01							4						1		2
620	232	5-Jul-01	31-Jul-01								2								1
626	291	8-Jun-01	8-Jun-01	15-Jun-01							2								1
657	281	17-Aug-02	6-Sep-02									2	1		1	1	3	2	6
682	80	22-May-02	29-Jul-02	18-Aug-02								6	23	2	7	10	3	13	7
685	684	4-Jul-02	4-Aug-02									5							1
686	717	3-Jul-02	3-Jul-02									3							1
687	683	25-Jul-02	29-Jul-02									2				7	1	3	4
688	91	5-Jul-02	15-Jul-02	6-Sep-02								6	5	4	10	11	2	4	7
698	67	7-Aug-02	6-Sep-02	14-Oct-02								4	8	1	12	9	1	10	7
714	144	5-Jul-02	4-Aug-02									1				6		16	3
720	143	29-Jul-02	3-Sep-02	30-Sep-02								1	10	7	6	5	6	18	7
786	232	9-Jun-03	3-Jul-03	15-Jul-03									11	6	2	16	5	11	6
797	81	28-Jul-03	28-Jul-03	30-Jul-03									1	2	7	18	12	11	6
798	175	12-May-03	12-May-03	16-Jun-03									1						1
860	216	26-Jul-03	28-Jul-03	26-Aug-03									3	4	4	9	2	1	6
811	815	19-Jun-04	17-Jul-04											5					1
814	372	25-Jun-04	30-Jun-04											2					1
818	101	17-Jul-04	17-Jul-04	20-Aug-04										2	2	5	2		4
819	67	4-Jun-04	27-Aug-04	22-Sep-04										8	6	20	20	14	5
824	93	30-Jun-04	11-Jul-04	14-Aug-04										4	8			9	3
862	801	3-May-05	3-May-05	21-Jul-05											5				1
863	92	27-Jun-05	24-Jul-05	4-Aug-05											10				1
882	80	18-Jun-05	19-Jun-05	4-Jul-05											3	10	13	14	4
976	973	14-Sep-07	14-Sep-07														1		1
990	94	8-Jul-07	5-Aug-07														4	7	2
994	993	5-Aug-07	14-Aug-07														1		1
1066	281	19-Apr-08	19-Apr-08															1	1

Table 13: RELEASE goodness of fit results for 3 regions using pooled and separate cohorts. When cohorts are separated as groups, Test 3 is always 0 because there are no sub-cohorts.

Region	Cohort	Test	χ^2	df	P
MUA-SVI	Pooled				
		Test 2	46.9987	16	1e-04
		Test 3	133.6637	17	0
		Total	180.6624	33	0
	Separate				
		Test 2	45.0847	36	0.1425
		Test 3	0	0	1
		Total	45.0847	36	0.1425
OR-SVI	Pooled				
		Test 2	55.7052	18	0
		Test 3	176.8239	17	0
		Total	232.5292	35	0
	Separate				
		Test 2	51.341	40	0.1079
		Test 3	0	0	1
		Total	51.341	40	0.1079
OR-NBC	Pooled				
		Test 2	84.9913	13	0
		Test 3	300.1332	17	0
		Total	385.1245	30	0
	Separate				
		Test 2	75.7837	36	1e-04
		Test 3	0	0	1
		Total	75.7837	36	1e-04
NCA-SEAK	Pooled				
		Test 2	97.2429	13	0
		Test 3	352.5911	17	0
		Total	449.834	30	0
	Separate				
		Test 2	79.777	35	0

Table 14: Number of whales seen each year, number that were new that year, and number that were new and were seen in a subsequent year for whales seen between June-November 1998-2008 in each region.

Region		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
MUA-SVI	Seen	73	48	60	116	68	96	95	104	92	45	103
	Non-calf: New	73	13	23	56	22	31	25	21	12	5	19
	Non-calf: New and Re-sighted	53	8	15	18	9	19	9	8	4	1	0
	Calf: New	1	0	0	5	6	3	5	3	0	1	0
	Calf: New and Re-sighted	0	0	0	2	4	3	3	1	0	1	0
OR-SVI	Seen	84	71	67	129	103	110	114	109	99	113	119
	Non-calf: New	84	26	26	58	40	26	29	21	11	24	20
	Non-calf: New and Re-sighted	63	12	17	19	20	17	11	9	3	3	0
	Calf: New	1	0	0	6	7	3	5	3	0	2	0
	Calf: New and Re-sighted	0	0	0	3	5	3	3	1	0	1	0
OR-NBC	Seen	116	120	113	151	179	154	177	138	129	118	135
	Non-calf: New	116	50	37	54	51	26	35	22	8	25	22
	Non-calf: New and Re-sighted	92	16	21	19	26	16	11	9	1	2	0
	Calf: New	3	0	0	6	9	3	5	3	0	3	0
	Calf: New and Re-sighted	0	0	0	3	7	3	3	1	0	1	0
NCA-SEAK	Seen	135	157	137	175	205	161	179	138	131	121	172
	Non-calf: New	135	77	53	66	56	25	32	22	8	23	48
	Non-calf: New and Re-sighted	103	18	30	25	22	14	9	10	1	3	0
	Calf: New	3	0	0	6	9	3	5	3	0	3	0
	Calf: New and Re-sighted	1	0	0	3	7	3	3	1	0	1	0

Table 15: Delta AICc and QAICc (for OR-NBC and NCA-SEAK models) for 18 models fitted to each set of data.

		φ Model							
Region	p model	1	2	3	4	5	6	7	8
MUA-SVI	1	72.8	41.1	62.6	33.1	41.5	33.2	31.7	33.8
	2	44.8	12.6	33.6	3.5	5.2	2.9	0.0	2.2
	3	132.8	97.0	125.0	92.1	93.7	89.2	87.3	89.4
OR-SVI	1	114.6	70.5	96.0	53.5	55.1	45.6	44.8	46.4
	2	72.4	27.0	52.4	8.4	10.2	1.8	0.0	1.6
	3	106.5	55.9	93.1	45.8	47.5	36.6	34.9	36.1
OR-NBC	1	76.9	60.5	27.2	35.1	35.9	32.0	33.9	35.8
	2	46.1	29.7	27.2	2.4	3.4	0.0	1.7	3.6
	3	69.6	51.8	53.1	28.8	30.3	27.2	28.9	30.7
NCA-SEAK	1	80.4	60.1	58.6	30.9	31.8	34.4	35.7	37.6
	2	52.2	31.4	28.8	0.0	1.1	4.7	5.7	7.6
	3	82.0	58.7	62.3	33.2	34.9	36.6	37.4	39.2

Table 16: Number of whales seen in each year and number seen in both years and abundance estimate ($\widehat{N}$), standard error and $N_{min} = \widehat{N}e^{-0.864\sqrt{log(1+(se(\widehat{N})/\widehat{N})^2}}$ for Lincoln-Petersen estimator applied to consecutive years from 1998-2008 in MUA-SVI and OR-SVI regions.

Region	Year (y)	Seen in year y-1	Seen in year y	Seen in both years	$\widehat{N}$	$se(\widehat{N})$	N_{min}
MUA-SVI	1999	73	48	35	99	6.1	94
	2000	48	60	29	98	8.1	91
	2001	60	116	46	150	8.1	143
	2002	116	68	42	186	14.0	174
	2003	68	96	40	162	12.4	151
	2004	96	95	56	162	8.8	154
	2005	95	104	56	175	10.1	167
	2006	104	92	61	156	7.4	150
	2007	92	45	30	136	11.6	127
	2008	45	103	33	139	10.1	130
OR-SVI	1999	84	71	45	131	8.0	125
	2000	71	67	34	138	11.9	128
	2001	67	129	50	171	9.4	163
	2002	129	103	53	249	18.2	234
	2003	103	110	59	191	11.0	182
	2004	110	114	68	183	8.6	176
	2005	114	109	61	202	11.6	193
	2006	109	99	64	167	7.9	161
	2007	99	113	59	188	10.7	179
	2008	113	119	69	194	9.3	186

Table 17: Number of whales seen in each year and number seen in both years and abundance estimate ($\widehat{N}$), standard error and $N_{min} = \widehat{N}e^{-0.864\sqrt{log(1+(se(\widehat{N})/\widehat{N})^2}}$ for Lincoln-Petersen estimator applied to consecutive years from 1998-2008 in OR-NBC and NCA-SEAK regions.

Region	Year (y)	Seen in year y-1	Seen in year y	Seen in both years	$\widehat{N}$	$se(\widehat{N})$	N_{min}
OR-NBC	1999	116	120	70	198	9.5	190
	2000	120	113	66	204	10.8	195
	2001	113	151	84	202	7.4	196
	2002	151	179	106	254	8.5	247
	2003	179	154	119	231	5.8	226
	2004	154	177	117	232	6.1	227
	2005	177	138	97	251	9.3	243
	2006	138	129	92	193	6.1	187
	2007	129	118	74	205	9.4	197
	2008	118	135	73	217	10.5	208
NCA-SEAK	1999	135	157	80	264	13.1	253
	2000	157	137	74	289	16.5	275
	2001	137	175	93	257	10.2	248
	2002	175	205	121	295	9.5	287
	2003	205	161	126	261	6.7	255
	2004	161	179	118	243	6.7	238
	2005	179	138	97	254	9.4	246
	2006	138	131	94	191	5.9	186
	2007	131	121	74	213	10.1	204
	2008	121	172	76	272	14.1	260

Table 18: Number of whales seen in each year and number seen in both years and abundance estimate ($\widehat{N}$), standard error and $N_{min} = \widehat{N}e^{-0.864\sqrt{log(1+(se(\widehat{N})/\widehat{N})^2}}$ for limited Lincoln-Petersen estimator applied to consecutive years from 1998-2008 in MUA-SVI and OR-SVI regions.

Region	Year (y)	Seen in year y-1	Seen in year y	Seen in both years	$\widehat{N}$	$se(\widehat{N})$	N_{min}
MUA-SVI	1999	51	41	33	62	2.7	60
	2000	43	52	29	76	5.2	72
	2001	49	77	43	87	2.9	84
	2002	77	56	39	109	6.7	104
	2003	58	86	39	127	8.4	119
	2004	83	78	52	123	5.9	118
	2005	81	91	55	133	6.3	128
	2006	89	81	58	123	5.0	119
	2007	84	42	30	116	8.9	109
	2008	40	82	31	104	6.8	99
OR-SVI	1999	60	54	42	76	2.9	74
	2000	57	58	34	96	6.6	91
	2001	55	90	47	104	3.9	101
	2002	90	85	50	152	9.1	144
	2003	83	99	54	151	8.1	144
	2004	101	96	65	148	6.2	143
	2005	97	96	59	157	7.8	150
	2006	96	89	62	137	5.6	132
	2007	91	93	59	142	6.6	137
	2008	89	95	65	129	4.6	125

Table 19: Number of whales seen in each year and number seen in both years and abundance estimate ($\widehat{N}$), standard error and $N_{min} = \widehat{N}e^{-0.864\sqrt{log(1+(se(\widehat{N})/\widehat{N})^2}}$ for limited Lincoln-Petersen estimator applied to consecutive years from 1998-2008 in OR-NBC and NCA-SEAK regions.

Region	Year (y)	Seen in year y-1	Seen in year y	Seen in both years	$\widehat{N}$	$se(\widehat{N})$	N_{min}
OR-NBC	1999	88	82	66	109	2.9	106
	2000	85	96	65	125	4.2	121
	2001	96	118	83	136	2.9	133
	2002	113	155	100	174	3.4	171
	2003	157	143	115	194	4.1	191
	2004	144	153	114	192	4.1	189
	2005	152	122	93	198	6.2	193
	2006	123	119	89	164	4.5	160
	2007	122	96	74	157	5.4	153
	2008	93	110	70	145	5.1	141
NCA-SEAK	1999	96	90	72	119	3.1	117
	2000	97	113	73	149	5.1	145
	2001	112	135	91	165	4.2	162
	2002	129	170	113	193	3.6	190
	2003	174	149	122	212	4.4	208
	2004	150	156	115	203	4.6	199
	2005	156	124	94	205	6.5	199
	2006	124	121	91	164	4.4	160
	2007	124	102	74	170	6.5	164
	2008	98	120	72	162	6.1	157

Table 20: Abundance estimate ($\widehat{N}$), standard error and $N_{min} = \widehat{N}e^{-0.864\sqrt{log(1+(se(\widehat{N})/\widehat{N})^2}}$ averaged over open population POPAN models using data from 1998-2008 in MUA-SVI and OR-SVI regions.

Region	Year	$\widehat{N}$	$se(\widehat{N})$	N_{min}
MUA-SVI	1998	78	2.9	75
	1999	64	5.0	60
	2000	81	5.8	76
	2001	130	7.5	124
	2002	113	8.9	106
	2003	121	8.3	114
	2004	143	10.2	135
	2005	136	9.5	128
	2006	129	10.3	121
	2007	125	12.1	115
	2008	136	12.7	125
OR-SVI	1998	88	2.7	86
	1999	88	5.5	83
	2000	99	7.2	93
	2001	144	7.8	138
	2002	143	9.3	136
	2003	134	8.6	127
	2004	167	10.7	158
	2005	157	10.5	148
	2006	146	11.0	136
	2007	164	12.8	153
	2008	153	13.2	142

Table 21: Abundance estimate ($\widehat{N}$), standard error and $N_{min} = \widehat{N}e^{-0.864\sqrt{log(1+(se(\widehat{N})/\widehat{N})^2}}$ averaged over open population POPAN models using data from 1998-2008 in OR-NBC and NCA-SEAK regions.

Region	Year	$\widehat{N}$	$se(\widehat{N})$	N_{min}
OR-NBC	1998	118	1.8	116
	1999	151	5.3	146
	2000	145	6.0	140
	2001	184	8.3	177
	2002	181	7.5	175
	2003	178	8.6	170
	2004	206	9.8	197
	2005	197	11.3	188
	2006	175	11.2	166
	2007	207	15.4	194
	2008	185	14.2	174
NCA-SEAK	1998	138	2.2	136
	1999	191	6.6	185
	2000	174	7.2	168
	2001	216	9.5	208
	2002	209	8.7	201
	2003	192	9.8	184
	2004	209	10.8	200
	2005	200	12.0	190
	2006	178	11.8	168
	2007	202	14.6	190
	2008	225	16.4	211

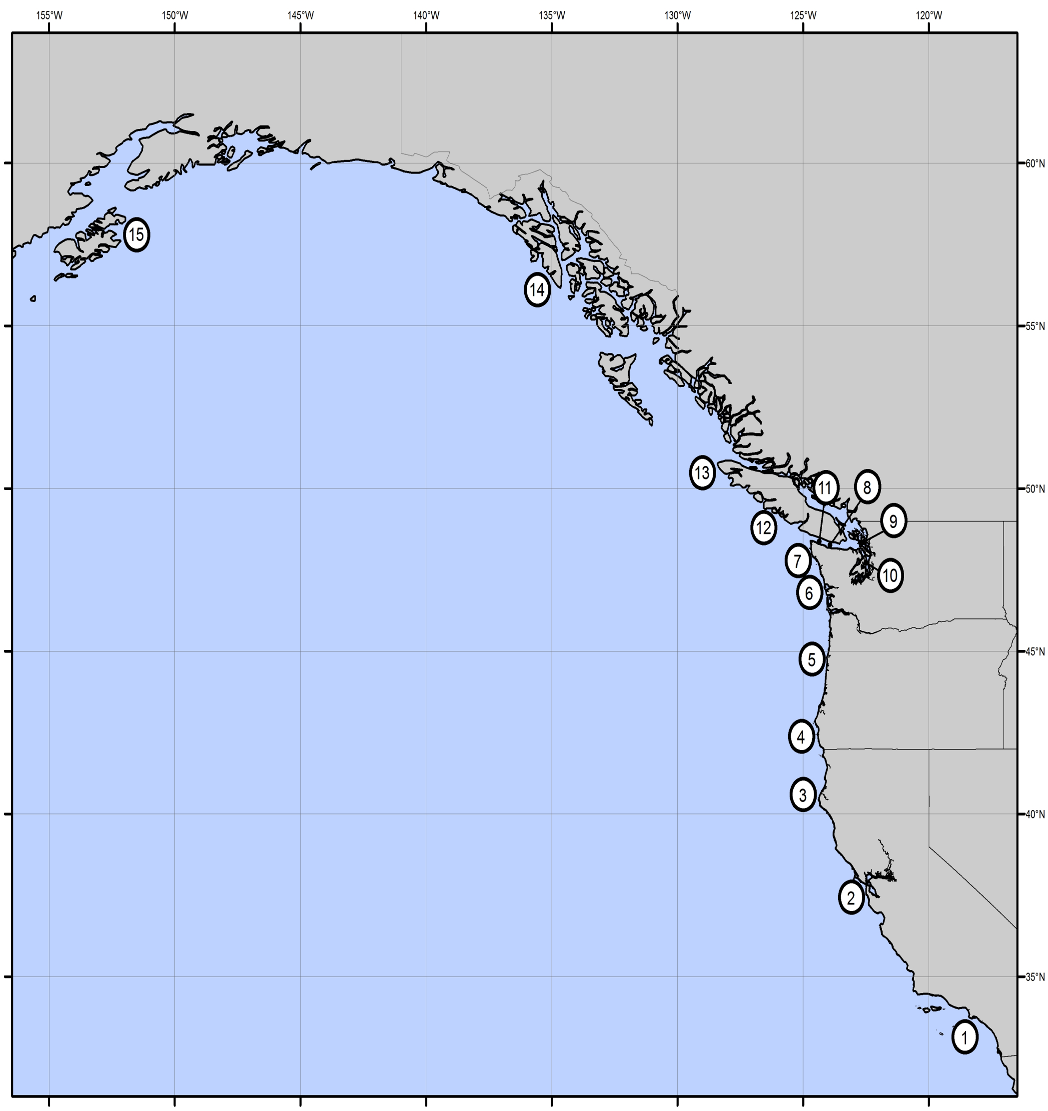

Figure 1: Locations for photo-identifications of gray whales. Numbers refer to values in Table 1.

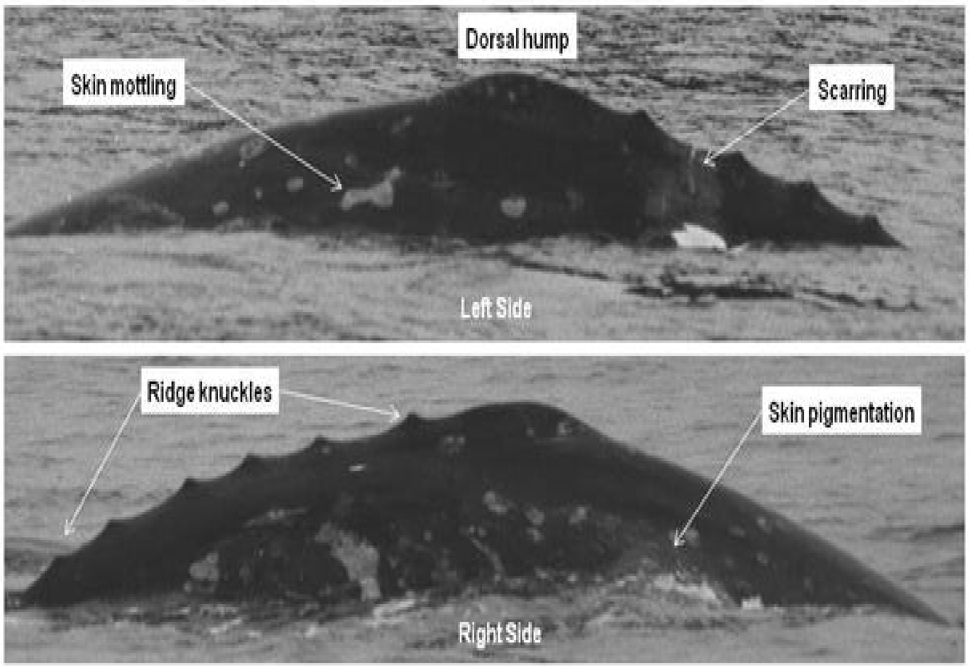

Figure 2: Characteristics used for gray whale photo-identification.

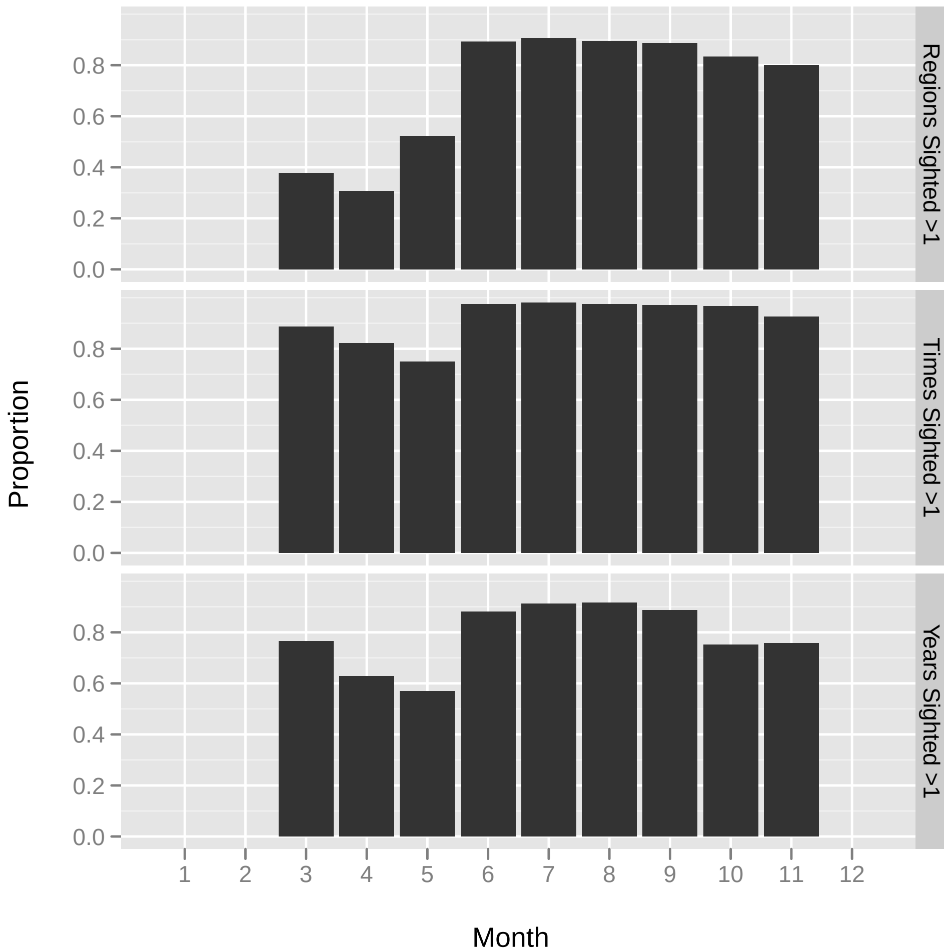

Figure 3: Monthly measures of proportion of whales that were seen in more than one region, seen on more than one day and seen in more than one year. The values include sightings from 1998-2008 in all regions from California to Alaska. Lower values imply whales were simply migrating through the area in a short time frame and were thus less likely to be seen at other times and in other regions. Values are not shown for months with fewer than 20 sightings.

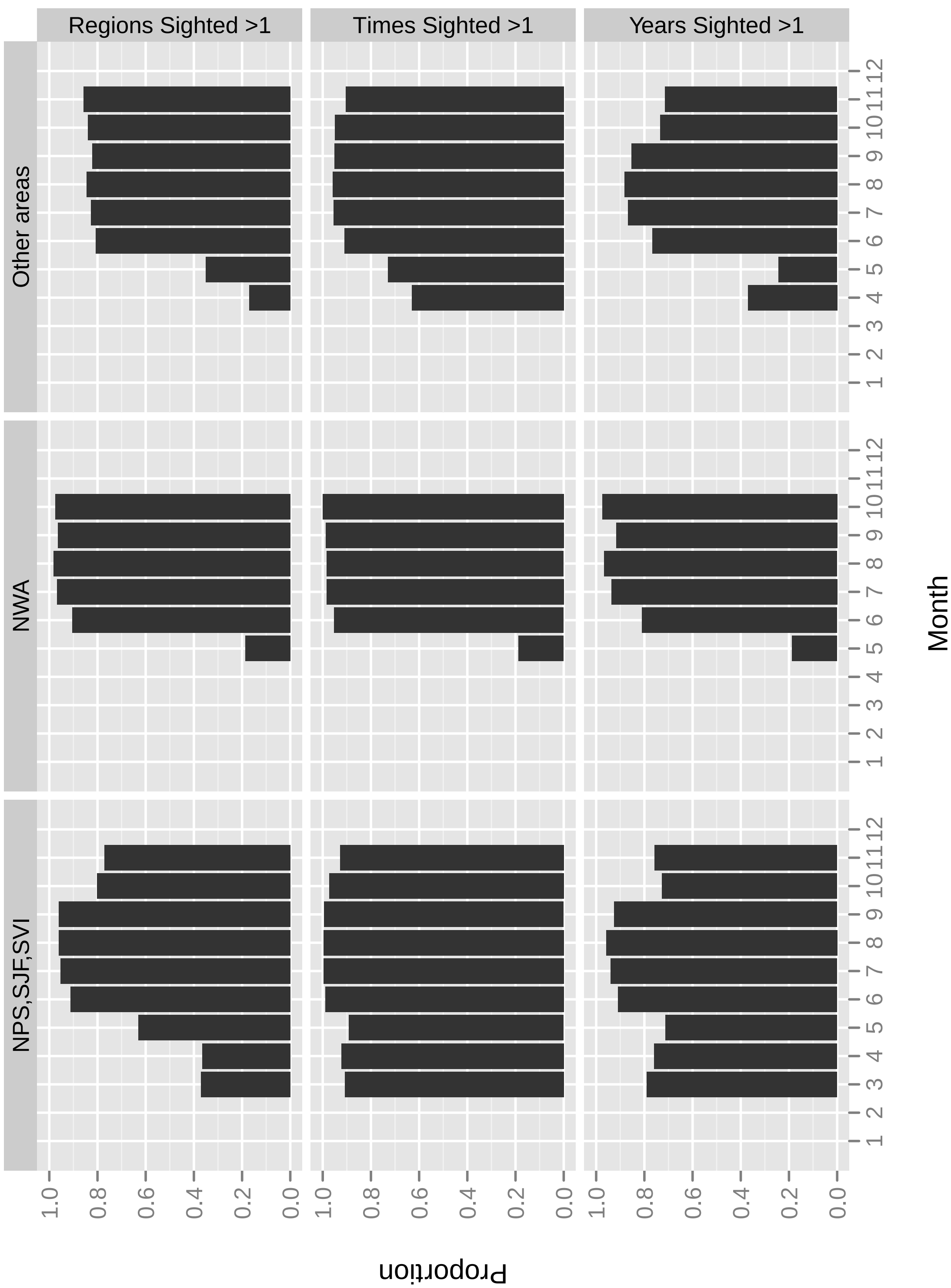

Figure 4: Region and monthly measures of proportion of whales that were seen in more than one region, seen on more than one day and seen in more than one year. The values include sightings from 1998-2008 in all regions from California to Alaska. Lower values imply whales were simply migrating through the area in a short time frame and were thus less likely to be seen at other times and in other regions. Values are not shown for months with fewer than 20 sightings.

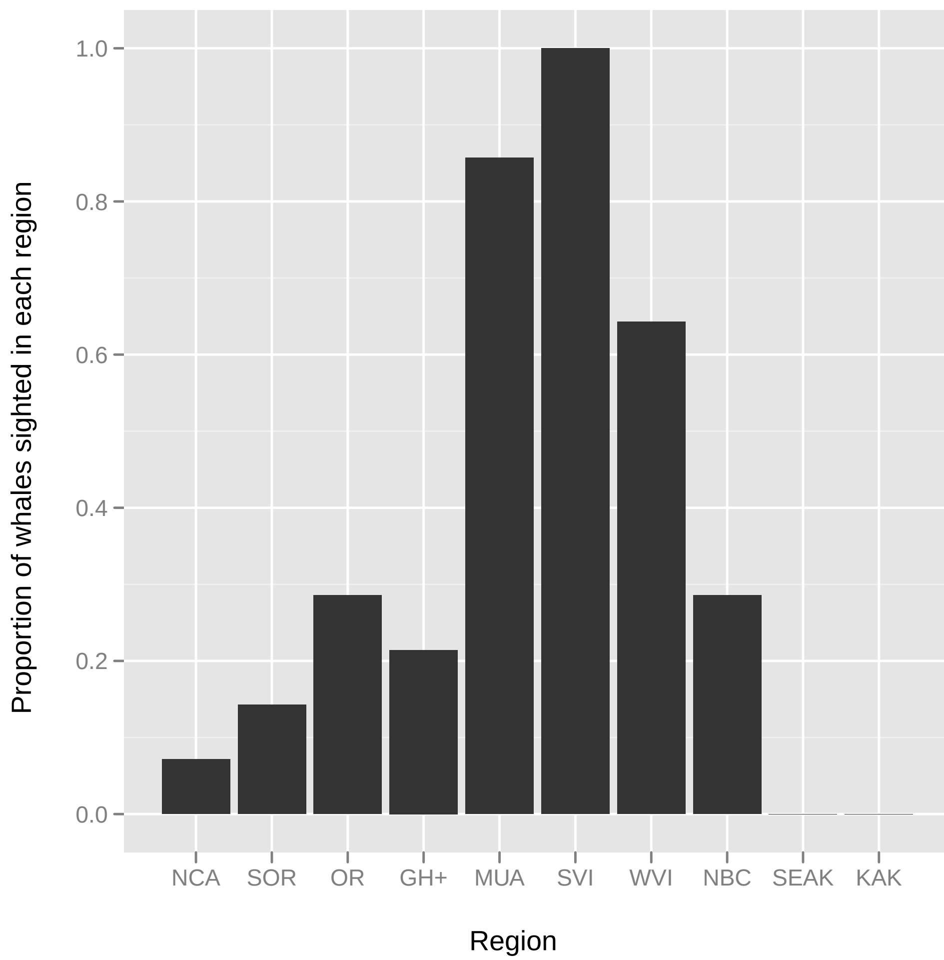

Figure 5: Proportion of the 14 whales seen in NWA during the spring and in the PCFA after 1 June that were seen in each PCFA sub-region after 1 June at least once from 1998-2008.

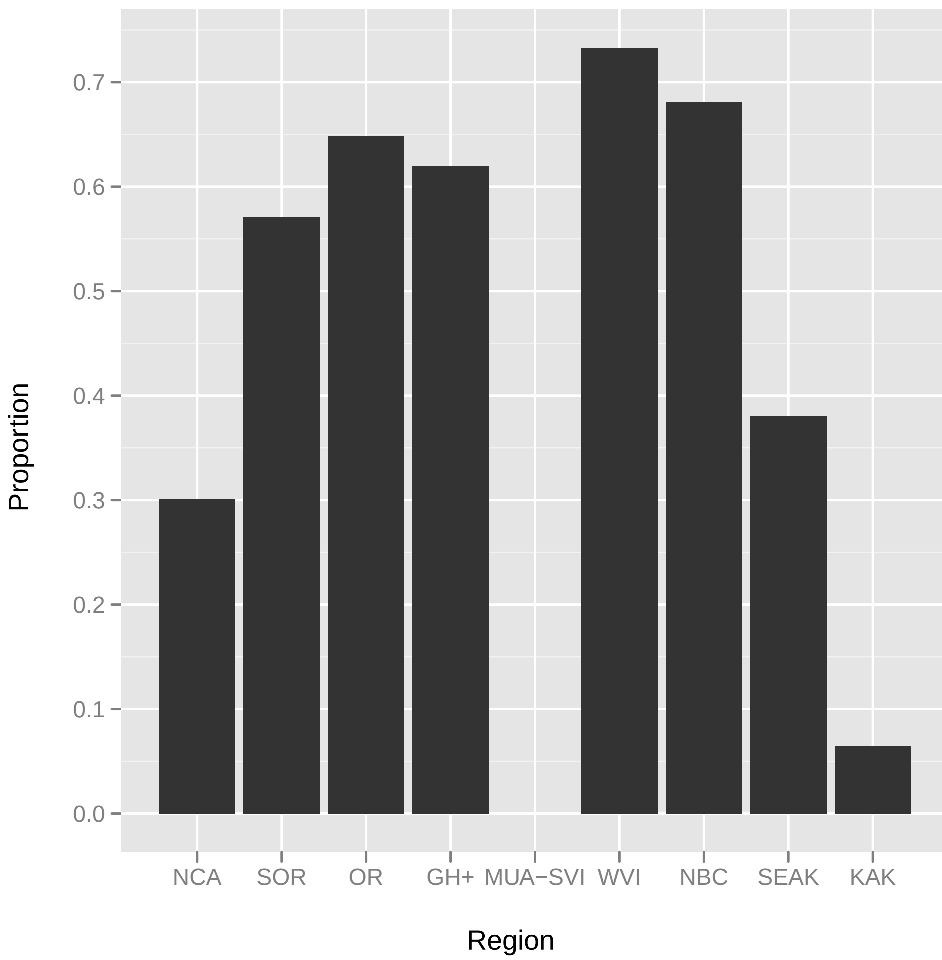

Figure 6: Proportion of whales in PCFA sub-regions that have been seen in the MUA-SVI using sightings after 1 June from 1998-2008.

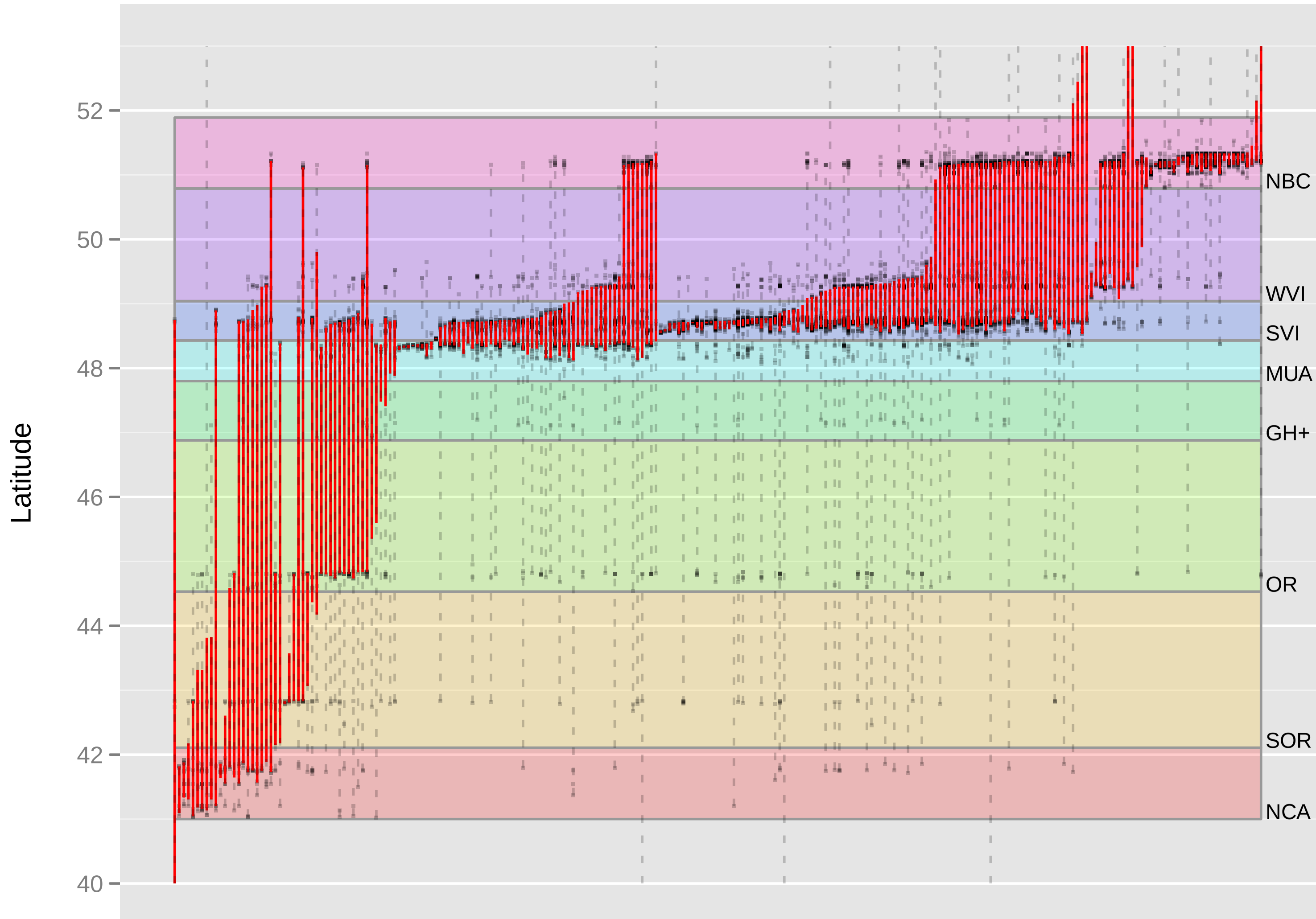

Figure 7: Distribution of latitudes of sightings (points) for whales with 6 or more sightings after 1 June from 1998-2008, the 75% inner quantile (solid thick line), and full range (light dashed line). Each position on the x axis represents an individual whale. Whales have been arranged on the plot by sorting first on the lower bound of the inner quantile (to a half-degree) and then the upper bound of the quantile. This has the effect of sorting from south to north and clusters whales with smaller quantile ranges followed by whales with larger ranges.

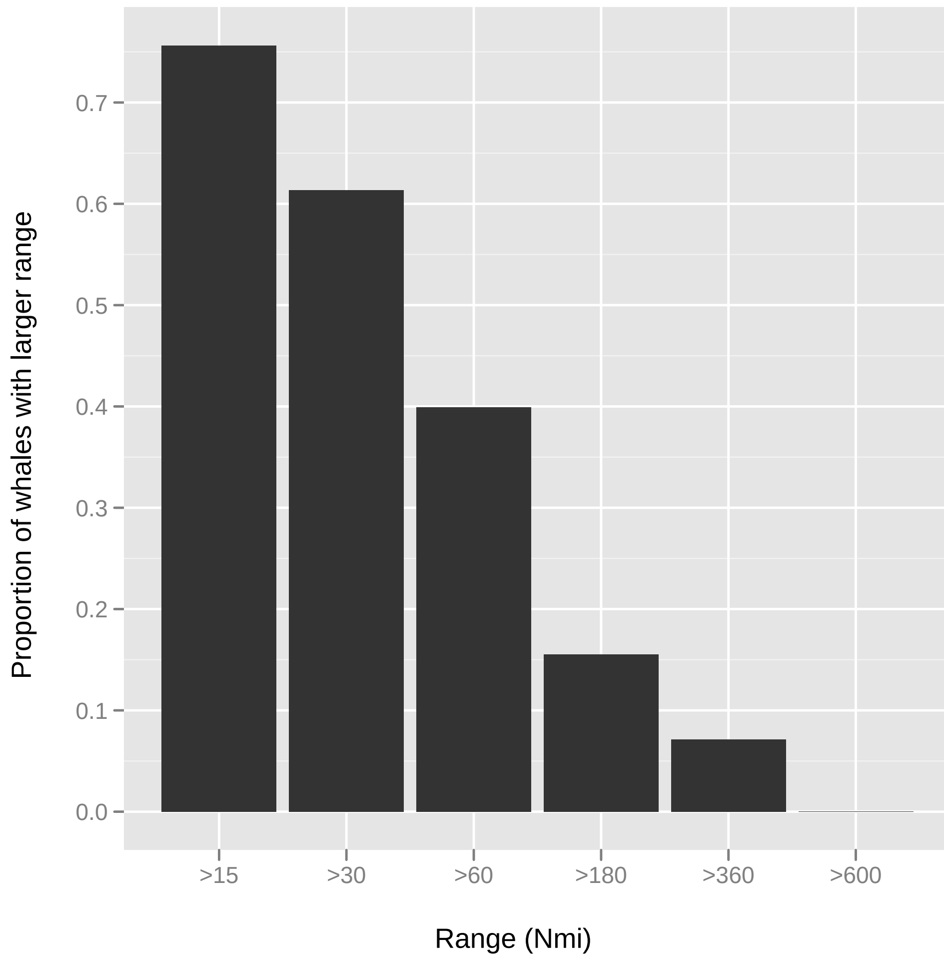

Figure 8: Distribution of ranges of 75% inner quantiles of latitudes expressed in nautical miles for whales sighted on 6 or more days during 1998-2008.

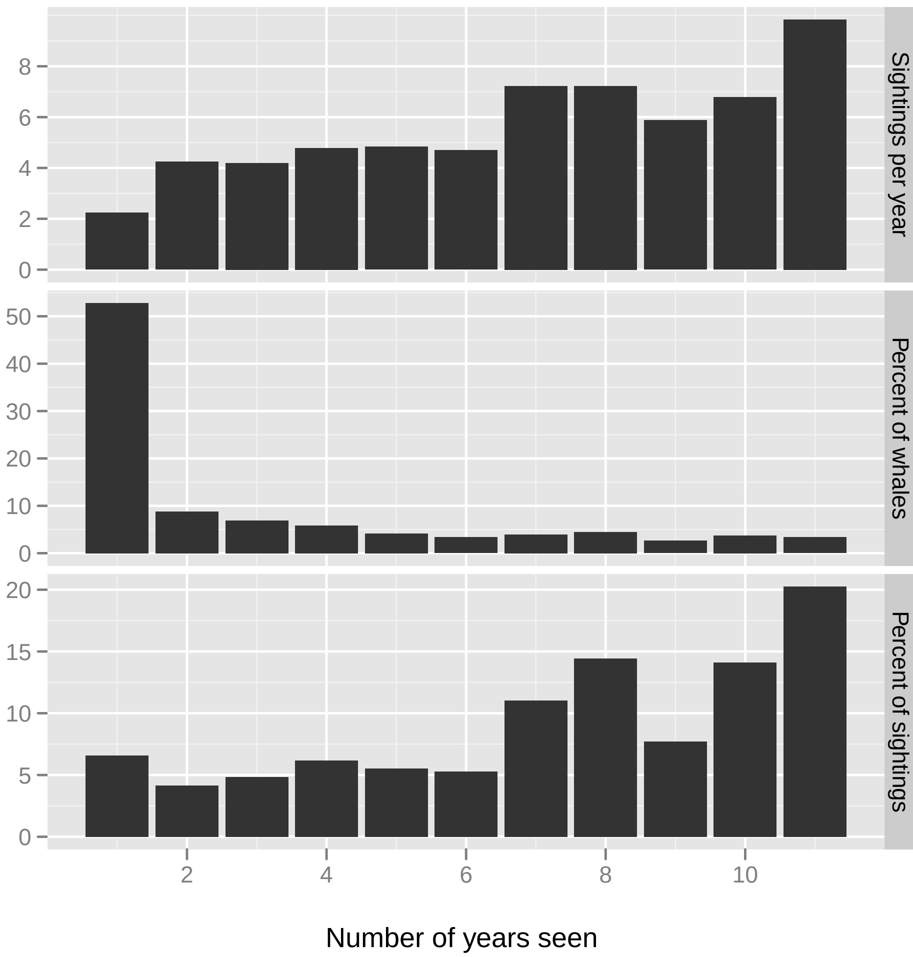

Figure 9: Average number of sightings per year and distribution of whales and numbers of sightings based on numbers of years a whale was seen in NCA-NBC between June-November during 1998-2008.

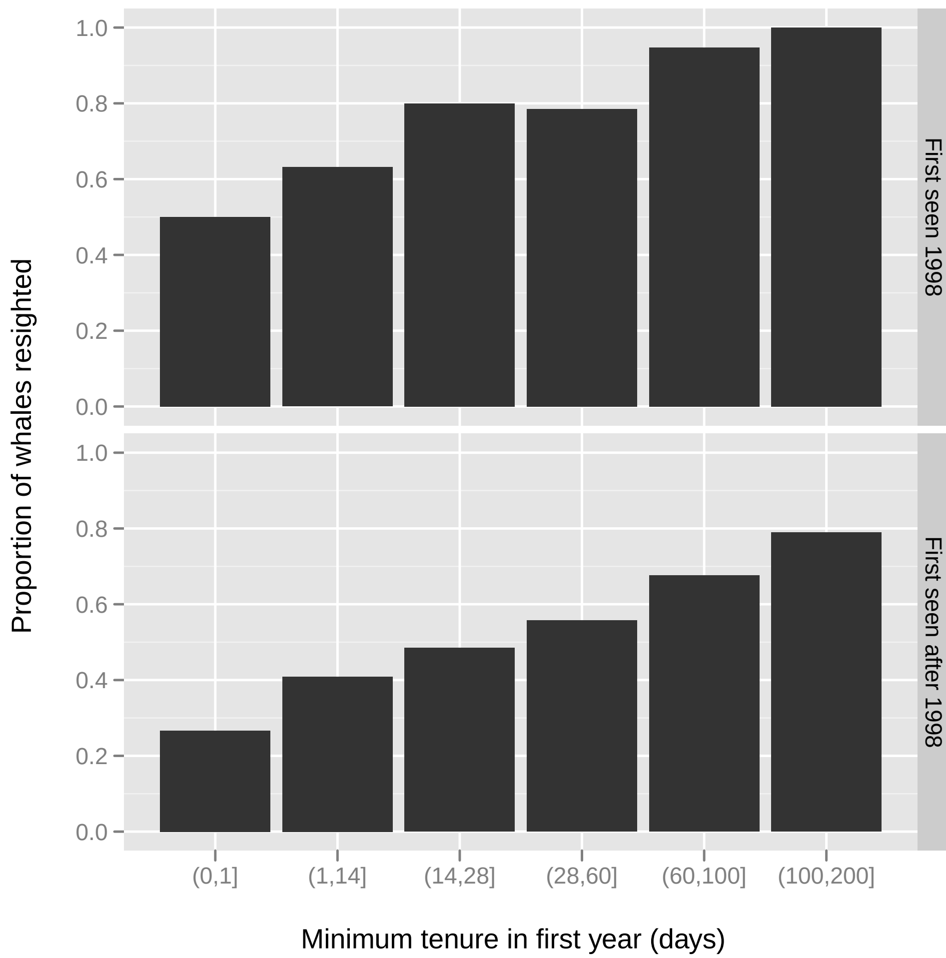

Figure 10: Influence of minimum tenure (MT) in the first year the whale was photographed on the probability it will be re-sighted in one or more following years for whales seen in NCA-NBC for June-November 1998-2008. The bar graphs are divided for 1998 and >1998 because 1998 is the start of the study and it may not be the first year for many of those whales. Re-sightings for 2008 are used but initial sightings for 2008 are excluded because there are no data beyond to evaluate re-sighting probability.

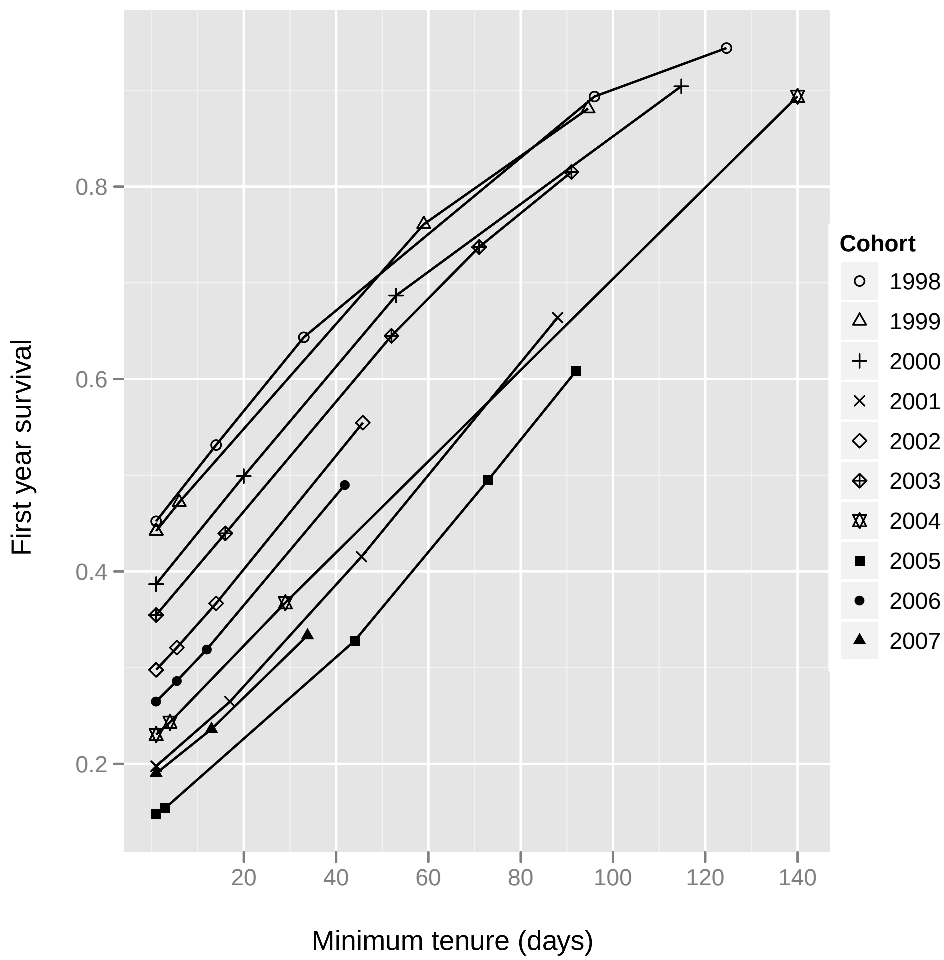

Figure 11: For MUA-SVI analysis of 1998-2008 data, model-averaged estimates of first year survival of non-calves for each cohort at 5%, 25%, 50%, 75%, and 95% quantiles of minimum tenure values for that cohort.

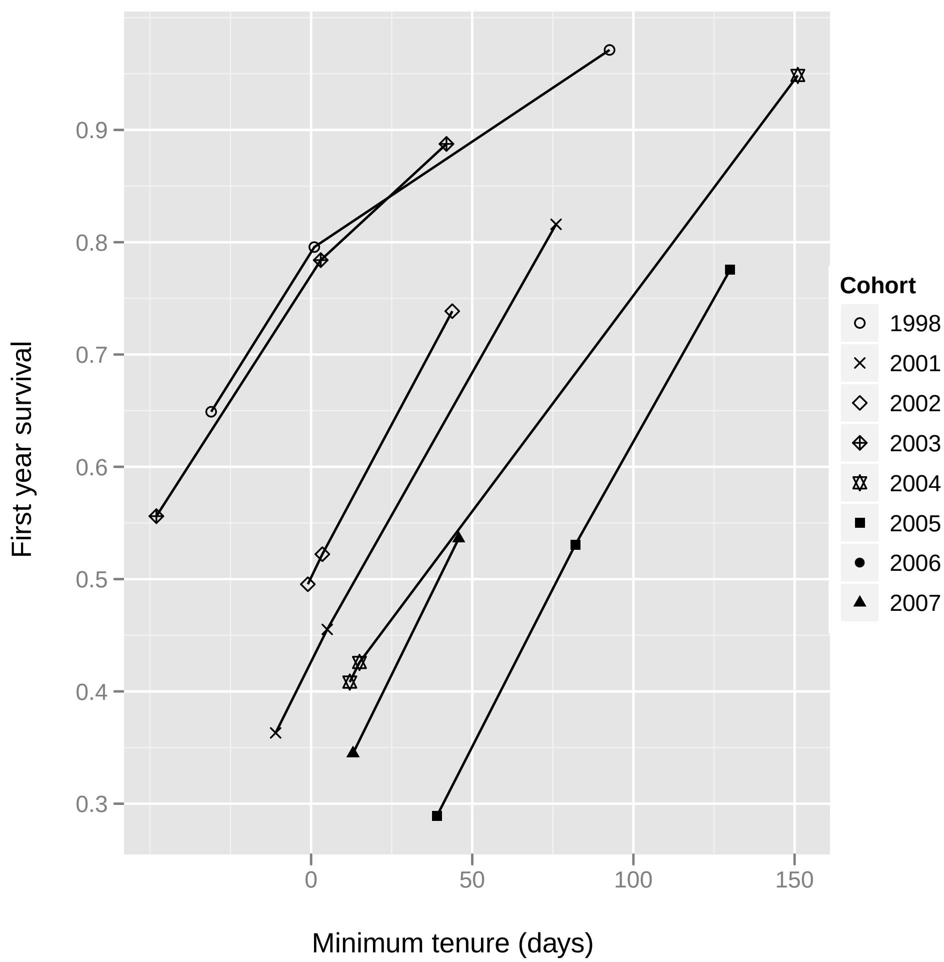

Figure 12: For MUA-SVI analysis of 1998-2008 data, model-averaged estimates of first year survival of calves for each cohort at 5%, 50%, and 95% quantiles of minimum tenure values for that cohort of calves. Cohorts 1999 and 2000 are not shown because no calves were identified in those years.

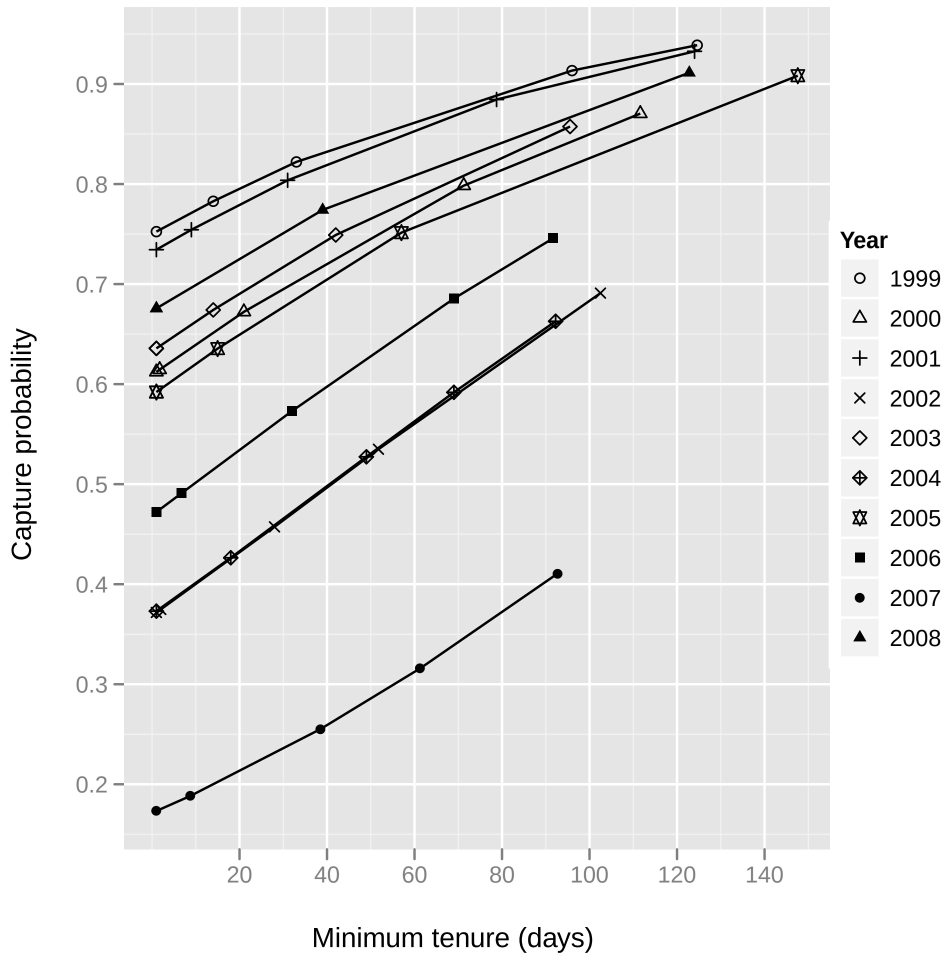

Figure 13: For MUA-SVI analysis of 1998-2008 data, model-averaged estimates of capture probability for each year at 5%, 25%, 50%, 75%, and 95% quantiles of minimum tenure values for whales in the previous year.

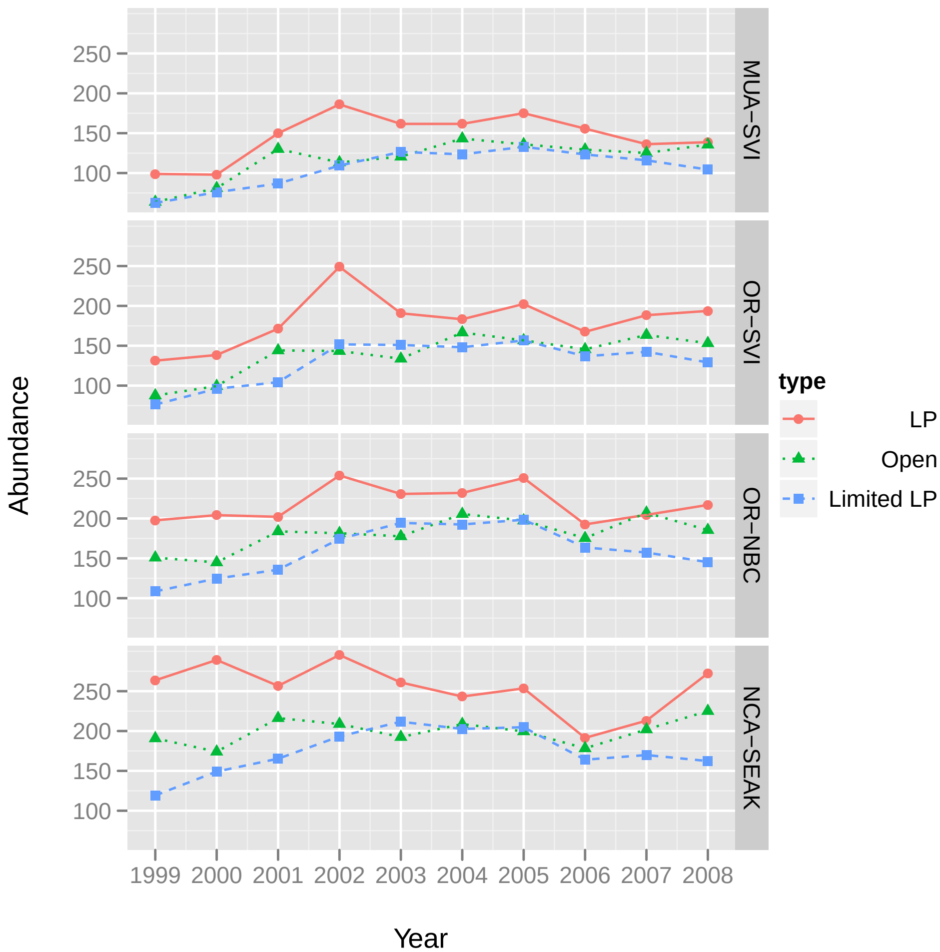

Figure 14: Annual abundance estimates for 1999-2008 in three sub-regions using closed population models, Lincoln-Petersen (LP) and Limited LP and the model averaged estimates for the open POPAN (Jolly-Seber) models.

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Updated analysis of abundance and population structure of seasonal gray whales in the Pacific Northwest, 1996-2015

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INTERNATIONAL
WHALING COMMISSION

Updated analysis of abundance and population structure of seasonal gray whales in the Pacific Northwest, 1996-2015

John Calambokidis, Jeffrey Laake, and Alie Pérez

Abstract

We update the results of a 20-year (1996-2015) collaborative study examining the abundance and the population structure of these animals conducted over a number of regions from Northern California to British Columbia using photographic identification. Some 21235 identifications representing 1638 unique gray whales were obtained during 1996-2015 from Southern California to Kodiak, Alaska. Gray whales seen from 1 June - 30 Nov (after the northward and before southward migrations) were more likely to be seen repeatedly and in multiple regions and years;therefore only whales seen during those data were included in the abundance estimates. Gray whales using the Pacific Northwest in summer and fall include two groups: 1) whales that return frequently and account for the majority of the sightings and 2) transients seen in only one year, generally for shorter periods and in more limited areas. A time series of abundance estimates of the non-transient whales for 1996-2015 was constructed for the region from N. California (NCA) to N. Vancouver Island (NBC). The most recent estimate for 2015 was 243 whales (se=18.9). The estimated abundance increased in the late 1990s and early 2000s during the period when the eastern North Pacific gray whale population was experiencing a high mortality event and this created an apparent influx of whales into the area. The earlier estimates for 1996-1997 are biased low because the survey coverage area was much smaller but those data were included to improve estimates later in the time series. The abundance estimates since the early 2000s has been relatively stable but it has increased in 2013-2015.

1 Introduction

Beginning in 1996, a collaborative effort among a number of research groups was initiated to conduct a range-wide photographic identification study of gray whales in the Pacific Northwest (Calambokidis et al. 2000, 2002b). An initial publication of findings from 1998 demonstrated there was considerable movement of individual whales among sub-areas from northern California to southeastern Alaska (which we broadly refer to as the Pacific Northwest) and also provided initial estimates of the abundance of whales within that geographical area (Calambokidis et al. 2002a). The ability to look at movements and employ more sophisticated capture-recapture models, however, was restricted by the lack of multiple years of data with broad geographic coverage. A subsequent report by Calambokidis et al. (2004) characterized the group of whales feeding in these survey areas during the summer-fall period as a "Pacific Coast Feeding Aggregation" (PCFA). They proposed that a smaller area within the PCFA survey areas – from Oregon to Southern Vancouver Island (OR-SVI) – was the most appropriate area for abundance estimation for managing a Makah gray whale hunt (Calambokidis et al. 2004). Subsequently the IWC has adopted the term PCFG for Pacific Coast Feeding group so we will use PCFG in place of PCFA.

This report updates information through 2015 from a collaborative effort to collect photographic identifications of gray whales from California to Alaska has continued since 1996 and these data now cover 20 years (1996-2015) and span fifteen survey regions along the coast from Southern California to Kodiak, Alaska (Figure 1). We provide estimates of abundance for the summer-fall seasons (1 June to 30 November) during 1996–2015 for survey regions between Northern California and Northern British Columbia (NCA-NBC), the region chosen by the IWC to represent the PCFG. For the National Marine Fisheries Service development of an Environmental Impact Statement, we also provide estimates for the smaller regions between Oregon and Southern Vancouver Island (OR-SVI) and Makah Usual and Accustomed area (MUA) which includes the outer coastal area of the Olympic Peninsula (NWA) and the Strait of Juan de Fuca (SJF), even though this area is quite small relative to the observed movements of whales within the PCFG.

2 Methods

Gray whales were photographed during small boat surveys conducted from California to Alaska by collaborating researchers (Table 1) between 1996 and 2015. Gray whale identifications were divided into the following regions (Figure 1): 1) SCA: Southern California, 2) CCA: Central California, 3) NCA: Northern California, 4) SOR: Southern Oregon, 5) OR: central Oregon, 6) GH+: Gray's Harbor and the surrounding coastal waters, 7) NWA: Northern Washington coast, 8) SJF: Strait of Juan de Fuca, 9) NPS: Northern Puget Sound, 10) PS: which includes southern Puget Sound, Hood Canal (HC), Boundary Bay (BB) and San Juan Islands (SJ), 11) SVI: Southern Vancouver Island, 12) WVI: West Vancouver Island, 13) NBC: Northern Vancouver Island and coastal areas of British Columbia, 14) SEAK: Southeast Alaska, and 15) KAK: Kodiak, Alaska. With some exceptions, research groups work primarily in one or two regions. Details of identifications obtained by the different research groups are are summarized in Tables 1-2.

2.1 Photographic Identification Procedures

Procedures during surveys by different research groups varied somewhat but were similar to one another in identification procedures. When a gray whale was sighted, the time, position, number of animals, and behaviors were recorded. Whales were generally approached to within 40-100 m and followed through several dive sequences until suitable identification photographs and associated field notes could be obtained.

For photographic identification of gray whales, both left and right sides of the dorsal region around the dorsal hump were photographed when possible. Most identification photographs were obtained with were obtained with 35mm cameras prior to 2004 and primarily with digital SLR after 2004 with both camera types paired with a telephoto lens (generally 200-300 mm). Researchers also photographed the ventral surface of the flukes for further identification when possible. The latter method was not as reliable since gray whales did not always raise their flukes out of the water. Markings used to distinguish whales included pigmentation of the skin, mottling, and scarring, which varied among individuals. These markings have provided a reliable means of identifying gray whales (Darling 1984). We also identified gray whales using the relative spacing between the knuckles along the ridge of the back behind the dorsal hump. The size and spacing of these bumps varies among whales and has not changed throughout the years these whales have been tracked, except with injury. Figure 2 shows typical photographs and features used in making gray whale identifications.

Comparisons of whale photographs were made in a series of steps. All photographs of gray whales were examined and the best photograph of the right and left sides of each whale (for each sighting) were selected. Identification photographs were initially compared within year to identify resightings and compared to the CRC catalog of whales seen in past years. Whale photographs that were deemed of suitable quality but did not match our existing catalog (compared by two independent persons) were considered "unique" identifications and assigned a new identification number and added to the catalog.

2.2 Data Analysis

The abundance of gray whales was estimated with open population models for three nested spatial scales consisting of contiguous survey regions (Figure 1; Table 3) 1) NCA-NBC: the coastal survey regions from Northern California (NCA) through Northern Vancouver Island/British Columbia (NBC) which matches the IWC definition of the PCFG, 2) OR-SVI: survey regions from southern Oregon through Southern Vancouver Island (SVI) identified in the Makah waiver request, and 3) MUA - survey regions NWA and SJF. Inland waters in WA (other than SJF) and in BC are excluded from the abundance estimates because these are used primarily by transient whales in the northward spring migration.

Gray whales photographed and identified anytime during the period between 1 June and 30 November (hereafter referred to as the "sampling period") within the defined region were considered to be "captured" or "recaptured". For each unique gray whale photographed, a capture history was constructed using 20 years of data from 1996-2015. For example, the capture history 00010010010000000000 could represent a gray whale photographed in 1999, 2002 and 2005 in the PCFG. The same gray whale may have had a capture history 00010010000000000000 for a smaller spatial scale such as OR-SVI or may not have been seen at all (00000000000000000000) and would not be used at the smaller spatial scale.

Multiple "detections" of a single whale within the sampling period were not treated differently than a single detection. A "1" in the capture history meant that it was detected on at least one day during the sampling period. However, multiple detections in the same year were used to construct an observed minimum tenure (MT) for each whale. MT was defined as the number of days between the earliest and latest date the whale was photographed with a minimum of one day for any whale seen.

We fitted open population models to the 20 yearly time series of capture history data for each spatial scale to estimate abundance and survival. Open models allow gains due to births/immigration and losses due to deaths/emigration. Using the RMark interface (Laake and Rexstad 2008) to program MARK (White and Burnham 1999), we fitted a range of models to the data using the POPAN model structure. The POPAN model structure (Schwarz and Arnason 1996) provides a robust parametrization of the Jolly-Seber (JS) model structure in terms of a super population size (N), probability of entry parameters (immigration), capture probability (p), and survival/permanent emigration (φ).

It is essential to consider the population structure and its dynamics to build adequate models. In particular, we know from previous analysis of a subset of these data (Calambokidis et al. 2004) that some whales were seen in only one year between 1 June and 30 November and were never seen again. Transient behavior is a well-known problem in capture-recapture models and it is often addressed using a robust design which involves coordinated multiple capture occasions within each year and typically assumes closure within the sampling period (June-November). Region-wide coordinated surveys may be possible but would be difficult with variation in weather conditions. Also, the closure assumption within the year would be suspect due to variable timing of whales arrivals and departures into the PCFG, so it would require nested open models. We know from prior analysis that whales newly seen in year (y) were less likely to return (i.e., seen at some year >y) than previously seen whales but also newly seen whales that stayed longer during their first year (i.e., longer MT) in the PCFG were more likely to return. Likewise, previously seen whales were more likely to be seen in the following year (y+1), if they had a longer MT in year y. Calambokidis et al. (2004) postulated that these observations were consistent with whale behavior that was determined by foraging success.

Transient behavior in which an animal is seen only once can be modeled by including a different "first year" survival (Pradel et al. 1997) for the newly seen animals. Survival in the time interval after being first seen is dominated by permanent emigration rather than true mortality. Survival in subsequent time intervals represents true survival under the assumption that animals do not permanently emigrate except in their first year. Pradel et al. (1997) were working with release-recapture data (Cormack-Jolly-Seber) where modeling this transient effect on survival is straightforward. For a Jolly-Seber type analysis where the first capture event is also modeled, the inclusion of a transient effect is less easily accommodated.

We divided the whales into cohorts based on the year in which they were first seen ("newly seen"). In the model, their first year survival could differ from subsequent annual survival as in Pradel et al. (1997). "Newly seen" is not a particularly useful concept for the first year of the study (1996), because all whales were being seen for the first time. The survey effort and coverage in 1996 and 1997 were not nearly as expansive as 1998 and later. We considered models that had three different first year survivals (1996&97, 1998, and >1998) and we also considered a model that allowed for a different first year survival for each year (cohort) to allow for different transient proportion in each year. The first year survival was also allowed to vary as a function of MT with a model in which the relationship was constant across years and varied for (1996&97, 1998, and >1998). We also considered models that allowed a different first-year survival for whales identified as calves under the presumption that their true survival might be lower but that their probability of returning to the PCFG might be higher. Discussion at the 2012 intersessional AWMP meeting led to consideration of an additional covariate which split whales into 2 groups for estimation of post-first-year survival. Whales seen initially as calves and any whale newly seen in 1998 or was in the CRC catalog because it had been seen prior to 1998 were put in one group and the remaining whales newly seen in 1999 or later were put in another group. The expectation was that the first group would have higher post-first-year survival because many of the newly seen whales that entered after the stranding event in 1999/2000 might eventually emigrate. When this covariate was included it made such a large improvement that any model without it would have no support. Therefore, it was included in all 10 models for survival (Table 4).

In Calambokidis et al. (2010) we estimated a cohort-specific super-population size for each cohort using the median MT covariate value for unseen whales but during the April 2011 AWMP meeting it became apparent that this may lead to bias in estimating abundance. Therefore, we used the method outlined in the 2011 AWMP report which is similar to the method used by Calambokidis et al. (2004) in that we assume that all whales in the PCFG for the first year are seen so the super-population size for each cohort is the number seen and thus there are no unknown covariate values. We fixed capture probability (p) and probability of entry (pent) to 1 for each cohort in their entry year. We are not interested in the number of transient whales so we used an estimator of abundance for non-transient whales (2011 AWMP report) which is a modification of the Jolly-Seber estimator which for any year can be expressed as:

$$\hat{N} = n/\hat{p} = (u+m)/\hat{p}$$

where $n = u + m$, n is the number seen in a year being composed of new animals (u=unmarked) and previously seen animals (m=marked), and $\hat{p}$ is the capture probability estimate. For the PCFG we are assuming that any new whale is sighted ($p = 1$) and we are only interested in estimating the abundance of whales that will remain part of the PCFG which is the portion of the new whales that do not permanently emigrate from the PCFG. We can modify the estimator for year j as follows:

$$\hat{N}_j = u_j\hat{\phi}_j + m_j/\hat{p}_j$$

where ϕ_j is the first year survival rate of "new" whales. When ϕ and p contain whale specific covariates like minimum tenure (MT) the estimator becomes:

$$\hat{N}_j = \sum_{i=1}^{u_j} \hat{\phi}_{ij} + \sum_{i=1}^{m_j} 1/\hat{p}_{ij}.$$

To obtain an abundance estimate for 2015, we assumed that the parameter for first year survival intercept in that year was the same as in 2014. A variance-covariance matrix for the abundance estimates was constructed using the variance estimator in Borchers et al. (1998) for a Horvitz-Thompson type estimator with an adaptation for the first component of the abundance estimator for prediction of number of new whales that do not permanently emigrate. For the estimated capture probabilities (p) not fixed to 1, we fitted 3 models that varied by time (year) and/or varied by MT in the previous year (Table 4).

We used Test 2 and Test 3 results from the Cormack-Jolly-Seber structure (Lebreton et al. 1992) as a general goodness of fit for the global model and as a measure of possible over-dispersion creating the lack of fit. We fitted each combination of models for S (survival) and p (capture probability) and used AICc (Burnham and Anderson 2002) to select the most parsimonious model of the 30 fitted models. Model averaging was used for all models to compute estimates and unconditional standard errors and confidence intervals.

3 Results

The database contains 25580 records for whales photographed between 1996 to 2015 from California to Kodiak, Alaska; however 4345 are replicate identifications of whales on the same day. We define a sighting as one or more photographs of a whale on a day. The number of sightings varied annually from 131 and 1959 with a total of 21235 sightings of 1638 unique gray whales (Table 1). The average number of sightings/whale was 13 (range: 1-339). Identifications were made throughout the year but with most effort from June to September. Number of sightings were most numerous in NCA, SVI, WVI, and NBC and (Table 2). The number of uniquely identified whales was greatest in NCA, NWA, SVI and WVI (Table 2).

3.1 Seasonal Sighting Patterns

Whales have been photographed in every month of the year (Table 5) but with very few during December-February when most of the whales are in or migrating to Mexico and survey effort is reduced. Previous analysis of these data have always used 1 June - 30 November as the sampling period to describe the whales in the PCFG because whales seen prior to 1 June and after 30 November are more likely to be whales that are migrating through the region. The southbound migration starts in December and the separation between May and June is clearly supported by the data. For example, of the 1638 unique whales sighted from California to Kodiak, Alaska, 666 whales were only seen between 1 Dec - 31 May and 87.2% of those were only sighted once (one day). Of the 972 whales sighted between 1 June -30 November at some time, 38.8% were only sighted once (one day). If sightings in Alaska are excluded, then only 31.7% of the 833 were seen only once (one day).

The break between May and June is apparent in various measures such as proportion of whales sighted more than once, sighted in more than one region, and sighted in more than one year (Figure 3). However, the break is more apparent if we separate out SJF, NPS and SVI from the other survey regions (Figure 4). The difference across months is not as strong for inland waters of Washington and British Columbia (NPS, SJF) because these are whales that have diverted from the migration and are either more likely to remain after 1 June or demonstrate high year-to-year fidelity during spring such as with NPS. Also, even though Southern Vancouver Island (SVI) is in the main migration corridor and not an inland water, the pattern across months is also weaker because the sampling has been focused on the spring herring spawn in Barkley Sound (effectively an inland waterway) and has purposefully undersampled passing migrant whales (Brian Gisborne, pers. comm.).

The break between May and June is much more apparent for NWA and the other areas in the migration corridor which is consistent with the northbound migration of gray whales proceeding past Washington through May. Resighting rates of whales seen after 1 June remained high through November.

A large photo-ID sample of gray whales in the MUA was conducted in 2015 by Makah Tribal biologists. At the time of this report the full comparison of these whales to historical images had not been completed but in the future will provide a better indication of proportion of PCFG whales present prior to 1 June.

Capture (sighting) histories of whales seen at least once in the PCFG from 1 June - 30 November are provided in Appendix Table 1 which show sightings of whales in 1 Mar -31 May only, 1 June - 30 Nov only and in both time periods within a year.

3.2 Regional Sighting Patterns

There is considerable variation in the annual regional distribution of numbers of whales photographed during the sampling period (Table 6) which is in part due to variation in effort. Although not a true measure of effort, the number of days whales were seen (Table 7) does reflect the amount of effort as well as abundance of whales. In particular, in comparison to other regions, the large number of sightings in SVI partly reflects large numbers of sampling days by Brian Gisborne who has routinely sampled SVI from summer through fall on almost a daily basis. On the other hand, the decline in sightings in SVI during 2007 was not due to reduced effort but to the distribution of whales with many of the whales having moved to waters off Oregon and Washington (Calambokidis et al. 2009b). Similarly, there were 40 survey days in SJF in 2010 but only 4 whales were seen on 4 different days (Table 6, Table 7) so this drop relative to other years was not due to lack of effort.

Whales were sighted across various survey regions and the interchange of whales (Table 8) between survey regions during 1 June - 30 November depends on proximity of the regions (Calambokidis et al. 2004). During 1 June-30 November for 1996 to 2015, 793 unique whales were seen in the PCFG range and 68.6% (544 of the 793 whales seen in the PCFG range) were seen within the smaller OR-SVI region and approximately 36.3% (288 of the 793 whales seen in the PCFG range) were seen within the smaller MUA area; however, there is variation in interchange between areas in the PCFG and the MUA. Of the whales sighted in regions from NCA to NBC, from 39.8% to 59.6% of the whales were seen at some point within MUA (Figure 5). If we exclude transients (whales seen in only one year), the interchange rates with MUA are much higher but the pattern is similar (Figure 6) with a range of 47.7% to 77.5%. Appendix Table 2 provides capture histories using data from 1 June - 30 Nov of whales seen in the MUA at least once. For each year, the table shows whether the whale was sighted in PCFG but not in the MUA during that year, only seen in MUA that year, and seen in both MUA and another PCFG area in that year.

Whales seen in the PCFG exhibited a wide range of movement across and within years. The 143 whales seen in 9 or more years provide a useful example. None of those whales was seen exclusively in a single region, and 67.1% were seen in at least 4 of the 9 survey regions from 1996 to 2015. However, whales did regularly visit the same regions across years with 94.4% were seen in at least one of the regions during six or more of the years they were seen and 65.7% were seen in a region two-thirds or more of the years they were seen. SVI was the region with the maximum number of years seen for 65 of the 143 whales, which in part reflects the larger amount of survey effort in SVI (Calambokidis et al. 2004a, Calambokidis et al. 2013). Thus, some whales regularly visit particular regions more often than others, but they are seen across the other regions as well.

Some of the whales not seen in the PCFG in a year were seen in Kodiak and Southeast Alaska (Table 9). Of the 25 whales identified in Southeast Alaska and the 153 whales identified in Kodiak, Alaska, 14 (56%) and 24 (15.7%), respectively have been seen farther south in the PCFG.

If we look at latitudes of sightings of individual whales across the 20 years using whales that have been sighted on at least 6 different days (Figure 7), we see that sightings of some whales are highly clustered; whereas, sightings of other whales are highly dispersed across several regions. We defined each whales primary range by the 75% inner quantile which is the middle of the range that includes 75% of the locations. The length of the 75% inner quantile in nautical miles exceeded 60 nautical miles (or 1 degree of latitude) for 49.0% of the whales (Figure 8) and it was more than 180 nautical miles for more than 29.6% of the whales. Thus, it makes little sense to compute an estimate of abundance for any region that spans less than a degree of latitude.

3.3 Annual Sighting Patterns

The average number of whales identified in any one year was 156, 104, and 37 for the PCFG, OR-SVI, and MUA, respectively (Table 10). However, those numbers do not represent the total numbers of whales that use each of these areas because not all whales using a region in a year are seen, not all whales return to the same region each year, and not all of the whales return to the PCFG region each year. The annual average number of newly seen whales (excluding 1996-1998 when the photo-id effort expanded to cover all survey regions) was 37.2, 25.8, and 13.6 for PCFG, OR-SVI, and MUA, respectively. The annual average number of newly seen whales that were "recruited" (seen in a subsequent year), excluding 1996-1998 and 2015, was 14.9, 12.6, and 6.4 for PCFG, OR-SVI, MUA respectively. Thus, there were a substantial number of new whales seen each year and 40.6, 49.6, and 47 percent of those were seen again in a subsequent year in the 3 regions respectively. The number of newly seen whales and the number newly seen and recruited (i.e., seen in at least one more year after the initial year it was seen) (Table 11) are displayed as discovery curves in Figures 9 and 10.

Of the whales that were seen during June-November 1996-2015 in the PCFG (NCA to NBC) about half were only seen in one year and the whales that were seen in more years were sighted more often each year and therefore represented a large proportion of the sightings (Figure 11). Of the 750 identified whales first seen before 2015 between 1 June and 30 November in the PCFG range (NCA-NBC), 52% were seen in only one year and only represent about 5% of the sightings (Figure 11). Many of the newly seen whales did not return in subsequent years. Some whales were seen in every year with 9.3% that were seen in every year after their initial identification, including 5 whales first seen in 1996 that were seen in all of 20 subsequent years. The remaining 39% were seen more than once but not in every year.

Likewise, examination of MT in the first sighting year demonstrates that whales who stay longer in their first year were more likely to be seen in a following year (Figure 12). Whales "first" seen in the first few years of the study (1996-1998) includes some whales that were truly new to the PCFG in those years but many were only "new" because it was the first year of the study or as the surveyed regions expanded over time. This is evident (Figure 12) in the much higher proportions for 1996-1998 than for the other years. These relationships will be important in the capture-recapture models for abundance estimation because whales that do not return after their first year (a large percentage in this analysis) would appeared to have not survived because they have permanently emigrated (with a small fraction that died).

3.4 Open Population Capture-Recapture Models

If the yearly cohorts were pooled, Test2+Test3 statistics indicated a significant lack of fit for the PCFG and subsets (Table 12) primarily resulting from Test 3. This was expected due to the different "survival" rates of previously seen whales (true survival) and newly seen whales of which many never returned (i.e., permanently emigrated) (Table 13) . By separating the cohorts, survival for each cohort was time-varying and thus each cohort has a separate first year survival. The goodness of fit test (Test 2) demonstrated a lack of fit for NCA-NBC and OR-SVI (Table 12). For those regions, we estimated an over-dispersion values of $\widehat{c}$=2.29 and $\widehat{c}$=1.23 respectively to adjust AICc and estimated standard errors.

For all areas, the best fitted model (Table 14) was model 2 for p with capture probability varying across years and higher when MT was greater in the previous year. Likewise, for φ the best model was model 4 for all areas. Model 9 was the second best model. Both models 4 and 9 included a separate first year survival which depends on MT. Model 9 included a different calf first-year "survival" which gave a higher survival for calves than non-calves the first year seen (redundant for calves) because they are more likely to return. In models 9 and 4, there are 3 intercepts for first year survival (1996&97, 1998, >1998) and in model 9 the slopes for MT differ as well. These results were consistent with Calambokidis et al. (2004) who demonstrated strong support for the effect of MT on first year survival (Figure 13) and capture probability (Figure 15) in the following year. These results differ some from Calambokidis et al. (2010) who used an annual median-centered MT. Use of MT with median centering was necessary to construct open model abundance estimates in the manner described in Calambokidis et al. (2010). However, that was not necessary for JS1 and the use of MT without median-centering resulted in lower AICc values.

There was large year to year variation in capture probability. The values for NCA-NBC ranged from 0.42 to 0.98 depending on the year and value of MT (Figure 15). The lowest values were from 2007 which reflects the temporary emigration of whales from MUA and SVI to waters offshore of Oregon in that year. In contrast, for MUA capture probabilities were much lower ranging from 0.08 to 0.76 depending on the year and value of MT (Figure 16). The lower overall capture probability and weaker relationship between capture probability and MT reflect the transitory behavior of whales in such a small area. The lower estimates of of capture probability in 1999-2004 for MUA was due to decreased effort by NMML which spread their survey effort across MUA to WVI during 1999-2002, lost a vessel in 2002 and had no funding in 2004 (Figure 16).

First year survival estimates were dominated by permanent emigration. For NCA-NBC, the estimates varied from 0.30 to 0.81 for non-calf whales with MT=1 in their first year and from 0.69 to 0.95 for MT>80 in their first year (Figure 13). Calf survival is by definition a first year survival rate and potentially includes permanent emigration from the PCFG. Depending on the value of MT, calf survival estimates ranged from about 0.35 to over 0.90 (Figure 14). The average calf survival estimate was 0.63 (se = 0.090). There was some support for a different first year calf survival with model 9 being the second best model (ϕ in Table 14) because calves are less likely to permanently emigrate. Unfortunately there is no way to separate permanent emigration from mortality with the existing data.

Survival subsequent to the first year was assumed to be constant but was less for non-calf whales that were newly seen in 1999 or later. Post-first-year suvival for calves and whales present in 1998 or earlier presumably represents true survival assuming there was little permanent emigration after the first year. Those estimates were 0.967 (se=0.0062) and 0.967 (se=0.0066) for OR-SVI and NCA-NBC respectively. The post-first-year survival estimates for whales that entered in 1999 or later and not identified as a calf were 0.912 (se=0.0125) and 0.917 (se=0.0142) for OR-SVI and NCA-NBC respectively.

3.5 Abundance and Recruitment

For NCA-NBC, OR-SVI and MUA annual estimates of abundance were constructed with model averaged values for JS1 (Table 15-16). Estimates for NCA-NBC in Figure 17 are only shown for 1998-2015 with the open models $p = 1$ for 1996 so it will certainly be an underestimate and the survey coverage in 1996 and 1997 was not as extensive as the later years.

The value of N_{min} for 2015 is 228 for NCA-NBC (Table 15). To gain a sense for how these values might be relevant to estimating a possible level of removal (e.g., due to harvest) we computed the MMPA's Potential Biological Removal (PBR) (typically reserved for stock-level assessments). Using the PBR formula, with an Rmax of 6.2% and a recovery factor of 0.5 (Caretta et al. 2013), the PBR for NCA-NBC (PCFG) would be 3.5.

New whales that are not identified as calves have appeared annually and many of these new (non-calf) whales have subsequently returned and been re-sighted (Table 13). In NCA-NBC from 1999-2014, an average of 32.1 (range: 8.0, 68.0) new whales not identified as a calf were seen each year. Of these new non-calf whales, on average 11.8 (range: 1.0, 28.0) whales returned and were seen in subsequent years. It is unknown what proportion of the non-calves used the PCFG as a calf but were not seen in that year. Currently recruitment appears to be offset by losses (either mortality or permanent emigration) as the abundance estimates have been fairly stable since 2002 and recently increasing.

4 Discussion

The population structure of gray whales using the Pacific Northwest in summer and fall is complicated and involves two elements. One group of whales return frequently and account for the majority of the sightings in the Pacific Northwest during summer and fall. This group is certainly not homogeneous and even within this group, there is some degree of preference for certain subareas. Despite widespread movement and interchange among areas, some of these gray whales are more likely to be seen returning to the same areas they were seen before. The second group of whales are transients that are seen in only one year, tend to be seen for shorter periods that year, and in more limited areas.

The existence of these two groups in the study area and their dynamics complicate estimating abundance. While the JS1 estimator may not be optimal, it provides a practical way of handling transients in this open population. Excluding 1996-1997, the JS1 sequence of abundance estimates provides the most reliable assessment of trend for the non-transient abundance and the best estimate of current abundance in 2015.

Despite extensive interchange among subregions in our study area, whales do not move randomly among areas. Abundance estimates were lower when using more limited geographic ranges but these more limited areas do not reflect closed populations. While the use of geographically stratified models can be useful in cases where populations have geographic strata they use (see for example Hilborn 1990), this would be difficult in our case because of the frequent sightings of animals in multiple regions within the same season and these models typically only allow an animal to be sighted in one strata per period. This could be dealt with by assigning animals to only a single region per season but this would be forcing the data into a somewhat inaccurate construct.

Several studies have considered the question of gray whale population structure. There is widespread agreement that at least two populations of gray whales in the North Pacific exist, a western North Pacific population (also called the Korean population) and an eastern North Pacific (ENP) population (sometimes called the California population) (Swartz et al. 2006; Angliss and Outlaw 2008; Rugh et al. 1999). The population structure of the gray whales feeding in the Pacific Northwest has remained in question and only a few studies have examined this. Steeves et al. (2001) did not find mtDNA differences in a preliminary comparison of gray whales from the summer off Vancouver Island and those from the larger ENP population. Ramakrishnan et al. (2001) did not find evidence that the Pacific Northwest whales represented a maternal genetic isolate, although even very low levels of recruitment from the larger overall population would prevent genetic drift. More recently, Frasier et al. (2011) generated mtDNA sequences from a larger sample of gray whales from Vancouver Island than tested by Steeves et al. (2001). They found significant differences in the haplotype frequencies between that sample and mtDNA sequence data reported for ENP gray whales, most of which were animals that stranded along the migratory route. The Frasier et al. (2011) samples were from a relatively small area; however, Lang et al. (2011) evaluated biopsy samples from California to southern Vancouver Island in the PCFG and ENP samples from whales sampled north of the Aleutians and also found significant mtDNA halpotype frequency differences. These two studies provide the strongest evidence to date that the Pacific Northwest whales might be sufficiently isolated to allow maternally inherited mtDNA to differ from the overall ENP population.

Population structure in other large whales has been the subject of recent inquiry and has revealed diverse results for different species. Clapham et al. (2008) examined 11 subpopulations of whales subjected to whaling that were extirpated possibly due to the loss of the cultural memory of that habitat and concluded subpopulations often exist on a smaller spatial scale than had been recognized. Studies of other baleen whales, particularly humpback whales, have shown evidence of maternally directed site fidelity to specific feeding grounds based on photographic identification studies (Calambokidis et al. 1996, 2001, 2008). This high degree of fidelity to specific feeding areas is often discernible genetically. In the North Pacific strong mtDNA differences were found among feeding areas even when there was evidence of low level of interchange from photo-ID (Baker et al. 2008). Similar findings were documented for humpback whales in the North Atlantic which feed in different areas but interbreed primarily on a single breeding ground (Palsboll et al. 1995) like ENP gray whales. In the North Pacific the differences for humpback whales were often dramatic. For example, humpback whales that feed off California have almost no overlap in mtDNA haplotypes with humpback whales feeding in Southeast Alaska (Baker et al. 1990, 1998, 2008). One difference between humpback and gray whales is the coastal migration route of gray whales which means gray whales going to arctic waters to feed would migrate right through the feeding areas to the south. Other species of large whales have not shown as strong site fidelity to specific feeding grounds. Blue whales have undergone an apparent shift in their feeding distribution in the North Pacific apparently due to shifting oceanographic conditions (Calambokidis et al. 2009a). Fin whales in the North Pacific have long migrations and while there do not appear to be multiple distinct feeding areas as was the case for humpback whales, there were some distinct and isolated apparently non-migratory populations (Mizroch et al. 2009; Berube et al. 2004).

Even though the population structure of gray whales off the Pacific Northwest remains unresolved, there is a consistent group of animals that use this area and we provide several estimates of their abundance. Different abundance methods and geographic scopes yield varied results but all suggest the annual abundance of animals using the Pacific Northwest for feeding through the summer is at most a couple hundred animals depending on the estimating method and how broadly the region is defined geographically.

The rapid increase in the abundance estimates at the start of this study is in part due to the smaller area of coverage during 1996 and 1997. We included those years to improve the estimate in 1998-1999 and the estimate for 1998 did increase by 7% from previous analysis. The increase from 1998-2000 occurred during a period the overall eastern North Pacific gray whale population was experiencing a high mortality event that included unusually high numbers of gray whales showing up in areas they were not common. The high rate of increase in the late 1990s and early 2000s should be verified with additional data such as compiling photographic identifications for this area from multiple sources to attempt to verify if the abundance of animals prior to the start of our study was as low as suggested by these trends. Even though the rate of increase may be too high, we believe the abundance did increase and now appears to be relatively stable since 2002.

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Table 1: Contributions of numbers of sightings (one or more photographs of a whale per day) by reseach group for 1996-2015 and resulting number of uniquely identified whales. Totals for whales are unique whales across all research groups.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Whales
Brian Gisborne	0	4	342	305	634	505	363	786	288	393	406	101	484	297	556	540	521	695	638	472	505
Canada Fisheries/Oceans	0	0	0	0	0	0	0	0	0	0	0	0	0	1	14	8	0	0	0	0	22
Carrie Newell	0	0	0	0	0	0	0	0	0	0	12	72	0	18	2	0	138	190	127	0	129
CERF	13	260	101	124	203	346	271	125	761	11	33	11	38	4	7	40	26	50	7	0	137
CRC	54	36	127	179	91	60	89	85	135	31	61	92	69	58	50	56	83	61	22	41	457
Dawn Goley-HSU	0	0	21	74	56	60	63	0	0	0	0	0	42	19	50	227	228	73	78	28	333
Jan Straley-UASE	0	0	0	0	0	0	0	7	0	0	1	1	0	0	0	0	0	0	0	0	7
Jeff Jacobsen-HSU	0	0	0	0	0	0	0	0	0	0	0	1	0	5	127	327	124	229	141	88	332
Jim Darling	18	0	48	0	0	34	13	0	0	0	0	0	0	0	0	23	0	0	0	0	80
MAKAH	0	0	0	0	0	0	0	0	30	45	129	62	247	102	45	66	145	196	150	202	284
MAKAH-NMML	0	0	0	0	0	0	0	0	0	0	0	0	0	71	24	45	116	53	43	9	137
NMML	34	110	125	159	121	115	71	64	13	99	46	37	65	25	6	11	19	13	25	28	377
North Slope Borough	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Opportunistic	12	3	8	14	1	1	0	0	0	1	28	46	66	82	70	196	43	183	70	38	314
OSU	0	0	0	0	0	0	0	0	0	0	0	0	0	212	68	0	91	45	0	34	119
SWFSC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	131	118
UAF	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	23
UVIC	0	0	308	125	128	0	113	0	0	0	0	1	0	0	0	0	0	0	58	100	177
Volker Deecke	0	0	39	40	26	2	0	0	0	0	11	0	0	0	0	0	0	0	0	0	73
Wendy Szaniszlo	0	0	0	0	0	0	0	0	0	87	50	58	117	4	23	90	136	171	52	32	150
Photo Totals	131	413	1119	1020	1260	1123	983	1067	1227	667	777	482	1152	898	1042	1629	1670	1959	1411	1203	
Whale Totals	70	77	158	247	179	196	251	178	196	202	182	159	225	242	234	284	330	384	295	266	1638

Table 2: Regional distribution of numbers of sightings (one or more photographs of a whale per day) and resulting number of uniquely identified whales by reseach group for 1996-2015. Totals for whales are unique whales across all research groups. NPS is northern Puget Sound and PS includes southern Puget Sound, San Juan Islands, Hood Canal and Boundary Bay.

	CA	NCA	SOR	OR	GH+	NWA	SJF	PS	NPS	SVI	WVI	NBC	SEAK	KAK
Brian Gisborne	0	0	0	0	0	0	0	1	0	8073	254	2	0	0
Canada Fisheries/Oceans	0	0	0	0	0	0	0	0	0	18	5	0	0	0
Carrie Newell	0	0	0	559	0	0	0	0	0	0	0	0	0	0
CERF	0	0	0	0	0	0	0	0	0	0	48	2383	0	0
CRC	23	98	117	100	254	112	40	68	521	38	0	95	14	0
Dawn Goley-HSU	0	919	64	36	0	0	0	0	0	0	0	0	0	0
Jan Straley-UASE	0	0	0	0	0	0	0	0	0	0	0	0	9	0
Jeff Jacobsen-HSU	13	992	31	6	0	0	0	0	0	0	0	0	0	0
Jim Darling	0	0	0	0	0	0	0	0	0	9	127	0	0	0
MAKAH	0	0	0	19	0	618	782	0	0	0	0	0	0	0
MAKAH-NMML	0	0	0	0	0	258	102	0	0	0	1	0	0	0
NMML	0	13	65	0	0	314	307	0	18	182	150	10	0	127
North Slope Borough	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Opportunistic	106	2	5	67	0	1	22	35	106	213	255	13	7	25
OSU	0	331	3	111	5	0	0	0	0	0	0	0	0	0
SWFSC	0	0	12	0	0	0	0	0	0	41	9	33	0	36
UAF	0	0	0	0	0	0	0	0	0	0	0	0	0	24
UVIC	0	0	0	0	0	0	0	0	0	1	832	0	0	0
Volker Deecke	0	0	0	0	0	0	0	1	0	71	0	42	4	0
Wendy Szaniszlo	0	0	0	0	0	0	0	0	0	467	353	0	0	0
Photo Totals	142	2355	297	898	259	1303	1253	105	645	9113	2034	2578	34	212
Whale Totals	121	526	122	188	146	357	210	44	51	489	338	138	25	155

Table 3: Survey regions and region subsets used for abundance estimation. Numbers refer to locations on the map in Figure 1.

Survey Region	Region Description	NCA-NBC	OR-SVI	MUA
(1) SCA = Southern California				
(2) CCA = Central California				
(3) NCA = Northern California	Eureka to Oregon border; mostly from Patricks Pt. and Pt. St George	x		
(4) SOR = Southern Oregon		x	x	
(5) OR = Oregon Coast	Primarily central coast near Depoe Bay and Newport, OR	x	x	
(6) GH+ = Gray's Harbor	Waters inside Grays Harbor and coastal waters along the S Washington coast	x	x	
(7) NWA = Northern Washington	Northern outer coast waters with most effort from Cape Alava (Sea Lion Rock) to Cape Flattery	x	x	x
(8) SJF = Strait of Juan de Fuca	US waters east of Cape Flattery extending to Admiralty Inlet (entrance to Puget Sound) with most effort ending at Sekiu Point	x	x	x
(9) NPS = Northern Puget Sound	Inside waters and embayments from Edmonds to the Canadian border			
(10) PS = Puget Sound	Central and southern Puget Sound (S of Edmonds), including Hood Canal, Boundary Bay, and the San Juan Islands			
(11) SVI = Southern Vancouver Island	Canadian waters of the Strait of Juan de Fuca along Vancouver Island from Victoria to Barkley Sound, along West Coast Trail	x	x	
(12) WVI = West Vancouver Island		x		
(13) NBC = Northern British Columbia	British Columbia waters north of Vancouver Island, with principal effort around Cape Caution	x		
(14) SEAK = Southeast Alaska	Waters of southeastern Alaska with the only effort in the vicinity of Sitka			
(15) KAK = Kodiak, Alaska				

Table 4: Model specifications for survival (φ) and capture probability (p) parameters in POPAN models for gray whale photo-identification data. For survival models, β_0 is the baseline intercept for non-transient survival. Fy is 1 if it is year the whale was first seen and 0 otherwise. A subscript for Fy means that it applies only for that cohort except that Fy_{99}applies to cohorts 1999 and beyond and Fy_c represents each of the cohorts from 1996 to 2015. C is 1 if identified as a calf in its first year and 0 otherwise. R is 1 for calves or any whale seen in 1998 or was already in the catalog prior to 1998 and 0 otherwise. β_r is an adjustment to post-first-year survival. MT is minimum tenure value of a whale and β_M is the estimated slope parameter for φ or p. $\beta_{M,96-97}$ applies to 1996-97, $\beta_{M,98}$ to 1998 and $\beta_{M,99}$ applies to 1999-2014. $\beta_{Fy,96-97}$, $\beta_{Fy,98}$ and $\beta_{Fy,99}$ are the first-year survival intercept adjustments for 1996-97, 1998 and cohorts 1999-2014 respectively and $\beta_{Fy,c}$ represents 19 cohort-specific first year survival parameters for 1996-2014. β_{CF} is an adjustment for calf first year survival and β_{CM} is an adjustment for calves to the slope of MT for survival. For the capture probability models, β_t has 18 levels for t=1998,...2015 and β_0 represents the 1997 value. For 1996 p=1.

Model	Parameter Logit Formula	Number of parameters
φ		
1	$\beta_0 + \beta_{Fy} Fy + \beta_r R(1 - Fy)$	3
2	$\beta_0 + \beta_{Fy} Fy + \beta_M MT\, Fy + \beta_r R(1 - Fy)$	4
3	$\beta_0 + \beta_{Fy,96-97} Fy_{96-97} + \beta_{Fy,98} Fy_{98} + \beta_{Fy,99} Fy_{99} + \beta R(1 - Fy)$	5
4	$\beta_0 + \beta_{Fy,96-97} Fy_{96-97} + \beta_{Fy,98} Fy_{98} + \beta_{Fy,99} Fy_{99} + \beta_M MT\, Fy + \beta_r R(1 - Fy)$	6
5	$\beta_0 + (\beta_{Fy,96-97} + \beta_{M,96-97} MT) Fy_{96-97} + (\beta_{Fy,98} + \beta_{M,98} MT) Fy_{98} + (\beta_{Fy,99} + \beta_{M,99} MT) Fy_{99} + \beta_r R(1 - Fy)$	8
6	$\beta_0 + \beta_{Fy,c} Fy_c + \beta_M MT\, Fy + \beta_r R(1 - Fy)$	22
7	$\beta_0 + \beta_{Fy,c} Fy_c + \beta_M MT\, Fy + \beta_{CF} C\, F_y + \beta_r R(1 - Fy)$	23
8	$\beta_0 + \beta_{Fy,c} Fy_c + \beta_M MT\, Fy + \beta_{CF} C\, F_y + \beta_{CM} C\, MT + \beta_r R(1 - Fy)$	24
9	$\beta_0 + (\beta_{Fy,96-97} + \beta_{M,96-97} MT) Fy_{96-97} + (\beta_{Fy,98} + \beta_{M,98} MT) Fy_{98} + (\beta_{Fy,99} + \beta_{M,99} MT) Fy_{99} + \beta_{CF} C\, F_y + \beta_r R(1 - Fy)$	9
10	$\beta_0 + (\beta_{Fy,96-97} + \beta_{M,96-97} MT) Fy_{96-97} + (\beta_{Fy,98} + \beta_{M,98} MT) Fy_{98} + (\beta_{Fy,99} + \beta_{M,99} MT) Fy_{99} + \beta_{CF} C\, F_y + \beta_{CM} C\, MT + \beta_r R(1 - Fy)$	10
p		
1	$\beta_0 + \beta_t$	19
2	$\beta_0 + \beta_t + \beta_M MT$	20
3	$\beta_0 + \beta_M MT$	2

Table 5: Regional distribution of numbers of whales seen by month for 1996-2015.

	1	2	3	4	5	6	7	8	9	10	11	12
CA	7	16	18	17	14	3	6	7	13	1	1	28
NCA	154	50	8	67	68	127	139	57	49	100	114	139
SOR	0	3	0	2	5	7	36	45	69	43	0	0
OR	0	1	4	4	30	28	53	83	93	64	2	0
GH+	6	2	30	60	29	17	3	0	27	1	0	0
NWA	7	5	26	61	110	79	78	102	103	73	13	1
SJF	0	0	3	15	32	47	60	62	83	105	79	21
PS-HC-BB-SJ	0	1	6	21	8	10	5	2	1	1	4	1
NPS	1	3	17	28	32	11	1	0	0	0	0	0
SVI	5	8	77	101	129	224	263	216	186	94	37	6
WVI	0	1	14	35	31	116	194	186	113	27	0	0
NBC	1	0	0	0	3	26	84	113	83	28	0	1
SEAK	0	0	0	0	0	17	4	1	3	0	5	0
KAK	0	0	0	0	2	19	34	57	60	0	0	0

Table 6: Regional distribution of numbers of whales seen during June-November for 1996-2015.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CA	0	0	0	1	0	5	0	0	4	0	3	0	0	3	7	1	7	0	0	2
NCA	0	0	16	38	27	32	37	15	3	0	0	1	47	62	62	82	95	81	53	8
SOR	0	0	0	0	0	2	46	24	16	1	0	23	15	2	15	10	11	5	26	30
OR	0	0	17	31	8	15	0	0	16	4	9	39	6	38	20	7	42	40	35	21
GH+	1	0	0	1	1	1	0	0	1	0	0	38	0	2	0	0	0	0	0	0
NWA	13	15	22	7	9	31	7	19	3	19	44	13	35	30	22	36	62	47	32	31
SJF	9	22	18	4	5	2	1	9	24	17	21	14	54	37	4	11	11	36	45	23
PS-HC-BB-SJ	0	0	3	8	4	0	0	0	0	1	0	0	0	4	0	0	1	0	0	1
NPS	0	0	0	0	10	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0
SVI	13	17	60	45	55	101	66	90	86	89	67	37	78	75	62	62	73	99	84	98
WVI	8	0	57	66	53	29	85	9	0	52	40	13	23	23	9	53	28	114	50	46
NBC	13	33	23	25	23	40	43	51	88	12	21	5	21	3	4	2	15	31	7	28
SEAK	0	0	5	6	0	1	0	6	0	1	2	3	0	5	0	0	0	0	0	0
KAK	0	0	0	0	0	0	42	4	0	48	0	0	23	0	17	0	2	0	0	35

Table 7: Number of days in which whales were seen for each region and year from 1996-2015 from 1 June - 30 November.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CA	0	0	0	1	0	2	0	0	2	0	1	0	0	2	4	1	2	0	0	2
NCA	0	0	8	8	20	13	20	2	2	0	0	2	9	19	21	32	28	20	14	4
SOR	0	0	0	0	0	1	4	1	2	1	0	3	1	1	7	6	3	4	6	5
OR	0	0	6	9	5	7	0	0	1	1	7	38	1	22	8	11	70	54	18	13
GH+	1	0	0	1	1	1	0	0	1	0	0	3	0	1	0	0	0	0	0	0
NWA	9	12	22	10	7	11	3	9	1	12	13	7	8	7	14	23	20	16	17	16
SJF	9	42	16	9	9	4	2	15	7	13	18	26	36	30	4	11	17	25	31	33
PS-HC-BB-SJ	0	0	3	11	4	0	0	0	0	2	0	0	0	4	0	0	1	0	0	1
NPS	0	0	0	0	1	0	0	0	0	0	0	0	0	2	3	0	0	0	0	0
SVI	9	10	91	87	82	55	68	66	48	73	59	39	82	71	80	106	75	64	77	28
WVI	10	0	54	46	28	7	10	3	0	6	14	27	31	5	1	22	7	46	25	28
NBC	7	53	39	50	53	43	34	29	53	11	16	9	13	2	8	1	3	6	1	5
SEAK	0	0	2	3	0	1	0	3	0	1	2	2	0	2	0	0	0	0	0	0
KAK	0	0	0	0	0	0	4	2	0	7	0	0	5	0	2	0	1	0	0	10

Table 8: Interchange of whales across regions for all years (1996-2015) for June-November. The diagonal is the number of unique whales seen in that region over the 20 year time span. Many of those whales were only seen once. Here PS includes NPS and CA represents SCA and CCA.

	CA	NCA	SOR	OR	GH+	NWA	SJF	PS	SVI	WVI	NBC	SEAK	KAK
CA	28												
NCA	10	301											
SOR	6	73	112										
OR	8	103	69	166									
GH+	1	19	11	21	43								
NWA	9	83	54	87	27	203							
SJF	6	49	27	48	17	97	182						
PS	0	0	0	0	0	1	1	32					
SVI	10	101	56	96	30	148	118	2	343				
WVI	7	87	45	81	30	120	99	2	200	295			
NBC	3	23	13	33	15	42	38	2	84	82	133		
SEAK	0	3	1	3	2	6	7	0	9	10	12	25	
KAK	1	10	1	6	0	3	2	1	13	12	8	1	153

Table 9: Sighting histories of whales seen in the PCFG during 1 June - 30 November in at least one year and also in Southeast Alaska (SEAK) or Kodiak (KAK) in one year. 1: whale sighted in PCFG but not SEAK or KAK that year, 2: only seen in SEAK or KAK that year, and 3: seen in both PCFG and in SEAK and KAK in that year.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
68	1	2	2																
187	1	1	1	1	1	1	1	1				1		1					2
126	1	1			1			1	2			1				1			
130	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1
140	1	1	3	1	1	1	1	1		1		1	1	1	1	1	1	1	1
141	1	1	1		1	1	1	1	1	1	3	1	1			1	1		1
152	1		1			2			2					2					
229	1	1	1	1	1	1	1	1	1	2									
323	1	1				1	1	1	2	1		2							
325	1	1			1	1	1	1	3	1							1	1	
328	1	1	1	1	1	1	1	1	1	1		1	3		1	1	1	1	1
899	1							1	2										
227		1	2	1	1	1	1	1	1	1	1		1		1	1	1	1	1
232		1		1	1	2	1								1			1	1
261		2				1		1							1		1	1	
316		1					2		2										
628			2	1	1	1	1	1				1					1		1
538				1	1	1		1	2										
555				1		1	1			1		2	1	1	1	1	1		
566				1		2		1	2					1					
601				1	1		1	1	1	1						2			
612				1	1	1	3	1	1	2						1	1	1	1
581					1		1	1	2	1	1					2	1	1	1
604					1		1		2					2	1				
639					1	2					1		1						
684						1	2				1								
687						1			1	1	1	1	3	1					
691						1	3	1	2			1							
723						2													1
760						1	1	1	3							1			2
800							3	1	1										
815								1				2						1	
900								1					2			1			1
834									2				1				1	1	
893									2							1		1	
918									2							1			
993											1			1	1				3
1778																		1	2

Table 10: Number of unique whales seen by year for MUA, OR-SVI, and PCFG (NCA-NBC) during 1996-2015.

Region	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Average
MUA	19	27	37	11	14	32	8	22	26	33	58	20	75	57	26	41	67	66	63	45	37
OR-SVI	30	36	86	71	70	128	103	110	118	107	96	114	123	118	93	91	127	145	151	161	104
PCFG	45	69	132	151	140	173	203	157	179	135	126	120	174	152	144	164	208	232	200	211	156

Table 11: Discovery of new unique whales over years 1996-2015 for PCFG,OR-SVI and MUA. Recruited only means that the whale was seen in at least one more year after the initial year it was seen. The number 'recruited' will usually be greater than the abundance estimate because some whales die and others may permanently emigrate and do not return.

Region	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
PCFG	45	90	161	229	283	345	398	418	448	466	474	494	544	566	581	600	653	711	750	793
ORSVI	30	50	105	128	155	211	249	275	306	323	333	355	377	394	402	411	439	476	512	544
MUA	19	34	57	58	69	88	89	100	114	123	146	148	177	190	194	205	227	249	273	288
PCFG-recruited	40	76	123	135	163	189	219	234	247	257	258	267	285	292	304	309	328	350	362	
ORSVI-recruited	26	39	76	85	100	122	149	169	185	195	198	205	216	222	229	234	248	266	278	
MUA-recruited	17	28	36	36	44	51	52	58	68	74	91	93	109	111	113	119	126	133	138	

Table 12: RELEASE goodness of fit results for each region using pooled and separate cohorts. When cohorts are separated as groups, Test 3 is always 0 because there are no sub-cohorts.

Region	Cohort	Test	χ^2	df	P
MUA	Pooled				
		Test 2	75.1301	35	1e-04
		Test 3	73.6519	34	1e-04
		Total	148.782	69	0
	Separate				
		Test 2	17.4696	79	1
OR-SVI	Pooled				
		Test 2	207.9702	47	0
		Test 3	358.0037	35	0
		Total	565.974	82	0
	Separate				
		Test 2	172.5884	140	0.0319
NCA-NBC	Pooled				
		Test 2	381.7309	47	0
		Test 3	738.8561	35	0
		Total	1120.587	82	0
	Separate				
		Test 2	302.1301	132	0

Table 13: Number of whales seen each year, number that were new that year in that region, and number that were new and were seen in a subsequent year for whales seen between June-November 1996-2015 in each region. The year a whale was seen as new can vary across regions and if it differs will be later in the smaller region.

Region		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
MUA	Seen	19	27	37	11	14	32	8	22	26	33	58	20	75	57	26	41	67	66	63	45
	Non-calf: New	19	15	22	1	11	18	1	10	12	9	23	2	28	13	4	9	20	17	21	12
	Non-calf: New/Resighted	17	11	7	0	8	7	1	5	8	6	17	2	15	2	2	4	6	4	5	0
	Calf: New	0	0	1	0	0	1	0	1	2	0	0	0	1	0	0	2	2	5	3	3
	Calf: New/Resighted	0	0	1	0	0	0	0	1	2	0	0	0	1	0	0	2	1	3	0	0
OR-SVI	Seen	30	36	86	71	70	128	103	110	118	107	96	114	123	118	93	91	127	145	151	161
	Non-calf: New	30	20	54	23	27	51	31	23	26	14	10	20	20	16	7	4	21	26	25	26
	Non-calf: New/Resighted	26	13	36	9	15	19	22	17	13	9	3	6	10	6	6	2	8	9	7	0
	Calf: New	0	0	1	0	0	5	7	3	5	3	0	2	2	1	1	5	7	11	11	6
	Calf: New/Resighted	0	0	1	0	0	3	5	3	3	1	0	1	1	0	1	3	6	9	5	0
NCA-NBC	Seen	45	69	132	151	140	173	203	157	179	135	126	120	174	152	144	164	208	232	200	211
	Non-calf: New	45	45	68	68	54	57	44	17	25	15	8	17	48	21	12	13	44	47	24	32
	Non-calf: New/Resighted	40	36	45	12	28	23	23	12	10	9	1	8	17	7	9	1	12	12	5	0
	Calf: New	0	0	3	0	0	5	9	3	5	3	0	3	2	1	3	6	9	11	15	11
	Calf: New/Resighted	0	0	2	0	0	3	7	3	3	1	0	1	1	0	3	4	7	10	7	0

Table 14: Delta AICc and QAICc (for OR-NBC and NCA-NBC models) for 30 models fitted to each set of data.

Region	p model	φ Model 1	2	3	4	5	6	7	8	9	10
MUA	1	20.1	11.2	11.8	1.4	4.5	7.9	5.0	7.1	4.2	5.6
	2	17.2	9.5	9.2	0.0	3.2	7.4	4.3	6.4	2.6	4.0
	3	98.1	91.2	88.1	80.6	82.9	86.8	84.4	86.2	82.5	83.5
OR-SVI	1	223.1	181.7	214.9	170.4	173.4	176.2	174.5	173.4	172.8	173.3
	2	42.1	10.0	35.7	0.0	3.1	6.5	4.8	4.8	2.0	2.9
	3	42.9	11.4	36.9	1.7	4.9	9.3	7.9	8.4	3.4	4.3
NCA-NBC	1	185.3	149.8	159.4	120.1	123.6	129.3	127.3	129.3	121.3	123.4
	2	58.9	28.8	33.9	0.0	3.6	10.0	8.6	9.9	0.6	3.5
	3	62.8	33.4	39.5	5.4	8.7	16.6	13.0	NA	6.2	7.7

Table 15: JS1 abundance estimates ($\widehat{N}$), standard errors and minimum population estimate $N_{min} = \widehat{N}e^{-0.842\sqrt{log(1+(se(\widehat{N})/\widehat{N})^2}}$ using data from 1996-2015 in OR-SVI and NCA-NBC regions.

Region	Year	$\widehat{N}$	$se(\widehat{N})$	N_{min}
OR-SVI	1996	24	2.2	22
	1997	42	6.2	38
	1998	81	9.1	74
	1999	84	10.3	76
	2000	91	13.3	81
	2001	132	14.3	121
	2002	134	16.1	121
	2003	158	14.2	146
	2004	163	16.6	150
	2005	169	17.2	155
	2006	155	17.1	141
	2007	162	14.6	150
	2008	170	17.4	156
	2009	161	13.6	150
	2010	150	17.7	135
	2011	146	16.0	133
	2012	163	13.6	152
	2013	177	13.2	167
	2014	189	16.5	175
	2015	196	19.3	180
NCA-NBC	1996	38	2.8	36
	1997	80	10.5	72
	1998	126	11.0	117
	1999	145	14.6	133
	2000	146	14.4	135
	2001	178	13.5	167
	2002	197	14.1	185
	2003	207	17.5	193
	2004	216	16.6	202
	2005	215	26.7	194
	2006	197	21.4	180
	2007	192	26.0	171
	2008	210	18.6	195
	2009	208	21.2	191
	2010	200	19.1	184
	2011	205	15.9	192
	2012	217	11.3	208
	2013	235	14.0	224
	2014	238	19.0	222
	2015	243	18.9	228

Table 16: JS1 abundance estimates ($\widehat{N}$), standard errors and minimum population estimate $N_{min} = \widehat{N}e^{-0.842\sqrt{log(1+(se(\widehat{N})/\widehat{N})^2}}$ using data from 1996-2015 in MUA region.

Year	$\widehat{N}$	$se(\widehat{N})$	N_{min}
1996	18	1.5	16
1997	32	4.6	28
1998	40	9.3	33
1999	38	14.8	28
2000	41	26.4	25
2001	53	14.1	43
2002	48	23.7	33
2003	53	17.6	41
2004	58	17.7	45
2005	62	12.5	52
2006	70	8.8	63
2007	71	20.1	56
2008	84	7.6	78
2009	86	11.8	77
2010	80	20.3	65
2011	79	14.6	68
2012	88	10.8	80
2013	91	11.8	82
2014	100	15.2	88
2015	105	21.5	88

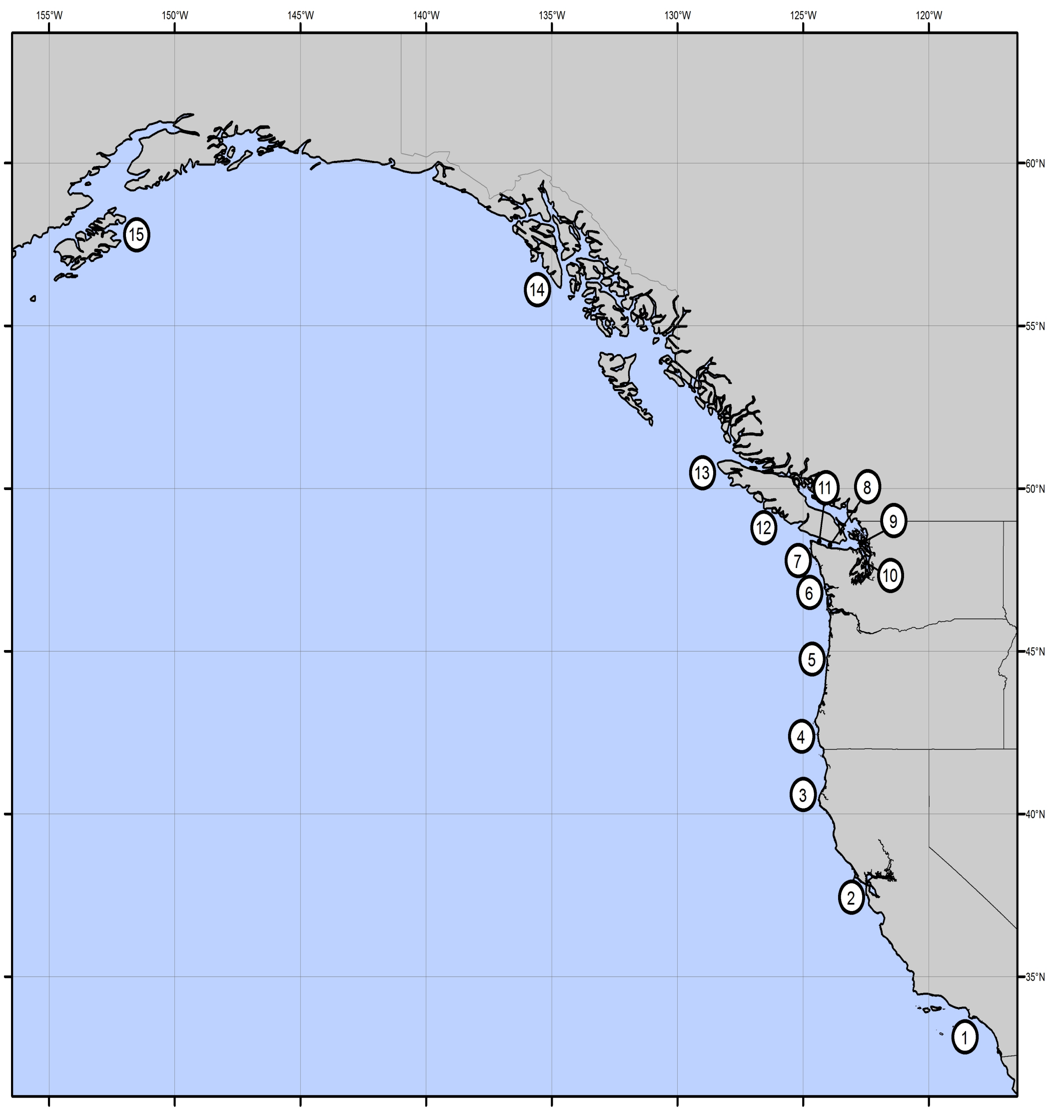

Figure 1: Locations for photo-identifications of gray whales. Numbers refer to values in Table 3.

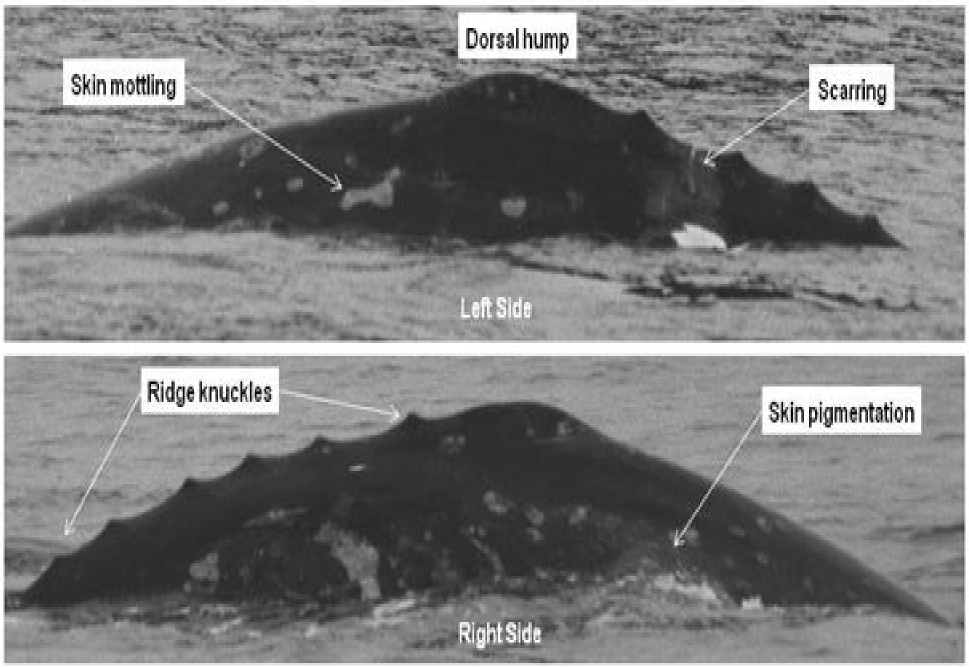

Figure 2: Characteristics used for gray whale photo-identification.

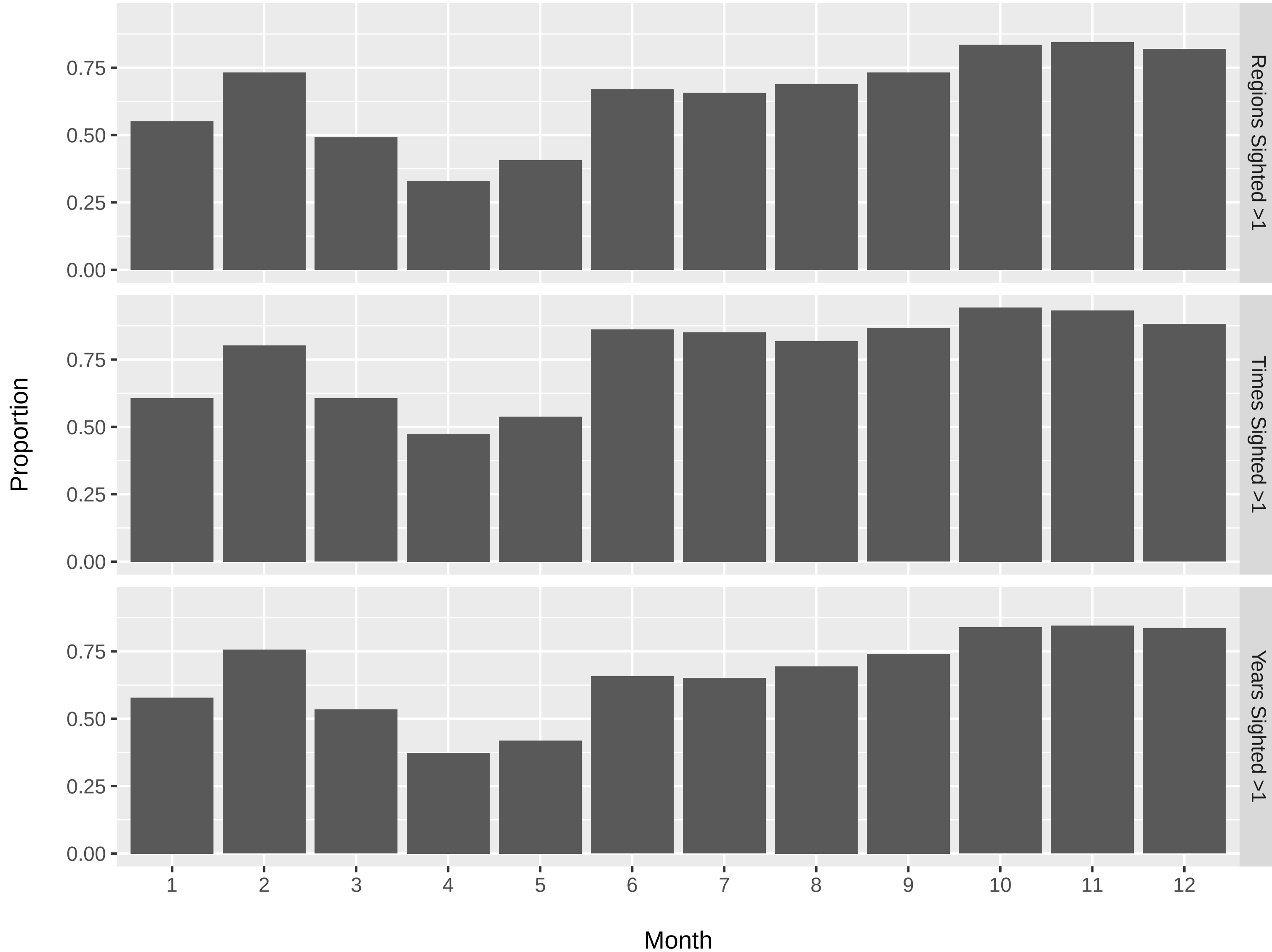

Figure 3: Monthly measures of proportion of whales that were seen in more than one region, seen on more than one day and seen in more than one year. The values include sightings from 1996-2015 in all regions from California to Alaska. Lower values imply whales were simply migrating through the area in a short time frame and were thus less likely to be seen at other times and in other regions. Values are not shown for months with fewer than 20 sightings. Whales seen more often are overrepresented because they are used in each month they were seen. For example a whale seen in June, July and August will be in each summary. Thus, these values may be larger than values computed without splitting by month (e.g., overall proportion of whales seen in more than one year).

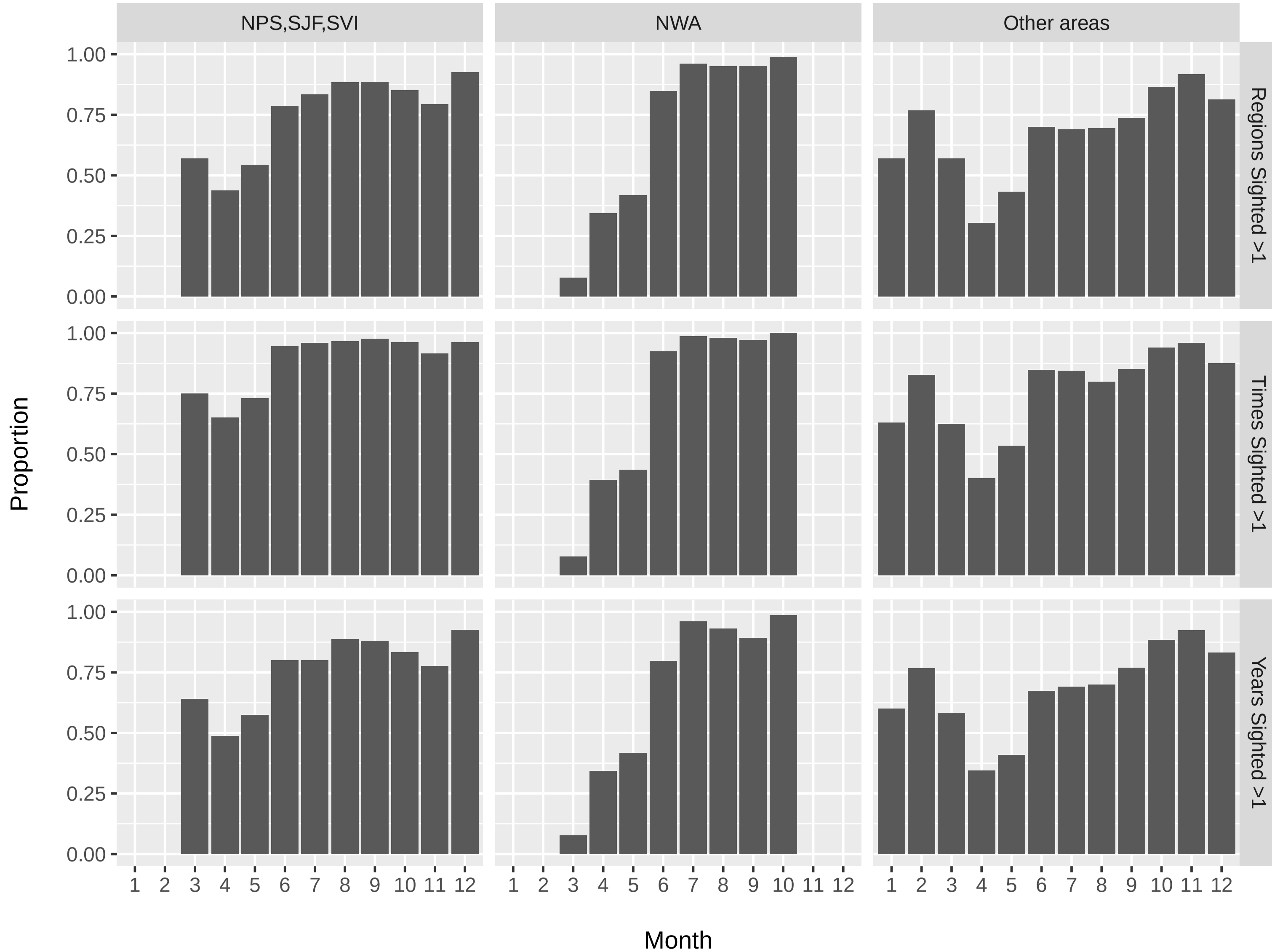

Figure 4: Region and monthly measures of proportion of whales that were seen in more than one region, seen on more than one day and seen in more than one year. The values include sightings from 1996-2015 in all regions from California to Alaska. Lower values imply whales were simply migrating through the area in a short time frame and were thus less likely to be seen at other times and in other regions. Values are not shown for months with fewer than 20 sightings. Whales seen more often are over-represented because they are used in each month they were seen. For example a whale seen in June, July and August will be in each summary. Thus, these values may be larger than values computed without splitting by month (e.g., overall proportion of whales seen in more than one year).

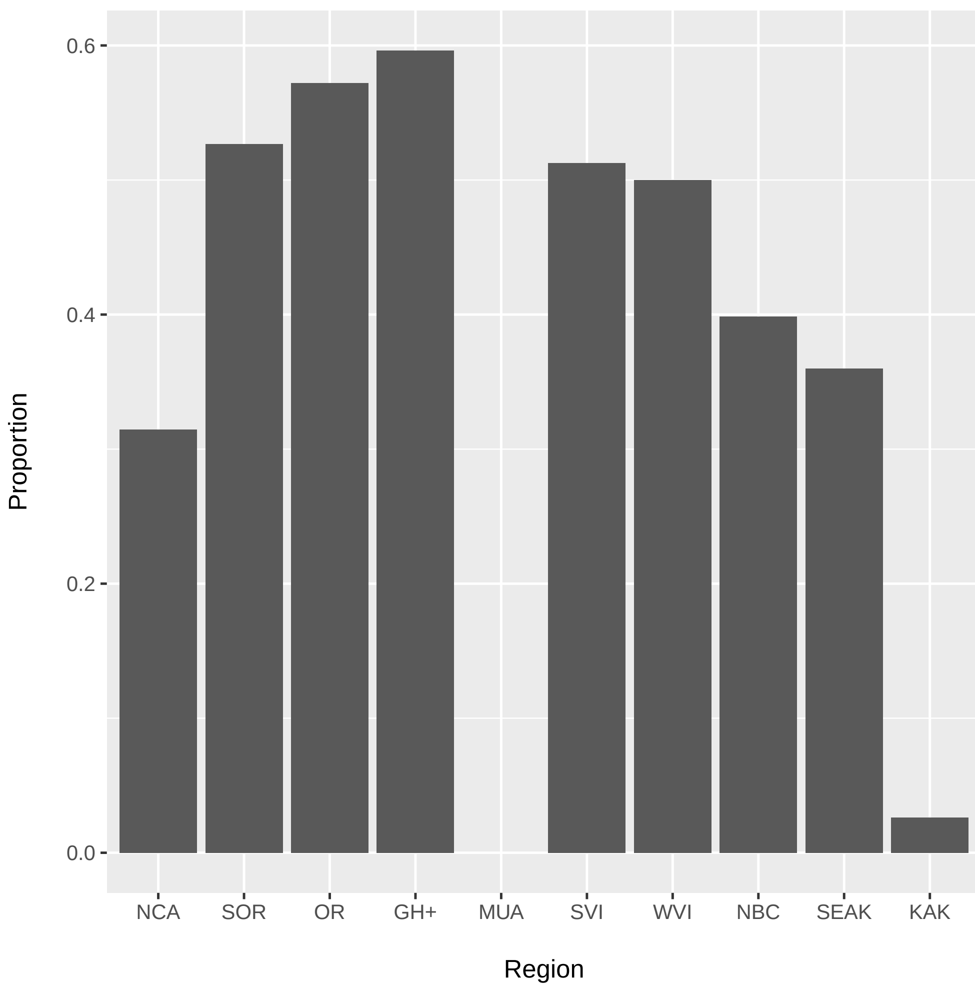

Figure 5: Proportion of whales in sub-regions from NCA to KAK that have been seen in the MUA using sightings after 1 June from 1996-2015.

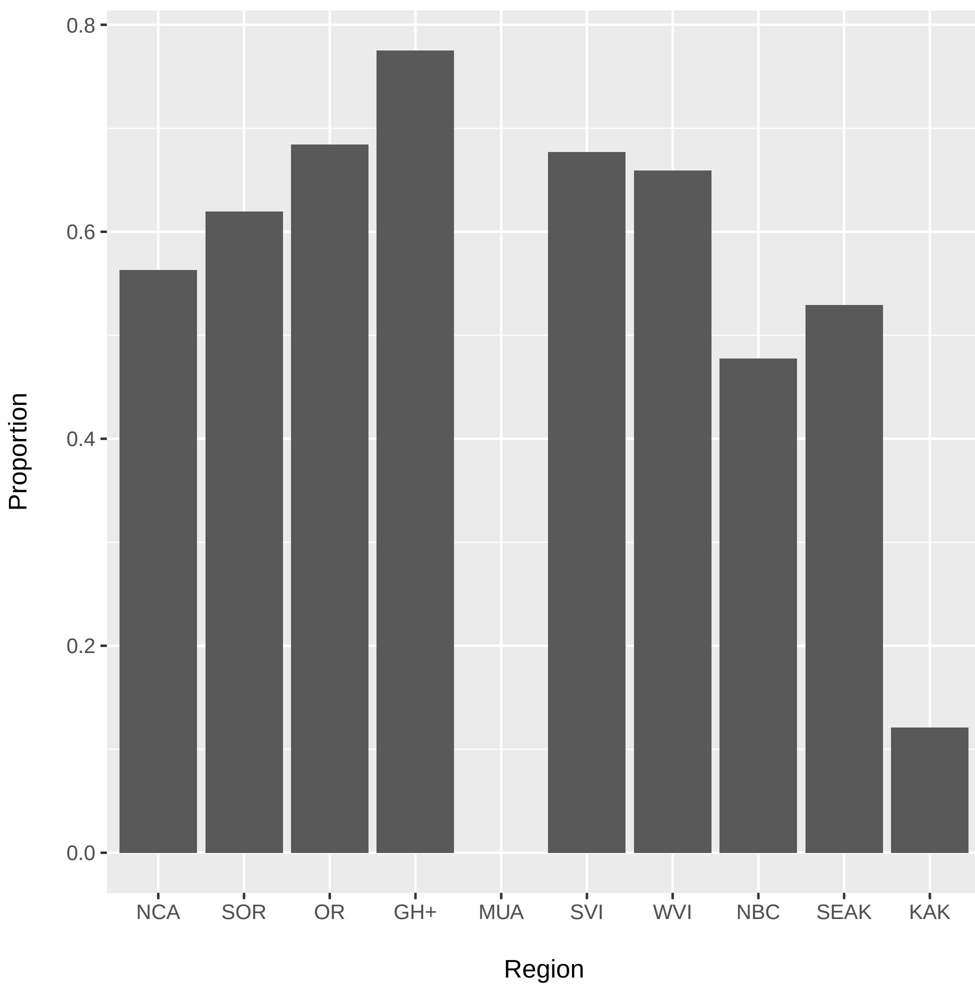

Figure 6: Proportion of whales seen in at least 2 years in sub-regions from NCA to KAK that have been seen in the MUA using sightings after 1 June from 1996-2015.

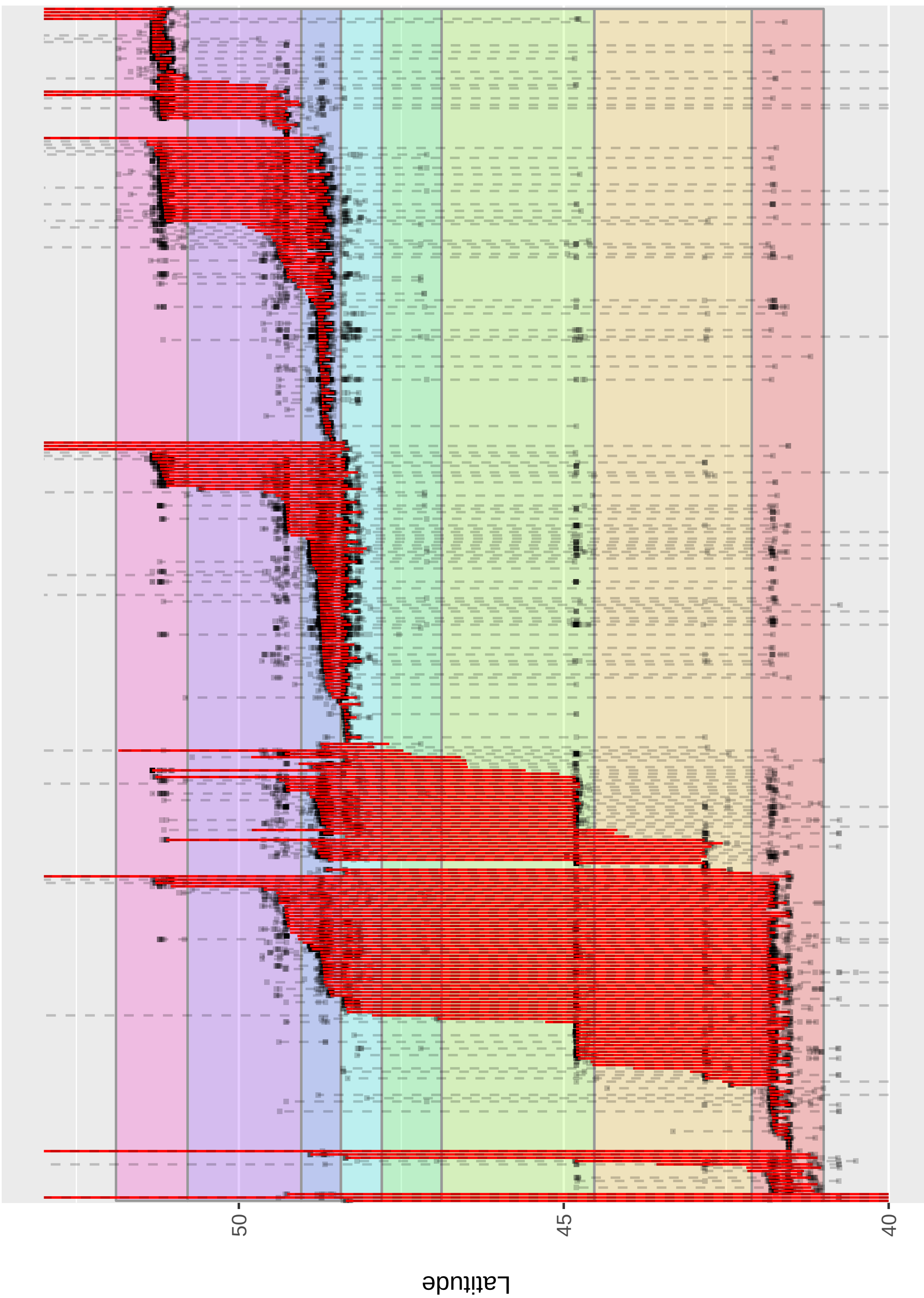

Figure 7: Distribution of latitudes of sightings (points) for whales with 6 or more sightings after 1 June from 1996-2015, the 75% inner quantile (solid thick line), and full range (light dashed line). Each position on the x axis represents an individual whale. Whales have been arranged on the plot by sorting first on the lower bound of the inner quantile (to a half-degree) and then the upper bound of the quantile. This has the effect of sorting from south to north and clusters whales with smaller quantile ranges followed by whales with larger ranges.

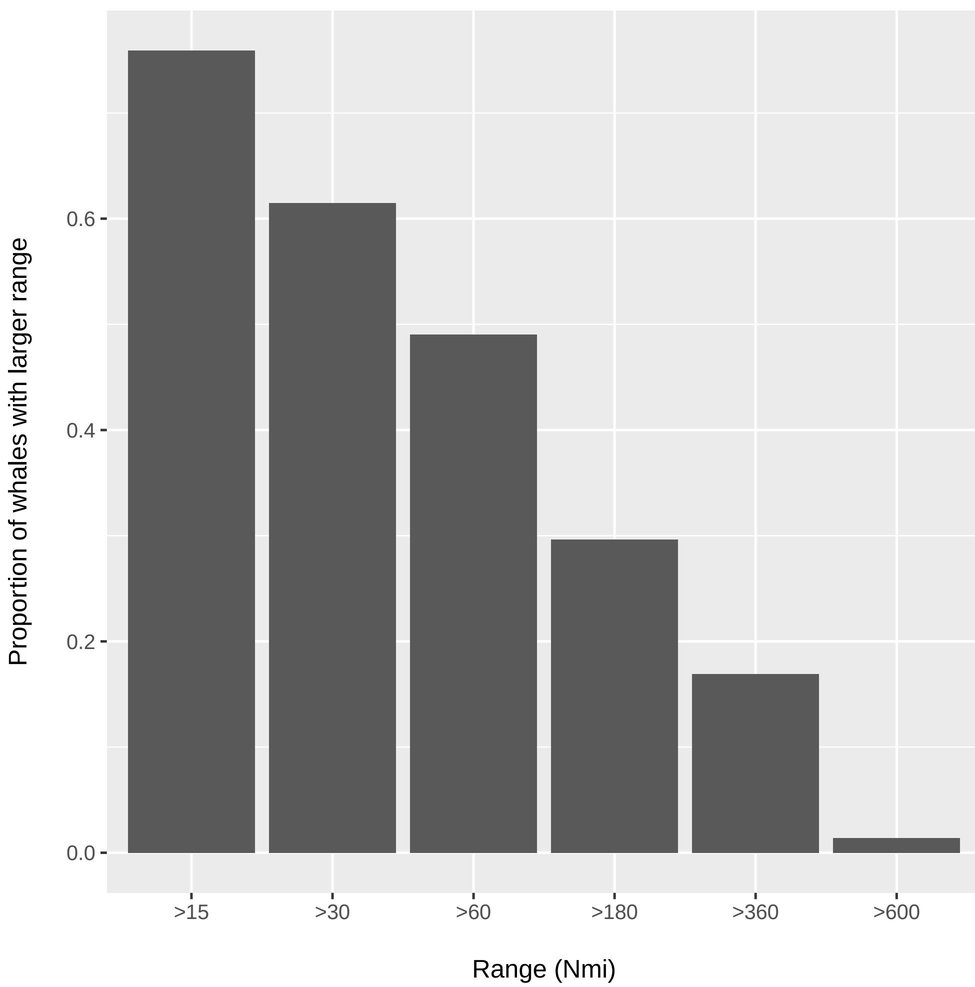

Figure 8: Distribution of ranges of 75% inner quantiles of latitudes expressed in nautical miles for whales sighted on 6 or more days during 1996-2015.

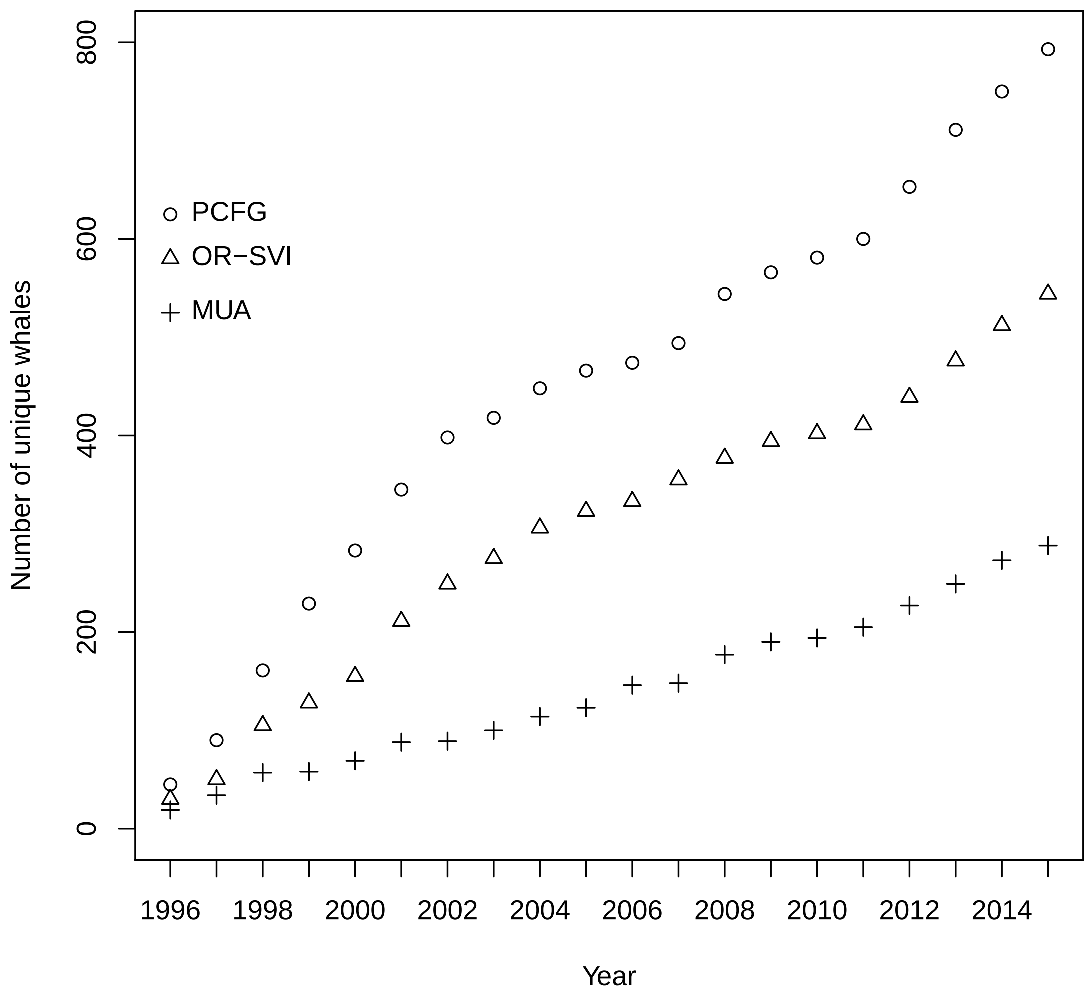

Figure 9: Discovery curves for unique whales seen in PCFG, OR-SVI and MUA for 1996-2015.

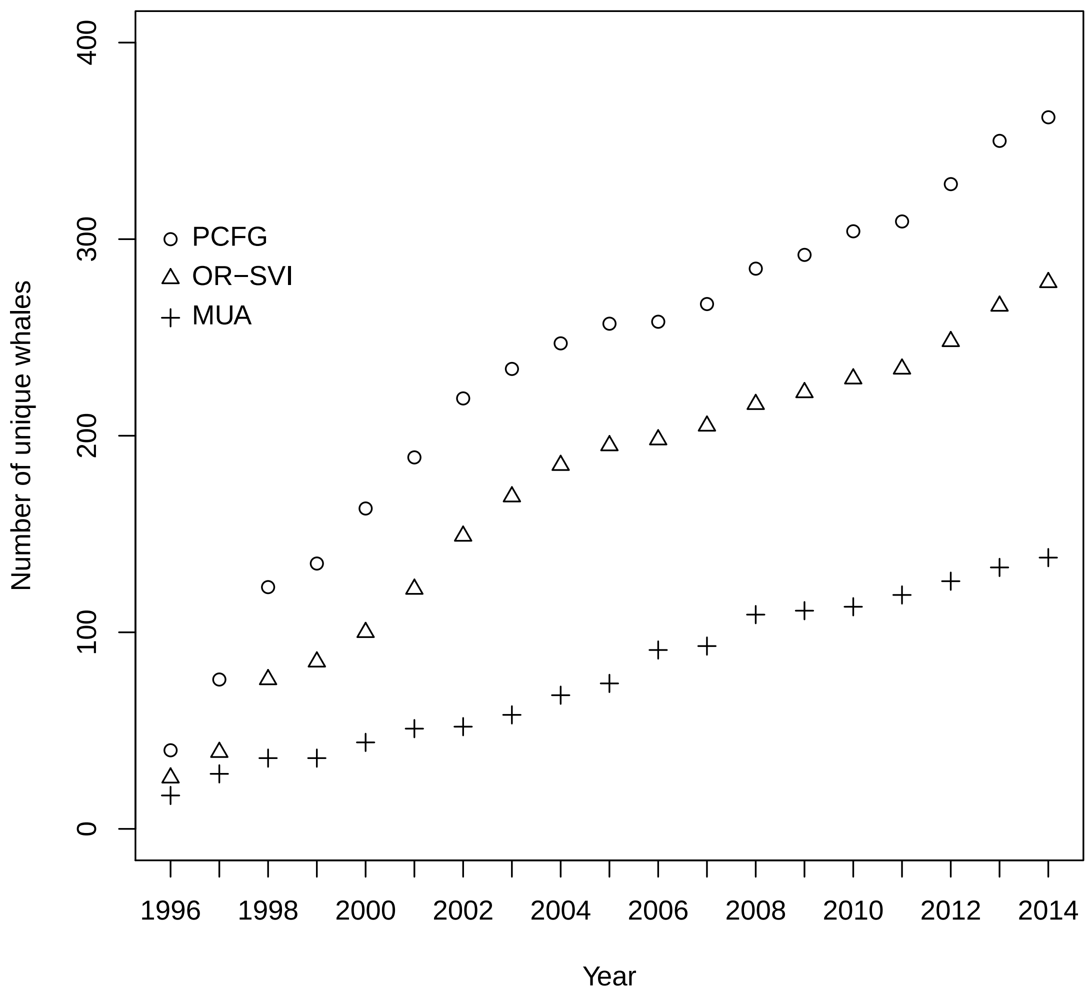

Figure 10: Discovery curves for unique recruited whales seen in PCFG, OR-SVI and MUA for 1996-2015.

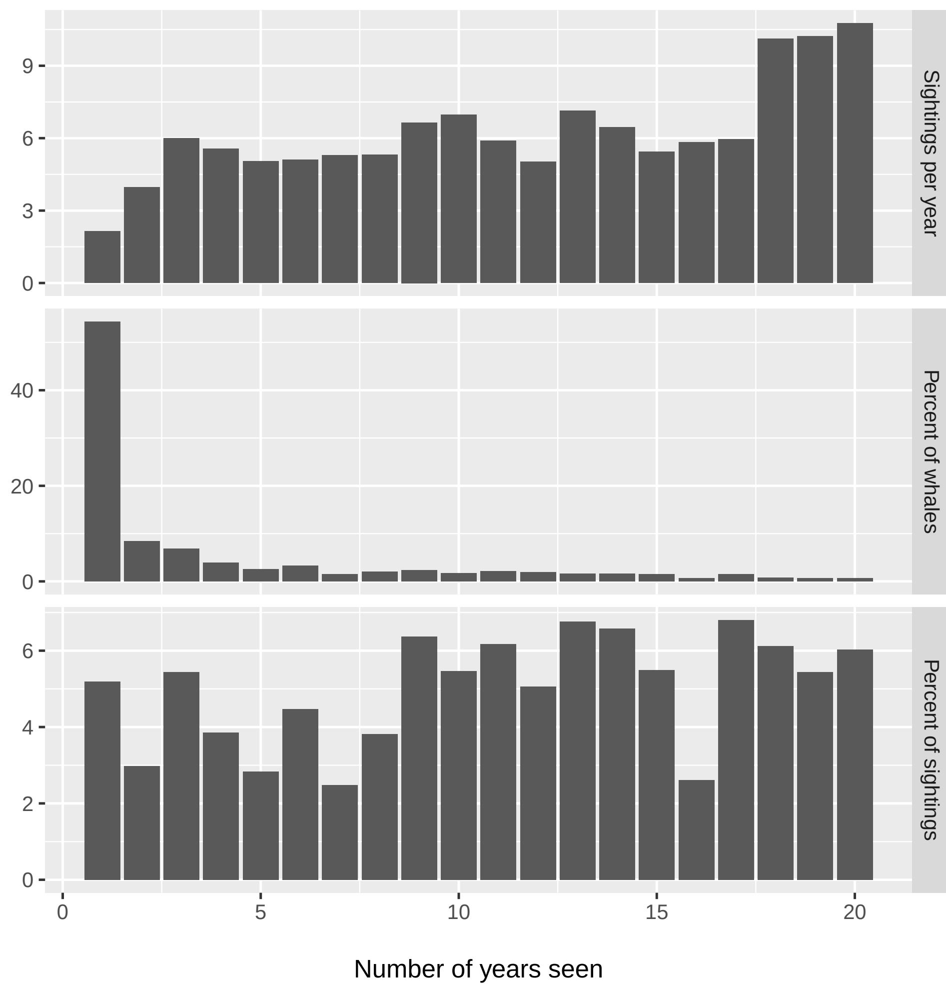

Figure 11: Average number of sightings per year and distribution of whales and numbers of sightings based on numbers of years a whale was seen in NCA-NBC between June-November during 1996-2015.

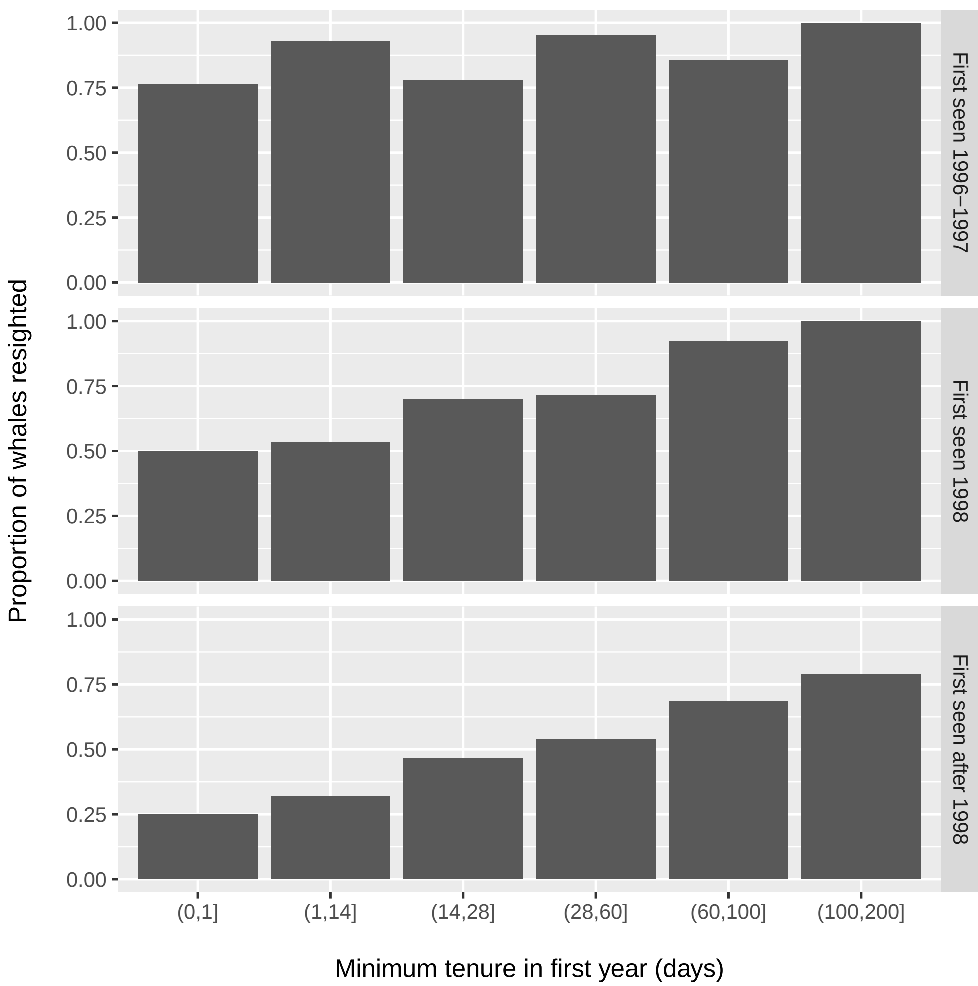

Figure 12: Influence of minimum tenure (MT) in the first year the whale was photographed on the probability it will be re-sighted in one or more following years for whales seen in NCA-NBC for June-November 1996-2015. The bar graphs are divided based on first year in 1996-1997, 1998 and after 1998. Re-sightings for 2015 are used but initial sightings for 2015 are excluded because there are no data beyond to evaluate re-sighting probability.

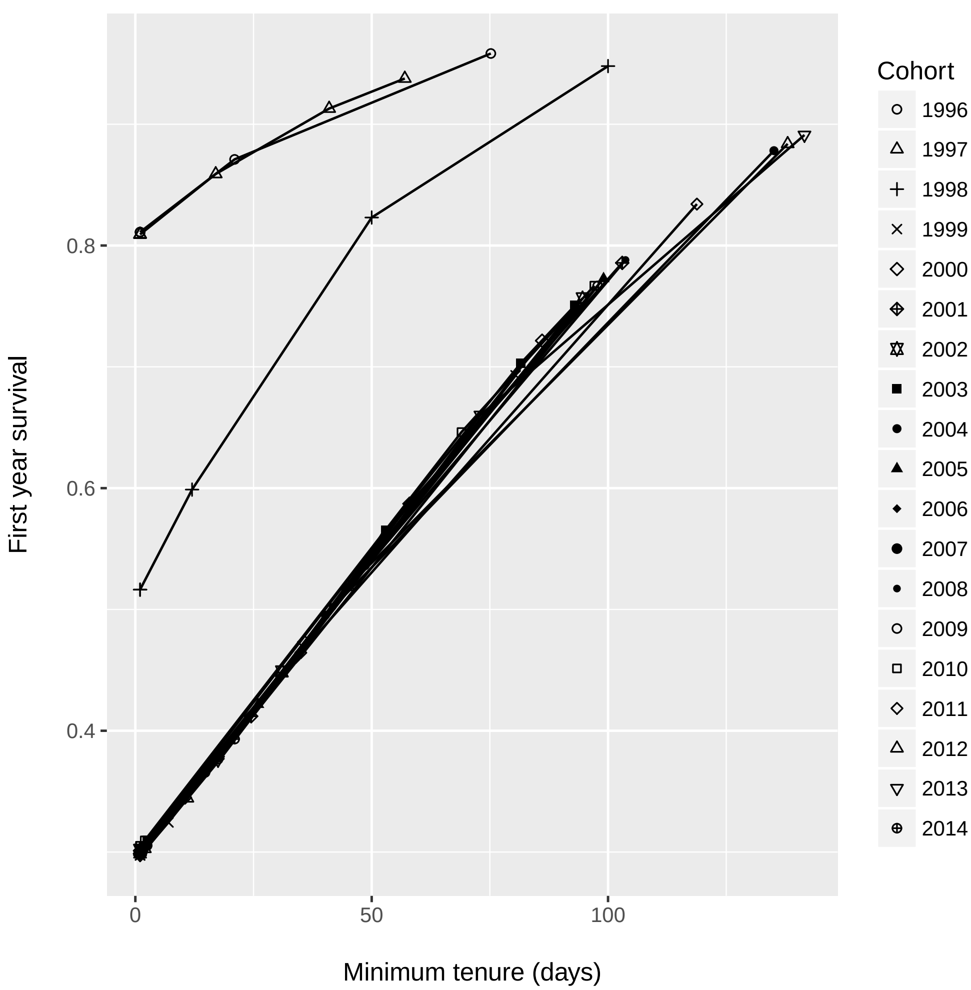

Figure 13: For NCA-NBC analysis of 1996-2015 data, model-averaged estimates of first year survival of non-calves for each cohort at 5%, 25%, 50%, 75%, and 95% quantiles of minimum tenure values for that cohort.

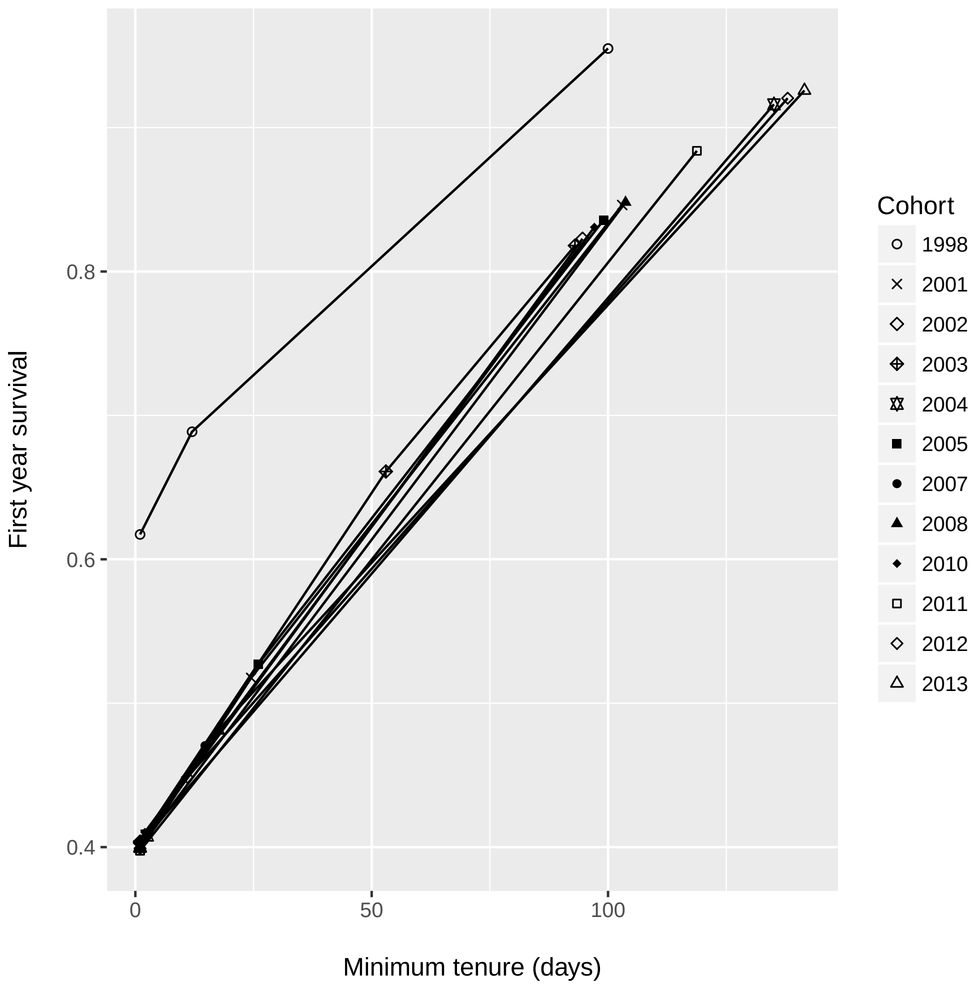

Figure 14: For NCA-NBC analysis of 1996-2015 data, model-averaged estimates of first year survival of calves for each cohort at 5%, 25%, 50%, 75%, and 95% quantiles of minimum tenure values for that cohort.

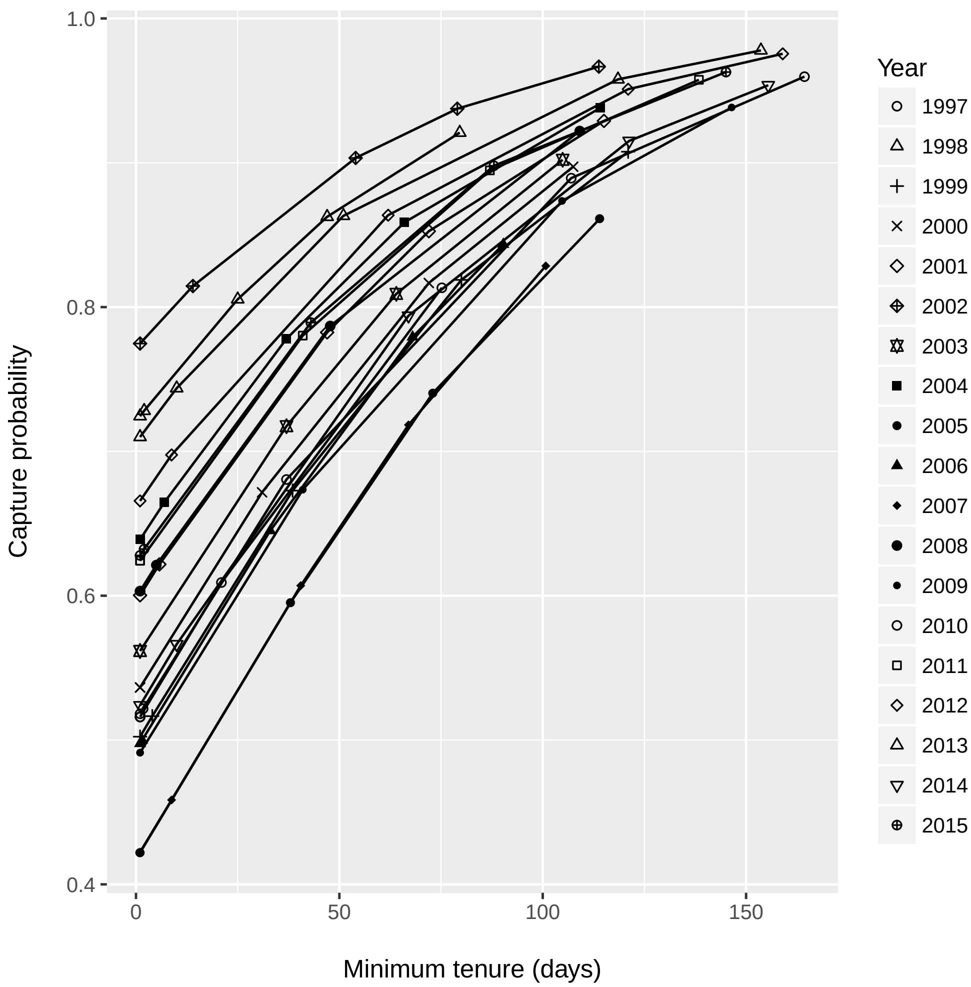

Figure 15: For NCA-NBC analysis of 1996-2015 data, model-averaged estimates of capture probability for each year at 5%, 25%, 50%, 75%, and 95% quantiles of minimum tenure values for whales in the previous year.

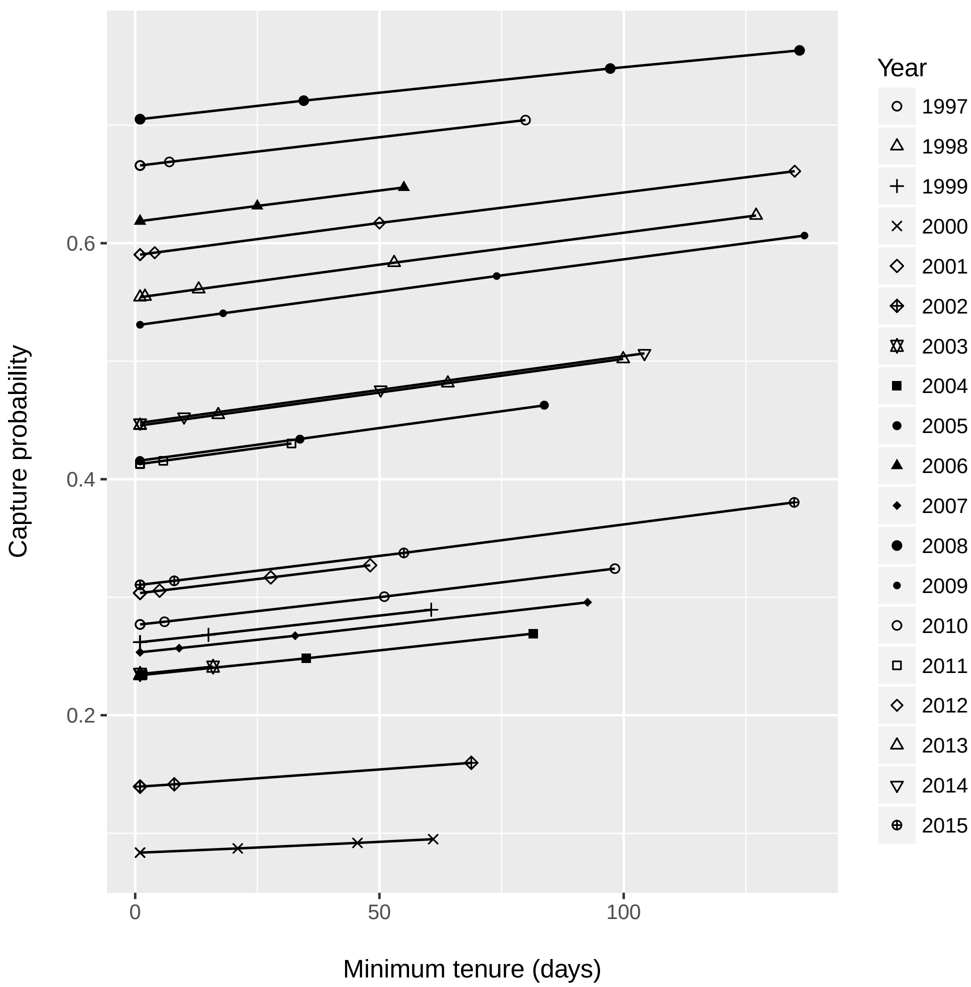

Figure 16: For MUA analysis of 1996-2015 data, model-averaged estimates of capture probability for each year at 5%, 25%, 50%, 75%, and 95% quantiles of minimum tenure values for whales in the previous year.

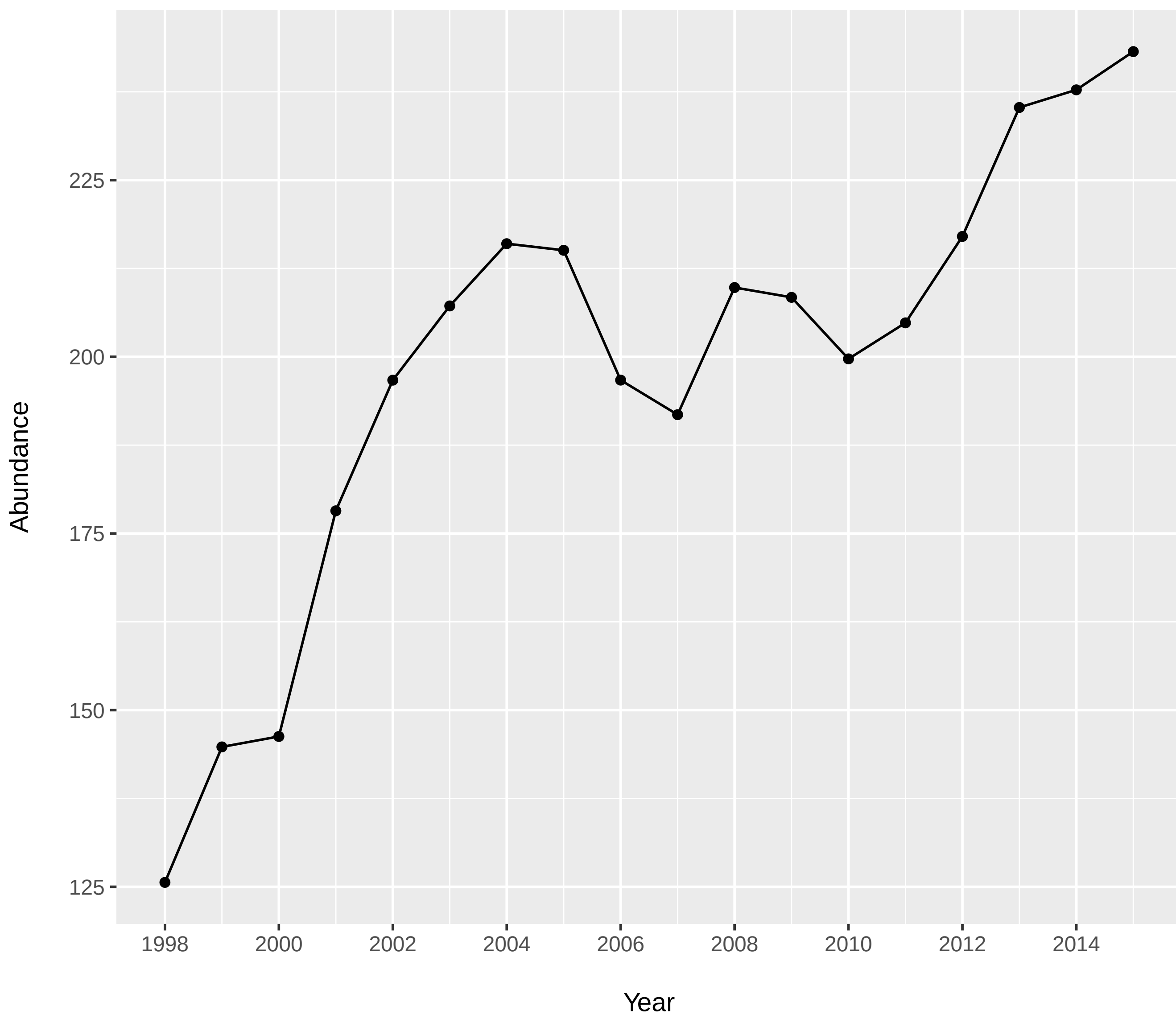

Figure 17: Annual abundance estimates for 1998-2015 in NCA-NBC using the open (Jolly-Seber; POPAN parametrization) population model approach JS1.

Appendix

Table 1 provides capture histories of whales seen in the PCFG at least once from 1 June - 30 November and displays by year, when they were seen only in spring (March-May), only from 1 June - 30 Nov and when they were seen in both time periods. Table 2 provides capture histories using data from 1 June - 30 Nov of whales seen in the MUA at least once. It shows when whales were seen only outside of the MUA but in the PCFG, only in the MUA and both inside the MUA and in the PCFG outside of the MUA

Table 1: Sighting histories of whales seen in the PCFG in at least one year. In year columns, a 1 means the whale was only sighted in the spring (March-May), 2 means it was only seen in June-Nov, and 3 means it was seen in both March-May and June-Nov. The region value is the nunber of years the whale was seen in that region.

1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	#years	NCA	SOR	OR	GH+	NWA	SJF	SVI	WVI	NBC	#areas
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							2	2	2	2	3			2																	9				1				9		2
																															1						1				1
																															1						1				1
				2	2						2	2	2	2	2	2	2		2	2	2										13					2	1	10	5	1	5
					2			2	2	2	2		2	2	2	2	2	2	2	2	2	2	2	2							18	1			1		6	15	7	4	6
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								2					2	2																	4			1		2		3	2		4
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2										2			2	2			2	2	2			1						2			9							2		7	2
	3																														1						1				1
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	2																														1						1				1
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					2																										1							1			1
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Cont.

Table 1: Sighting histories of whales seen in the PCFG in at least one year. In year columns, a 1 means the whale was only sighted in the spring (March-May), 2 means it was only seen in June-Nov, and 3 means it was seen in both March-May and June-Nov. The region value is the nunber of years the whale was seen in that region.

1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	#years	NCA	SOR	OR	GH+	NWA	SJF	SVI	WVI	NBC	#areas
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											1	2	2	3	3	2	2	2		2	3	3	2	2	1	2	3	3	2	3	19							16	12	3	3

Cont.

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1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	#years	NCA	SOR	OR	GH+	NWA	SJF	SVI	WVI	NBC	#areas
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											2		1																		2				2						1
											1			1			2	2	2	2	2										7				1	1	1	5	1	1	6
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											1												2								2				1		1				2
											2	2	2																		3					2	1	2			3
											2																				1					1					1
											1		2				2	2	2			2		2							7	2	3	3	1	1	1				6
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											2	2	2	2	2	2	2	3	2												9			1				2	2	9	4
											2		2	2	2	2	2			2		3		2	2	2	3	3	2	2	15	2	1	2		2		11	9		6
											2	2	2	2	2	2	2	2	2							2	2	2			12							1	1	12	3
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											2																				1									1	1
											2																				1									1	1
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													2		2	2	2	2	2		3	2	3	3	3						11				1			9	5		3
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													2																		1						1				1
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Cont.

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1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	#years	NCA	SOR	OR	GH+	NWA	SJF	SVI	WVI	NBC	#areas
													2																		1						1				1
													2																		1						1				1
													2																		1					1					1
													2		2									2		3	3	3			6	5			1	2			1		4
													2			2	2	2		2				2	3	3	2	2	2	2	12	10	1	1							3
													2																		1	1									1
													2				2	2			2	2		2	2	2	2	2	2	2	12	5	1		1	2	1	4	3	1	8
													2																		1	1									1
													2	2	2	2	2	2	2	2	2		2	2	2	2	3	2			15	11	2	4		1	1	3	1		7
													2																		1	1									1
													2			2	2	2	2			2				2	3	2	2	2	11	5	6	4		1					4
													2																		1	1									1
													2			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	16	10	8	2		1		6	1		6
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													2																		1					1					1
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													2	2																	2	1							1		2
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														2																	1	1									1

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														2																	1			1							1
														2	2	2	2					2	2	2	3	3					9	8		3							2
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														1	2		2						2	2	3	2	2	3		3	10	8	1	2		1	1				5
														2																	1	1									1
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															2	2	2		2												4			1						3	2
															2		2														2					1			1		2
															2		2		2					2	3	2	2	2	2		9	6	3	3		1		2	1		6
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Cont.

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																2															1					1					1
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																2	2	2	2		1										5					4	2	2	1		4
																2															1							1	1		2
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																2						2		2	2	2	2	2	2		8	6	1	4				1	1		5
																2	3	3													3							3	1		2
																2															1							1			1
																2	2						2	2	2	2	2	2			8	7						1			2
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																	2														1	1									1
																	2		2			2			1		2		3	2	7	2	2	2		2		1			5
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																	2														1							1			1
																	2	2	2	3	3		2	2	2	2	3	2			11	4		2		6	8	11	1		6
																	3			1						3					3						1	3			2
																	2	2	2	3	3	2	2	2	3	2	2	3	2	2	14	5	1	5	2	5		10	2		7
																	2	2	2	2											4	1						2	1		3
																	2														1	1									1

Cont.

Table 1: Sighting histories of whales seen in the PCFG in at least one year. In year columns, a 1 means the whale was only sighted in the spring (March-May), 2 means it was only seen in June-Nov, and 3 means it was seen in both March-May and June-Nov. The region value is the nunber of years the whale was seen in that region.

1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	#years	NCA	SOR	OR	GH+	NWA	SJF	SVI	WVI	NBC	#areas
																	2		2		3	2		1				2			6	2		2	1	3		2			5
																	2														1	1									1
																	2		2			2		2		2		2			6	5	1								2
																	2														1	1									1
																	2														1	1									1
																	2														1	1									1
																	2														1	1									1
																	2														1	1									1
																	2	2													2	1						1			2
																	2														1	1									1
																	2														1	1									1
																	2	2		2	2	2	2	3	2	2	2	2	2		12	3			1	1		4	8		5
																	2														1								1		1
																	2				2	2	2	2	3	2	3	2	2	2	11	4	2	2	1	6	2	3	6		8
																	2			1											2						1		1		2
																	2										2		1		3							2	1		2
																	2	2		2	2	1	2	3	3	3	3	2	1	2	13						1	10	8	2	4
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																	2	2	2	2							3				5					1				5	2
																	2	2	2			2		2	3	2	3	3	3	2	11	6	3	5	1	2					5
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																		2		2											2					2		1			2
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																			2	2	2	2	2	3	2	2	2	3	2	2	12	1			1	5	7	10	3		6
																			2												1		1								1
																			2												1			1							1
																			2	2											2							1		1	2
																			2	2	2	3	3	2	3	3	3	2		3	11					5	7	9	5		4
																			2		2		2								3						2		1		2
																			2	2											2						2	1			2

Cont.

Table 1: Sighting histories of whales seen in the PCFG in at least one year. In year columns, a 1 means the whale was only sighted in the spring (March-May), 2 means it was only seen in June-Nov, and 3 means it was seen in both March-May and June-Nov. The region value is the nunber of years the whale was seen in that region.

1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	#years	NCA	SOR	OR	GH+	NWA	SJF	SVI	WVI	NBC	#areas
																			2	2											2								1	1	2
																			2												1						1				1
																			2												1						1				1
																			2								2			2	3									3	1
																			2												1									1	1
																			2												1									1	1
																			2												1									1	1
																			2												1						1				1
																				2			2	2	2	2	3	2	3	3	9	7		1		4	1	4			5
																				2											1								1		1
																				2											1								1		1
																				2											1					1					1
																				2		2	2	2	2	2	2	2	2	2	10	2				1	5	4	5		5
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																				2	2	3									3							1	3		2
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																				3											1						1	1			2
																				2											1							1			1
																				2											1						1		1		2
																				2	2	1	2		2	2	1	1			8					4	1	3	4		4
																				2	2		3					3		2	5		1	1		5		2			4
																				2	2	3	3	2	1						6						2	4	1		3
																				2	2	2	2	2	2	2		2	2	2	10					5	5	7	7		4
																				2	2										2						1	2			2
																				2	2	2	3	2	3	3	3	3	3	3	11					3	4	11	5		4
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																					2										1						1				1
																					2										1							1			1
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																							2	2	3	2	3	2	2		7	7				1					2
																							2								1							1			1
																							2								1								1		1

Cont.

Table 1: Sighting histories of whales seen in the PCFG in at least one year. In year columns, a 1 means the whale was only sighted in the spring (March-May), 2 means it was only seen in June-Nov, and 3 means it was seen in both March-May and June-Nov. The region value is the nunber of years the whale was seen in that region.

1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	#years	NCA	SOR	OR	GH+	NWA	SJF	SVI	WVI	NBC	#areas
																							2			2	2				3					2	2	2	1		4
																							2								1									1	1
																							2			2					2					2	1				2
																							2	2	1	3	3	2	2		7	3				2	6	3		1	5
																							2	2							2	1					2				2
																							2				2	2	2		4					2	3				2
																							2	3	2	2	3	2	2		7	1					6	5	2		4
																							2								1						1				1
																							2	2	2						3						3				1
																							2								1						1				1
																							2	2	2						3	2				1	1				3
																							2								1						1				1
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																							2								1		1								1
																							2	2	2	2				2	5					1	2	4			3
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																								2				2	2		3	1						2	1		3
																								3	2	2	2	2	2	3	7						1	5	4		3
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																								2							1							1			1
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																								3							1							1			1
																								2							1							1	1		2
																								2							1	1									1
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Cont.

Table 1: Sighting histories of whales seen in the PCFG in at least one year. In year columns, a 1 means the whale was only sighted in the spring (March-May), 2 means it was only seen in June-Nov, and 3 means it was seen in both March-May and June-Nov. The region value is the nunber of years the whale was seen in that region.

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																								1			3				2					1		1	1		3
																								2							1					1					1
																								2							1						1				1
																								2							1						1				1
																								2	2	2	3	2	2	2	7			3		3	1	4	2		5
																								2							1	1									1
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																									2	2	2	2	2	2	6	2	1	4							3
																									2	2		2			3					1		1	1	1	4
																									2	2	2	3	2	2	6	4	1			2	2	2			5
																									2		2	3	2	2	5								5		1
																									2						1									1	1
																									2		2				2					2					1
																									2		2	2	3		4	3	1	1							3
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																									2	2	2	2			4	2	1	2				1			4
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																									3	3	3	2	3	3	6							6	3		2
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																									2		3	2	3	2	5	2	2	1		1		2	1		6
																									2						1	1									1
																									2	2	2	3	3	2	6		3	1		3	1	2	3		6
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																										3	2	2	3	2	5						1	5	1		3
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Cont.

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																											2				1	1									1
																											2	2	3	3	4	1		2			2	2	3		5
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																												2			1	1									1
																												2			1	1									1
																												2		2	2					2		1			2
																												2			1								1		1
																												2			1								1		1
																												2			1								1		1
																												2	3	3	3						1	2	1		3
																												2			1								1		1
																												2			1								1		1
																												2	3	2	3					2	1	3			3

Cont.

Table 1: Sighting histories of whales seen in the PCFG in at least one year. In year columns, a 1 means the whale was only sighted in the spring (March-May), 2 means it was only seen in June-Nov, and 3 means it was seen in both March-May and June-Nov. The region value is the nunber of years the whale was seen in that region.

1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	#years	NCA	SOR	OR	GH+	NWA	SJF	SVI	WVI	NBC	#areas
																												2	3	3	3					1		3	1		3
																												2	2		2						1	2			2
																												2	2	2	3			1				3			2
																												2	3	2	3		2				2	1			3
																												2	3	2	3							3	1		2
																												2	3	3	3						2	3			2
																												2			1							1	1		2
																												2			1	1		1							2
																												2			1								1		1
																												2	3	3	3	1						3			2
																												2			1								1		1
																												3	2	3	3	1						3	1		3
																												2	2		2							2			1
																												2			1								1		1
																												3			1	1							1		2
																												2			1								1		1
																												2	3		2					1		1	1		3
																												2			1								1		1
																												2			1								1		1
																												2		2	2					1		1	1	1	4
																												3			1	1									1
																												3			1	1									1
																												2			1	1									1
																												2			1								1		1
																												2			1			1							1
																												2	2	2	3			1		1	2	1			4
																												2	2		2	1		1							2
																												2			1			1							1
																												1	2	2	3		2	1							2
																												2			1									1	1
																													2	2	2					1	1	1			3
																													2		1					1					1
																													2		1					1					1
																													2	2	2						1	1		1	3
																													2	2	2	1		2			1				3
																													3		1	1	1								2
																													2		1	1									1
																													2	3	2	2							1		2
																													2	2	2	1	1								2
																													2	2	2	2	1								2
																													2		1	1									1
																													2		1	1		1							2
																													2		1	1									1
																													2		1	1									1
																													2		1	1		1							2
																													2		1	1									1
																													2		1	1									1
																													2		1			1							1
																													2		1			1							1
																													2		1			1							1
																													2		1			1							1
																													2		1			1							1
																													2		1			1							1
																													2		1								1		1
																													2		1								1		1
																													2	2	2							2			1
																													2	2	2		1				1	1			3
																													2	3	2							2	1		2
																													2		1					1	1	1			3
																													2		1					1		1			2

Cont.

Table 1: Sighting histories of whales seen in the PCFG in at least one year. In year columns, a 1 means the whale was only sighted in the spring (March-May), 2 means it was only seen in June-Nov, and 3 means it was seen in both March-May and June-Nov. The region value is the nunber of years the whale was seen in that region.

1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	#years	NCA	SOR	OR	GH+	NWA	SJF	SVI	WVI	NBC	#areas
																													2		1	1						1	1		3
																													2	2	2							1		1	2
																													2		1								1		1
																													3	2	2					1			1		2
																													2		1						1				1
																													2		1						1				1
																													2		1						1				1
																													2		1			1			1				2
																														2	1							1			1
																														2	1		1				1				2
																														2	1									1	1
																														2	1					1					1
																														2	1					1					1
																														3	1							1	1		2
																														2	1						1				1
																														2	1						1				1
																														2	1						1				1
																														2	1		1								1
																														2	1		1								1
																														2	1		1								1
																														2	1		1								1
																														2	1	1	1								2
																														2	1		1								1
																														2	1							1			1
																														2	1								1		1
																														2	1								1		1
																														2	1								1		1
																														2	1								1		1
																														2	1								1		1
																														2	1								1		1
																														2	1							1	1		2
																														2	1							1			1
																														2	1								1		1
																														2	1								1		1
																														2	1							1			1
																														2	1					1		1			2
																														2	1							1			1
																														2	1							1			1
																														2	1							1			1
																														3	1							1			1
																														2	1							1			1
																														2	1								1		1
																														2	1					1		1			2
																														2	1									1	1
																														2	1									1	1
																														2	1									1	1
																														2	1		1			1					2
																														3	1		1				1				2
																														2	1		1	1							2
																														2	1						1				1

Table 2: Sighting histories of whales seen in the MUA during 1 June - 30 November in at least one year. 1: whale sighted in PCFG but not in the MUA during that year, 2: only seen in MUA that year, and 3: seen in both MUA and another PCFG area.

1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	3	3	1	1	1	1		1	1	1									
1		3	1	1	1	1	1	1	1	1	1	1		1	1	1	1		1
1		3	1	1	1	1	1	1	1	1		2		3	1	1	1	1	
3		3	1	1	1	1	1	1	1	2		1	2	1	1	1	3	1	1
1		3	3	1	1	1	1	1	1	1	1	3	3						
1	3	3	1	1	1	1	3	1											
2	2		3			1		3	2	2					2	3	1	3	
2	2																		
1		3	3	1	1	1	1	3	3										
3		3	3	1	1	1	1	1	3										
3	2	3	1	3	3	1	1	1				1							
2		1	1	1	1	1	1	1	1	3	1	3	1	1	1	3	1	1	1
2																			
1	1	3		1	1	1	1		1		1	1			1			1	3
1	3	3	1	1	1	1	3	3	3	3	3	3	3	1	1	3	3	3	1
1	1	3	1	1	1	3	1	3		1		1	1		1	3	1	1	1
1		3	1	1	1	1	1	1	1	3	1	3	1	1	1	3	1	3	1
1		1	1	1	1	1	1		1	1		3	1	1	1	1	1	1	1
3		1	1	1	1			1	1	3									
2	2	3	1	1	3	1	1	1	1	1		3	1	1				1	3
2	3	2																	
2	2	3	1	1	1	1	1	1	3	3	3								
2	2	1	1	1	1		1	1	3	1	3	2	2		3		3	2	1
3	2	1	3	1	1	1	1	1	3	3	1	3	3	1	3	3	1	3	1
3	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1
2	3	3	1	1	1	1	1	1				1		1					
2	3	3	1	1	1	1	1	1	1	3	1	3	3	1	3	1	3	3	1
2	2		2	2	2	1	3					3	3	1				1	
1	2	3																	
2																			
2	2	1	1		1	1		1											
1		1	1	1	1	1			1		1		1	1	3	3	1	1	1
	2	3	3	1	3	1	1	1	1	3	1		1				1		
	1	1	1	1	1	1	1	1	1	3	3	3	3	1	3	3	3	3	1
	3	3		1	3	2	3	1	1	1	1	3	1	3	1	3	1	1	1
	2	1	1	1	3	1	1		1		1		1	1	1	1	1	1	1
	1	1		1	3	1	1	1	1	1	1	3	3	1	1	1	3		1
	1	3	1	1	1	1	1	1		1		1	1	1	1	1	3	1	1
	3	1	3		1	1	1	1	3	1	3	1	1			1	1		1
	2	1	3																
	2																		
	2	1	1	1	1	1	2	3	3										
	2																		
	2																		
	2	1	1	1	1	1	1	3	1	3	1	3	3	1	1	3	3	1	1
	2																		
	1	1	1	1	1	1	1	1	3	3	3	3	3	1	1	3	1	1	1
	1	1	1	1	1	1		1	1	3	1	3				1	1		
	1	1		1	1		1	1	1	1		1				1	3		1
	1	1	1	1	1	1	1	1	1	1		3	1		1	1	1	1	1
	1			1	1	1	1	1		2	1	3	3	1	1			1	1
		1			3	1	3	1	3										
		3	1																
		1	1	1	1	1	1	1	3	1	1	3	3	3	3	3	3	1	1
		1	1	1	1	1	1	1	1	1	1	3	3	1	1	1	3	3	3
		1	1	1	1	1	1	1	1	3	3								
		1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1
		1	1	3	1	1	1		3	1	1	1	3	3	3	3	3	1	3
		1				1	2	1			1		1						
		1	1	1	3	1			1	3				1					3
		2																	
		1	1			1	1	1	1	3	1	1	1	1	1	3	1	2	
		1		1	1		1								1			1	2
		2																	
		3	3	3	3	1		1	1	3	2	3	1				1		3
		2																	
		2																	
		2																	
		2																	
		2																	
		2																	
		2																	
		2																	
		2																	
		1				1	1			1	1		1	1	3	1	3	1	1
		1	1	1	1	1	3	1	1	2		1	1	1	1	1	1		
		1			1	1	1	1	1	2	1	1	1	1	1	1	1	1	1
		1	1	2	2	3	3	1		3	3	2			1	1	3	1	2
		1	1		1	1	2		1	1		1	1		1	1		1	1
		1	1	1	1	1	1	2	3										
		1	1	1		1	1	1	1	3	1	3	1	3	3	3	3	1	
		1	1		1	1	1	1		2	1		1	1	1	1	1	1	1
		2																	
		1	1	1	1	1	1	1		1	1	1	1	1	3	3	1	1	1
		1	1	1	1	1	1	1	1	1	1	3	3		1	3	1	1	1
		1		3	3	1	1	1		3		3	1	1	1	1	1		

Cont.

Table 2: Sighting histories of whales seen in the MUA during 1 June - 30 November in at least one year. 1: whale sighted in PCFG but not in the MUA during that year, 2: only seen in MUA that year, and 3: seen in both MUA and another PCFG area.

1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
		1				1	1	1		1		3	2	2		1	1		1
		2																	
			1		1	1		1			1	1	3	1	1	1	1	1	
			2																
			1	1		1			1		1		3	1	1	1	1	1	1
			1		1	1								1	1	1	3	1	1
			1	3		1	1	1	1	3	1		3	3	1	3	3	2	3
			1		1	1	3	1			1								
				1	3	1		1											
				1		1	1		1	3	3	1	3	3	1	3	3	1	3
				3	3	3	3	1		3		3	3	3	3	3		1	3
				1		1						1	1	1	3	1	1		1
				1	3														
				3															
				2	2	3	1	1		1	1	3	1	3	1	3	3	3	3
				3	3	1													
				2															
				1	1	1		1	1	1	1	3	1	3		1	1	1	1
				3	2	1	1	1	2	3		3	1	1	3	3	3	3	
				1			1				1	1	1	1	3	1	1		
				2		1													
				1		1		1					1	3	1	1	1	1	
				1	1	1	1	1	1	3	1	1	1	1	3	3	1		
				1	1	1	1	1	1							3	3	2	2
					3	1		1						1					
					2	1	1	1	3	2	1	3	1	1	1	3	1		1
					3	1	3												
					3														
					1	1	1		1	1	1	3	3	1	1	1	1		1
					3														
					3														
					3	1													
					2														
					2														
					2		1								1				
					3	3	2	2											
					2	3													
					2														
					2														
					1	1	3												
					1	1	1		1			1	1	1	1	3	1	1	1
					1	1	1	1	1		1	1	2	1	1	1	1	1	
						1	3	1	1	1									
						1		1							1		1	3	
						1		1				1	1	1	1	3		1	
						1		1			1					2		1	2
						1	1	2	1	3	1	3	3	1	3	1	3	3	3
						1			1	2	1	1	1	1					
						1	1	1	1	3	1	3		1	3	1	3		3
						3	3	3	3	2		3	3	3	3	3	1		
						1	1	1	1	3	1	3	1	1	3	1	3	1	1
						1		1		3	3						1		
						1	1		1	1	1	1	3	1	1	1	1	1	
						1				3	1	3	3	1	3	3	3	3	1
						1	1		1	1		3	1	1	1	1	1		1
						1	3	3	1	3	1	3	3	3	3	3	3	3	1
						1	1	1			1		1	1	1	1	3	1	1
							1	1	1	1						1	3		
							2	1		2									
							3	3	2										
							1	1	1	3	1	3	1	1	1	3	3	3	3
							1	3	2	2	1	3		1	3	1	1	3	3
							3		2										
							1		1	3		3	3	3	1	3	3		
							1	1	1				1	3	3	3	3	3	1
							1	1	1	1	1	3	1						1
							1	1	3										
							2	3	1	2	1	1	1	3	1	3	1	1	1
								2											
								3	3	3	1	3	3	1	3	3	1	3	3
								1	1	3									
								3	2	3	2	3	3	1	1	1	3	1	
								3	2	2	3	2	2	3	3	3	3	1	3
								3	3			3	3	3	3	3	1	3	1
								1	1	3	2	3	3	3	3	3	3	3	1
								2	3	3	3	3	1	3	1	3	3		1
								2		2		1							
								2	3										
								2											
								2											
								2											
									1			1	3	1	3	3	3	1	3
									2										
									1		2	2	2	1	3	1	1	3	1
									2			1	1	1	1	1	1	3	1
									3										
									2	3		2		2	1				

Cont.

Table 2: Sighting histories of whales seen in the MUA during 1 June - 30 November in at least one year. 1: whale sighted in PCFG but not in the MUA during that year, 2: only seen in MUA that year, and 3: seen in both MUA and another PCFG area.

1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
									3	2		1					3		3
									1	1	2	1	2						
									3	3	2	3	3	1	3		3	1	1
									1	3									
									1	3	3	3	3	1	1	3	1	1	1
										3	2	3	3		1				
										2									
											1	1				2			
											1		2						
											1	2	3						
											1	1	3						
											1			1	2				1
												2							
												1	1	1	3	1	1	1	
												3			3	3			
												2			2				
												3	3		2	1	3	2	
												3	2						
												2				2	2	2	
												2	3	1	3	3	3	3	
												2							
												2	2	2					
												2							
												2	3	1					
												2							
												3		1	1				
												2							
												2							
												2	3	1	1				1
												3							
												1	2	2	1	3	1		
												2	3	1			3	3	1
													3	1	1	1	1	1	1
													1	1	1		1	1	2
													2						
													2						
													2						
													2						
													1	1	1	3	3	2	1
														2	1		1		
														1	1	1	3	3	1
														2		2			
														1	1	1	1	3	1
														1		3	1	1	1
														1	1	3	3	2	1
															2	2			
															1	1	1	3	1
															3	2	1		
															3	1	3	3	2
															2				
																1			2
																3	2	1	1
																2			
																2			
																1	1	3	2
																1	1	3	3
																2			
																3			
																1	2		
																1	3	3	3
																1	1	3	3
																3	3	3	1
																1	1	3	1
																2			
																3	3	3	3
																2			
																2			
																2			
																2			
																2			
																3	1	1	1
																	1	1	2
																	3		
																	2		
																	3		
																	2		
																	3		
																	2		
																	3		
																	3	3	1
																	3		
																	3		
																	3	2	1
																	3		2
																	1	3	1
																	3	3	1
																	1	3	

Cont.

Table 2: Sighting histories of whales seen in the MUA during 1 June - 30 November in at least one year. 1: whale sighted in PCFG but not in the MUA during that year, 2: only seen in MUA that year, and 3: seen in both MUA and another PCFG area.

1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
																	3	3	1
																	1	3	3
																	1	2	
																	3		1
																	1	3	2
																		1	2
																		2	
																		2	
																		3	1
																		3	1
																		3	1
																		3	
																		3	
																		2	1
																		2	
																		2	
																		2	
																		3	
																			3
																			2
																			2
																			2
																			2
																			2
																			3
																			3
																			3
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Marine Mammal Science

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Recovery rates of bottlenose dolphin (*Tursiops truncatus*) carcasses estimated from stranding and survival rate data

JAMES V. CARRETTA,[1] **KERRI DANIL, SUSAN J. CHIVERS** and **DAVID W. WELLER,** NOAA Fisheries, Southwest Fisheries Science Center, Marine Mammal and Turtle Division, 8901 La Jolla Shores Drive, La Jolla, California 92037, U.S.A.; **DAVID S. JANIGER,** Los Angeles County Museum, 900 Exposition Blvd, Los Angeles, California 90007, U.S.A.; **MICHELLE BERMAN-KOWALEWSKI,** Department of Vertebrate Zoology, Santa Barbara Museum of Natural History, 2559 Puesta del Sol, Santa Barbara, California 93101, U.S.A.; **KEITH M. HERNANDEZ** and **JAMES T. HARVEY,** Moss Landing Marine Laboratories, Vertebrate Ecology Lab, 8272 Moss Landing Road, Moss Landing, California 95039, U.S.A.; **ROBIN C. DUNKIN** and **DAVID R. CASPER,** Center for Ocean Health, Long Marine Laboratory, University of California, Santa Cruz, California 95060, U.S.A.; **SHELBI STOUDT,** The Marine Mammal Center, 2000 Bunker Road, Fort Cronkhite, Sausalito, California 94965, U.S.A.; **MAUREEN FLANNERY,** California Academy of Sciences, 55 Music Concourse Drive, Golden Gate Park, San Francisco, California 94118, U.S.A.; **KRISTIN WILKINSON,** Protected Resources Division, West Coast Region, National Marine Fisheries Service, NOAA, 7600 Sand Point Way, NE, Seattle, Washington 98115, U.S.A.; **JESSIE HUGGINS,** Cascadia Research Collective, 218 1/2 W 4th Avenue, Olympia, Washington 98501, U.S.A.; **DYANNA M. LAMBOURN,** Washington Department of Fish and Widlife, 7801 Phillips Road, SW Lakewood, Washington 98498, U.S.A.

ABSTRACT

Recovery of cetacean carcasses provides data on levels of human-caused mortality, but represents only a minimum count of impacts. Counts of stranded carcasses are negatively biased by factors that include at-sea scavenging, sinking, drift away from land, stranding in locations where detection is unlikely, and natural removal from beaches due to wave and tidal action prior to detection. We estimate the fraction of carcasses recovered for a population of coastal bottlenose dolphins (*Tursiops truncatus*), using abundance and survival rate data to estimate annual deaths in the population. Observed stranding numbers are compared to expected deaths to estimate the fraction of carcasses recovered. For the California coastal population of bottlenose dolphins, we estimate the fraction of carcasses recovered to be 0.25 (95% CI = 0.20–0.33). During a 12 yr period, 327 animals (95% CI = 253–413) were expected to have died and been available for recovery, but only 83 carcasses attributed to this population were documented. Given the coastal habits of California coastal bottlenose dolphins, it is likely that carcass recovery rates of this population greatly exceed recovery rates of more pelagic dolphin species in the region.

Key words: bottlenose dolphin, *Tursiops truncatus*, strandings, carcass recovery, survival rates, human-caused mortality.

[1]Corresponding author (e-mail: jim.carretta@noaa.gov).

Estimated levels of human-caused mortality and serious injury for cetaceans suffer from negative biases due to incomplete detection and recovery of carcasses. Contributing factors may include scavenging, drift, sinking, decomposition, natural removal from beaches due to wave action, undocumented bycatch, remoteness of cases, carcass removal or burial by municipalities prior to a stranding response, and failure to detect visible carcasses. It follows that documenting *natural* mortality through carcass recovery also suffers from negative bias for many of the same reasons. Previous carcass recovery studies have utilized abundance data, annual survival rates, tagging of carcasses at sea, and stranding numbers to estimate the degree of negative bias. Where reported, the fraction of carcass recovery is quite low, ranging from 0 to 0.062 for Gulf of Mexico cetaceans (Williams *et al.* 2011), <0.01 for North Atlantic harbor porpoises (*Phocoena phocoena*) (Moore and Read 2008), 0.039–0.13 for eastern Pacific gray whales (*Eschrichtius robustus*) (Punt and Wade 2012), 0.17 for north Atlantic right whales (*Eubalaena glacialis*) (Kraus *et al*. 2005), 0.08 for common dolphins (*Delphinus*) off France (Peltier *et al.* 2012), 0.05–0.18 for Brazilian franciscana dolphins (*Pontoporia blainvillei*) (Prado *et al.* 2013), and 0.33 for Sarasota Bay bottlenose dolphins (*Tursiops truncatus*) (Wells *et al*. 2015) (Table 1).

Our goal is to estimate the fraction of carcasses recovered for the "California coastal" population of bottlenose dolphin that occurs along the U.S. west coast and Baja California (Defran *et al*. 1999). This population is a good case study because of factors including habitat preferences, reliability and stability of abundance estimates, and population distinctness. The population has a high degree of nearshore site fidelity, with >99% of all sightings within 500 m of shore (Hanson and Defran 1993, Carretta *et al.* 1998). The population's nearshore distribution suggests that individual California coastal bottlenose dolphins may be the most likely delphinid species to strand in the region, given a mortality event. If stranding probabilities of coastal bottlenose dolphins are indeed higher than other delphinid species in the area, the population serves as an excellent "best case scenario" with respect to carcass recovery.

Table 1. Published estimates of cetacean carcass recovery rates.

Study	Species	Area (years)	Minimum estimate of carcass recovery	Maximum estimate of carcass recovery
Kraus *et al.* (2005)	Right whale (*Eubalaena glacialis*)	NE United States (1986–2005)	—	0.17
Moore and Read (2008)	Harbor porpoise (*Phocoena phocoena*)	NE United States (1999–2003)	—	<0.01
Peltier *et al.* (2012)	Common dolphin (*Delphinus delphis*)	France (2004–2009)	—	0.08
Prado *et al.* (2013)	Franciscana dolphin (*Pontoporia blainvillei*)	Brazil (2005–2009)	0.05	0.18
Punt and Wade (2012)	Gray whale (*Eschrichtius robustus*)	Alaska to Mexico (1999–2000)	0.039	0.13
Wells *et al.* (2014)	Bottlenose dolphin (*Tursiops truncatus*)	SE United States (1993–2012)	—	0.33
Williams *et al.* (2011)	Multiple species	Gulf of Mexico (2003–2007)	0	0.062

The range of California coastal bottlenose dolphins is well-known, spanning approximately 1,000 km of coastline from Ensenada, Mexico, to San Francisco, California (Defran *et al.* 1999) (Fig. 1). Rarely, carcasses from this population are found as far north as the states of Oregon and Washington. High rates of photo-identification overlap (percent of identified individuals documented between regions) are documented between Ensenada and Santa Barbara in the southern California Bight (55% to 90%) and between the southern California Bight and Monterey Bay (>50%) (Feinholz 1996, Defran *et al*. 1999, Hwang *et al.* 2014; Fig. 1). Individual animals have traveled nearly 1,000 km between Ensenada and Monterey and rapid movements of 300 km in 5 d between San Diego and Santa Barbara are known (Hwang *et al.* 2014). From this we infer that the area from Ensenada to San Francisco includes one population. Approximately 18% of the stock's range occurs south of the U.S./Mexico border (Carretta *et al.* 2013). Based on mark-recapture movement data, individuals appear to use this entire range and exhibit limited site fidelity to any particular region (Defran *et al*. 1999, Hwang *et al.* 2014). In contrast, only 3% of animals identified near San Quintín, Mexico were also identified in the southern California Bight (Caldwell 1992, Defran *et al*. 2015), suggesting a southern limit of this population somewhere between Ensenada and San Quintín. The coastal stock of bottlenose dolphins is distinct from the offshore stock, based on morphology and genetics (Perrin *et al.* 2011, Lowther-Thielking *et al.* 2015). Of 56 haplotypes found among coastal and offshore bottlenose dolphins in the region, only one is shared by both populations (Perrin *et al.* 2011). Approximately 90% of stranding records of bottlenose dolphins along the mainland coast represent coastal stock animals (Perrin *et al*. 2011; NMFS,

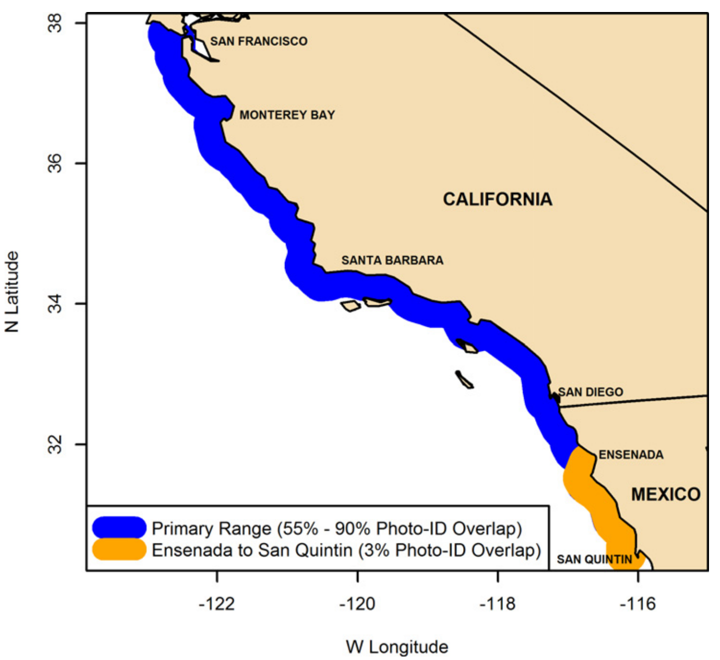

Figure 1. Normal range of California coastal bottlenose dolphins, including estimates of photo-ID match overlap between geographic regions. Photographic mark-recapture evidence indicates that individuals from the population utilize the entire coastal range.

unpublished data), despite the fact that the offshore population is estimated to be 6–7 times more abundant (Barlow 2010, Carretta *et al.* 2013).

Abundance estimates of the coastal stock are based on three different photographic mark-recapture estimates between 1987 and 2005 and appear stable over a 20 yr period, with approximately 300 − 400 marked individuals (Dudzik 1999, Dudzik *et al.* 2006) (Table 2). Such a stable population size facilitates comparison of annual stranding data with expected carcass numbers, in contrast with a population where abundance may be changing rapidly.

Estimation of annual dolphin deaths requires data or assumptions about life history parameters such as annual survival rate. While survival rates for the California coastal population are not currently estimated, other bottlenose dolphin populations (both captive and wild) have been studied, from which published estimates of survival can be used in tandem with abundance data to estimate the number of carcasses available to strand.

Methods

Our analysis focuses on the years 1995–2006, when both reliable abundance estimates and stranding numbers of coastal bottlenose dolphins were available. We reviewed the literature to obtain survival rate estimates for bottlenose dolphins, which are used in combination with abundance data from the California coastal population to estimate the expected number of deaths annually. The number of carcasses recovered annually by stranding networks is compared to the number of expected deaths estimated *via* Monte Carlo simulations and used to estimate the fraction of carcasses recovered.

Strandings

Stranding records of bottlenose dolphins from the U.S. west coast were obtained from several institutions: NOAA Fisheries Southwest Fisheries Science Center, Los Angeles County Museum, Santa Barbara Museum of Natural History, Moss Landing Marine Laboratories, Long Marine Lab (UC Santa Cruz), The Marine Mammal Center, California Academy of Sciences, Oregon State University, Cascadia Research Collective, and the Washington Department of Fish and Wildlife. Stranding records were available as early as 1935, however, we focus on the time period beginning in 1995 for a few reasons. First, 1995 represents the first year that systematic accounting of human-caused mortality for U.S. marine mammal populations was required after 1994 revisions to the Marine Mammal Protection Act (MMPA) (Barlow *et al.* 1995).

Table 2. Estimates of California coastal bottlenose dolphin abundance and coefficients of variation (CV) obtained from photo-ID mark-recapture studies. Estimates represent only marked animals in the population.

Years	Estimated abundance (CV)	Source
1987–1989	354 (0.04)	Dudzik (1999)
1996–1998	356 (0.09)	Dudzik (1999)
2004–2005	323 (0.12)	Dudzik *et al.* (2006)

Second, new field efforts designed to estimate the abundance of the California coastal bottlenose dolphin stock began in 1996 (Dudzik 1999). Third, stranding networks in the region were well-established by this time. Stranding reporting and documentation was much-improved compared with earlier decades and facilitated by increased cell phone use and improved education and outreach efforts with local lifeguards and other coastal authorities compared to earlier periods. In previous decades, it was not uncommon for local municipalities to bury cetacean carcasses or relocate them to landfills before marine mammal experts were contacted. This may still occur on occasion, but public and municipal cooperation is improved, and from a historical perspective, the percentage of strandings reported to biologists today is probably at its highest.

For 1995–2006, we reviewed 92 bottlenose dolphin mainland stranding records from the U.S. west coast from the States of California, Oregon, and Washington. A majority of strandings occurred in California (n = 91), none in Oregon, and one in Washington. We strived to account for all stranding records during this time, but cannot guarantee that records are all-inclusive. Strandings from offshore islands were rare and were not included in this analysis, as stranding response effort there is minimal and opportunistic. Population identity (coastal *vs.* offshore) is not known for every stranding because many lack genetic or skeletal material. Perrin *et al.* (2011) reported finding 56 haplotypes among California coastal and offshore bottlenose dolphin populations, with only one shared haplotype. Of 80 mainland strandings examined by Perrin *et al*. (2011), 73 (91%) were assigned to the coastal population based on having haplotypes known only from coastal reference animals. A larger data set of genetic determinations from strandings along the California, Oregon, and Washington mainland coast between 1953 and 2013 shows that 94% (163/173) of animals have a high probability of being from the coastal population (NMFS, unpublished data). Likewise, during our study period, 54 of 61 (88%) mainland strandings for which genetic material was available were assigned to the coastal population, while the remaining 31 animals were not assigned to any population, usually because genetic material was insufficient or lacking. Based on the historic ratios of bottlenose dolphin carcasses from the mainland that were identified as coastal *vs*. offshore stock animals, we prorated the number of observed mainland strandings by 0.90 to correct for the approximately 10% that represent offshore animals. This implies that of the 92 mainland strandings recorded between 1995 and 2006, approximately 83 animals were from the coastal population.

Dolphin Abundance

We estimate mean dolphin abundance from 1995 to 2006, using the two most recent estimates from Table 2. Our analysis period extends one year before and after field data were collected for those abundance estimates, with the assumption that abundance did not change significantly during the 1 yr periods before and after each field study. Mean abundance for the period is calculated as the geometric mean of the 1996–1998 and 2004–2005 abundance estimates, in the same manner used in Pacific marine mammal stock assessment reports (Carretta *et al.* 2013). The resulting mean estimate (and CV) is 339 animals (CV = 0.07). This estimate represents only *marked* animals in the population (those with distinctive dorsal fins). Dudzik *et al.* (2006) estimated that the fraction of marked animals in the population was 0.63, but did not report a variance for this value. Using the sample sizes of marked (n = 164) and unmarked (n = 97) animals given by Dudzik *et al*. (2006), we assume that the fraction of marked animals in the population is a binomial random variable with mean = 0.63 (see *Simulations* below). This fraction marked represents a correction factor to estimate "true" population size, such that mean abundance is estimated as 339 animals divided by 0.63, or approximately 538 animals.

Annual Survival Rate

Bottlenose dolphins are among the most-studied cetaceans, with long-term studies of small populations yielding a variety of survival rate estimates, including some age- and sex-specific estimates (DeMaster and Drevenak 1988, Hersh *et al.* 1990, Wells and Scott 1990, Small and DeMaster 1995, Stolen and Barlow 2003, Currey *et al*. 2009, Nicholson *et al.* 2012). We reviewed the literature for bottlenose dolphin survival rate estimates, including wild and captive populations. Large differences in annual survival for animals ≤1 yr old (calves) and older animals was apparent from multiple studies, with the lowest annual survival rates found among calves (Table 3).

Simulations

Monte Carlo methods were used to simulate abundance (N_{sim}) and annual survival rate (S) for each year from 1995 to 2006. Annual abundance was modeled as a lognormal random deviate with a mean of 339 animals, a CV = 0.07, and a sample size of 1,000. Simulated annual abundance was divided by the fraction of marked animals in the population (Fr_{marked}), reported as 0.63 by Dudzik *et al.* 2006), to correct for the unmarked portion of the population not reflected in mark-recapture estimates. No estimate of uncertainty was given for Fr_{marked}, but the number of marked (n = 164) and unmarked (n = 97) animals was reported, from which we generated a binomial random variable to represent the fraction of the population marked for each of 1,000 uncorrected annual abundance estimates. The resulting distribution of Fr_{marked} has a mean of 0.63 with an approximate 95% confidence interval of 0.57 to 0.69.

Roughly 18% of the population's range occurs in Mexican waters where we do not have reliable stranding data, thus, all simulated abundances were multiplied by a

Table 3. Published estimates of annual survival rates for captive and wild bottlenose dolphin populations. Only estimates based on wild populations are used in the present study.

Study	Area	Population type	Annual survival rate (age class)
Currey *et al.* (2009)	Doubtful Sound, New Zealand	Wild	0.862 (<1 yr) 0.937 (adults)
DeMaster and Drevenak (1988)	Various display facilities	Captive	0.61 (<1 yr) 0.93 (all ages)
Hersh *et al.* (1990)	Florida	Wild	0.908–0.931 (all ages)
Nicholson *et al.* (2012)	Australia	Wild	0.95 (all ages)
Small and DeMaster (1995)	Various display facilities	Captive	0.666 (<1 yr) 0.948 (adults)
Stolen and Barlow (2003)	Florida	Wild	0.836 (<1 yr) 0.902 (all ages)
Wells and Scott (1990)	Florida	Wild	0.81 (<1 yr) 0.96 (adults)

"range correction factor" ($R_f = 0.82$) to reflect only those carcasses available to strand on U.S. beaches. This is equivalent to assuming that animals are equally likely to utilize areas in southern California and Mexico, which is supported by high resighting rates of individuals between southern California and Mexico (Defran *et al*. 1999, Hwang *et al.* 2014). If on average, more than 18% of the population occurs south of U.S./Mexico border, this approach would overestimate the number of carcasses available to strand on U.S. beaches, which would negatively bias carcass recovery estimates. Insufficient fine-scale and short-term movement data for individual dolphins in this population are available to test this assumption.

Annual survival rate (S) was allowed to vary as a uniform random variable for each of 1,000 N_{sim}, with lower and upper limits taken from the literature (Table 3). Separate survival rates were assumed for two different age classes: animals ≤1 yr old and animals >1 yr. Calf survival (S_{calf}) ranged between 0.81 and 0.862 and adult survival (S_{adult}) ranged between 0.937 and 0.96, based on published values for wild populations only (Table 3).

Use of separate estimates of survival for calves and adults required knowledge about the fraction of calves in the population. Hansen (1990) and Weller (1991) found that calves (defined as animals ≤1 yr old) represented 7% and 11%, respectively, of all individuals photographed in the California coastal population. Values from other coastal bottlenose dolphin populations are similar, with calves representing between 8% and 11% of animals (Würsig 1978, Shane *et al.* 1986, Campbell *et al.* 2002, Stolen and Barlow 2003). The fraction of calves in the population (Fr_{calf}) was based on sampling with replacement from a uniform distribution ranging from 0.07 to 0.11, and was allowed to vary for each of 1,000 values of N_{sim}. The fraction of adult animals (Fr_{adult}) is simply 1 – Fr_{calf}. The expected number of carcasses available to strand each year ($C_{expected}$) is a simulated distribution of 1,000 values derived from $N_{sim,}$ Fr_{calf}, Fr_{adult}, S_{calf}, and S_{adult}, and can be expressed as:

$$C_{expected} = C_{calf} + C_{adult} \tag{1}$$

where

$$C_{calf} = N_{sim}/Fr_{marked} \cdot R_f \cdot (1 - S_{calf}) \cdot Fr_{calf} \tag{2}$$

and

$$C_{adult} = N_{sim}/Fr_{marked} \cdot R_f \cdot (1 - S_{adult}) \cdot Fr_{adult} \tag{3}$$

where $C_{expected}$ = expected dolphin carcasses in year y; C_{calf} = expected calf carcasses in year y; C_{adult} = expected adult carcasses in year y; N_{sim} = simulated abundance in year y, Lognormal(mean = 339, CV = 0.07); Fr_{marked} = fraction of population that is marked, Binomial(mean = 0.63, 95% CI = 0.58–0.69); Fr_{calf} = fraction of calves in the population in year y, Uniform(0.07–0.11); Fr_{adult} = fraction of adults in the population in year y, Uniform(0.89–0.93); S_{calf} = annual calf survival rate in year y, Uniform(0.81–0.862); S_{adult} = annual adult survival rate in year y, Uniform(0.937–0.96); and R_f(0.82) represents the fraction of carcasses assumed to occur in U.S. waters at any one time.

For each year, the estimated fraction of carcasses recovered is simply the observed number of strandings (prorated by 0.90 to account for some animals being of offshore origin) divided by the mean of $C_{expected}$. 95% confidence limits for the fraction of carcasses recovered are calculated as number of stranding events divided by the 2.5th and 97.5th percentiles of C_{expected}.

Results

Over the 12 yr study period, 92 stranded bottlenose dolphin carcasses were documented on the mainland. After prorating for the proportion historically identified as coastal (*vs*. offshore) stock animals, 83 strandings were assumed to originate from the coastal stock. The number of expected deaths for this same period was 327 animals (78 calves and 249 adults). Calves represented 24% of the expected carcasses over the study period, which is less than that documented from long-term stranding data (38%). Estimated carcass recovery for all ages averaged 0.25 (95% CI = 0.20–0.33) over the 12 yr study period (Table 4). Annually, carcass recovery estimates ranged from 0.099 to 0.46 (Table 4), reflecting annual variability in carcass numbers found ashore under an assumption of stable population size. Simulated annual deaths (calves and adults combined) represented 6% of the estimated population size, which is equivalent to an annual all-ages survival rate of 0.94. The mean number of expected deaths each year ($n = 27$) converges towards a single value because we assumed a fixed population size over the study period and simulation sample sizes were sufficient to result in such convergence.

Discussion

With the exception of an embayment population of Florida bottlenose dolphins where carcass recovery was estimated to be 0.33 (Wells *et al.* 2015), carcass recovery estimates for California coastal bottlenose dolphins from this study (0.25) are higher than values found for other cetaceans (Table 1). This is not surprising, considering the coastal habits of the population, the effectiveness of stranding networks, and the high density of human activity along this coast. Our results are case-specific to this particular population and stranding network characteristics, but likely represent a maximum carcass recovery rate for dolphin species along the U.S. west coast. One caveat to our estimates is that they reflect background rates of mortality in the absence of an unusual or mass mortality event, such as those associated with morbillivirus (Lipscomb *et al*. 1994).

Both natural and anthropogenic mortality are represented in strandings, but confirming evidence of anthropogenic mortality is sometimes difficult due to carcass decomposition or the cryptic nature of the evidence (*e.g.*, gill net marks that may not be detected by responders). Our results contain the implicit assumption that stranding probability is equal for natural and anthropogenic mortality, but this may not be true. In a study of harbor porpoise, Moore and Read (2008) suggested that natural mortality involves processes such as predation and starvation that may have lower stranding probabilities than previously healthy gill net-caught animals discarded at sea that are more likely to float. They also found evidence of age-biased mortality for animals caught in gill nets compared to beach strandings representing an unknown mix of natural and anthropogenic mortality. Given the extremely coastal habits of California coastal bottlenose dolphin and infrequent interaction with gill nets that

Table 4. Observed and prorated numbers of strandings, expected carcass numbers, and estimated fraction of carcasses recovered for the period 1995–2006. Prorated strandings may not be whole numbers because observed strandings were prorated by 0.90 to account for some strandings originating from the offshore population.

Year	Observed strandings	Prorated strandings	Mean expected deaths	L95 expected deaths	U95 expected deaths	Mean expected calves	Mean expected adults	Mean *Fr* recovered	L95 *Fr* recovered	U95 *Fr* recovered
1995	8	7.2	27.2	20.8	34.8	6.6	20.6	0.26	0.21	0.35
1996	5	4.5	27.1	21.3	34.2	6.5	20.6	0.17	0.13	0.21
1997	3	2.7	27.1	20.8	34	6.5	20.6	0.1	0.079	0.13
1998	5	4.5	27.3	21.2	34.3	6.5	20.8	0.16	0.13	0.21
1999	3	2.7	27.2	21.1	34.2	6.5	20.7	0.099	0.079	0.13
2000	10	9	27.2	20.7	34.4	6.5	20.7	0.33	0.26	0.43
2001	12	11	27.3	21	34.4	6.5	20.7	0.4	0.31	0.52
2002	11	9.9	27.2	21	34.3	6.5	20.7	0.36	0.29	0.47
2003	7	6.3	27.3	21.4	34.7	6.5	20.8	0.23	0.18	0.29
2004	14	13	27.3	21.1	34.5	6.5	20.8	0.46	0.37	0.6
2005	7	6.3	27.3	21.1	35.1	6.5	20.7	0.23	0.18	0.3
2006	7	6.3	27.2	21.1	33.9	6.5	20.8	0.23	0.19	0.3
All years	92	83	327	253	413	78	249	0.25	0.2	0.33

are fished at least 3 mi (4.8 km) from shore, we believe that any differences in stranding probabilities for natural and anthropogenic mortality are likely to be small.

Levels of uncertainty in carcass recovery estimates are likely underestimated. The fraction of the coastal bottlenose dolphin population that occurs in U.S. waters at any one time is unknown and cannot be estimated without tracking individual dolphin movements. Rather, we assume that 18% of coastal bottlenose dolphin carcasses are unavailable to U.S. west coast stranding networks, based on the fraction of their known range that occurs south of the U.S./Mexico border. Our method of estimating carcass recovery is crude compared with multivariate models that consider factors such as drift, wind, buoyancy, and decomposition (Peltier *et al.* 2012, 2013; Prado *et al.* 2013). However, while it is interesting to know *why* all carcasses are not recovered, we reduce the problem to a simple metric of *how many* carcasses are recovered relative to the expected number, similar to the work of Williams *et al.* (2011). The reasons behind negative biases in carcass recovery are interesting subjects, but are not necessary to develop correction factors for stranding numbers.

Length data for strandings collected during 1995–2006 were available for only 42 of 92 records, so a direct comparison of observed and expected carcass numbers for calves and adults is not possible. Length-at-age data are not available for this population, but two animals from this population as large as 168 cm and 171 cm have been aged at <1 yr (NMFS, unpublished data). By comparison, Read *et al*. (1993) reported a lower-bound length of 171 cm for 1-yr-old bottlenose dolphins in Sarasota Bay. When a larger data set (n = 162) of mainland bottlenose dolphin strandings from 1948 to 2013 is examined, a distinct modal length of 125 cm is apparent, corresponding to high numbers of neonate strandings compared to other age classes (Fig. 2). If animals <1 yr old are assumed to be <170 cm, then approximately 38% of all strandings between 1948 and 2013 represent calves (Fig. 2). From simulations, the fraction of expected calf carcasses is 0.24 (78/327) (Table 4), which is considerably less than the fraction of calves (0.38) observed from long-term stranding data. If we assume that 38% of the 83 strandings attributed to the coastal population between 1995 and 2006 are animals <1 yr old, then 32 calves are represented. The number of expected calves from simulations is 78 over the same period, implying a calf recovery fraction of 0.41. The corresponding estimate of carcass recovery for

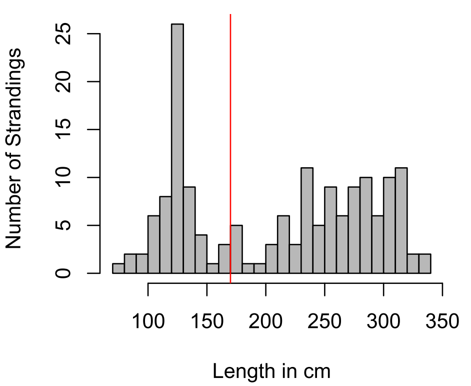

Figure 2. Distribution of dolphin lengths recorded for 162 stranded specimens of *Tursiops truncatus* along the mainland U.S. west coast, 1948–2013. Vertical red line delineates approximate length of animals <1 yr old (≤170 cm).

adults (assuming that 51 of 83 coastal animal strandings were adults) is 51 recovered/249 expected = 0.20. Both observed (38%) and simulated (24%) percentages of calf carcasses are high relative to the percent of calves observed in the population at any one time (7%–11%) (Hansen 1990, Weller 1991), implying that calf recovery rates are relatively high compared to adults. Differences in stranding probabilities by age probably exist, especially if currents and beach conditions favorable to deposition overlap with calving seasonality. For example, the long-term stranding data for 1948–2013 includes 62 strandings <170 cm in length, 48 (77%) of which stranded during the 4 mo spring/summer period of May–August. By comparison, only 46% of "large" carcasses (>170 cm) were collected during this same 4 mo period. These observations imply a seasonal peak in calving, spring/summer ocean conditions conducive to beach deposition of carcasses, or both. Spring and summer are characterized by gentle wave action conducive to deposition, in contrast to autumn and winter conditions more favorable to erosion and removal of objects from beaches. Although newly born calves are seen year-round in this population, calving seasonality is not well-studied. If calving seasonality coincides with summer beach conditions favorable for deposition (and detection due to increased human presence), then high calf recovery levels are not surprising.

Another potential contributing factor to higher calf recovery estimates is that simulated calf survival estimates from wild populations are optimistically high because field researchers fail to detect all births. Wells and Scott (1990) noted that birth rates can be underestimated, especially if field efforts are far enough apart in time such that neonates that die soon after birth have no chance of being counted by researchers unless they strand. Studies of captive calves indicate that a large percentage of neonates die within days of birth (Venn-Watson *et al.* 2011) and this may apply to wild births too. The lower bound of 0.81 for wild calf survival (Wells and Scott 1990) used in our simulations resulted in approximately 6–7 expected calf carcasses annually. Had we included *captive* calf survival estimates in our simulations, annual calf survival could have ranged as low as 0.61 (DeMaster and Drevenak 1988) and the expected number of calf carcasses would have increased to 10–11 annually, representing approximately one-third of annual expected carcasses, which is in close agreement with long-term stranding observations.

Our estimates of carcass recovery (0.25, 95% CI = 0.20–0.33) for an extremely coastal dolphin population suggests that observed anthropogenic mortality values of dolphins in this region derived from strandings should be corrected to account for unobserved mortality. This assumes that the probability of stranding is equal for natural and human-caused deaths, an assumption that is difficult to test. Our estimates have implications for developing carcass recovery correction factors for other more pelagic dolphin species in the region that might be less likely to strand (Perrin *et al.* 2011). Context clues as to the degree of negative bias in carcass recovery for more pelagic dolphins in this region are apparent when abundance and strandings are considered across multiple populations. Perrin *et al.* (2011) noted that a coastal bottlenose dolphin carcass is 50 times more likely to reach shore than an offshore ecotype, based on differences in estimated abundance for each population and assuming similar mortality rates. Danil *et al.* (2010) reported that the more pelagic common dolphin (*Delphinus delphis* and *D. capensis* combined) accounted for 43% of cetacean stranding records in San Diego County, while bottlenose dolphins (largely coastal animals) represented 16% of records. This yields a crude stranding ratio of 2.6 common dolphins for every bottlenose dolphin. In Santa Barbara County, the ratio of common dolphin to bottlenose dolphin strandings is approximately 10:1 (Santa

Barbara Museum of Natural History, unpublished data). Estimates of common dolphin abundance (both species combined) in southern California waters are approximately 400,000 animals (Barlow 2010, Carretta *et al.* 2011), compared with approximately 500–600 animals for coastal bottlenose dolphins. The ratio of common dolphin to bottlenose dolphin abundance is roughly 700:1 and expected stranding ratios should reflect relative abundance if both groups had equal stranding probabilities. Taken in context, abundance and strandings data imply a very low probability of stranding for the extremely abundant, but more pelagic common dolphins.

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GRAY WHALE (*Eschrichtius robustus*): Western North Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Gray whales occur along the eastern and western margins of the North Pacific. In the western North Pacific (WNP), gray whales feed during summer and fall in the Okhotsk Sea off northeast Sakhalin Island, Russia, and off southeastern Kamchatka in the Bering Sea (Weller et al. 1999, 2002; Vertyankin et al. 2004; Tyurneva et al. 2010; Burdin et al. 2013; Figure 1). Some gray whales observed feeding off Sakhalin and Kamchatka migrate during the winter to the west coast of North America in the eastern North Pacific (Mate et al. 2011; Weller et al. 2012; Urbán *et al*. 2013), while others, including at least one whale first identified as a calf off Sakhalin, migrate to areas off Asia in the WNP (Weller et al. 2008; Weller et al. 2013a). Despite the observed movements between the WNP and eastern North Pacific (ENP), genetic comparisons show significant mitochondrial and nuclear genetic differences between whales sampled in the ENP and those sampled on the feeding ground off Sakhalin Island in the WNP (LeDuc et al. 2002; Lang et al. 2011). While a few previously unidentified non-calves are identified annually, a recent population assessment using photo-identification data from 1994 to 2011 fitted to an individually-based model found that whales feeding off Sakhalin Island have been demographically self-contained, at least in recent years, as new recruitment to the population is almost exclusively a result of calves born to mothers from within the group (Cooke et al. 2013).

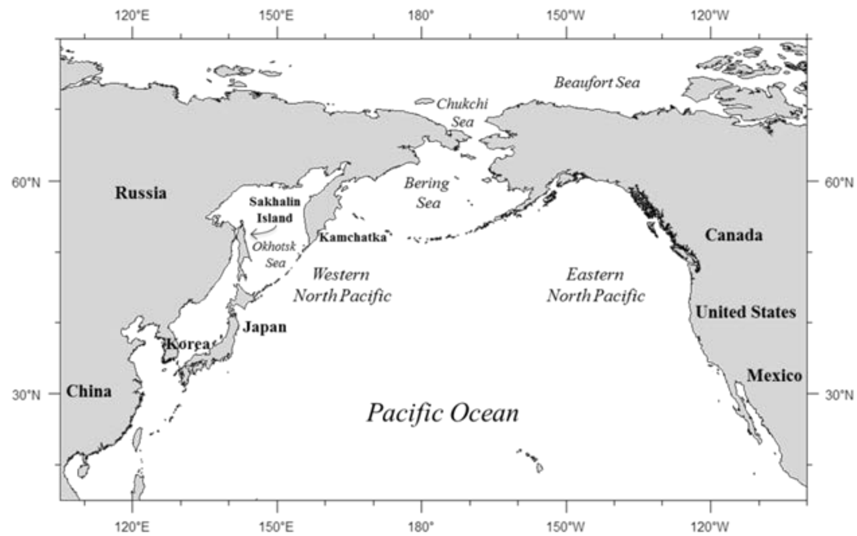

Figure 1. Range map of the Western North Pacific Stock of gray whales, including summering areas off Russia and wintering areas in the western and eastern Pacific.

Historical evidence indicates that the coastal waters of eastern Russia, the Korean Peninsula and Japan were once part of the migratory route in the WNP and that areas in the South China Sea may have been used as wintering grounds (Weller et al. 2002; Weller et al. 2013a). However, contemporary records of gray whales off Asia are rare, with only 13 from Japanese waters between 1990 and 2007 (Nambu *et al*. 2010) and 24 from Chinese waters since 1933 (Wang 1984; Zhu 2002). The last known record of a gray whale off Korea was in 1977 (Park 1995; Kim et al. 2013). While recent observations of gray whales off the coast of Asia are infrequent, they nevertheless continue to occur, including: (1) March/April 2014 - one or possibly two gray whales were sighted and photographed off the Shinano River in Teradomari (Niigata Prefecture) on the Sea of Japan coast of Honshu, Japan (Kato et al. 2014), (2) March 2012 - a gray whale was sighted and photographed in Mikawa Bay (Aichi Prefecture), on the Pacific coast of Honshu, Japan (Kato *et al*. 2012), and (3) November 2011 - a 13 m female gray whale was taken in fishing gear offshore of Baiqingxiang, China, in the Taiwan Strait (Zhu 2012).

Information from tagging, photo-identification and genetic studies show that some whales identified in the WNP off Russia have been observed in the ENP, including coastal waters of Canada, the U.S. and Mexico (Lang 2010; Mate et al. 2011; Weller et al. 2012; Urbán et al. 2013, Mate et al. 2015). In combination, these studies have recorded a total of 27 gray whales observed in both the WNP and ENP. Some whales that feed off Sakhalin Island in summer migrate east across the Pacific to the west coast of North America in winter, while others migrate south to waters off Japan and China. Taken together, these observations indicate that not all gray whales in the WNP share a common wintering ground (Weller et al. 2013a).

In 2012, the National Marine Fisheries Service convened a scientific task force to appraise the currently recognized and emerging stock structure of gray whales in the North Pacific (Weller et al. 2013b). The charge of the task force was to evaluate gray whale stock structure as defined under the Marine Mammal Protection Act (MMPA) and implemented through the National Marine Fisheries Service's Guidelines for Assessing Marine Mammal Stocks (GAMMS; NMFS 2005). Significant differences in both mitochondrial and nuclear DNA between whales sampled off Sakhalin Island (WNP) and whales sampled in the ENP provided convincing evidence that resulted in the task force advising that WNP gray whales should be recognized as a population stock under the MMPA and GAMMS guidelines. Given the interchange of some whales between the WNP and ENP, including seasonal occurrence of WNP whales in U.S. waters, the task force agreed that a stand-alone WNP gray whale population stock assessment report was warranted.

POPULATION SIZE

Photo-identification data collected between 1994 and 2011 on the gray whale summer feeding ground off Sakhalin Island in the WNP were used to calculate an abundance estimate of 140 (SE = ± 6, CV=0.043) whales for the age 1-plus (non-calf) population size in 2012 (Cooke et al. 2013). Some whales (approximately 70 individuals) sighted during the summer off southeastern Kamchatka have not been sighted off Sakhalin Island, but it is as yet unclear whether those whales are part of the WNP stock (IWC 2014).

Minimum Population Estimate

The minimum population estimate (N_{min}) for the WNP stock is calculated from Equation 1 from the PBR Guidelines (Wade and Angliss 1997): $N_{min} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$ and the abundance estimate of 140 (CV=0.043) whales from Cooke et al. (2013), resulting in a minimum population estimate of 135 gray whales on the summer feeding ground off Sakhalin Island in the WNP.

Current Population Trend

The WNP gray whale stock has increased over the last 10 years (2002-2012). The estimated realized average annual rate of population increase during this period is 3.3% per annum (± 0.5%) (Cooke et al. 2013).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

An analysis of the ENP gray whale population led to an estimate of R_{max} of 0.062, with a 90% probability the value was between 0.032 and 0.088 (Punt and Wade 2012). This value of R_{max} is also applied to WNP gray whales, as it is currently the best estimate of R_{max} available for any gray whale population.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (135), times one-half the estimated maximum annual growth rate for a gray whale population (½ of 6.2% for the Eastern North Pacific Stock, Punt and Wade 2012), times a recovery factor of 0.1 (for an endangered stock with N_{min} < 1,500, Taylor et al. 2003), and also multiplied by estimates for the proportion of the stock that uses U.S. EEZ waters (0.575) and the proportion of the year that those animals are in the U.S. EEZ (3 months, or 0.25 years) (Moore and Weller 2013), resulting in a PBR of 0.06 WNP gray whales per year, or approximately 1 whale every 17 years (if abundance and other parameters in the PBR equation remained constant over that time period).

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Serious Injury Guidelines

NMFS uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to distinguis serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "injury that is more likely than not to result in mortality".

Fisheries Information

The decline of gray whales in the WNP is attributable to commercial hunting off Korea and Japan between the 1890s and 1960s. The pre-exploitation abundance of WNP gray whales is unknown, but has been estimated to be between 1,500 and 10,000 individuals (Yablokov and Bogoslovskaya 1984). By 1910, after some commercial exploitation had already occurred, it is estimated that only 1,000 to 1,500 gray whales remained in the WNP population (Berzin and Vladimirov 1981). The basis for how these two estimates were derived, however, is not apparent (Weller et al. 2002). By the 1930s, gray whales in the WNP were considered by many to be extinct (Mizue 1951; Bowen 1974).

Today, a significant threat to gray whales in the WNP is incidental catches in coastal net fisheries (Weller et al. 2002; Kato et al. 2012; Weller et al. 2008; Weller et al. 2013a). Between 2005 and 2007, four female gray whales (including one mother-calf pair and one yearling) died in fishing nets on the Pacific coast of Japan. In addition, one adult female gray whale died as a result of a fisheries interaction in November 2011 off Pingtan County, China (Zhu 2012). An analysis of anthropogenic scarring of gray whales photographed off Sakhalin Island found that at least 18.7% (n=28) of 150 individuals identified between 1994 and 2005 had evidence of previous entanglements in fishing gear (Bradford et al. 2009), further highlighting the overall risks coastal fisheries pose to WNP gray whales.

In summer 2013, salmon net fishing was observed for the first time on the gray whale feeding ground off Sakhalin Island. Observations of whales within 100 m of salmon fishing nets have been made and a male gray whale was observed dragging fishing gear (rope), with a related injury on the caudal peduncle at the dorsal insertion point with the flukes (Weller et al. 2014).

Given that some WNP gray whales occur in U.S. waters, there is some probability of WNP gray whales being killed or injured by ship strikes or entangled in fishing gear within U.S. waters.

Subsistence/Native Harvest Information

In 2005, the Makah Indian Tribe requested authorization from NOAA/NMFS, under the Marine Mammal Protection Act of 1972 (MMPA) and the Whaling Convention Act, to resume limited hunting of gray whales for ceremonial and subsistence purposes in the coastal portion of their usual and accustomed (U&A) fishing grounds off Washington State (NOAA 2008). Observations of gray whales moving between the WNP and ENP highlight the need to estimate the probability of a gray whale observed in the WNP being taken during a hunt by the Makah Tribe (Moore and Weller 2013). Given conservation concerns for the WNP population, the Scientific Committee of the International Whaling Commission (IWC) emphasized the need to estimate the probability of a WNP gray whale being struck during aboriginal gray whale hunts (IWC 2012). Additionally, NOAA is required by the National Environmental Policy Act (NEPA) to prepare an Environmental Impact Statement (EIS) pertaining to the Makah's request. The EIS needs to address the likelihood of a WNP whale being taken during the proposed Makah gray whale hunt.

To estimate the probability that a WNP whale might be taken during the proposed Makah gray whale hunt, four alternative models were evaluated. These models made different assumptions about the proportion of WNP whales that would be available for the hunt or utilized different types of data to inform the probability of a WNP whale being taken (Moore and Weller 2013). Based on the preferred model, the probability of striking at least one WNP whale in a single year was estimated to range from 0.006 – 0.012 across different scenarios for the annual number of total gray whales that might be struck. This corresponds to an expectation of ≥ 1 WNP whale strike in one of every 83 to 167 years.

HABITAT CONCERNS

Near shore industrialization and shipping congestion throughout the migratory corridors of the WNP gray whale stock represent risks by increasing the likelihood of exposure to pollutants and ship strikes as well as a general degradation of the habitat. In addition, the summer feeding area off Sakhalin Island is a region rich with offshore oil and gas reserves. Two major offshore oil and gas projects now directly overlap or are in near proximity to this important feeding area, and more development is planned in other parts of the Okhotsk Sea that include the migratory routes of these whales. Operations of this nature have introduced new sources of underwater noise, including seismic surveys, increased shipping traffic, habitat modification, and risks associated with oil spills (Weller et al. 2002). During the past decade, a Western Gray Whale Advisory Panel, convened by the International Union for Conservation of Nature (IUCN), has been providing scientific advice on the matter of anthropogenic threats to gray whales in the WNP (see http://www.iucn.org/wgwap/). Ocean acidification could reduce the abundance of shell-forming organisms (Fabry et al. 2008, Hall-Spencer et al. 2008), many of which are important in the gray whales' diet (Nerini 1984).

STATUS OF STOCK

The WNP stock is listed as "Endangered" under the U.S. Endangered Species Act of 1973 (ESA) and is therefore also considered "strategic" and "depleted" under the MMPA. At the time the ENP stock was delisted, the WNP stock was thought to be geographically isolated from the ENP stock. Recent documentation of some whales moving between the WNP and ENP seems to indicate otherwise (Lang 2010; Mate et al. 2011; Weller et al. 2012; Urbán et al. 2013). Other research findings, however, provide continued support for identifying two separate stocks of North Pacific gray whales, including: (1) significant mitochondrial and nuclear genetic differences between whales that feed in the WNP and those that feed in the ENP (LeDuc et al. 2002; Lang et al. 2011), (2) recruitment into the WNP stock is almost exclusively internal (Cooke et al. 2013), and (3) the abundance of the WNP stock remains low while the abundance of the ENP stock grew steadily following the end of commercial whaling (Cooke et al. 2013). As long as the WNP stock remains listed as endangered under the ESA, it will continue to be considered as depleted under the MMPA.

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U.S. PACIFIC MARINE MAMMAL STOCK ASSESSMENTS: 2016

James V. Carretta, Karin A. Forney, Erin M. Oleson, David W. Weller, Aimee R. Lang, Jason Baker, Marcia M. Muto, Brad Hanson, Anthony J. Orr, Harriet Huber, Mark S. Lowry, Jay Barlow, Jeffrey E. Moore, Deanna Lynch, Lilian Carswell, and Robert L. Brownell Jr.

NOAA-TM-NMFS-SWFSC-577

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

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NOAA Technical Memorandum NMFS
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JUNE 2017

U.S. PACIFIC MARINE MAMMAL STOCK ASSESSMENTS: 2016

James V. Carretta[1], Karin A. Forney[3], Erin M. Oleson[2], David W. Weller[1], Aimee R. Lang[9], Jason Baker[2], Marcia M. Muto[4], Brad Hanson[5], Anthony J. Orr[4], Harriet Huber[4], Mark S. Lowry[1], Jay Barlow[1], Jeffrey E. Moore[1], Deanna Lynch[6], Lilian Carswell[7], and Robert L. Brownell Jr.[8]

1 - NOAA Fisheries, Southwest Fisheries Science Center, 8901 La Jolla Shores Drive, La Jolla, CA 92037
2 - NOAA Fisheries, Pacific Islands Fisheries Science Center, 1845 Wasp Blvd., Building 176, Honolulu, HI 96818
3 - NOAA Fisheries, Southwest Fisheries Science Center, 110 Shaffer Road, Santa Cruz, CA 95060
4 - NOAA Fisheries, National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115
5 - NOAA Fisheries, Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle WA 98112
6 - U.S. Fish and Wildlife Service, Western Washington Fish and Wildlife Office, 510 Desmond Drive SE, Suite 102, Lacey, WA 98503
7 - U.S. Fish and Wildlife Service, 2493 Portola Road, Suite B, Ventura, California, 93003
8 - NOAA Fisheries, Southwest Fisheries Science Center, 34500 Highway 1, Monterey, Ca 93940
9 - Ocean Associates Inc., under contract to Southwest Fisheries Science Center, 8901 La Jolla Shores Drive, La Jolla, CA 92037

NOAA-TM-NMFS-SWFSC-577

U.S. DEPARTMENT OF COMMERCE
Wilbur L. Ross, Secretary of Commerce

National Oceanic and Atmospheric Administration
Benjamin Friedman, Acting NOAA Administrator

National Marine Fisheries Service
Samuel D. Rauch III, Acting Assistant Administrator for Fisheries

PREFACE

Under the 1994 amendments to the Marine Mammal Protection Act (MMPA), the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) are required to publish Stock Assessment Reports for all stocks of marine mammals within U.S. waters, to review new information every year for strategic stocks and every three years for non-strategic stocks, and to update the stock assessment reports when significant new information becomes available.

Pacific region stock assessments include those studied by the Southwest Fisheries Science Center (SWFSC, La Jolla, CA), the Pacific Islands Fisheries Science Center (PIFSC, Honolulu, HI), the National Marine Mammal Laboratory (NMML, Seattle, WA), and the Northwest Fisheries Science Center (NWFSC, Seattle, WA). The 2016 Pacific marine mammal stock assessments include revised reports for 23 Pacific marine mammal stocks under NMFS jurisdiction, including eight "strategic" stocks: Hawaiian monk seal, Guadalupe fur seal, Southern Resident killer whale, California/Oregon/Washington humpback whale, California/Oregon/Washington fin whale, Eastern North Pacific sei whale, Main Hawaiian Islands Insular false killer whale, and Hawaii Pelagic false killer whale. New abundance estimates are available for 16 U.S. west coast stocks: Guadalupe fur seal, Washington Inland Waters harbor porpoise, California/Oregon/Washington stocks of Dall's porpoise, Pacific white-sided dolphin, Risso's dolphin, coastal and offshore stocks of common bottlenose dolphin, striped dolphin, short- and long-beaked common dolphin, northern right whale dolphin, short-finned pilot whale, pygmy sperm whale, fin whale, Eastern North Pacific sei whale and Southern Resident killer whales. New information on fishery-related serious injury and mortality has been updated for those stocks where possible. Updated estimates of stock abundance are also available for the Hawaiian monk seal.

New abundance estimates for several species along the U.S. west coast are considerably higher than previous estimates (Barlow 2016). This is attributed to two factors: 1) estimates of the trackline detection probability, *g(0)* are lower than in previous surveys, because new Beaufort sea state-specific estimates of *g(0)* have been calculated that better reflect differing probabilities of detection with increasing wind and swell (Barlow 2015); and 2) warm-temperate species such as short-beaked common dolphin, long-beaked common dolphin, and striped dolphin were encountered more frequently during a 2014 line-transect survey compared to previous years, due to anomalous warm-water conditions in the California Current (Barlow 2016, Cavole *et al*. 2016).

Human-caused mortality and injury documentation is often based on stranding data, where raw counts are negatively-biased because only a fraction of carcasses are detected (Williams *et al*. 2011), even for extremely coastal species (Wells *et al*. 2015). Carretta *et al*. (2016a) estimated that only 25% of California coastal bottlenose dolphin carcasses are recovered / documented, and given the extremely coastal habits of the population, Carretta *et al*. (2016a) argue that carcass recovery rates for this population represent a maximum rate, compared to more pelagic dolphin and porpoise species in the region. Therefore, for U.S. west coast stock assessment reports involving dolphins and porpoises, human-related deaths and injuries counted from mainland beach strandings are multiplied by a factor of 4 to account for the non-detection of most carcasses. Species / stocks for which the stranding correction factor has been applied include: California coastal bottlenose dolphin, Washington Inland waters harbor porpoise, Risso's dolphin, striped dolphin, and short-beaked and long-beaked common dolphin. This carcass recovery correction factor has not been applied to large whale serious injuries and mortalities, because the method of detection for most large whale entanglement and vessel strike cases are opportunistic offshore sightings, and it is currently unknown what fraction of injured or dead large whales are detected at sea or ashore.

New estimates of human-caused mortality and serious injury are included for U.S. west coast stocks that interact with the California swordfish drift gillnet fishery (Carretta *et al*. 2016b). Estimates are model-based and are based on inclusion of 25 years of bycatch data, in contrast to previous ratio estimates of bycatch that relied on within-year data only (Carretta *et al*. 2014). The main effects of implementing model-based bycatch estimation are that resulting estimates are less volatile inter-annually, have better precision, and are less prone to biases associated with rare bycatch events and low observer coverage (Carretta and Moore 2014). Model-based estimates also result in positive estimates of bycatch even in years when no bycatch of a particular species is recorded by fishery observers.

This is a working document and individual stock assessment reports will be updated as new information on marine mammal stocks and fisheries becomes available. Background information and guidelines for preparing stock assessment reports are reviewed in Wade and Angliss (1997). The authors solicit any new information or comments which would improve future stock assessment reports.

Draft versions of the 2016 stock assessment reports were reviewed by the Pacific Scientific Review Group at the February 2016 meeting.

These Stock Assessment Reports summarize information from a wide range of original data sources and an extensive bibliography of all sources is given in each report. We recommend users of this

document refer to and cite *original* literature sources cited within the stock assessment reports rather than citing this report or previous Stock Assessment Reports.

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PINNIPEDS

CETACEANS - U.S. WEST COAST

CETACEANS – HAWAII & WESTERN PACIFIC

APPENDICES

Revised 6/30/2015

CALIFORNIA SEA LION (*Zalophus californianus*): U.S. Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The breeding areas of the California sea lion are on islands located in southern California, western Baja California, and the Gulf of California (Figure 1). Mitochondrial DNA analysis identified five genetically distinct geographic populations: (1) Pacific Temperate, (2) Pacific Subtropical, (3) Southern Gulf of California, (4) Central Gulf of California and (5) Northern Gulf of California (Schramm *et al*. 2009). In that study, the Pacific Temperate population included rookeries within U.S. waters and the Coronados Islands just south of U.S./Mexico border. Animals from the Pacific Temperate population range into Canadian waters, and movement of animals between U.S. waters and Baja California waters occurs. Males from western Baja California rookeries may spend most of the year in the United States.

There are no international agreements between the U.S., Mexico, and Canada for joint management of California sea lions, and the number of sea lions at the Coronado Islands is not regularly monitored. Consequently, this stock assessment report considers only the U.S. Stock, i.e. sea lions at rookeries within the U.S. Pup production at the Coronado Islands is minimal (between 12 and 82 pups annually; Lowry and Maravilla-Chavez 2005) and does not represent a significant contribution to the overall size of the Pacific Temperate population.

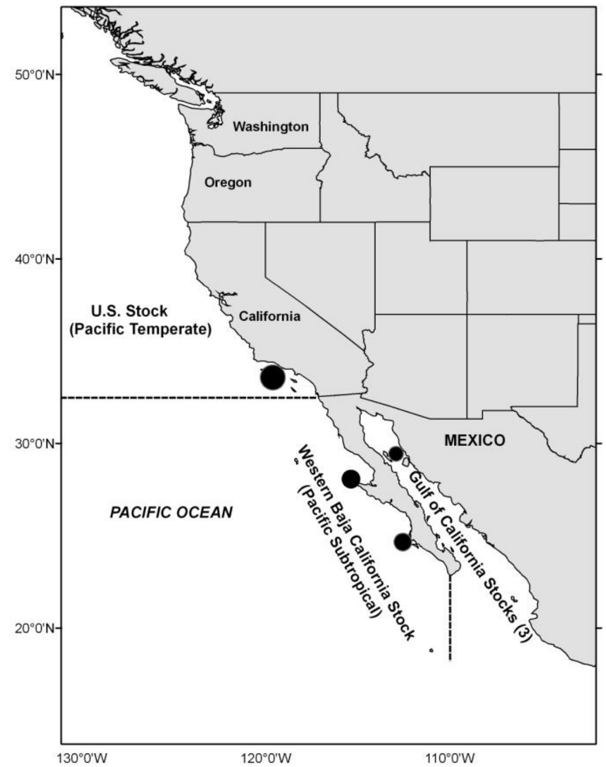

Figure 1. Geographic range of California sea lions showing stock boundaries and locations of major rookeries. The U.S. stock also ranges north into Canadian waters.

POPULATION SIZE

The entire population cannot be counted because all age and sex classes are not ashore at the same time. In lieu of counting all sea lions, pups are counted during the breeding season (because this is the only age class that is ashore in its entirety), and the number of births is estimated from the pup count. Population size is then estimated from the number of births and the proportion of pups in the population. Surveys are conducted in July after all pups have been born. To estimate the number of pups born, the pup count for rookeries in southern California in 2008 (59,774) was adjusted for an estimated 15% pre-census mortality (Boveng 1988; Lowry *et al*. 1992), giving an estimated 68,740 live births in the population. The fraction of newborn pups in the population (23.2%) was estimated from a life table derived for the northern fur seal (*Callorhinus ursinus*) (Boveng 1988, Lowry *et al*. 1992) which was modified to account for the growth rate of this California sea lion population (5.4% yr^{-1}, see below). Multiplying the number of pups born by the inverse of this fraction (4.317) results in a population estimate of 296,750. More recent pup counts made in 2011 totaled 61,943 animals, the highest recorded to date (Figure 2). Estimates of total population size based on these counts are currently being developed, along with new estimates of the fraction of newborn pups in the population.

Minimum Population Estimate

The minimum population size was determined from counts of all age and sex classes that were ashore at all the major rookeries and haulout sites in southern and central California during the 2007 breeding season. The minimum population size of the U.S. stock is 153,337 (NMFS unpubl. data). It includes all California sea lions counted during the July 2007 census at the Channel Islands in southern California and at haulout sites located between Point Conception and Point Reyes, California. An additional unknown number of California sea lions are at sea or hauled out at locations that were not surveyed.

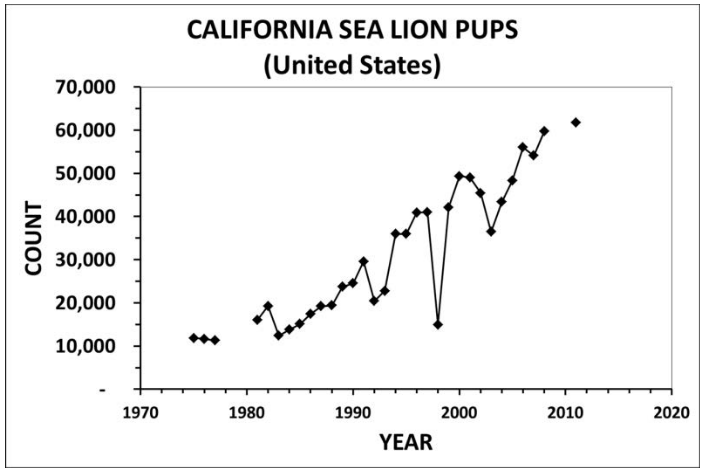

Figure 2. U.S. pup count index for California sea lions (1975-2011). Trends in pup counts from 1975 through 2011 are shown for four rookeries in southern California and for haulouts in central and northern California.

Current Population Trend

Trends in pup counts from 1975 through 2011 are shown in Figure 2 for four rookeries in southern California and for haulouts in central and northern California. The number of pups at rookeries that were not counted were estimated using multiple regression analyses derived from counts of two neighboring rookeries using data from 1975-2000 (Lowry and Maravilla 2005): (1) 1980 at Santa Barbara Is.; (2) 1978-1980 at San Clemente Is.; and (3) 1978 and 1979 at San Nicolas Is. The mean was used when more than one count was available for a given rookery. A regression of the natural logarithm of the pup counts by year indicates that pup counts increased at an annual rate of 5.4% between 1975 and 2008, when pup counts for El Niño years (1983, 1984, 1992, 1993, 1998, and 2003) were removed from the 1975-2005 time series. Using 1975-2008 non-El Niño year data, the coefficient of variation for this average annual growth rate (CV=0.04) was computed via bootstrap sampling of the count data. The 1975-2008 time series of pup counts shows the effect of four El Niño events on the sea lion population (Figure 2). Pup production decreased by 35% in 1983, 27% in 1992, 64% in 1998, and 20% in 2003. After the 1992-93, 1997-98 and 2003 El Niños, pup production rebounded to pre-El Niño levels within two years. In contrast, however, the 1983-1984 El Niño affected adult female survivorship (DeLong *et al*. 1991), which prevented an immediate rebound in pup production because there were fewer adult females available in the population to produce pups (it took five years for pup production to return to the 1982 level). Other characteristics of El Niños are higher pup and juvenile mortality rates (DeLong *et al*. 1991, Lowry and Maravilla-Chavez, 2005) which affect future recruitment into the adult population for the affected cohorts. The 2002 and 2003 decline can be attributed to (1) reduced number of reproductive adult females being incorporated into the population as a result of the 1992-93 and 1997-98 El Niños, (2) domoic acid poisoning (Scholin *et al*. 2000, Lefebvre *et al*. 2000), (3) lower survivorship of pups due to hookworm infestations (Lyons *et al*. 2001), and (4) the 2003 El Niño. Large numbers of emaciated sea lion pups stranded in early 2013 in California and pup weight indices at the San Miguel Island rookery were significantly lower in 2012 compared with previous years (Wells *et al*. 2013). As a result of the large numbers of sea lion strandings in 2013, NOAA declared an unusual mortality event (UME)[1]. Although the exact causes of this UME are unknown, two hypotheses meriting further study include nutritional stress of pups resulting from a lack of forage fish available to lactating mothers and unknown disease agents during that time period.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

We use the default maximum net productivity rate for pinnipeds (12% per year) (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (153,337) <u>times</u> one half the default maximum net growth rate for pinnipeds (½ of 12%) <u>times</u> a recovery factor of

[1] http://www.nmfs.noaa.gov/pr/health/mmume/californiasealions2013.htm

1.0 (for a stock of unknown status that is growing, Wade and Angliss 1997); resulting in a PBR of 9,200 sea lions per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Serious Injury Guidelines

NMFS uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to distinguish serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*".

Historical Depletion

Historic exploitation of California sea lions include harvest for food by native Californians in the Channel Islands 4,000-5,000 years ago (Stewart *et al*. 1993) and for oil and hides in the mid-1800s (Scammon 1874). More recent exploitation of sea lions for pet food, target practice, bounty, trimmings, hides, reduction of fishery depredation, and sport are reviewed in Helling (1984), Cass (1985), Seagers *et al*. (1985), and Howorth (1993). There are few historical records to document the effects of such exploitation on sea lion abundance (Lowry *et al*. 1992).

Fisheries Information

California sea lions are killed in a variety of trawl, purse seine, and gillnet fisheries along the U.S. west coast (Barlow *et al*. 1994, Carretta and Barlow 2011, Carretta *et al*. 2013, Julian and Beeson 1998, Jannot *et al*. 2011, Stewart and Yochem 1987). Those for which recent observations or estimates of bycatch mortality exist are summarized in Table 1. In addition to bycatch estimates from fishery observer programs, information on fishery-related sea lion deaths and serious injuries comes largely from stranding data (Carretta *et al*. 2013). Stranding data represent a minimum number of animals killed or injured, as many entanglements are likely unreported or undetected.

California sea lions are also incidentally killed and injured by hooks from recreational and commercial fisheries. Sea lion deaths due to hook-and-line fisheries are often the result of complications resulting from ingestion of hooks, perforation of body cavities leading to infections, or the inability of the animal to feed. Many of the animals die post-stranding during rehabilitation or are euthanized as a result of their injuries. Between 2008 and 2012, there were 124 California sea lion deaths / serious injuries attributed to hook and line fisheries, or an annual average of 25 animals (Carretta *et al*. 2014b). One sea lion death was reported in a tribal salmon gillnet in 2009 along the U.S. west coast.

Table 1. Summary of available information on the mortality and serious injury of California sea lions in commercial fisheries that might take this species (Carretta *et al*. 2014a. 2009, 2010, 2012a, 2012b; Heery *et al*. 2010; Jannot *et al*. 2011; Appendix 1). Mean annual takes are based on 2008-2012 data unless noted otherwise.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality	Estimated Mortality (CV in parentheses)	Mean Annual Takes (CV in parentheses)
CA/OR thresher shark/swordfish large mesh drift gillnet fishery	2008 2009 2010 2011 2012	observer	13.5% 13.3% 11.9% 19.5% 18.6%	7 5 0 18 6	51 (0.52) 37 (0.83) 0 (n/a) 92 (0.79) 32 (0.60)	42 (0.50)
CA halibut and white seabass set gillnet fishery	2008 2009 2010 2011 2012	observer	0% 0% 12.5% 8.0% 5.5%	n/a n/a 25 6 18	n/a n/a 199 (0.30) 74 (0.39) 326 (0.33)	200 (0.21)
CA small-mesh drift gillnet fishery for white seabass, yellowtail, barracuda, and tuna	2010 2011 2012	observer	0.7% 3.3% 4.6%	0 0 0	0 (n/a) 0 (n/a) 0 (n/a)	0 (n/a)
CA anchovy, mackerel, sardine, and tuna purse- seine fishery	2004-2008	observer	~5%	2	n/a	≥2 (n/a)

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality	Estimated Mortality (CV in parentheses)	Mean Annual Takes (CV in parentheses)
WA, OR, CA domestic groundfish trawl fishery (includes at-sea hake and other limited-entry groundfish sectors)	2005 2006 2007 2008 2009	observer	98% to 100% of tows in at-sea hake fishery Generally less than 30% of landings observed in other groundfish sectors	14 21 8 7 4	21 (n/a) 95 (n/a) 31 (n/a) 13 (n/a) 10 (n/a)	34 (n/a)
Unknown entangling net fishery	2008-2012	stranding	n/a		n/a	≥ 53 (n/a)
Unknown trawl fishery and bait barge net entanglement	2008-2012	stranding	n/a	2		≥ 2 (n/a)
Minimum total annual takes						≥ 331 (0.14)

Other Mortality

Live strandings and dead beach-cast California sea lions are regularly observed with gunshot wounds in California (Lowry and Folk 1987, Goldstein *et al*. 1999, Carretta *et al*. 2013). A summary of stranding records for 2008 to 2012 from California, Oregon, and Washington shows the following non-fishery related human-caused mortality and serious injuries: boat collisions (13), car collisions (3), entrainment in power plants (59), shootings (151), marine debris entanglement or ingestion (37), research-related (18), and other sources, including dog attacks, harassment, seal bombs, stabbings, and, blunt force trauma (10). Stranding records are a gross under-estimate of mortality and serious injury because many animals and carcasses are never recovered. The minimum number of non-fishery related deaths and serious injuries during 2008-2012 was 291 sea lions, or an annual average of 58 animals.

Under authorization of MMPA Section 120, individually identifiable California sea lions have been killed or relocated since 2008 in response to their predation on endangered salmon and steelhead stocks in the Columbia River. Relocated animals were transferred to aquaria and/or zoos. Between 2009 and 2013, a total of 47 California sea lions were removed from this stock (40 lethal removals and 7 relocations to aquaria and/or zoos). The average annual mortality due to direct removals for the 2009-2013 period is 9.4 animals per year (relocations to aquaria/zoos are treated the same as mortality because animals are effectively removed from the stock).

Between 2008 and 2012, 18 California sea lions were incidentally killed, 2 seriously injured, and 8 non-serious injuries along the U.S. west coast during scientific trawl and longline operations conducted by NMFS (Carretta *et al*., 2014b). The average annual research-related mortality and serious injury of California sea lions from 2008 to 2012 is 4.0 animals.

Habitat Concerns

Sea lion mortality linked to the algal-produced neurotoxin domoic acid has been documented sporadically since 1998 (Scholin *et al*. 2000, Brodie *et al*. 2006, Ramsdell and Zabka 2008). Future mortality may be expected to occur, due to the repeated occurrence of such harmful algal blooms.

Exposure to anthropogenic sound may impact individual sea lions. Experimental exposure of captive California sea lions to simulated mid-frequency sonar (Houser *et al*. 2013) and acoustic pingers (Bowles and Anderson 2012) resulted in a wide variety of behavioral responses, including increases in respiration, refusal to participate in tasks involving food rewards, evasive hauling out, and prolonged submergence. Despite exposure to sources of anthropogenic sound in the wild, the California sea lion population continues to grow.

Expanding pinniped populations in general have resulted in increased human-caused serious injury and mortality, due to shootings, entrainment in power plants, interactions with recreational hook and line fisheries, separation of mothers and pups due to human disturbance, dog bites, and vessel and vehicle strikes (Carretta et al. 2014b).

STATUS OF STOCK

California sea lions in the U.S. are not listed as "endangered" or "threatened" under the Endangered Species Act or as "depleted" under the MMPA. The optimum sustainable population (OSP) status of this population has not been formally determined. The average annual commercial fishery mortality is 331 animals per year (Table 1). Other sources of human-caused mortality (shootings, direct removals, recreational hook and line fisheries, tribal takes, entrainment in power plant intakes, etc.) average 58 animals per year. Total human-caused mortality of this stock is at least 389 animals per year. California sea lions are not considered "strategic" under the MMPA because total human-caused mortality is less than the PBR (9,200). The total fishery mortality and serious injury rate (389 animals/year) for this stock is less than 10% of the calculated PBR and, therefore, is considered to be insignificant and approaching a zero mortality and serious injury rate.

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HARBOR SEAL (*Phoca vitulina richardii*): California Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Harbor seals (*Phoca vitulina*) are widely distributed in the North Atlantic and North Pacific. Two subspecies exist in the Pacific: *P. v. stejnegeri* in the western North Pacific, near Japan, and *P. v. richardii* in the eastern North Pacific. The latter subspecies inhabits coastal and estuarine areas from Mexico to Alaska. These seals do not make extensive pelagic migrations, but do travel 300-500 km to find food or suitable breeding areas (Herder 1986; Harvey and Goley 2011). In California, approximately 400-600 harbor seal haulout sites are widely distributed along the mainland and on offshore islands, including intertidal sandbars, rocky shores and beaches (Hanan 1996; Lowry *et al.* 2008).

Within the subspecies *P. v. richardii*, abundant evidence of geographic structure comes from differences in mitochondrial DNA (Huber *et al.* 1994, 2010, 2012; Burg 1996; Lamont *et al.* 1996; Westlake and O'Corry-Crowe 2002; O'Corry-Crowe *et al.* 2003), mean pupping dates (Temte 1986), pollutant loads (Calambokidis *et al.* 1985), pelage coloration (Kelly 1981) and movement patterns (Jeffries 1985; Brown 1988). LaMont *et al.* (1996) identified four discrete subpopulation differences in mtDNA between harbor seals from Washington (two locations), Oregon, and California. Another mtDNA study (Burg 1996) supported the existence of three separate groups of harbor seals between Vancouver Island and southeastern Alaska. Three genetically distinct populations of harbor seals within Washington inland waters are also evident, based on work by Huber *et al.* (2010, 2012). Although geographic structure exists along an almost continuous distribution of harbor seals from California to Alaska, stock boundaries are difficult to draw because any rigid line is arbitrary from a biological perspective. Nonetheless, failure to recognize geographic structure in defining management stocks can lead to depletion of local populations. Previous assessments of the status of harbor seals have recognized three stocks along the west coast of the continental U.S.: 1) California, 2) Oregon and Washington outer coast waters, and 3) inland waters of Washington. Although the need for stock boundaries for management is real and is supported by biological information, the exact placement of a boundary between California and Oregon was largely a political/jurisdictional convenience. An unknown number of harbor seals also occur along the west coast of Baja California, at least as far south as Isla Asuncion, which is about 100 miles south of Punta Eugenia. Animals along Baja California are not considered to be a part of the California stock because it is not known if there is any demographically significant movement of harbor seals between California and Mexico and there is no international agreement for joint management of harbor seals. Lacking any new information on which to base a revised boundary, the harbor seals of California are treated as a separate stock in this report (Fig. 1). Other Marine Mammal Protection Act (MMPA) stock assessment reports cover the other stocks that are recognized along the U.S. west coast: 1) Southern Puget Sound (south of the Tacoma Narrows Bridge); 2) Washington Northern Inland Waters (including Puget Sound north of the Tacoma Narrows Bridge, the San Juan Islands, and the Strait of Juan de Fuca); 3) Hood Canal; and 4) Oregon/Washington Coast.

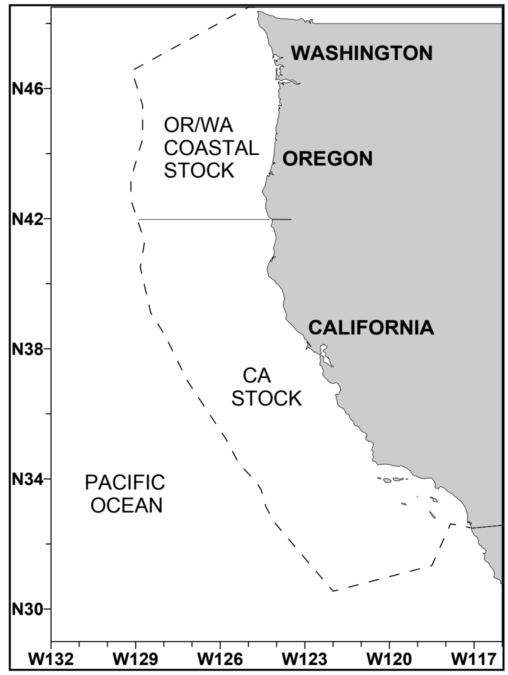

Figure 1. Stock boundaries for the California and Oregon/Washington coastal stocks of harbor seals. Dashed line represents the U.S. EEZ.

POPULATION SIZE

A complete count of all harbor seals in California is impossible because not all animals are hauled out simultaneously. A complete pup count (as is done for other pinnipeds in California) is also not possible because harbor seal pups enter the water almost immediately after birth. Population size is estimated by counting the number of seals ashore during the peak haul-out period (May to July) and by multiplying this count by a correction factor equal to the inverse of the estimated fraction of seals on land. Harvey and Goley (2011) calculated a correction factor of 1.54 (CV=0.157), based on 180 radio-tagged seals in California. This correction factor is based on the mean of four date-specific correction factors (1.31, 1.38, 1.62, 1.84) calculated for central and northern California. Based on the most recent harbor seal counts during May-July of 2012 (20,109 animals) (NMFS unpublished data) and the Harvey and Goley (2011) correction factor, the harbor seal population in California in 2012 is estimated to number 30,968 seals (CV=0.157).

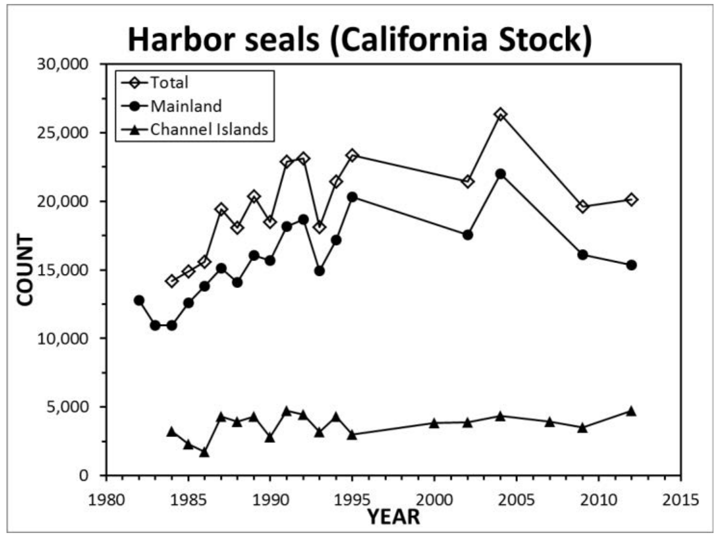

Figure 2. Harbor seal haulout counts in California during May to July (Hanan 1996; R. Read, CDFG unpubl. data; Lowry *et al*. 2008, NMFS unpubl. data from 2009-2012 surveys).

Minimum Population Estimate

The minimum population size is estimated from the number of hauled out seals counted in 2012 (20,109), multiplied by the lower 20th percentile of the correction factor (1.36), or 27,348 seals.

Current Population Trend

Counts of harbor seals in California increased from 1981 to 2004 when the statewide maximum count was recorded. Subsequent surveys conducted in 2009 and 2012 have been lower than the 2004 maximum count (Fig. 2).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Historically, the largest known source of human-caused mortality of California harbor seals was the California halibut set gillnet fishery (Julian and Beeson 1998), where estimates of bycatch mortality were approximately 1-2% of the estimated population size between 1990 and 1995. Since 1996, that fishery been observed infrequently and at low observer coverage levels, though fishing effort levels have declined. Any estimate of current net productivity level should account for human-caused mortality, otherwise estimated net productivity will be negatively-biased. At this time, there are insufficient data on bycatch (only 3 of the last 5 years have observations from the fishery, with low observer coverage) and uncertainty regarding the degree of negative biases for other sources of human-caused mortality to reliably estimate the current net productivity level. An assessment of *maximum net productivity levels* is not possible, because abundance estimates were not available when the population was very small and presumably recovering from past exploitation (Bonnot 1928).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (27,348) times one half the default maximum net productivity rate for pinnipeds (½ of 12%) times a recovery factor of 1.0 (for a stock of unknown status that is growing or for a stock at OSP, Wade and Angliss 1997), resulting in a PBR of 1,641 animals per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Serious Injury Guidelines

NMFS uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to distinguish serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*".

Historical Takes

Prior to state and federal protection and especially during the nineteenth century, harbor seals along the west coast of North America were greatly reduced by commercial hunting (Bonnot 1928, 1951; Bartholomew and Boolootian 1960). Only a few hundred individuals survived in a few isolated areas along the California coast (Bonnot 1928). In the last half of the last century, the population increased dramatically.

Fishery Information

A summary of known commercial fishery mortality and serious injury for this stock of harbor seals for the period 2008-2012 is given in Table 1. Historically, the set gillnet fishery for halibut and white seabass was the largest source of fishery mortality and remains the most likely fishery in California to interact with harbor seals. Julian and Beeson (1998) reported a range of annual mortality estimates from 227 to 1,204 seals (mean = 584) from 1990 to 1994, based on 5% to 15% fishery observer coverage and representing between 1-2% of the estimated population size. This fishery has been observed infreqently since 1995 and fishing effort has declined from approximately 5,000 trips in the early 1990s to 1,300 trips in 2012 (Carretta *et al*. 2014a.).

Table 1. Summary of available information on the mortality and serious injury of harbor seals (California stock) in commercial fisheries that might take this species (Carretta and Enriquez 2006, 2009, Carretta *et al*. 2014a; Heery *et al*. 2010); n/a indicates that data are not available. Mean annual takes are based on 2008-2012 data unless noted otherwise.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality	Estimated Mortality (CV in parentheses)	Mean Annual Takes (CV in parentheses)
CA halibut and white seabass set gillnet fishery	2008 2009 2010 2011 2012	observer	0% 0% 12.5% 8.0% 5.5%	0 0 3 0 0	n/a n/a 23 (0.59) n/a n/a	23 (0.59)
CA small-mesh drift gillnet fishery for white seabass, yellowtail, barracuda, and tuna	2010 2011 2012	observer	0.7% 3.3% 4.6%	0 0 0	0 (n/a) 0 (n/a) 0 (n/a)	0 (n/a)
WA, OR, CA groundfish trawl (includes at-sea hake and other limited-entry groundfish sectors)	2005 2006 2007 2008 2009	observer	99% to 100% of tows in at-sea hake fishery; 18%-26% of landings in other groundfish sectors	1 1 0 4 1	1 (n/a) 1 (n/a) 0 (n/a) 29 (n/a) 1 (n/a)	6.4 (n/a)
Unknown net fisheries	2008-2012	stranding	n/a	5	n/a	≥ 1.0
Total annual takes						30 (0.59)

Other Mortality

NMFS stranding records for California for the period 2008-2012 include the following human-caused mortality and serious injury not included in Table 1: shootings (1), ship/vessel strikes (3), entrainment in power plants (40), hook and line fisheries (6), human-induced abandonment of pups or harassment (9), marine debris entanglement (2), stabbing/gaff wounds (2), and research-related deaths (1) (Carretta *et al*. 2014b.). The total non-fishery related mortality and serious injury for the period totals 64 harbor seals, or an annual average of 12.8 seals.

STATUS OF STOCK

A review of harbor seal dynamics through 1991 concluded that their status relative to OSP could not be determined with certainty (Hanan 1996). California harbor seals are not listed as "endangered" or "threatened" under the Endangered Species Act nor designated as "depleted" under the MMPA. Annual human-caused mortality from commercial fisheries (30/yr) and other human-caused sources (12.8/yr) is 42.8 animals, which is less than the calculated PBR for this stock (1,641), and thus they are <u>not</u> considered a "strategic" stock under the MMPA. The average annual rate of incidental commercial fishery mortality (30 animals) is less than 10% of the calculated PBR (1,641 animals); therefore, fishery mortality is considered insignificant and approaching zero mortality and serious injury rate. The population size has increased since the 1980s when statewide censuses were first conducted. The highest population counts occurred in 2004 and subsequent counts in 2009 and 2012 have been lower. Expanding pinniped populations in general have resulted in increased human-caused serious injury and mortality, due to shootings, entrainment in power plants, interactions with recreational hook and line fisheries, separation of mothers and pups due to human disturbance, dog bites, and vessel and vehicle strikes (Carretta et al. 2014b). All west-coast harbor seals that have been tested for morbilliviruses were found to be seronegative, indicating that this disease is not endemic in the population and that this population is extremely susceptible to an epidemic of this disease (Ham-Lammé *et al*. 1999).

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HARBOR SEAL (*Phoca vitulina richardii*): Oregon/Washington Coast Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Harbor seals inhabit coastal and estuarine waters off Baja California, north along the western coasts of the continental U.S., British Columbia, and Southeast Alaska, west through the Gulf of Alaska and Aleutian Islands, and in the Bering Sea north to Cape Newenham and the Pribilof Islands. They haul out on rocks, reefs, beaches, and drifting glacial ice and feed in marine, estuarine, and occasionally fresh waters. Harbor seals generally are non-migratory, with local movements associated with tides, weather, season, food availability, and reproduction (Scheffer and Slipp 1944; Fisher 1952; Bigg 1969, 1981). Harbor seals do not make extensive pelagic migrations, though some long distance movement of tagged animals in Alaska (900 km) and along the U.S. west coast (up to 550 km) have been recorded (Brown and Mate 1983, Herder 1986, Womble 2012). Harbor seals have also displayed strong fidelity to haulout sites (Pitcher and Calkins 1979, Pitcher and McAllister 1981).

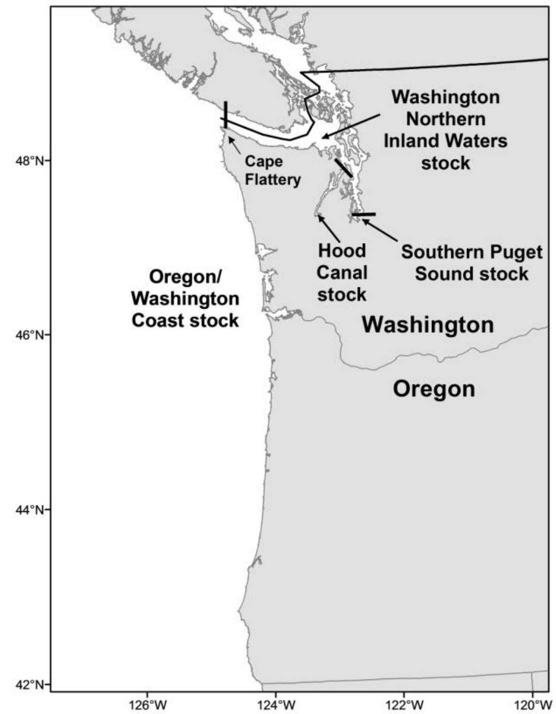

Figure 1. Harbor seal stocks in the U.S. Pacific Northwest

Until recently, differences in mean pupping date (Temte 1986), movement patterns (Jeffries 1985, Brown 1988), pollutant loads (Calambokidis et al. 1985), and fishery interactions led to the recognition of three separate harbor seal stocks along the west coast of the continental U.S. (Boveng 1988): 1) inland waters of Washington State (including Hood Canal, Puget Sound, and the Strait of Juan de Fuca out to Cape Flattery), 2) outer coast of Oregon and Washington, and 3) California Recent genetic evidence suggests that the population of harbor seals in Washington inland waters has more structure than was previously recognized. Studies of pupping phenology, mitochondrial DNA, and microsatellite variation of harbor seals in Washington and Canada-U.S. transboundary waters confirm the currently recognized stock boundary between the Washington Coast and Washington Inland Waters harbor seal stocks, but three genetically distinct populations of harbor seals within Washington inland waters are also evident (Huber et al. 2010, 2012). Within U.S. west coast waters, five stocks of harbor seals are recognized: 1) Southern Puget Sound (south of the Tacoma Narrows Bridge); 2) Washington Northern Inland Waters (including Puget Sound north of the Tacoma Narrows Bridge, the San Juan Islands, and the Strait of Juan de Fuca); 3) Hood Canal; 4) Oregon/Washington Coast; and 5) California. This report considers only the Oregon/Washington Coast stock. Stock assessment reports for California harbor seals and harbor seals in Washington inland waters (including the Southern Puget Sound, Washington Northern Inland Waters, and Hood Canal stocks) also appear in this volume. Harbor seal stocks that occur in the inland and coastal waters of Alaska are discussed separately in the Alaska Stock Assessment Reports. Harbor seals occurring in British Columbia are not included in any of the U.S. Marine Mammal Protection Act (MMPA) stock assessment reports.

POPULATION SIZE

Aerial surveys of harbor seals in Oregon and Washington were conducted by personnel from the National Marine Mammal Laboratory (NMML) and the Oregon and Washington Departments of Fish and Wildlife (ODFW and WDFW) during the 1999 pupping season. Total numbers of hauled-out seals (including pups) were counted during these surveys. In 1999, the mean count of harbor seals occurring along the Washington coast was 10,430 (CV=0.14) animals (Jeffries et al. 2003). In 1999, the mean count of harbor seals occurring along the Oregon coast and in the Columbia River was 5,735 (CV=0.14) animals (Brown 1997; ODFW, unpublished data). Combining these counts results in 16,165 (CV=0.10) harbor seals in the Oregon/Washington Coast stock.

Radio-tagging studies conducted at six locations (three Washington inland waters sites and three Oregon and Washington coastal sites) collected information on haulout patterns from 63 harbor seals in 1991 and 61 harbor seals in 1992. Haulout data from coastal and inland sites were not significantly different and were thus pooled, resulting in a correction factor of 1.53 (CV=0.065) to account for animals in the water which are missed during the aerial surveys (Huber et al. 2001). Using this correction factor results in a population estimate of 24,732 (16,165 x 1.53; CV=0.12) for the Oregon/Washington Coast stock of harbor seals in 1999 (Jeffries et al. 2003; ODFW, unpublished data). However, because the most recent abundance estimate is >8 years old, there is no current estimate of abundance available for this stock.

Minimum Population Estimate

No current information on abundance is available to obtain a minimum population estimate for the Oregon/Washington Coast stock of harbor seals.

Current Population Trend

Historical levels of harbor seal abundance in Oregon and Washington are unknown. The population apparently decreased during the 1940s and 1950s due to state-financed bounty programs. Approximately 17,133 harbor seals were killed in Washington by bounty hunters between 1943 and 1960 (Newby 1973). More than 3,800 harbor seals were killed in Oregon between 1925 and 1972 by bounty hunters and a state-hired seal hunter (Pearson 1968). The population remained relatively low during the 1960s but, since the termination of the harbor seal bounty program and with the protection provided by the passage of the MMPA in 1972, harbor seal counts for this stock have increased from 6,389 in 1977 to 16,165 in 1999 (Jeffries et al. 2003; ODFW, unpublished data). Based on the analyses of Jeffries et al. (2003) and Brown et al. (2005), both the Washington and Oregon portions of this stock were reported as reaching carrying capacity (Fig. 2). In the absence of recent abundance estimates, the current population trend is unknown.

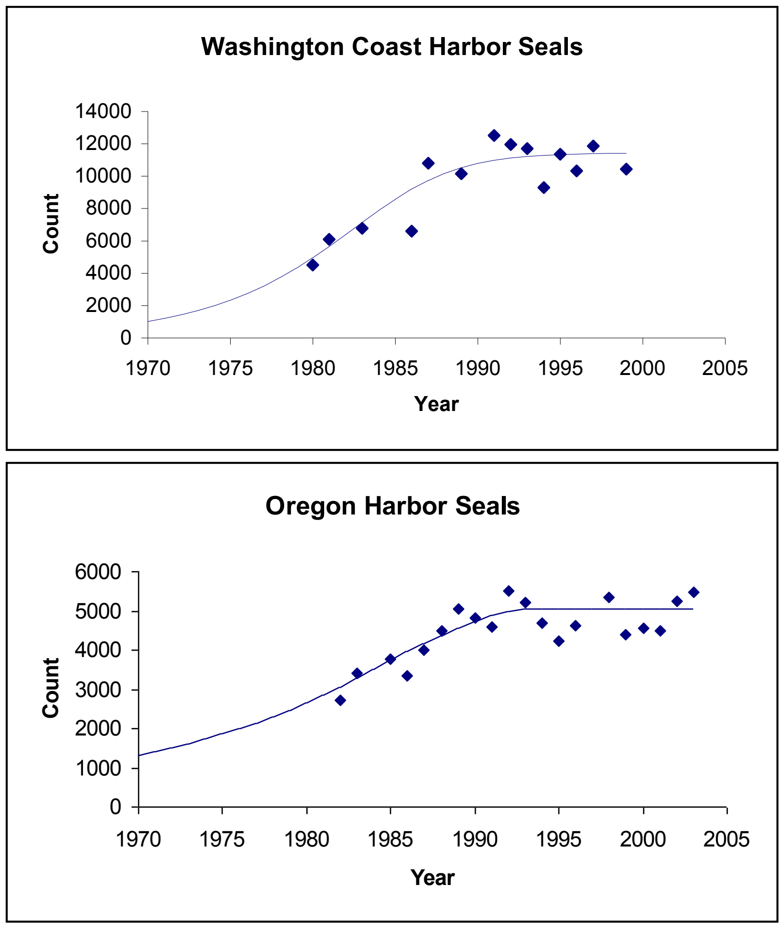

Figure 2. Generalized logistic growth curves of Washington Coast (Jeffries et al. 2003) and Oregon (Brown et al. 2005) harbor seals.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

The Oregon/Washington Coast harbor seal stock increased at an annual rate of 7% from 1983 to 1992 and at 4% from 1983 to 1996 (Jeffries et al. 1997). Because the population was not at a very low level by 1983, the observed rates of increase may underestimate the maximum net productivity rate (R_{MAX}). When a logistic model was fit to the Washington portion of the 1975-1999 abundance data, the resulting estimate of R_{MAX} was 18.5% (95% CI = 12.9-26.8%) (Jeffries et al. 2003). When a logistic model was fit to the Oregon portion of the 1977-2003 abundance data, estimates of R_{MAX} ranged from 6.4% (95% CI = 4.6-27%) for the south coast of Oregon to 10.1% (95% CI = 8.6-20%) for the north coast (Brown et al. 2005). Until a combined analysis for the entire stock is completed, the pinniped default maximum theoretical net productivity rate (R_{MAX}) of 12% will be used for this harbor seal stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Because there is no current estimate of minimum abundance, a potential biological removal (PBR) cannot be calculated for this stock.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen *et al*. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fisheries Information

Fishing effort in the northern Washington marine gillnet tribal fishery is conducted within the range of the Oregon/Washington Coast and Washington Northern Inland Waters stocks of harbor seals. Movement of animals between Washington's coastal and inland waters is likely, although tagging data do not show movement of harbor seals between the two locations (Huber et al. 2001). For the purposes of this report, animals taken in waters south and west of Cape Flattery, WA, are assumed to belong to the Oregon/Washington Coast stock and Table 1 includes data only from that portion of the fishery. Fishing effort in the coastal marine set gillnet tribal fishery has declined since 2004. A test set gillnet fishery, with 100% observer coverage, was conducted in coastal waters in 2008 and 2010. This test fishery required the use of nets equipped with acoustic alarms, and observers reported one harbor seal death in 2008 and three in 2010 (Makah Fisheries Management, unpublished data). The mean annual mortality for the marine set gillnet tribal fishery in 2007-2011 is 0.8 (CV=0) harbor seals from observer data.

The U.S. West Coast groundfish fishery was monitored for incidental takes in 2005-2009 (Jannot et al. 2011). Harbor seal deaths were observed in the groundfish trawl fishery (Pacific hake at-sea processing component) in 2005, 2006, and 2008; the nearshore fixed gear fishery in 2006 and 2008; and the non-nearshore fixed gear (limited entry non-primary sablefish) fishery in 2009. The mean annual mortality for each of these fisheries in 2005-2009 is 1.0 (CV=0.24) harbor seals for the groundfish trawl fishery, 5.6 (CV=0.68) for the nearshore fixed gear fishery, and 0.2 for the non-nearshore fixed gear fishery.

Table 1. Summary of available information on the incidental mortality and serious injury of harbor seals (Oregon/Washington Coast stock) in commercial and tribal fisheries that might take this species and calculation of the mean annual mortality rate; n/a indicates that data are not available. Mean annual takes are based on 2007-2011 data unless otherwise noted.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean annual takes (CV in parentheses)
Northern WA marine set gillnet (tribal test fishery in coastal waters)	2007 2008 2009 2010 2011	observer data	no fishery 100% no fishery 100% no fishery	0 1 0 3 0	0 (0) 1 (0) 0 (0) 3 (0) 0 (0)	0.8 (0)
West Coast groundfish trawl (Pacific hake at-sea processing component)	2005 2006 2007 2008 2009	observer data	67%[1] 83%[1] 73%[1] 76%[1] 79%[1]	1 1 0 2 0	1 (0.52) 1 (0.42) 0 3 (0.34) 0	1.0 (0.24)
West Coast groundfish nearshore fixed gear	2005 2006 2007 2008 2009	observer data	5%[2] 11%[2] 9%[2] 7%[2] 4%[2]	0 1 0 2 0	0 n/a[3] 0 27 (0.68) 0	5.6 (0.68)

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean annual takes (CV in parentheses)
West Coast groundfish non-nearshore fixed gear (limited entry non-primary sablefish)	2009	observer data	n/a	1	n/a[3]	>0.2 (n/a)
WA Grays Harbor salmon drift gillnet[2]	1991-1993	observer data	4-5%	0, 1, 1	0, 10, 10	see text[24]
WA Willapa Bay drift gillnet[2]	1991-1993	observer data	1-3%	0, 0, 0	0, 0, 0	see text[24]
WA Willapa Bay drift gillnet[2]	1990-1993	fisherman self-reports	n/a	0, 0, 6, 8	n/a	see text[24]
Unknown West Coast fisheries	2007-2011	stranding data	n/a	0, 0, 0, 0, 3	n/a	>0.6 (n/a)
Minimum total annual takes						>8.2 (0.52)

[1]Percent hauls observed for marine mammals.
[2]Percent observed landings of target species.
[3]Bycatch estimate not provided due to high CV (>80%) for estimate; minimum bycatch of one observed harbor seal is included in the calculation of mean annual take.
[4]This fishery has not been observed since 1993 (see text); these data are not included in the calculation of recent minimum total annual takes.

Commercial salmon drift gillnet fisheries in Washington outer coast waters (Grays Harbor, Willapa Bay) were last observed in 1993 and 1994, with observer coverage levels typically less than 10% (Erstad et al. 1996, Pierce et al. 1994, Pierce et al. 1996, NWIFC 1995). Drift gillnet fishing effort in the outer coast waters has declined considerably since 1994 because fewer vessels participate today (NMFS NW Region, unpublished data), but entanglements of harbor seals likely continue to occur. The most recent data on harbor seal mortality from commercial and tribal gillnet fisheries is included in Table 1.

Combining recent estimates from commercial fisheries observer data for the West Coast groundfish trawl (1.0), West Coast groundfish nearshore fixed gear (5.6), and West Coast groundfish non-nearshore fixed gear (0.2) fisheries results in a mean annual mortality rate of 6.8 harbor seals from these fisheries. An additional 0.8 harbor seals per year were taken in the northern Washington marine set gillnet tribal fishery.

Strandings of harbor seals entangled in fishing gear or with serious injuries caused by interactions with gear are another source of fishery-related mortality. Based on stranding network data, there were three commercial fishery-related deaths of harbor seals from this stock reported in 2011 (listed as unknown West Coast fisheries in Table 1), resulting in a mean annual mortality of 0.6 harbor seals in 2007-2011. Fishery entanglements included two gillnet and one trawl net interaction. Hook and line gear is used by both commercial (salmon troll) and recreational fisheries in coastal waters. Two harbor seal deaths due to ingested hooks were reported in 2007-2011, resulting in an additional mean annual mortality of 0.4 seals from unknown hook and line fisheries. Estimates from stranding data are considered minimum estimates because not all stranded animals are found, reported, or examined for cause of death (via necropsy by trained personnel). An additional harbor seal that stranded with a serious hook injury in 2011 was treated and released with non-serious injuries (Carretta et al. 2013); therefore, it was not included in the mean annual mortality in this report.

Data on fisheries mortality reported in Table 1 likely represent minimum estimates, particularly for fisheries where observer coverage is low and bycatch events are too infrequent to be documented by fishery observers. The magnitude of negative bias in mortality estimates is unknown and methods to correct for such negative biases in these fisheries have not been developed.

Other Mortality

During 2007-2011, one harbor seal from this stock was incidentally killed during scientific halibut longline operations in 2011, resulting in a mean annual research-related mortality of 0.2 animals.

According to Northwest Marine Mammal Stranding Network records, maintained by the NMFS Northwest Region (NMFS, Northwest Regional Office, unpublished data), a total of nine human-caused harbor seal deaths were reported from non-fisheries sources in 2007-2011. Six animals were shot, two animals were struck by boats, and one animal was killed by a dog, resulting in a mean annual mortality of 1.8 harbor seals from this stock. This estimate is considered a minimum because not all stranded animals are found, reported, or examined for cause of death (via necropsy by trained personnel).

Subsistence Harvests by Northwest Treaty Indian Tribes

Tribal subsistence takes of this stock may occur, but no data on recent takes are available.

STATUS OF STOCK

Harbor seals are not considered to be "depleted" under the MMPA or listed as "threatened" or "endangered" under the ESA. Based on currently available data, the minimum level of human-caused mortality and serious injury is 10.6 harbor seals per year: (8.2 from fishery sources in Table 1, plus 0.4 from unknown hook and line fisheries, plus 0.2 scientific takes annually, plus 1.8 non-fishery causes annually). A PBR cannot be calculated for this stock because there is no current abundance estimate. Human-caused mortality relative to PBR is unknown, but it is considered to be small relative to the stock size. Therefore, the Oregon/Washington Coast stock of harbor seals is not classified as a "strategic" stock. The minimum annual commercial fishery mortality and serious injury for this stock, based on recent observer data (6.8) and stranding data (0.6) is 7.4. Since a PBR cannot be calculated for this stock, fishery mortality relative to PBR is unknown. The stock was previously reported to be within its Optimum Sustainable Population (OSP) range (Jeffries et al. 2003, Brown et al. 2005), but in the absence of recent abundance estimates, this stock's status relative to OSP is unknown.

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HARBOR SEAL (*Phoca vitulina richardii*): Washington Inland Waters Stocks: (Hood Canal, Southern Puget Sound, Washington Northern Inland Waters)

STOCK DEFINITION AND GEOGRAPHIC RANGE

Harbor seals inhabit coastal and estuarine waters off Baja California, north along the western coasts of the continental U.S., British Columbia, and Southeast Alaska, west through the Gulf of Alaska and Aleutian Islands, and in the Bering Sea north to Cape Newenham and the Pribilof Islands. They haul out on rocks, reefs, beaches, and drifting glacial ice and feed in marine, estuarine, and occasionally fresh waters. Harbor seals generally are non-migratory, with local movements associated with such factors as tides, weather, season, food availability, and reproduction (Scheffer and Slipp 1944; Fisher 1952; Bigg 1969, 1981). Harbor seals do not make extensive pelagic migrations, though some long distance movement of tagged animals in Alaska (900 km) and along the U.S. west coast (up to 550 km) have been recorded (Brown and Mate 1983, Herder 1986, Womble 2012). Harbor seals have also displayed strong fidelity for haulout sites (Pitcher and Calkins 1979, Pitcher and McAllister 1981).

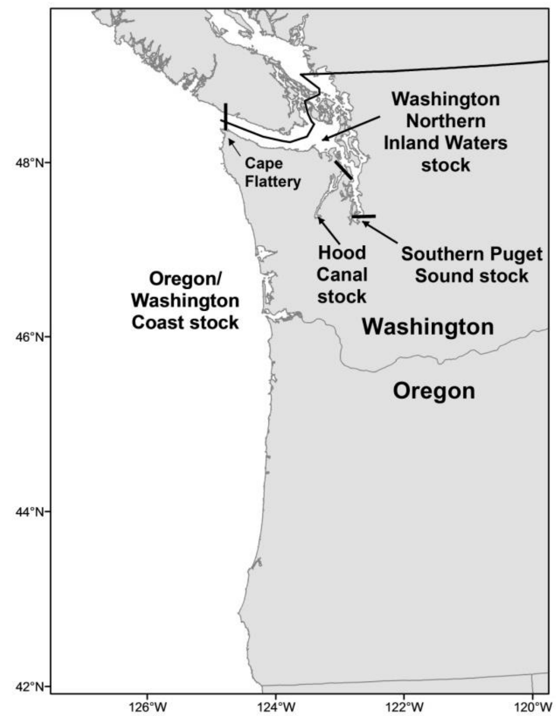

Figure 1. Approximate distribution of harbor seal stocks in the U.S. Pacific Northwest (shaded area). Stock boundaries separating the three stocks are shown.

Until recently, differences in mean pupping date (Temte 1986), movement patterns (Jeffries 1985, Brown 1988), pollutant loads (Calambokidis et al. 1985), and fishery interactions have led to the recognition of three separate harbor seal stocks along the west coast of the continental U.S. (Boveng 1988): 1) inland waters of Washington State (including Hood Canal, Puget Sound, and the Strait of Juan de Fuca out to Cape Flattery), 2) outer coast of Oregon and Washington, and 3) California Recent genetic evidence suggests that the population of harbor seals in Washington inland waters has more structure than is currently was previously recognized . Studies of pupping phenology, mitochondrial DNA, and microsatellite variation of harbor seals in Washington and Canada-U.S. transboundary waters confirm the currently recognized stock boundary between the Washington Coast and Washington Inland Waters harbor seal stocks, but three genetically distinct populations of harbor seals within Washington inland waters are also evident (Huber et al. 2010, 2012). Within U.S. west coast waters, five stocks of harbor seals are recognized: 1) Southern Puget Sound (south of the Tacoma Narrows Bridge); 2) Washington Northern Inland Waters (including Puget Sound north of the Tacoma Narrows Bridge, the San Juan Islands, and the Strait of Juan de Fuca); 3) Hood Canal; 4) Oregon/Washington Coast; and 5) California. This report includes only the stocks in Washington's inland waters. Stock assessment reports for Oregon/Washington Coast and California harbor seals also appear in this volume. Harbor seal stocks that occur in the inland and coastal waters of Alaska are discussed separately in the Alaska Stock Assessment Reports. Harbor seals occurring in British Columbia are not included in any of the U.S. Marine Mammal Protection Act (MMPA) stock assessment reports.

POPULATION SIZE

Aerial surveys of harbor seals in Washington were conducted during the pupping season in 1999, during which time the total numbers of hauled-out seals (including pups) were counted. In 1999, the mean count of harbor seals occurring in Washington's inland waters was 7,213 (CV=0.14) in Washington Northern Inland Waters, 711 (CV=0.14) in Hood Canal, and 1,025 (CV=0.14) in Southern Puget Sound (Jeffries et al. 2003).

Radio-tagging studies conducted at six locations (three Washington inland waters sites and three Oregon and Washington coastal sites) collected information on haulout patterns from 63 harbor seals in 1991 and 61 harbor seals in 1992. Data from coastal and inland sites were not significantly different and were thus pooled, resulting in a correction factor of 1.53 (CV=0.065) to account for animals in the water which are missed during the aerial surveys (Huber et al. 2001). Using this correction factor results in a population estimates of 11,036 (7,213 x 1.53; CV=0.15) for the Washington Northern Inland Waters stock; 1,088 (711 x 1.53; CV=0.15) for the Hood Canal stock; and 1,568 (1,025 x 1.53; CV=0.15) for the Southern Puget Sound stock of harbor seals (Jeffries et al. 2003). However, because the most recent abundance estimates are >8 years old, there are no current estimates of abundance for these stocks. Surveys of harbor seals in Washington inland waters are planned for 2013.

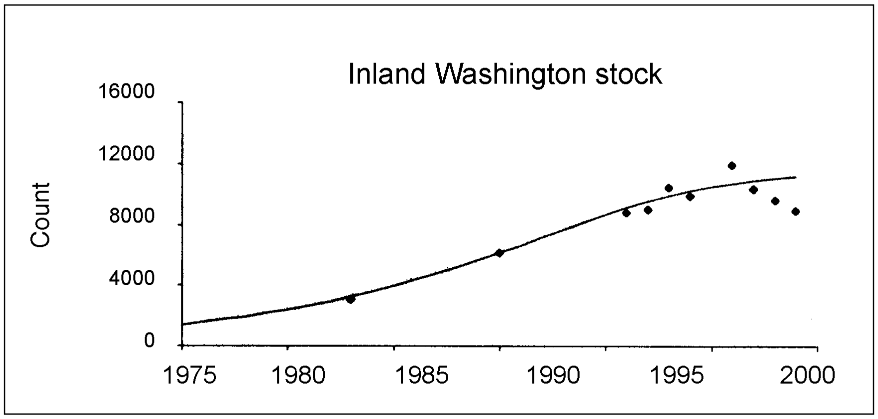

Figure 2. Generalized logistic population growth curve for the Washington Inland Waters stock of harbor seals, 1978-1999 (Jeffries et al. 2003).

Minimum Population Estimate

No current information on abundance is available to obtain a minimum population estimate for the Washington Inland Waters stock of harbor seals.

Current Population Trend

Historical levels of harbor seal abundance in Washington are unknown. The population apparently decreased during the 1940s and 1950s due to a state-financed bounty program. Approximately 17,133 harbor seals were killed in Washington by bounty hunters between 1943 and 1960 (Newby 1973). The population remained relatively low during the 1970s but, since the termination of the harbor seal bounty program in 1960 and with the passage of the Marine Mammal Protection Act (MMPA) in 1972, harbor seal numbers in Washington have increased (Jeffries 1985).

Between 1983 and 1996, the annual rate of increase for this stock was 6% (Jeffries et al. 1997). The peak count occurred in 1996 and, based on a fitted generalized logistic model (Fig. 2), the population is thought to be stable (Jeffries et al. 2003). In the absence of recent abundance estimates, the current population trend is unknown.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

From 1991 to 1996, counts of harbor seals in Washington State have increased at an annual rate of 10% (Jeffries et al. 1997). Because the population was not at a very low level by 1991, the observed rate of increase may underestimate the maximum net productivity rate (R_{MAX}). When a logistic model was fit to the 1978-1999 abundance data, the resulting estimate of R_{MAX} was 12.6% (95% CI = 9.4-18.7%) (Jeffries et al. 2003). This value of R_{MAX} is very close to the default pinniped maximum theoretical net productivity rate of 12% (R_{MAX}), therefore, 12% will be employed for this harbor seal stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Because there is no current estimate of minimum abundance, a potential biological removal (PBR) cannot be calculated for this stock.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen *et al*. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fisheries Information

Fishing effort in the northern Washington marine gillnet tribal fishery is conducted within the range of the Oregon/Washington Coast and Washington Northern Inland Waters stocks of harbor seals. Some movement of animals between Washington's coastal and inland waters is likely, although data from tagging studies have not shown movement of harbor seals between the two locations (Huber et al. 2001). For the purposes of this stock assessment report, the animals taken in waters east of Cape Flattery, WA, are assumed to have belonged to the Washington Northern Inland Waters stock, and Table 1 includes data only from that portion of the fishery. There was no observer coverage in the northern Washington marine set gillnet tribal fishery in inland waters in 2007-2011; however, there were two fishermen self-reports of harbor seal deaths in this fishery in 2008 and five in 2009 (Makah Fisheries Management, unpublished data). The mean annual mortality for this fishery in 2007-2011 is 1.4 harbor seals from self-reports. Fishing effort in the northern Washington marine drift gillnet tribal fishery in inland waters is also conducted within the range of the Washington Northern Inland Waters stock of harbor seals. This fishery is not observed; however, there was one self-report of a harbor seal death in 2008 (Makah Fisheries Management, unpublished data). The mean annual mortality for this fishery in 2007-2011 is 0.2 harbor seals from self-reports.

Commercial salmon drift gillnet fisheries in Washington inland waters were last observed in 1993 and 1994, with observer coverage levels typically less than 10% (Erstad et al. 1996, Pierce et al. 1994, Pierce et al. 1996, NWIFC 1995). Drift gillnet fishing effort in the inland waters has declined considerably since 1994 because far fewer vessels participate today (NMFS NW Region, unpublished data), but entanglements of harbor seals likely continue to occur. The most recent data on harbor seal mortality from commercial gillnet fisheries is included in Table 1.

Table 1. Summary of available information on the incidental mortality and serious injury of harbor seals (Washington Northern Inland Waters, Hood Canal, and Southern Puget Sound stocks) in commercial and tribal fisheries that might take this species and calculation of the mean annual mortality rate; n/a indicates that data are not available. Mean annual takes are based on 2007-2011 data unless noted otherwise.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean annual takes (CV in parentheses)
Northern WA marine set gillnet (tribal fishery in inland waters)	2008 2009	fisherman self-reports	-	2 5	n/a n/a	1.4 (n/a)
Northern WA marine drift gillnet (tribal fishery in inland waters)	2008	fisherman self-reports	-	1	n/a	>0.2 (n/a)
WA Puget Sound Region salmon set/drift gillnet (observer programs listed below covered segments of this fishery):	-	-	-	-	-	-
Puget Sound non-treaty salmon gillnet (all areas and species)	1993	observer data	1.3%	2	n/a	see text
Puget Sound non-treaty chum salmon gillnet (areas 10/11 and 12/12B)[1]	1994	observer data	11%	1	10	see text[1]
Puget Sound treaty chum salmon gillnet (areas 12, 12B, and 12C)[1]	1994	observer data	2.2%	0	0	see text[1]
Puget Sound treaty chum and sockeye salmon gillnet (areas 4B, 5, and 6C)[1]	1994	observer data	7.5%	0	0	see text[1]
Puget Sound treaty and non-treaty sockeye salmon gillnet (areas 7 and 7A)[1]	1994	observer data	7%	1	15	see text[1]

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean annual takes (CV in parentheses)
Unknown Washington Northern Inland Waters fisheries	2007-2011	stranding data	n/a	1, 1, 1, 1, 2	n/a	≥1.2 (n/a)
Unknown Hood Canal fisheries	2007-2011	stranding data	n/a	0, 0, 0, 0, 1	n/a	> 0.2 (n/a)
Unknown Southern Puget Sound fisheries	2007-2011	stranding data	n/a	0, 5, 0, 0, 0	n/a	>1.0 (n/a)
Minimum total annual takes Washington Northern Inland Waters						> 2.8 (n/a)
Minimum total annual takes Hood Canal						> 0.2 (n/a)
Minimum total annual takes Southern Puget Sound						>1.0 (n/a)

[1]This fishery has not been observed since 1994 (see text); these data are not included in the calculation of recent minimum total annual takes.

Strandings of harbor seals entangled in fishing gear or with serious injuries caused by interactions with gear are a final source of fishery-related mortality information. As these strandings could not be attributed to a particular fishery, they have been included in Table 1 as occurring in unknown Washington inland waters fisheries. According to Northwest Marine Mammal Stranding Network records, maintained by the NMFS Northwest Region (NMFS, Northwest Regional Office, unpublished data), 12 fishery-related harbor seal deaths and serious injuries were reported in Washington inland waters in 2007-2011: six from the Washington Northern Inland Waters stock, one from the Hood Canal stock, and five from the Southern Puget Sound stock, resulting in mean annual takes of 1.2 harbor seals in Washington Northern Inland Waters, 0.2 in Hood Canal, and 1.0 in Southern Puget Sound. Fishery interactions included two gaff injuries, two gillnet entanglements, in one fishing net entanglement, and one entanglement in fishing gear in Washington Northern Inland Waters; one gillnet entanglement in Hood Canal; and five gillnet entanglements in Southern Puget Sound. Harbor seal deaths caused by interactions with recreational hook and line fishing gear were also reported in 2007-2011: two seals had hook injuries and one ingested a hook in Washington Northern Inland Waters and two seals ingested hooks in Southern Puget Sound, resulting in mean annual mortalities of 0.6 and 0.4, respectively, from these two stocks. Estimates from stranding data are considered minimum estimates because not all stranded animals are found, reported, or examined for cause of death (via necropsy by trained personnel). Two additional harbor seals that stranded with serious hook injuries from recreational hook and line gear in Washington Northern Inland Waters in 2007-2011 were treated and released with non-serious injuries (Carretta et al. 2013); therefore, they were not included in the mean annual mortality in this report.

Other Mortality

According to Northwest Marine Mammal Stranding Network records, maintained by the NMFS Northwest Region (NMFS, Northwest Regional Office, unpublished data), a total of 32 human-caused harbor seal deaths or serious injuries were reported from non-fisheries sources in 2007-2011 for the Washington Northern Inland Waters stock. Eight animals were shot, 13 nine were struck by boats, two died in oil spills, three two were killed by dogs, and 13 were entangled in marine debris, resulting in a mean annual mortality of 6.4 harbor seals from this stock. During the same time period, 10 human-caused deaths or serious injuries were reported for the Southern Puget Sound stock: one animal entangled in marine debris, six were shot, one was killed by a dog, one entangled in a buoy line, and one entangled in a scientific research net, resulting in a mean annual mortality of 2.0 harbor seals. These are considered minimum estimates because not all stranded animals are found, reported, or examined for cause of death (via necropsy by trained personnel). An additional seriously injured harbor seal was disentangled from marine debris and released with non-serious injuries in Washington Northern Inland Waters in 2007 (Carretta et al. 2013); therefore, it was not included in the mean annual mortality in this report.

Subsistence Harvests by Northwest Treaty Indian Tribes

Tribal subsistence takes of this stock may occur, but no data on recent takes are available.

STATUS OF STOCK

Harbor seals are not considered to be "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act. Based on currently available data, the minimum level of human-caused mortality and serious injury is 9.8 harbor seals per year for the Washington Northern Inland Waters stock (2.8 from fishery sources in Table 1 + 0.6 from recreational hook and line fisheries + 6.4 from non-fishery sources). Annual human-caused serious injury and mortality for the Hood Canal stock is 0.2 from unknown fishery sources. Annual human-caused serious injury and mortality for the Southern Puget Sound stock is 3.4, including 1.0 from fishery sources listed in Table 1, 0.4 from recreational hook and line fisheries, and 2.0 from non-fishery sources. PBRs cannot be calculated for these stocks because there are no current abundance estimates. Human-caused mortality relative to PBR is unknown for these stocks, but is considered to be small relative to stock size. Therefore, the Washington Northern Inland Waters, Hood Canal, and Southern Puget Sound stocks of harbor seals are not classified as "strategic" stocks. At present, the minimum annual fishery mortality and serious injury for these stocks (based on stranding data) are 1.2 for the Washington Northern Inland Waters stock, 0.2 for the Hood Canal stock, and 1.0 for the Southern Puget Sound stock. Since a PBR cannot be calculated for these stocks, fishery mortality relative to PBR is unknown. The stock was previously reported to be within its Optimum Sustainable Population (OSP) range (Jeffries et al. 2003), but in the absence of recent abundance estimates, this stock's status relative to OSP is unknown.

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NORTHERN ELEPHANT SEAL (*Mirounga angustirostris*): California Breeding Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Northern elephant seals breed and give birth in California (U.S.) and Baja California (Mexico), primarily on offshore islands (Stewart et al. 1994), from December to March (Stewart and Huber 1993). Spatial segregation in foraging areas between males and females is evident from satellite tag data (Le Beouf et al. 2000). Males migrate to the Gulf of Alaska and western Aleutian Islands along the continental shelf to feed on benthic prey, while females migrate to pelagic areas in the Gulf of Alaska and the central North Pacific to feed on pelagic prey (Le Beouf et al. 2000). Adults return to land between March and August to molt, with males returning later than females. Adults return to their feeding areas again between their spring/summer molting and their winter breeding seasons.

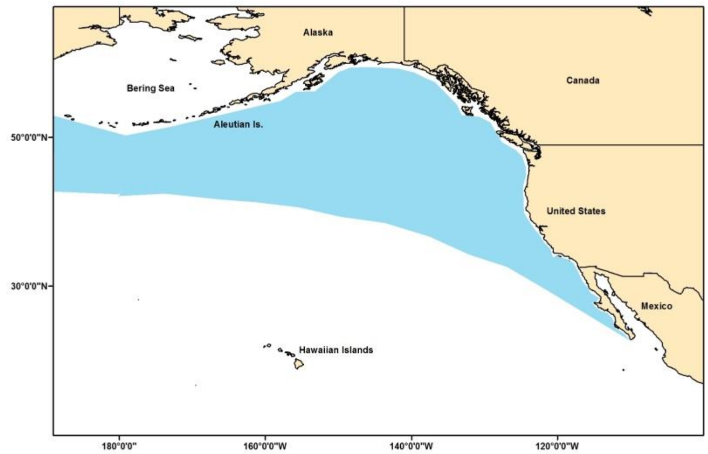

Figure 1. Pelagic range of northern elephant seals in the eastern North Pacific. Major breeding rookeries occur along the west coast of Baja California and the California coast, as described in Lowry et al. (2014).

Populations of northern elephant seals in the U.S. and Mexico have recovered after being nearly hunted to extinction (Stewart et al. 1994). Northern elephant seals underwent a severe population bottleneck and loss of genetic diversity when the population was reduced to an estimated 10-30 individuals (Hoelzel *et al*. 2002). Although movement and genetic exchange continues between rookeries, most elephant seals return to natal rookeries when they start breeding (Huber et al. 1991). The California breeding population is now demographically isolated from the Baja California population. No international agreements exist for the joint management of this species by the U.S. and Mexico. The California breeding population is considered here to be a separate stock.

POPULATION SIZE

A complete population count of elephant seals is not possible because all age classes are not ashore simultaneously. Elephant seal population size is estimated by counting the number of pups produced and multiplying by the inverse of the expected ratio of pups to total animals (McCann 1985). Based on counts of elephant seals at U.S. rookeries in 2010, Lowry *et al*. (2014) reported that 40,684 pups were born. Lowry *et al*. (2014) applied a multiplier of 4.4 to extrapolate from total pup counts to a population estimate of approximately 179,000 elephant seals. This multiplier is derived from life tables based on published elephant seal fecundity and survival rates, and reflects a population with approximately 23% pups (Cooper & Stewart, 1983; Le Boeuf & Reiter, 1988; Hindell, 1991; Huber et al., 1991; Reiter & Le Boeuf, 1991; Clinton & Le Boeuf, 1993; Le Boeuf et al., 1994; Pistorius & Bester, 2002; McMahon et al., 2003; Pistorius et al., 2004; Condit et al., 2014).

Minimum Population Estimate

The minimum population size for northern elephant seals in 2010 can be estimated very conservatively as 81,368 seals, which is equal to twice the observed pup count (to account for the pups and their mothers) .

Current Population Trend

The population is reported to have grown at 3.8% annually since 1988 (Lowry *et al*. 2014).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATE

An annual growth rate of 17% for elephant seals in the U.S. from 1958 to 1987 is reported by Lowry *et al.* (2014), but some of this growth is likely due to immigration of animals from Mexico and the consequences of a small population recovering from past exploitation. From 1988 to 2010, the population is estimated to have grown 3.8% annually (Lowry et al. 2014). For this stock assessment report, we use the default maximum theoretical net productivity rate for pinnipeds, or 12% (Wade and Angliss 1997).

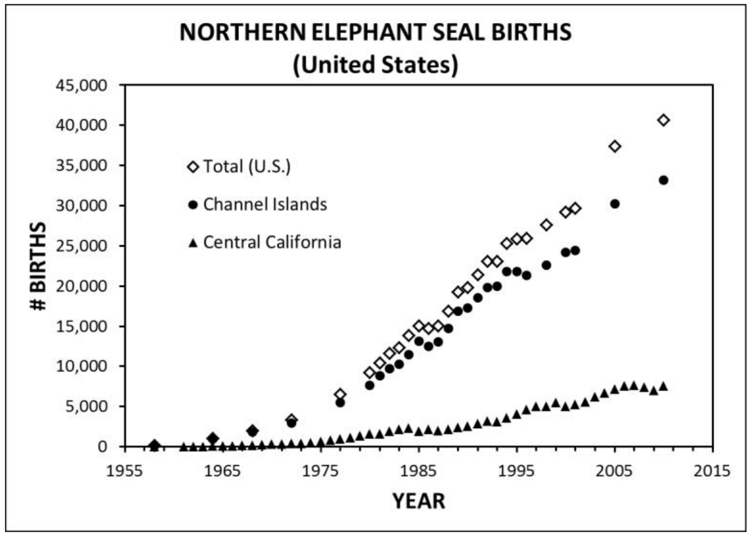

Figure 2. Estimated number of northern elephant seal births in California 1958-2010. Multiple independent estimates are presented for the Channel Islands 1988-91. Estimates are from Stewart et al. (1994), Lowry et al. (1996), Lowry (2002), Lowry et al. (2014), and unpublished data from Sarah Allen, Dan Crocker, Brian Hatfield, Ron Jameson, Bernie Le Boeuf, Mark Lowry, Pat Morris, Guy Oliver, Derek Lee, and William Sydeman.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (81,368) times one half the observed maximum net growth rate for this stock (½ of 12%) times a recovery factor of 1.0 (for a stock of unknown status that is increasing, Wade and Angliss 1997) resulting in a PBR of 4,882 animals per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Serious Injury Guidelines

NMFS uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to distinguish serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*".

Fisheries Information

A summary of known commercial fishery mortality and serious injury for this stock of northern elephant seals is given in Table 1. More detailed information on these fisheries is provided in Appendix 1.

Table 1. Summary of available information on the mortality and serious injury of northern elephant seals (California breeding stock) in commercial fisheries that might take this species (Carretta and Enriquez 2009, 2010, 2012a, 2012b, Carretta *et al*. 2014a). n/a indicates information is not available. Mean annual takes are based on 2008-2012 data unless noted otherwise.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality	Estimated Mortality (CV in parentheses)	Mean Annual Takes (CV in parentheses)
CA thresher shark/swordfish drift gillnet fishery	2008 2009 2010 2011 2012	observer data	13.5% 13.3% 11.9% 19.5% 18.6%	0 0 0 0 0	0 0 0 0 0	0 (n/a)

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality	Estimated Mortality (CV in parentheses)	Mean Annual Takes (CV in parentheses)
CA halibut and white seabass set gillnet fishery	2008 2009 2010 2011 2012	observer data	0% 0% 12.5% 8.0% 5.5%	n/a n/a 0 0 0	n/a n/a 0 0 0	0 (n/a)
CA small-mesh drift gillnet fishery for white seabass, yellowtail, barracuda, and tuna	2010 2011 2012	observer data	0.7% 3.3% 4.6%	0 0 0	0 0 0	0 (n/a)
WA, OR, CA domestic groundfish trawl fishery (includes at-sea hake and other limited-entry groundfish sectors)	2005 2006 2007 2008 2009	observer data	98% to 100% of tows in at-sea hake fishery Generally less than 30% of landings observed in other groundfish sectors	0 1 3 7 2	0 (n/a) 1 (n/a) 3 (n/a) 9 (n/a) 2 (n/a)	3 (n/a)
Unknown gillnet fishery	2008-2012	stranding	n/a	1	1 (n/a)	≥1
Total annual takes						≥4.0 (n/a)

Although all of the mortality in Table 1 occurred in U.S. waters, some may be of seals from Mexico's breeding population that are migrating through U.S. waters.

Other Mortality

For the period 2008-2012, mortality and serious injuries from the following non-commercial fishery sources were documented: shootings (9); marine debris entanglement (7); hook and line fisheries (3); power plant entrainment (2); research-related (1); tar/oil (1); and vessel strike (1) (Carretta *et al.* 2014b). These non-commerical fishery sources of mortality and serious injury total 24 animals, or an average of 4.8 elephant seals annually (Carretta *et al.* 2014b).

STATUS OF STOCK

Northern elephant seals are not listed as "endangered" or "threatened" under the Endangered Species Act nor designated as "depleted" under the MMPA. Because their annual human-caused mortality (≥8.8) is much less than the calculated PBR for this stock (4,882), northern elephant seals are not considered a "strategic" stock under the MMPA. The average rate of incidental fishery mortality for this stock over the last five years ≥4.0) also appears to be less than 10% of the calculated PBR; therefore, the total fishery mortality appears to be insignificant and approaching a zero mortality and serious injury rate. The population growth rate between 1958 and 1987 was 17% annually (Lowry *et al.* 2014). From 1988 to 2010, the population grew at an annual rate of 3.8% (Lowry *et al.* 2014). The population continues to grow, with most births occurring at southern California rookeries (Lowry et al. 2014). No estimate of carrying capacity is available for this population and the population status relative to OSP is unknown. There are no known habitat issues that are of concern for this stock. However, expanding pinniped populations in general have resulted in increased human-caused serious injury and mortality, due to shootings, entrainment in power plants, interactions with recreational hook and line fisheries, separation of mothers and pups due to human disturbance, dog bites, and vessel and vehicle strikes (Carretta et al. 2014b).

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GUADALUPE FUR SEAL (*Arctocephalus townsendi*)

STOCK DEFINITION AND GEOGRAPHIC RANGE

Commercial sealing during the 19th century reduced the once abundant Guadalupe fur seal to near extinction in 1894 (Townsend 1931). Prior to the harvest it ranged from Monterey Bay, California, to the Revillagigedo Islands, Mexico (Hanni *et al.* 1997, Repenning *et al.* 1971; Figure 1). The prehistoric distribution of Guadalupe fur seals during the Holocene was apparently quite different from today, as the archeological record indicates Guadalupe fur seal remains accounted for 40%-80% of all pinniped bones at the California Channel Islands (Rick *et al.* 2009). The live capture of two adult males (and killing of ~ 60 more animals) at Guadalupe Island in 1928 established the continued existence of the species (Townsend 1931). Guadalupe fur seals pup and breed mainly at Isla Guadalupe, Mexico. In 1997, a second rookery was discovered at Isla Benito del Este, Baja California (Maravilla-Chavez and Lowry 1999) and a pup was born at San Miguel Island, California (Melin and DeLong 1999). Since 2008, individual adult females, subadult males, and between one and three pups have been observed annually on San Miguel Island (NMFS, unpublished data). The population at Isla Benito del Este is now well-established, though very few pups are observed there. Population increases at Isla San Benito are attributed to immigration of animals from Isla Guadalupe (Aurioles-Gamboa *et al.* 2010, García-Capitanachi 2011). Along the U.S. west coast, strandings occur almost annually in California waters and animals are increasingly observed in Oregon and Washington waters. In 2015-2016, Guadalupe fur seal strandings totaled approximately 175 animals along the coast of California (compared with approximately 10 animals annually in prior years), and NMFS declared an unusual mortality event[1]. Most strandings involved animals less than 2 years old with evidence of malnutrition. Individuals have stranded or been sightedinside the Gulf of California and as far south as Zihuatanejo, Mexico (Hanni et al. 1997 and Aurioles-Gamboa and Hernadez-Camacho 1999) and another in 2012, at Cerro Hermoso, Oaxaca, Mexico (Esperon-Rodriguez and Gallo-Reynoso 2012). Recent video records of pinnipeds hooked in the mouth from international waters west of the California Current involving the shallow set Hawaii longline fishery were independently reviewed by pinniped experts and at least one animal in early 2016 was identified as a Guadalupe fur seal. Guadalupe fur seals that stranded in central California and treated at rehabilitation centers were fitted with satellite tags and documented to travel as far north as Graham Island and Vancouver Island, British Columbia, Canada (Norris *et al.* 2015). Some satellite-tagged animals traveled far offshore outside the U.S. EEZ to areas 700 nmi west of the California / Oregon border. The population is considered to be a single stock because all are recent descendants from one breeding colony at Isla Guadalupe, Mexico.

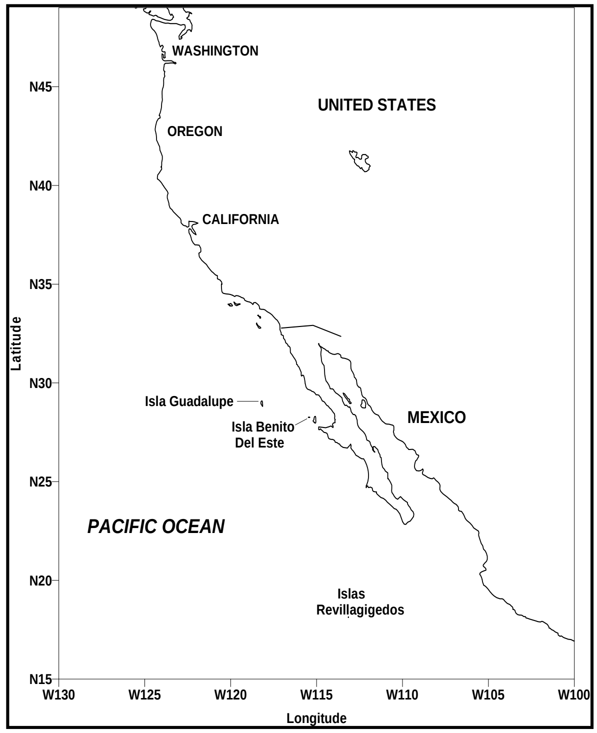

Figure 1. Geographic range of the Guadalupe fur seal, showing location of two rookeries at Isla Guadalupe and Isla Benito Del Este.

POPULATION SIZE

[1] http://www.nmfs.noaa.gov/pr/health/mmume/guadalupefurseals2015.html

The size of the population prior to the commercial harvests of the 19th century is not known, but estimates range from 20,000 to 100,000 animals (Fleischer 1987). Surveys conducted between 2008 and 2010 resulted in a total estimated population size of approximately 20,000 animals, with ~17,500 at Isla Guadalupe and ~2,500 at Isla San Benito (García-Capitanachi 2011, Aurioles-Gamboa 2015). These estimates are corrected for animals not seen during the surveys.

Minimum Population Estimate

All the individuals of the population cannot be counted because all age and sex classes are never ashore at the same time and some individuals that are on land are not visible during the census. Direct counts of animals at Isla Guadalupe and Isla San Benito during 2010 resulted in a minimum of 13,327 animals and 2,503 animals respectively, for a minimum population size of 15,830 animals (García-Capitanachi 2011).

Current Population Trend

Counts of Guadalupe fur seals have been made sporadically since 1954. Records of Guadalupe fur seal counts through 1984 were compiled by Seagars (1984), Fleischer (1987), and Gallo (1994). The count for 1988 was taken from Torres et al. (1990). More recent counts from 1977-2010 are summarized in García-Capitanachi (2011). Also, the counts that are documented in the literature generally provide only the total of all Guadalupe fur seals counted (i.e., the counts are not separated by age/sex class). The counts that were made during the breeding season, when the maximum number of animals are present at the rookery, were used to examine population growth (Gallo 1994, García-Capitanachi 2011). The natural logarithm of the counts was regressed against year to calculate the growth rate of the population. These data indicate that Guadalupe fur seals are increasing at an average annual growth rate of 10.3% (Figure 2).

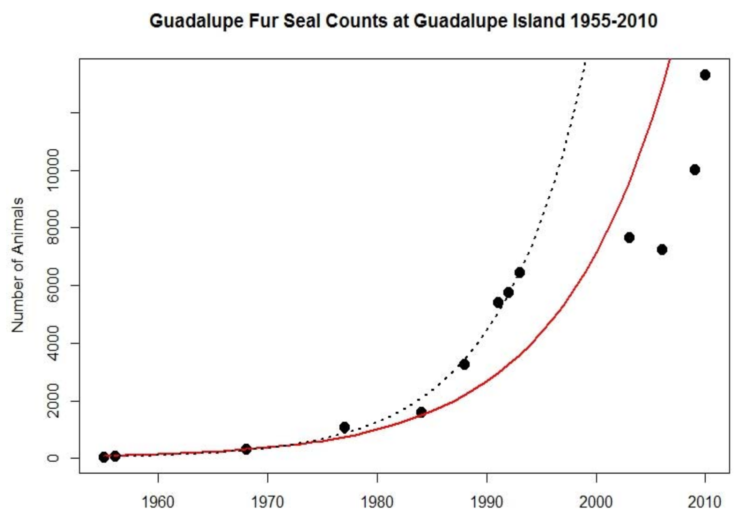

Figure 2. Counts of Guadalupe fur seals at Guadalupe Island, Mexico, and the estimated population growth curves derived from counts made during the breeding season. Direct counts of animals are shown as black dots. An estimated annual growth rate of 13% is based on counts made between 1955 and 1993 (black dashed line). The estimated growth rate over the period 1955-2010 is approximately 10% annually (solid red line).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Reported annual growth rates of 21% at Isla San Benito over an 11-year period are too high and likely result from immigration from Isla Guadalupe (Esperón-Rodríguez and Gallo-Reynoso 2012). The maximum net productivity rate can be assumed to be equal to the maximum annual growth rate observed between 1955 and 1993 (13.7%) because the population was at a very low level and should have been growing at nearly its maximum rate (Gallo 1994). Based on direct counts of animals at Guadalupe Island between 1955 and 2010, the estimated annual population growth rate is 10.3%.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) for this stock is calculated as the minimum population size (15,830) <u>times</u> one half the maximum net growth rate observed for this species (½ of 13.7%) <u>times</u> a recovery factor of 0.5 (for a threatened species, Wade and Angliss 1997), resulting in a PBR of 542 Guadalupe fur seals per year. The vast majority of this PBR would apply towards incidental mortality in Mexico as most of the population occurs outside of U.S. waters.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY
Fisheries Information

Table 1. Summary of available information on the incidental mortality and injury of Guadalupe fur seals in commercial fisheries and other unidentified fisheries that might take this species.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality and Serious Injury	Estimated Mortality and Serious Injury (CV)	Mean Annual Takes (CV)
CA driftnet fishery for sharks and swordfish	2010-2014	observer	12%-37%	0	0	0
CA set gillnet fishery for halibut/white seabass and other species	2010-2014	observer	9%	0	0	0
Unidentified fishery interactions	2010-2014	strandings	n/a	16	≥ 16	≥ 3.2
Minimum total annual takes						≥3.2

No Guadalupe fur seals have been observed entangled in California gillnet fisheries between 1990 and 2014 (Julian and Beeson 1998, Carretta *et al*. 2004, Carretta *et al*. 2016b), although stranded animals have been found entangled in gillnet of unknown origin (see 'Other mortality' below). Gillnets have been documented to entangle marine mammals off Baja California (Sosa-Nishizaki *et al*. 1993), but no recent bycatch data from Mexico are available.

One confirmed interaction of a mouth-hooked Guadalupe fur seal in the Hawaii shallow set longline fishery has been reviewed by U.S. west coast pinniped experts from video taken at sea in early 2016. Two additional videos of unidentified pinnipeds that were hooked in the mouth in 2015 in the same fishery were also reviewed. These interactions occurred outside of the U.S. EEZ, west of the California Current.

Other mortality and serious injury

There were 16 records of human-related deaths and/or serious injuries to Guadalupe fur seals from stranding data for the most recent 5-year period of 2010-2014 (Carretta *et al.* 2016a). These strandings included entanglement in marine debris and gillnet of unknown origin, and shootings. The average annual observed human-caused mortality and serious injury of Guadalupe fur seals for 2010-2014 is 3.2 animals annually (16 animals / 5 years). Observed human-caused mortality and serious injury for this stock very likely represents a fraction of the true impacts because not all cases are documented. No correction factors to account for undetected mortality and injury are currently available for pinnipeds along the U.S. west coast.

STATUS OF STOCK

The Endangered Species Act lists the Guadalupe fur seal as a threatened species, which automatically qualifies this stock as "depleted" and "strategic" stock under the Marine Mammal Protection Act. There is insufficient information to determine whether fishery mortality in Mexico exceeds the PBR for this stock, but given the observed growth of the population over time, this is unlikely. The total U.S. fishery mortality and serious injury for this stock (≥ 3.2 animals per year) is less than 10% of the calculated PBR for the entire stock, but it is not currently possible to calculate a prorated PBR for U.S. waters with which to compare serious injury and mortality from U.S. fisheries. Therefore, it is unknown whether total U.S. fishery mortality is insignificant and approaching zero mortality and serious injury rate. The population is growing at approximately 10% per year.

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NORTHERN FUR SEAL (*Callorhinus ursinus*): California Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

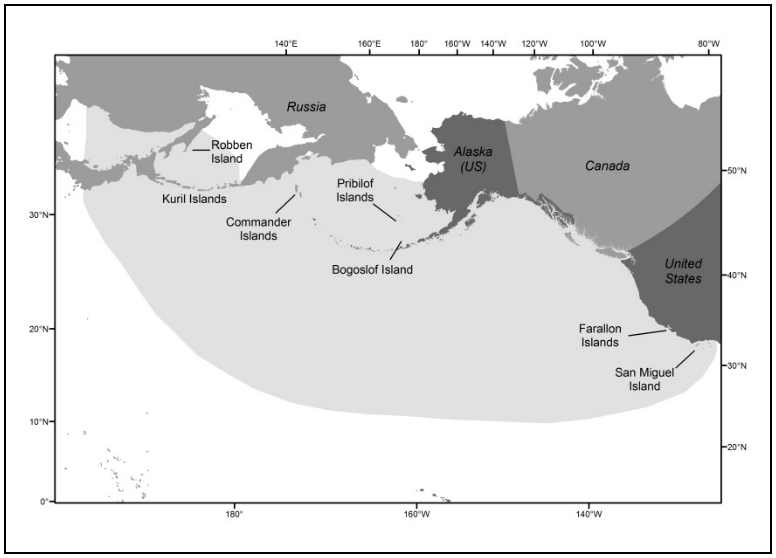

Figure 1. Approximate distribution of northern fur seals in the North Pacific (shaded area).

Northern fur seals occur from southern California north to the Bering Sea and west to the Okhotsk Sea and Honshu Island, Japan (Fig. 1). As of 2014, the worldwide population size is approximately 1.1 million animals (Gelatt *et al*. 2015). During the breeding season, approximately 45% of the worldwide population is found on the Pribilof Islands in the southern Bering Sea, with the remaining animals spread throughout the North Pacific Ocean (Gelatt *et al*. 2015). Of the seals in U.S. waters outside of the Pribilofs, approximately 9% of the population is found on Bogoslof Island in the southern Bering Sea, 1% on San Miguel Island off southern California, and 0.3% on the Farallon Islands off central California (Gelatt *et al*. 2015). Northern fur seals may temporarily haul out on land at other sites in Alaska, British Columbia, and on islets along the coast of the continental United States, but generally this occurs outside of the breeding season (Fiscus 1983).

Due to differing requirements during the annual reproductive season, adult males and females typically occur ashore at different, though overlapping, times. Adult males occur ashore and defend reproductive territories during a 3-month period from June through August, though some may be present until November (well after giving up their territories). Adult females are found ashore for as long as 6 months (June-November). After their respective times ashore, fur seals of both sexes spend the next 7 to 8 months at sea (Roppel 1984). Adult females and pups from the Pribilof Islands migrate through the Aleutian Islands into the North Pacific Ocean, often to waters off Washington, Oregon, and California. Many pups may remain at sea for 22 months before returning to their natal rookery. Adult females and pups from San Miguel Island and the Farallon Islands migrate northward to these same areas (Lea *et al*. 2009). Adult males from the Pribilof Islands generally migrate only as far south as the Gulf of Alaska (Kajimura 1984). Little is known about where adult males from San Miguel Island and the Farallon Islands migrate.

The following information was considered in classifying stock structure based on the Dizon *et al*. (1992) phylogeographic approach: 1) Distributional data: continuous geographic distribution during feeding, geographic separation during the breeding season, and high natal site fidelity (DeLong 1982); 2) Population response data: substantial differences in population dynamics between the Pribilofs and San Miguel Island (DeLong 1982, DeLong and Antonelis 1991, NMFS 2007); 3) Phenotypic data: unknown; and 4) Genotypic data: little evidence of genetic differentiation among breeding islands (Ream 2002, Dickerson *et al*. 2010). Based on this information, two separate stocks of northern fur seals are recognized within U.S. waters: an Eastern Pacific stock and a California stock (including San Miguel Island and the Farallon Islands). The Eastern Pacific stock is reported separately in the Stock Assessment Reports for the Alaska Region.

POPULATION SIZE

The population estimate for northern fur seals on San Miguel Island is calculated as the estimated number of pups at rookeries multiplied by an expansion factor. Based on research conducted on the Eastern Pacific stock of northern fur seals, Lander's (1981) life table analysis was used to estimate the number of yearlings, two-year-olds, three-year-olds, and animals at least four years old. The resulting population estimate was equal to the pup count multiplied by 4.475. The expansion factors are based on a sex and age distribution estimated after the commercial harvest of juvenile males was terminated in 1984. A more appropriate expansion factor for San Miguel Island is 4.0, because immigration of recruitment-aged females is occurring in the population (DeLong 1982), as well as mortality and possible emigration of adults associated with the El Niño events in 1982-1983 and 1997-1998 (Melin *et al*. 2008). A 1998 pup count resulted in an 80% decrease from the 1997 count (Melin *et al*. 2005). In 1999, the population began to recover, and in 2010 the highest total pup count of 3,408 was recorded (Orr *et al*. in review). A possible cause for the decline in total pup counts from 2010 to 2011 was a combination of oceanographic events that occurred in the California Current in 2009, a coastal upwelling relaxation event in May and June and an El Niño event from Fall 2009 to Spring 2010. The oceanographic events caused fewer reproductive males and females to return to San Miguel Island to breed in 2010. During 2012, the population increased 9.4% from 2011 and this level was maintained during 2013. No counts were conducted at Castle Rock in 2014; however, a record number of pups (2,289) were counted at Adam's Cove that year. Additionally, the second highest number of territorial bulls (224) was observed in 2014 (Orr *et al*. in review). Based on these factors, and assuming the trends were similar at Castle Rock, the population size during 2014 would have been the highest recorded. However, based on the 2013 count (the most recent complete data set) and the expansion factor, the most recent population estimate of northern fur seals at San Miguel Island is 13,384 (3,346 x 4.0) northern fur seals (Orr *et al*. in review). Currently, a coefficient of variation (CV) for the expansion factor is unavailable; however, studies are underway to determine the accuracy and precision of the expansion factor.

The population estimate for northern fur seals on the Farallon Islands is calculated as the highest number of pups, juveniles, and adults counted at the rookery. The long-term population estimate at the Farallon Islands should be regarded as an index of abundance rather than a precise indicator of population size for several reasons: 1) population censuses are incomplete because researchers do not enter rookery areas until the end of the breeding/pupping season in order to reduce human disturbance to other breeding pinnipeds and nesting seabirds; 2) mortality occurring early in the season is not accounted for; and 3) estimates of the number of pups are compromised because by the time counts are conducted, many pups have learned to swim and may not be present at the rookery. Additionally, yearlings may be present at rookeries and misidentified as pups. Keeping these factors in mind, the peak counts of northern fur seals increased steadily from 1995 to 2006 and have increased exponentially from 2008 to 2013 (Tietz 2012, Berger *et al*. 2013). Based solely on the count, the population estimate of northern fur seals at the Farallon Islands was 666 in 2013 and increased to 1,019 in 2014 (Orr *et al*. in review).

The most recent population estimate for the entire stock of California northern fur seals, which incorporates estimates from San Miguel Island and the Farallon Islands in 2013, is 14,050 (13,384 + 666).

Minimum Population Estimate

Minimum population size is calculated as the sum of the minimum number of animals at San Miguel Island and the Farallon Islands in 2013 (Tietz 2012, Berger *et al*. 2013, Orr *et al*. in review). The minimum number of animals at San Miguel Island is twice the pup count (3,346 x 2 = 6,692), to account for pups and mothers, plus the number of territorial males (166) counted the same year (i.e., 2013), or 6,858 fur seals. The minimum number at the Farallon Islands is the total number of individuals (666) counted during the survey in 2013. It should be noted that 1,019 individuals were counted in 2014, but this number is not used here to be consistent with data collected at San Miguel Island. The total minimum population size is the sum of the minimum population sizes at San Miguel Island (6,858) and the Farallon Islands (666) in 2013, or 7,524 northern fur seals.

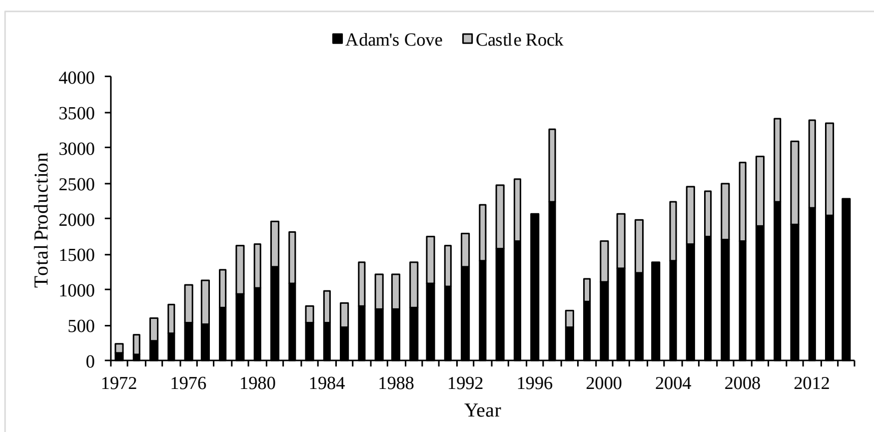

Figure 2. Total production of northern fur seal pups counted on San Miguel Island, including the mainland (Adam's Cove) and the offshore islet (Castle Rock), 1972-2014.

Current Population Trend

Northern fur seals were extirpated on San Miguel Island and the Farallon Islands during the late 1700s and early 1800s. Immigrants from the Pribilof Islands and Russian populations recolonized San Miguel Island during the late 1950s or early 1960s (DeLong 1982). The colony has increased steadily, since its discovery in 1968, except for severe declines in 1983 and 1998 associated with El Niño events in 1982-1983 and 1997-1998 (DeLong and Antonelis 1991, Melin *et al*. 2005). El Niño events impact population growth of northern fur seals at San Miguel Island and are an important regulatory mechanism for this population (DeLong and Antonelis 1991; Melin and DeLong 1994, 2000; Melin *et al*. 1996, 2005, 2008; Orr *et al.* 2012, in review).

Live pup counts increased about 24% annually from 1972 through 1982 (Fig. 2), partly due to immigration of females from the Bering Sea and the western North Pacific Ocean (DeLong 1982). The 1982-1983 El Niño event resulted in a 60% decline in the northern fur seal population at San Miguel Island (DeLong and Antonelis 1991). It took the population 7 years to recover from this decline, because adult female mortality or emigration occurred in addition to pup mortality (Melin and DeLong 1994). The 1992-1993 El Niño resulted in reduced pup production in 1992, but the population recovered in 1993 and increased during 1994 (Melin *et al*. 1996).

The northern fur seal population appears to be greatly affected by El Niño events. These events cause changes in marine communities by altering sea-level height, sea-surface temperature, thermocline and nutricline depths, current-flow patterns, and upwelling strength. Fur seal prey generally move to more productive areas farther north and deeper in the water column and, thereby, become less accessible for fur seals. Consequently, fur seals at San Miguel Island are in poor physical condition during El Niño events and the population experiences reduced reproductive success and high mortality of pups and, occasionally, adults. From July 1997 through May 1998, the most severe El Niño event in recorded history affected California coastal waters (Lynn *et al*. 1998). In 1997, total fur seal pup production was the highest recorded since the colony has been monitored. However, it appears that up to 87% of the pups born in 1997 died before weaning, and total production in 1998 declined 80% from 1997 (Melin *et al*. 2005). Total production increased to a record high of 3,408 in 2010 and, except for a slight decrease during 2011, levels have remained around 3,350 individuals in subsequent years (Orr *et al*. in review). The total production of northern fur seals has exceeded the 1997 levels during three of the last four years with complete counts; therefore, the San Miguel Island population has recovered from the 1997-1998 El Niño event.

Compared to San Miguel Island, less information is known about the population of northern fur seals on the Farallon Islands. Based on tag-resight data, it appears that the population originated from emigrants from San Miguel Island. The first pup was observed on the Farallon Islands in 1996 (Pyle *et al*. 2001). After this discovery, annual ground surveys were conducted in early fall to document population trends of the colony (Tietz 2012). The colony increased steadily from 1996 to the early 2000s. However, the population has grown exponentially during the past several years, with an occasional decline (Tietz 2012). Because counts are conducted during the fall after the breeding season, population trends and demographic information are less clear than for San Miguel Island.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Currently, productivity rates for northern fur seals on the Farallon Islands are unknown. A growth rate of 20% was calculated for northern fur seals on San Miguel Island in 1972-1982 by linear regression of the natural logarithm of pup count against year. However, it is clear that this rate of increase was due in part to immigration of females from Russian and Pribilof Islands populations (DeLong 1982). Immigration was also occurring from the early 1980s to 1997. In the absence of a reliable estimate of the maximum net productivity rate for the California stock of northern fur seals, the pinniped default maximum theoretical net productivity rate (R_{MAX}) of 12% (Wade and Angliss 1997) is used as an estimate of R_{MAX}.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population estimate (7,524) times one-half the default maximum net growth rate (½ of 12%) times a recovery factor of 1.0 (for stocks of unknown status that are increasing in size: Wade and Angliss 1997), resulting in a PBR of 451 northern fur seals from the California stock per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Northern fur seals taken by commercial fisheries during the winter/spring along the west coast of the continental U.S. could be from either the Eastern Pacific or California stock; therefore, any mortality or serious injury of northern fur seals reported off the coasts of California, Oregon, or Washington during December through May will be assigned to both the Eastern Pacific and California stocks of northern fur seals. There were no observer reports of northern fur seal deaths or serious injuries in any observed fishery along the west coast of the continental U.S. in 2009-2013 (Carretta and Enriquez 2010, 2012a, 2012b; Jannot *et al*. 2011; Carretta *et al*. 2014a, 2015).

Table 1. Summary of available information on the incidental mortality and serious injury of the California stock of northern fur seals in commercial fisheries that might take this species and calculation of the mean annual mortality and serious injury rate; n/a indicates that data are not available. Mean annual takes are based on 2009-2013 data unless noted otherwise.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean annual takes (CV in parentheses)
Unknown West Coast fisheries	2009-2013	stranding data	n/a	1, 0, 2, 1, 0	n/a	$\geq$0.8 (n/a)
Minimum total annual takes						$\geq$0.8 (n/a)

Strandings of northern fur seals entangled in fishing gear or with serious injuries caused by interactions with gear are another source of fishery-related mortality information. According to stranding records for California, Oregon, and Washington (Carretta *et al*. 2014b, 2015), four fishery-related deaths (in unidentified net and unknown trawl fisheries) were reported between 2009 and 2013 (Table 1), resulting in a mean annual mortality and serious injury rate of 0.8 California northern fur seals. This estimate is considered a minimum because not all stranded animals are found, reported, or examined for cause of death (via necropsy by trained personnel). Two of the fishery-related deaths (one in an unidentified fishing net in February 2009 and one in trawl gear in April 2011) were also assigned to the Eastern Pacific stock of northern fur seals. Two additional northern fur seal strandings in 2012 (one in May and one in July) with serious injuries due to fishery interactions were treated and released with non-serious injuries (Carretta *et al*. 2014b). Both of these animals were assigned to the California stock of northern fur seals and the animal that stranded in May 2012 was also assigned to the Eastern Pacific stock.

Other Mortality

Since the Eastern Pacific and California stocks of northern fur seals overlap off the west coast of the continental U.S. during December through May, non-fishery mortality and serious injury reported off the coasts of California, Oregon, or Washington during that time will be assigned to both stocks. Mortality and serious injury of northern fur seals may occur incidental to research fishery activities. In 2007 and 2008, four northern fur seals were incidentally killed in California waters during scientific sardine trawling operations conducted by NMFS (Carretta *et al*. 2013): one death in 2007 and one in 2008 occurred before NMFS scientists implemented a mitigation plan to avoid future mortality. The initial mitigation plan included use of 162 dB acoustic pingers, a marine mammal watch, and scheduling trawls to occur when the ship first arrived on station to avoid attracting animals to a stationary vessel. Two additional northern fur seals were killed in subsequent 2008 trawls, so a marine mammal excluder device was added to the trawls in 2009 and no northern fur seal deaths or serious injuries were observed in this research fishery in 2009-2013. However, one northern fur seal was killed in a scientific rockfish trawling operation conducted by NMFS (Carretta *et al*. 2014b) in California waters in May 2009. This death was assigned to both the California and Eastern Pacific stocks of northern fur seals. The mean annual research-related mortality and serious injury rate of California northern fur seals from 2009 to 2013 is 0.2 northern fur seals.

According to stranding records for California, Oregon, and Washington (Carretta *et al*. 2014b, 2015), four human-caused northern fur seal deaths were reported from non-fisheries sources in 2009-2013. Three northern fur seals were entangled in marine debris in Oregon waters in April 2009 and one was entrained in the cooling water system of a California power plant in May 2012. All four of these deaths were assigned to both the California and Eastern Pacific stocks of northern fur seals. The mean annual mortality and serious injury rate from non-fishery sources in 2009-2013 is 0.8 California northern fur seals. This estimate is considered a minimum because not all stranded animals are found, reported, or examined for cause of death (via necropsy by trained personnel).

STATUS OF STOCK

The California northern fur seal stock is not considered to be "depleted" under the Marine Mammal Protection Act (MMPA) or listed as "threatened" or "endangered" under the Endangered Species Act. Based on currently available data, the minimum annual level of total human-caused mortality and serious injury (1.8) does not exceed the PBR (451). Therefore, the California stock of northern fur seals is not classified as a "strategic" stock. The minimum annual commercial fishery mortality and serious injury rate for this stock (0.8) is not known to exceed 10% of the calculated PBR (45) and, therefore, appears to be insignificant and approaching zero mortality and serious injury rate. The stock (based on San Miguel Island data) decreased 80% from 1997 to 1998, began to recover in 1999, and currently has surpassed the 1997 level by 2%. The status of this stock relative to its Optimum Sustainable Population (OSP) is unknown, unlike the Eastern Pacific northern fur seal stock which is formally listed as "depleted" under the MMPA.

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HAWAIIAN MONK SEAL (*Neomonachus schauinslandi*)

STOCK DEFINITION AND GEOGRAPHIC RANGE

Hawaiian monk seals are distributed throughout the Northwestern Hawaiian Islands (NWHI), with subpopulations at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, Kure Atoll, and Necker and Nihoa Islands. They also occur throughout the main Hawaiian Islands (MHI). Genetic variation among monk seals is extremely low and may reflect a long-term history at low population levels and more recent human influences (Kretzmann *et al*. 1997, 2001, Schultz *et al*. 2009). Though monk seal subpopulations often exhibit asynchronous variation in demographic parameters (such as abundance trends and survival rates), they are connected by animal movement throughout the species' range (Johanos *et al*. 2013). Genetic analysis (Schultz *et al*. 2011) indicates the species is a single panmictic population. The Hawaiian monk seal is therefore considered a single stock. Scheel et al. (2014) established a new genus, *Neomonachus*, comprising the Caribbean and Hawaiian monk seals, based upon molecular and skull morphology evidence.

POPULATION SIZE

The best estimate of the total population size is 1,272, which is the sum of abundance estimates throughout the species' range (Table 1). In 2014, for the third consecutive year, NWHI field camps were shorter in duration relative to historic field effort levels. The low effort at some sites certainly resulted in negatively-biased abundance estimates and a degradation of the long-term monk seal demographic database. The number of individual seals identified is used as the population estimate at NWHI sites where total enumeration is achieved, according to the criteria established by Baker *et al*. (2006). Where total enumeration is not achieved, capture-recapture estimates from Program CAPTURE are used (Baker 2004; Otis *et al*. 1978, Rexstad & Burnham 1991, White *et al*. 1982). When no reliable estimator is obtainable in Program CAPTURE (i.e., the model selection criterion is < 0.75, following Otis *et al*. 1978), the total number of seals identified is the best available estimate. Sometimes capture-recapture estimates are less than the known minimum abundance (Baker 2004), and in these cases, the total number of seals actually identified is used. In 2014, total enumeration was achieved only at Kure Atoll, and capture-recapture estimates were obtained for Laysan Island and Midway Atoll. At French Frigate Shoals, Lisianski Island and Pearl and Hermes Reef, capture-recapture estimates were either not obtainable or were lower than known minimum abundance. Consequently, only minimum abundance was available for those sites. Counts at Necker and Nihoa Islands are conducted from zero to a few times per year. A new method for estimating non-pup abundance uses the empirical distribution of the ratio of beach counts to total population size at other NWHI subpopulations to correct beach counts at Necker and Nihoa Islands. This method is described in a manuscript currently in preparation (Harting *et al*. in prep.) and the resulting estimates are presented in Table 1. Pups are born over the course of many months and have very different haulout patterns compared to older animals. Therefore, pup production at Necker and Nihoa Islands is estimated as the mean of the total pups observed in the past 5 years, excluding counts occurring early in the pupping season when most have yet to be born. There were no counts conducted at Necker Island in 2014, so two beach counts conducted in 2013 were used to estimate abundance (no change in abundance since 2013 assumed). Three counts were conducted at Nihoa Island in 2014.

In the MHI, NMFS collects information on seal sightings reported throughout the year by a variety of sources, including a volunteer network, the public, and directed NMFS observation effort. In recent years, a small number of surveys of Ni'ihau and nearby Lehua Islands have been conducted through a collaboration between NMFS, Ni'ihau residents and the U.S. Navy. Total MHI monk seal abundance is estimated by adding the number of individually identifiable seals documented in 2014 on all MHI other than Ni'ihau and Lehua to an estimate for these latter two islands based on counts expanded by a haulout correction factor. A recent telemetry study (Wilson *et al*., in prep.) found that MHI monk seals (N=23) spent a greater proportion of time ashore than Harting *et al*. (in prep) estimated for NWHI seals. Therefore, the total non-pup estimate for Ni'ihau and Lehua Islands was the total beach count at those sites (less three individual seals already counted at other MHI) divided by the mean proportion of time hauled out in the MHI (Wilson *et al*., in prep). The total pups observed at Ni'ihau and Lehua Islands were added to obtain the total (Table 1).

Table 1. Total and minimum estimated abundance of Hawaiian monk seals by location in 2014. The estimation method is indicated for each site.

	Total			Minimum			
Location	**Non-pups**	**Pups**	**Total**	**Non-pups**	**Pups**	**Total**	**Method**
French Frigate Shoals	136	38	174	136	38	174	Minimum count
Laysan	188	35	223	181	35	216	Capture-recapture
Lisianski	129	11	140	129	11	140	Minimum count
Pearl and Hermes Reef	119	16	135	119	16	135	Minimum count
Midway	55	8	63	53	8	61	Capture-recapture
Kure	62	13	75	62	13	75	Total enumeration
Necker	63	5	68	50	5	55	Haulout correction
Nihoa	110	9	119	87	9	96	Haulout correction
MHI_(without Ni'ihau/ Lehua)	132	15	147	132	15	147	Minimum count
Ni'ihau/Lehua	108	20	128	86	20	106	Haulout correction
Total	*1102*	*170*	***1272***	*1035*	*170*	***1205***	

Minimum Population Estimate

The total numbers of seals identified at the NWHI subpopulations other than Necker and Nihoa, and in the MHI other than Ni'ihau and Lehua, are the best estimates of minimum population size at those sites. Minimum population sizes for Necker and Nihoa Islands are estimated as the lower 20^{th} percentiles of the non-pup abundance distributions generated using the Harting *et al*. (in prep.) haulout correction, plus the pup estimate. The mean proportion of time non-pups spent hauled out in the MHI was 0.370 (sd = 0.089, CV = 0.241) (Wilson *et al*. in prep.). Minimum abundance at Ni'ihau and Lehua Islands were calculated by applying the formula in Wade and Angliss (1997) to the Ni'ihau and Lehua non-pup estimate with a CV of 0.241, plus the observed pup tally. The minimum abundance estimates for each site and for all sites combined (1,205) are presented in Table 1.

Current Population Trend

In past years, the total stock abundance was not adequately assessed. However, in 2014, a range-wide total abundance estimate was generated using new methods for correcting beach counts at rarely visited sites (Necker, Nihoa and Ni'ihau/Lehua). Maintaining the commitment to conduct future counts at these latter sites will allow for the eventual estimation of total population trend. The following describes trends within different portions of the monk seal's range. The trend in abundance at the six most-studied NWHI subpopulations estimated with a log-linear regression of estimated abundance on year for the past 10 years (2005- 2014) yields a decline of -2.8% yr^{-1} (95% CI = -3.7% to -1.9% yr^{-1}). This rate of decline has been moderating in recent years. Sporadic beach counts at Necker and Nihoa Islands suggest either stability or some positive growth over the past decade. The MHI monk seal population appears to be increasing. Using life table analysis, Baker *et al*. (2011) estimated an intrinsic population growth rate (λ) of 6.5% per year based on data available through 2008. An updated analysis using MHI monk seal data through 2014 yields an estimated growth rate of 5.2% per year. However, the realized growth rate may differ considerably from λ, depending upon the unknown current age and sex structure. Given the uncertainties in these regional trends, it is not known whether the total stock abundance is decreasing, stable or possibly increasing. A reliable conclusion regarding population trend will only be apparent after more annual range-wide abundance estimates have accrued.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Trends in abundance vary considerably among subpopulations. Mean non-pup beach counts are used as a long-term index of abundance for years when data are insufficient to estimate total abundance as described above. Prior to 1999, beach count increases of up to 7% annually were observed at Pearl and Hermes Reef, and this is the highest estimate of the maximum net productivity rate (R_{max}) observed for this species.

POTENTIAL BIOLOGICAL REMOVAL

Using current minimum population size (1,205), R_{max} (0.07) and a recovery factor (F_r) for ESA endangered stocks (0.1), would yield a Potential Biological Removal (PBR) of 4.2. However, PBR is designed to allow stocks to recover to, or remain above, the maximum net productivity level (MNPL) (Wade 1998). An underlying assumption in the application of the PBR equation is that marine mammal stocks exhibit certain dynamics. Specifically, it is assumed that a depleted stock will naturally grow toward OSP (Optimum Sustainable Population), and that some surplus growth could be removed while still allowing recovery. The Hawaiian monk seal population is far below historical levels and has undergone a prolonged decline in abundance. Thus, past reports have concluded that the stock's dynamics do not conform to the underlying model for calculating PBR such that PBR for the Hawaiian monk seal has been undetermined. Given what appears to be an easing of the decline in the NWHI and continued growth in the MHI, this situation may have changed. If future monitoring reveals that the population is exhibiting positive growth, a valid PBR could be determined.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Human-related mortality has caused two major declines of the Hawaiian monk seal (Ragen 1999). In the 1800s, this species was decimated by sealers, crews of wrecked vessels, and guano and feather hunters (Dill and Bryan 1912; Wetmore 1925; Bailey 1952; Clapp and Woodward 1972). Following a period of at least partial recovery in the first half of the 20th century (Rice 1960), most subpopulations again declined. This second decline has not been fully explained, but long-term trends at several sites appear to have been driven both by variable oceanic productivity (represented by the Pacific Decadal Oscillation) and by human disturbance (Baker *et al*. 2012, Ragen 1999, Kenyon 1972, Gerrodette and Gilmartin 1990). Currently, human activities in the NWHI are limited and human disturbance is relatively rare, but human-seal interactions, have become an important issue in the MHI. Intentional killing of seals in the MHI is a relatively new and alarming issue (Table 2).

Table 2. Intentional and potentially intentional killings of MHI monk seals, and anthropogenic mortalities not associated with fishing gear since 2010.

Year	Age/sex	Island	Cause of Death	Comments
2010	Juvenile female	Kauai	Multiple skull fractures, blunt force trauma	Intent unconfirmed
2011	Adult male	Molokai	Skull fracture, blunt force trauma	Intent unconfirmed
	Juvenile female	Molokai	Skull fracture, blunt force trauma	Intent unconfirmed
2012	Juvenile male	Kauai	Gunshot wound	
	Subadult male	Kauai	Skull fracture	Intent unconfirmed
2014	Adult male	Oahu	Suspected trauma	Intent unconfirmed
	Pup female	Kauai	Skull fracture, blunt force trauma	Likely intentional
	Pup male	Kauai	Dog attack/bite wounds	4 other seals injured during this event

In July 2014, single or multiple dogs on Kauai attacked and injured at least five monk seals, one of which, a nursing pup, died from its wounds. The other four injured seals all recovered, one of which was a female nursing pup that required subsequent treatment for a bite-caused abscess. Four months later this same pup was killed on Kauai when its skull was crushed, likely by a human using a rock that was found nearby. An adult male on Oahu also died from what appeared to be trauma in 2014, but the carcass was too decomposed to draw conclusions about the cause of death. It is extremely unlikely that all carcasses of intentionally killed monk seals are discovered and reported. Studies of the recovery rates of carcasses for other marine mammal species have shown that the probability of detecting and documenting most deaths (whether from human or natural causes) is quite low (Peltier *et al*. 2012; Williams *et al*. 2011; Perrin *et al*. 2011; Punt and Wade 2010).

Fishery Information

Fishery interactions with monk seals can include direct interaction with gear (hooking or entanglement), seal consumption of discarded catch, and competition for prey. Entanglement of monk seals in derelict fishing gear, which is believed to originate outside the Hawaiian archipelago, is described in a separate section. Fishery interactions are a serious concern in the MHI, especially involving nearshore fisheries managed by the State of Hawaii. In 2014, 14 seal hookings were documented, 13 of which either were captured and had the hooks removed, or the hooks detached without intervention. A yearling male seal was found dead as result of hooking and the necropsy revealed that a 'J' hook had perforated the esophagus and part of one lung, causing pneumothorax and acute death. The remaining 13 hookings were all classified as non-serious injuries, although 9 of these would have been deemed serious had they not been mitigated. Several incidents involved hooks used to catch ulua (jacks, *Caranx* spp.). Nearshore gillnets became a more common source of mortality in the 2000s, with three seals confirmed dead in these gillnets (2006, 2007, and 2010), and one additional seal in 2010 may have also died in similar circumstances but the carcass was not recovered. No gillnet-related mortality or injuries have been documented since 2010. Most reported hookings and gillnet entanglements have occurred since 2000 (NMFS unpubl. data). The MHI monk seal population appears to have been increasing in abundance during this period (Baker *et al*. 2011). No mortality or serious injuries have been attributed to the MHI bottomfish handline fishery (Table 3). Published studies on monk seal prey selection based upon scat/spew analysis and video from seal-mounted cameras revealed evidence that monk seals fed on families of bottomfish which contain commercial species (many prey items recovered from scats and spews were identified only to the level of family; Goodman-Lowe 1998, Longenecker *et al*. 2006, Parrish *et al*. 2000). Quantitative fatty acid signature analysis (QFASA) results support previous studies illustrating that monk seals consume a wide range of species (Iverson *et al*. 2011). However, deepwater-slope species, including two commercially targeted bottomfishes and other species not caught in the fishery, were estimated to comprise a large portion of the diet for some individuals. Similar species were estimated to be consumed by seals regardless of location, age or gender, but the relative importance of each species varied. Diets differed considerably between individual seals. These results highlight the need to better understand potential ecological interactions with the MHI bottomfish handline fishery.

Table 3. Summary of mortality, serious and non-serious injury of Hawaiian monk seals due to fisheries and calculation of annual mortality rate. n/a indicates that sufficient data are not available. Percent observer coverage for the deep and shallow-set components, respectively, of the pelagic longline fishery, are shown. Total non-serious injuries are presented as well as, in parentheses, the number of those injuries that would have been deemed serious had they not been mitigated (*e.g.,* by de-hooking or disentangling). Data for MHI bottomfish and nearshore fisheries are based upon incidental observations (i.e., hooked seals and those entangled in active gear). All hookings not clearly attributable to either fishery with certainty were attributed to the bottomfish fishery, and hookings which resulted in injury of unknown severity were classified as serious. Nearshore fisheries injuries and mortalities include seals entangled/drowned in nearshore gillnets and hooked/entangled in hook-and-line gear, recognizing that it is not possible to determine whether the nets or hook-and-line gear involved were being used for commercial purposes.

Fishery Name	Year	Data Type	% Obs. coverage	Observed/Reported Mortality/Serious Injury	Estimated Mortality/ Serious Injury	Non-serious (Mitigated serious)	Mean Takes (CV)
Pelagic Longline	2010 2011 2012 2013 2014	observer observer observer observer observer	21.1% & 100% 20.3% & 100% 20.4% & 100% 20.4% & 100% 20.8% & 100%	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 (0)
MHI Bottomfish	2010 2011 2012 2013 2014	Incidental observations of seals	none	0 0 0 0 0	n/a	0 0 0 0 0	n/a
Nearshore	2010 2011 2012 2013 2014	Incidental observations of seals	none	1 0 4 0 1	n/a	11(2) 9 (3) 12 (5) 15 (6) 14 (9)	≥ 1.2
Minimum total annual takes							≥ 1.2

There are no fisheries operating in or near the NWHI. In the past, interactions between the Hawaii-based domestic pelagic longline fishery and monk seals were documented (Nitta and Henderson 1993). This fishery targets swordfish and tunas and does not compete with Hawaiian monk seals for prey. In October 1991, in response to 13 unusual seal wounds thought to have resulted from interactions with this fishery, NMFS established a Protected Species Zone extending 50 nautical miles around the NWHI and the corridors between the islands. Subsequently, no additional monk seal interactions with the swordfish or tuna components of the longline fishery have been observed.

Fishery Mortality Rate

Total fishery mortality and serious injury is not insignificant and approaching a rate of zero. Monk seals are being hooked and entangled in the MHI at a rate that has not been reliably assessed but is certainly greater than zero. The information above represents only reported direct interactions, and without directed observation effort, the true interaction rate cannot be estimated. Monk seals also die from entanglement in fishing gear and other debris throughout their range (likely originating from various sources outside of Hawaii), and NMFS along with partner agencies are pursuing a program to mitigate entanglement (see below). Indirect interactions (i.e., involving competition for prey or consumption of discards) remain a topic of ongoing investigation.

Entanglement in Marine Debris

Hawaiian monk seals become entangled in fishing and other marine debris at rates higher than reported for other pinnipeds (Henderson 2001). A total of 347 cases of monk seals entangled in fishing gear or other debris have been observed from 1982 to 2014 (Henderson 2001; NMFS, unpubl. data). Nine documented deaths resulted from entanglement in marine debris (Henderson 1990, 2001; NMFS, unpubl. data). The fishing gear fouling the reefs and beaches of the NWHI and entangling monk seals only rarely includes types used in Hawaii fisheries. For example, trawl net and monofilament gillnet accounted for approximately 35% and 34%, respectively, of the debris removed from reefs in the NWHI by weight, and trawl net alone accounted for 88% of the debris by frequency (Donohue *et al*. 2001), despite the fact that trawl fisheries have been prohibited in Hawaii since the 1980s.

The NMFS and partner agencies continue to mitigate impacts of marine debris on monk seals as well as turtles, coral reefs and other wildlife. Marine debris is removed from beaches and seals are disentangled during annual population assessment activities at the main reproductive sites. Since 1996, annual debris survey and removal efforts in the NWHI coral reef habitat have been ongoing (Donohue *et al*. 2000, Donohue *et al*. 2001, Dameron *et al*. 2007).

Other Mortality

In the past 10 years (2004-2013) two monk seals died during enhancement activities (in 2005 and 2006) and one died during research in 2007 (NMFS unpubl. data).

Sources of mortality that impede recovery include food limitation (see Habitat Issues), single and multiple-male intra-species aggression (mobbing), shark predation, and disease/parasitism. Male seal aggression has caused episodes of mortality and injury. Past interventions to remove aggressive males greatly mitigated, but have not eliminated, this source of mortality (Johanos *et al*. 2010). Galapagos shark predation on monk seal pups has been a chronic and significant source of mortality at French Frigate Shoals since the late 1990s, despite mitigation efforts by NMFS (Gobush 2010). Infectious disease effects on monk seal demographic trends are low relative to other stressors. However, land-to-sea transfer of pathogens has been increasingly evident; since the early 2000's through 2014, six monk seal mortalities have been directly caused by protozoal infections, most often by *Toxoplasma gondii*, a protozoal parasite that is shed in the feces of cats. Furthermore, the consequences of a disease outbreak introduced from livestock, feral animals, pets or other carrier wildlife may be catastrophic to the immunologically naïve monk seal population. Key disease threats include West Nile virus, morbillivirus and influenza.

Habitat Issues

Poor juvenile survival rates and variability in the relationship between weaning size and survival suggest that prey availability is limiting recovery of NWHI monk seals (Baker and Thompson 2007, Baker *et al*. 2007, Baker 2008). Multiple strategies for improving juvenile survival, including translocation and captive care are being implemented (Baker and Littnan 2008, Baker *et al*. 2013, Norris 2013). A testament to the effectiveness of past actions to improve survival, Harting *et al.* (2014) demonstrated that approximately one-third of the monk seal population alive in 2012 was made up of seals that either had been intervened with to mitigate life-threatening situations, or were descendants of such seals. In 2014, NMFS produced a final Programmatic Environmental Impact Statement (PEIS) on current and future anticipated research and enhancement activities, and issued a permit covering the activities described in the PEIS preferred alternative (http://www.nmfs.noaa.gov/pr/permits/eis/hawaiianmonksealeis.htm). A major habitat issue involves loss of terrestrial habitat at French Frigate Shoals, where some pupping and resting islets have shrunk or virtually disappeared (Antonelis *et al*. 2006). Projected increases in global average sea level may further significantly reduce terrestrial habitat for monk seals in the NWHI (Baker *et al*. 2006, Reynolds *et al*. 2012).

Goodman-Lowe (1998) provided information on prey selection using hard parts in scats and spewings. Information on at-sea movement and diving is available for seals at all six main subpopulations in the NWHI using satellite telemetry (Stewart *et al*. 2006). Cahoon (2011) and Cahoon *et al*. (2013) described diet and foraging behavior of MHI monk seals, and found no striking difference in prey selection between the NWHI and MHI.

Remains of the seawall at Tern Island, French Frigate Shoals, is an entrapment hazard for seals. Vessel groundings pose a continuing threat to monk seals and their habitat, through potential physical damage to reefs, oil spills, and release of debris into habitats.

Monk seal abundance is increasing in the main Hawaiian Islands (Baker *et al*. 2011). Further, the excellent condition of pups weaned on these islands suggests ample prey resource availability, perhaps in part due to fishing pressure that has reduced monk seal competition with large fish predators (sharks and jacks) (Baker and Johanos 2004). If the monk seal population continues to expand in the MHI, it may bode well for the species' recovery and long-term persistence. In contrast, there are many challenges that may limit the potential for growth in this region. The human population in the MHI is approximately 1.4 million compared to fewer than 100 in the NWHI, so that the potential impact of disturbance in the MHI is great. Intentional killing of seals (noted above) is a very serious concern. Also, the same fishing pressure that may have reduced the monk seal's competitors is a source of injury and mortality. Finally, vessel traffic in the populated islands carries the potential for collision with seals and impacts from oil spills. The causes of two recent non-serious injuries (in 2010 and 2011) to seals were attributed to boat propellers. Thus, issues surrounding monk seals in the main Hawaiian Islands will likely become an increasing focus for management and recovery of this species.

STATUS OF STOCK

In 1976, the Hawaiian monk seal was designated depleted under the Marine Mammal Protection Act and as endangered under the Endangered Species Act. The species is well below its optimum sustainable population and has not recovered from past declines. Therefore, the Hawaiian monk seal is a strategic stock. Annual human-caused mortality for the most recent 5-year period (2010-2014) was at least ≥2.8 animals, including fishery-related mortality in nearshore gillnets and hook-and-line gear (≥1.2/yr, Table 3), and intentional killings and other human-caused mortalities (≥1.6/yr, Table 2).

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HARBOR PORPOISE (*Phocoena phocoena*): Morro Bay Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the Pacific, harbor porpoise are found in coastal and inland waters from Point Conception, California to Alaska and across to Kamchatka and Japan (Gaskin 1984). Harbor porpoise appear to have more restricted movements along the western coast of the continental U.S. than along the eastern coast. Regional differences in pollutant residues in harbor porpoise indicate that they do not move extensively between California, Oregon, and Washington (Calambokidis and Barlow 1991). That study also showed some regional differences within California (although the sample size was small). This pattern stands as a sharp contrast to the eastern coast of the U.S. and Canada where harbor porpoise are believed to migrate seasonally from as far south as the Carolinas to the Gulf of Maine and Bay of Fundy (Polacheck et al. 1995). A phylogeographic analysis of genetic data from northeast Pacific harbor porpoise did not show complete concordance between DNA sequence types and geographic location (Rosel 1992). However, an analysis of molecular variance (AMOVA) of the same data with additional samples found significant genetic differences for four of the six pair-wise comparisons between the four areas investigated: California, Washington, British Columbia, and Alaska (Rosel et al. 1995). These results demonstrate that harbor porpoise along the west coast of North America are not panmictic or migratory, and movement is sufficiently restricted that genetic differences have evolved. Subsequent genetic analyses of samples ranging from Monterey Bay, California to Vancouver Island, British Columbia indicate that there is small-scale subdivision within the U.S. portion of this range (Chivers *et al.*, 2002, 2007).

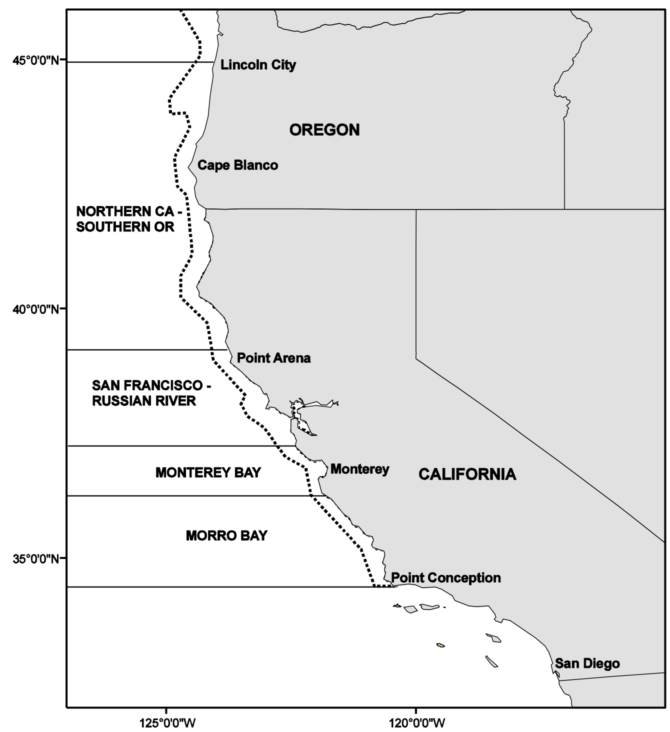

Figure 1. Stock boundaries and distributional range of harbor porpoise along the California and southern Oregon coasts. Dashed line represents harbor porpoise habitat (0-200 m) in this region.

In their assessment of harbor porpoise, Barlow and Hanan (1995) recommended that the animals inhabiting central California (defined to be from Point Conception to the Russian River) be treated as a separate stock. Their justifications for this were: 1) fishery mortality of harbor porpoise was limited to central California, 2) movement of individual animals appears to be restricted within California, and consequently 3) fishery mortality could cause the local depletion of harbor porpoise if central California is not managed separately. Although geographic structure exists along an almost continuous distribution of harbor porpoise from California to Alaska, stock boundaries are difficult to draw because any rigid line is (to a greater or lesser extent) arbitrary from a biological perspective. Nonetheless, failure to recognize geographic structure by defining management stocks can lead to depletion of local populations. Based on more recent genetic findings (Chivers *et al.*, 2002, 2007), California coast stocks were re-evaluated, and significant genetic differences were found among 4 identified sampling sites. Revised stock boundaries are presented here based on these genetic data and density discontinuities identified from aerial surveys, resulting in six California/Oregon/Washington stocks where previously there had been four (Carretta *et al.*

2001a). The stock boundaries for animals that occur in California/southern Oregon waters are shown in Figure 1. For the 2009 Marine Mammal Protection Act (MMPA) Stock Assessment Reports, other Pacific coast harbor porpoise stocks include: 1) a Monterey Bay stock, 2) a San Francisco-Russian River stock, 3) a northern California/southern Oregon stock, 4) a northern Oregon/Washington coast stock, 5) an Inland Washington stock, 6) a Southeast Alaska stock, 7) a Gulf of Alaska stock, and 8) a Bering Sea stock. Stock assessment reports for harbor porpoise stocks within waters of California, Oregon, and Washington appear in this volume. The three Alaska harbor porpoise stocks are reported separately in the Stock Assessment Reports for the Alaska Region.

POPULATION SIZE

Previous estimates of abundance for California harbor porpoise were based on aerial surveys conducted between the coast and the 50-fm isobath during 1988-95 (Barlow and Forney 1994, Forney 1999). These estimates did not include an unknown number of animals found in deeper waters. Barlow (1988) found that the vast majority of harbor porpoise in California were within the 0-50-fm depth range; however, Green et al. (1992) found that 24% of harbor porpoise seen during aerial surveys of Oregon and Washington were between the 100m and 200m isobaths (55 to 109 fathoms). A systematic ship survey of depth strata out to 90 m in northern California showed that porpoise abundance declined significantly in waters deeper than 60 m (Carretta *et al.* 2001b). Since 1999, aerial surveys have extended farther offshore (to the 200m depth contour or a minimum of 10 nmi from shore in the region of the Morro Bay stock) to provide a more complete abundance estimate. The most recent estimate of abundance for the Morro Bay stock, based on 2012 aerial surveys is 2,917 (CV=0.41) harbor porpoises (Forney et al. 2013). This estimate includes a correction factor of 3.42 (1/g(0); g(0)=0.292, CV=0.366) (Laake *et al.* 1997), to adjust for groups missed by aerial observers.

Minimum Population Estimate

The minimum population estimate for the Morro Bay harbor porpoise stock is taken as the lower 20th percentile of the log-normal distribution of the abundance estimated from the 2012 aerial surveys, or 2,102 animals.

Current Population Trend

The latest abundance estimate is greater than previous estimates dating back to 1988, which were < 2,100 harbor porpoises (see previous stock assessment reports). However, confidence limits are wide and estimates are not independent, so it is not statistically valid to infer a population trend directly from these points. Further analyses will be required to estimate population trends from the available abundance estimates, taking into account the fact that individual estimates were derived using common parameters and some shared survey data.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Based on what are argued to be biological limits of the species (i.e. females give birth first at age 4 and produce one calf per year until death), the theoretical, maximum-conceivable growth rate of a closed harbor porpoise population was estimated as 9.4% per year based on a human survivorship curve (Barlow and Boveng 1991). This maximum theoretical rate represents maximum survival in a protected environment and may not be achievable for any wild population (Barlow and Boveng 1991). Woodley and Read (1991) calculate a maximum growth rate of approximately 5% per year, but their argument for this being a maximum (i.e. that porpoise survival rates cannot exceed those of Himalayan thar) is not well justified. Population growth rates have not actually been measured for any harbor porpoise population. Because a reliable estimate of the maximum net productivity rate is not available for harbor porpoise, we use the default maximum net productivity rate (R_{MAX}) of 4% for cetaceans (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (2,102) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.5 (for a stock of unknown status; Wade and Angliss 1997), resulting in a PBR of 21.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Gillnet fisheries for halibut and white seabass that historically operated in the vicinity of Morro Bay were eliminated in this stock's range in 2002 by a ban on gillnets inshore of 60 fathoms (~110 m) from Point Arguello to Point Reyes, California. The large-mesh drift gillnet fishery for swordfish and thresher shark operates too far offshore to interact with harbor porpoise in this region. In the most recent five-year period for which data are available (2007-2011), one fishery-related stranding of harbor porpoise was documented within this stock's range (in 2008, Table 1). The responsible fishery has not been identified.

Table 1. Summary of available on incidental mortality and serious injury of Morro Bay Stock harbor porpoise in commercial fisheries that might take this species. Mean annual takes are based on 2007-2011 data. n/a indicates that data are not available.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality	Kill/Day	Estimated Mortality (CV in parentheses)	Mean Annual Takes (CV in parentheses)
Unidentified gillnet fishery	2007-2011	Stranding	n/a	1	n/a	≥1	≥ 0.2 (n/a)
Minimum total annual takes							≥ 0.2 (n/a)

STATUS OF STOCK

Harbor porpoise in California are not listed as threatened or endangered under the Endangered Species Act nor as depleted under the Marine Mammal Protection Act. Barlow and Hanan (1995) calculate the status of harbor porpoise relative to historic carrying capacity (K) using a technique called back-projection. They calculate that the central California population (including Morro Bay, Monterey Bay, and San Francisco-Russian River stocks) could have been reduced to between 30% and 97% of K by incidental fishing mortality, depending on the choice of input parameters. They conclude that there is no practical way to reduce the range of this estimate. New information does not change this conclusion, and the status of central California harbor porpoise populations relative to their Optimum Sustainable Population (OSP) levels must be treated as unknown.

Fishery-related mortality of harbor porpoises is occasionally documented through strandings within this stock's range, although the total bycatch levels and responsible fisheries are unknown. Because the overall level of fishery mortality is unknown relative to the PBR it cannot be considered to be insignificant and approaching zero mortality and injury rate. Although there is uncertainty regarding the observed levels of fishery-related mortality for this stock, documented mortality is much less than the PBR, and thus this stock is not considered "strategic" under the MMPA. There are no known habitat issues that are presently of concern for this stock, although harbor porpoise are sensitive to disturbance by anthropogenic sound sources, such as those generated during the installation and operation of marine renewable energy facilities (Teilmann and Carstensen 2012).

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Revised 6/4/2014

HARBOR PORPOISE (*Phocoena phocoena*): Monterey Bay Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the Pacific, harbor porpoise are found in coastal and inland waters from Point Conception, California to Alaska and across to Kamchatka and Japan (Gaskin 1984). Harbor porpoise appear to have more restricted movements along the western coast of the continental U.S. than along the eastern coast. Regional differences in pollutant residues in harbor porpoise indicate that they do not move extensively between California, Oregon, and Washington (Calambokidis and Barlow 1991). That study also showed some regional differences within California (although the sample size was small). This pattern stands as a sharp contrast to the eastern coast of the U.S. and Canada where harbor porpoise are believed to migrate seasonally from as far south as the Carolinas to the Gulf of Maine and Bay of Fundy (Polacheck et al. 1995). A phylogeographic analysis of genetic data from northeast Pacific harbor porpoise did not show complete concordance between DNA sequence types and geographic location (Rosel 1992). However, an analysis of molecular variance (AMOVA) of the same data with additional samples found significant genetic differences for four of the six pair-wise comparisons between the four areas investigated: California, Washington, British Columbia, and Alaska (Rosel et al. 1995). These results demonstrate that harbor porpoise along the west coast of North America are not panmictic or migratory, and movement is sufficiently restricted that genetic differences have evolved. Subsequent genetic analyses of samples ranging from Monterey Bay, California to Vancouver Island, British Columbia indicate that there is small-scale subdivision within the U.S. portion of this range (Chivers *et al*., 2002, 2007).

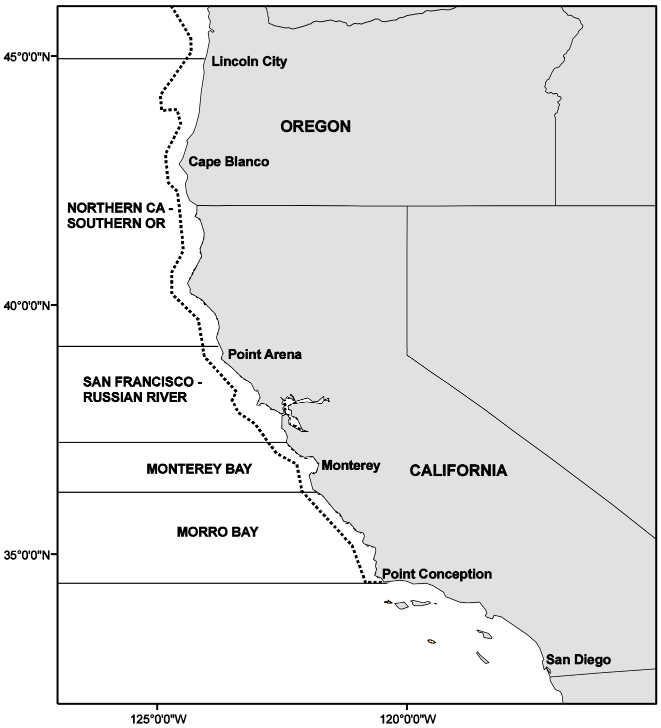

Figure 1. Stock boundaries and distributional range of harbor porpoise along the California/southern Oregon coast. Dashed line represents harbor porpoise habitat (0-200 m) along the U.S. west coast.

In their assessment of harbor porpoise, Barlow and Hanan (1995) recommended that the animals inhabiting central California (defined to be from Point Conception to the Russian River) be treated as a separate stock. Their justifications for this were: 1) fishery mortality of harbor porpoise was limited to central California, 2) movement of individual animals appears to be restricted within California, and consequently 3) fishery mortality could cause the local depletion of harbor porpoise if central California is not managed separately. Although geographic structure exists along an almost continuous distribution of harbor porpoise from California to Alaska, stock boundaries are difficult to draw because any rigid line is (to a greater or lesser extent) arbitrary from a biological perspective. Nonetheless, failure to recognize geographic structure by defining management stocks can lead to depletion of local populations. Based on more recent genetic findings (Chivers *et al*., 2002, 2007), California coast stocks were re-evaluated, and significant genetic differences were found among 4 identified sampling sites. Revised stock boundaries are presented here based on these genetic data and density discontinuities identified from aerial surveys, resulting in six California/Oregon/Washington stocks where previously there had been four (Carretta *et al.* 2001a). The stock boundaries for animals that occur in California/southern Oregon waters are shown in Figure 1. For the 2009 Marine Mammal Protection Act (MMPA) Stock Assessment Reports, other Pacific coast harbor porpoise stocks include: 1) a Monterey Bay stock, 2) a San Francisco-Russian River stock, 3) a northern California/southern Oregon stock, 4) a northern Oregon/Washington coast stock, 5) an Inland Washington stock, 6) a Southeast Alaska stock, 7) a Gulf of Alaska stock, and 8) a Bering Sea stock. Stock assessment reports for harbor porpoise stocks within waters of California, Oregon, and Washington appear in this volume. The three Alaska harbor porpoise stocks are reported separately in the Stock Assessment Reports for the Alaska Region.

POPULATION SIZE

Previous estimates of abundance for California harbor porpoise were based on aerial surveys conducted between the coast and the 50-fm isobath during 1988-95 (Barlow and Forney 1994, Forney 1999). These estimates did not include an unknown number of animals found in deeper waters. Barlow (1988) found that the vast majority of harbor porpoise in California were within the 0-50-fm depth range; however, Green et al. (1992) found that 24% of harbor porpoise seen during aerial surveys of Oregon and Washington were between the 100m and 200m isobaths (55 to 109 fathoms). A systematic ship survey of depth strata out to 90 m in northern California showed that porpoise abundance declined significantly in waters deeper than 60 m (Carretta et al. 2001b). Starting in 1999, aerial surveys extended farther offshore (to the 200m depth contour or a minimum of 15 nmi from shore in the region of the Monterey Bay stock) to provide a more complete abundance estimate. The most recent estimate of abundance for the Monterey Bay stock, based on 2011 aerial surveys is 3,715 (CV=0.51) harbor porpoises (Forney et al. 2013). This estimate includes a correction factor of 3.42 (1/g(0); g(0)=0.292, CV=0.366) (Laake *et al.* 1997), to adjust for groups missed by aerial observers.

Minimum Population Estimate

The minimum population estimate for the Monterey Bay harbor porpoise stock is taken as the lower 20th percentile of the log-normal distribution of the abundance estimated from the 2011 aerial surveys, or 2,480 animals.

Current Population Trend

The latest abundance estimate is markedly greater than previous estimates dating back to 1988, which were < 1,500-2,000 harbor porpoises (see previous stock assessment reports), but confidence limits are wide. Further analyses will be required to estimate population trends from the available abundance estimates, particularly because the abundance estimates are derived using common parameters and some shared survey data.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Based on what are argued to be biological limits of the species (i.e. females give birth first at age 4 and produce one calf per year until death), the theoretical, maximum-conceivable growth rate of a closed harbor porpoise population was estimated as 9.4% per year based on a human survivorship curve (Barlow and Boveng 1991). This maximum theoretical rate represents maximum survival in a protected environment and may not be achievable for any wild population (Barlow and Boveng 1991). Woodley and Read (1991) calculate a maximum growth rate of approximately 5% per year, but their argument for this being a maximum (i.e. that porpoise survival rates cannot exceed those of Himalayan thar) is not well justified.. Population growth rates have not actually been measured for any harbor porpoise population. Because a reliable estimate of the maximum net productivity rate is not available for harbor porpoise, we use the default maximum net productivity rate (R_{MAX}) of 4% for cetaceans (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (2,480) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50(for a stock of unknown status ; Wade and Angliss 1997), resulting in a PBR of 25.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Gillnet fisheries for halibut and white seabass that historically operated in the vicinity of Monterey Bay were eliminated in this stock's range in 2002 by a ban on gillnets inshore of 60 fathoms (~110 m) from Point Arguello to Point Reyes, California. The large-mesh drift gillnet fishery for swordfish and thresher shark operates too far offshore to interact with harbor porpoise in this region. In the most recent five-year period for which data are available (2007-2011), no fishery-related mortality or injury of harbor porpoise within the range of the Monterey Bay stock has been documented.

Table 1. Summary of available on incidental mortality and injury of harbor porpoise in commercial fisheries that might take this species. Mean annual takes are based on 2007-2011 data. n/a indicates that data are not available.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality	Kill/Day	Estimated Mortality (CV in parentheses)	Mean Annual Takes (CV in parentheses)
Unidentified fisheries	2007-2011	Stranding	n/a	none	n/a	n/a	0 (n/a)
Minimum total annual takes							0 (n/a)

STATUS OF STOCK

Harbor porpoise in California are not listed as threatened or endangered under the Endangered Species Act nor as depleted under the Marine Mammal Protection Act. Barlow and Hanan (1995) calculate the status of harbor porpoise relative to historic carrying capacity (K) using a technique called back-projection. They calculate that the central California population could have been reduced to between 30% and 97% of K by incidental fishing mortality, depending on the choice of input parameters. They conclude that there is no practical way to reduce the range of this estimate. New information does not change this conclusion, and the status of harbor porpoise relative to their Optimum Sustainable Population (OSP) levels in central California must be treated as unknown.

No fishery-related mortality of harbor porpoise has been documented within this stock's range during 2007-2011, and fishery mortality can be considered insignificant and approaching zero mortality rate. The Monterey Bay harbor porpoise stock is not considered "strategic" under the MMPA. There are no known habitat issues that are of particular concern for this stock, although harbor porpoise are sensitive to disturbance by anthropogenic sound sources, such as those generated during the installation and operation of marine renewable energy facilities (Teilmann and Carstensen 2012).

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HARBOR PORPOISE (*Phocoena phocoena*): San Francisco-Russian River Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the Pacific, harbor porpoise are found in coastal and inland waters from Point Conception, California to Alaska and across to Kamchatka and Japan (Gaskin 1984). Harbor porpoise appear to have more restricted movements along the western coast of the continental U.S. than along the eastern coast. Regional differences in pollutant residues in harbor porpoise indicate that they do not move extensively between California, Oregon, and Washington (Calambokidis and Barlow 1991). That study also showed some regional differences within California (although the sample size was small). This pattern stands as a sharp contrast to the eastern coast of the U.S. and Canada where harbor porpoise are believed to migrate seasonally from as far south as the Carolinas to the Gulf of Maine and Bay of Fundy (Polacheck et al. 1995). A phylogeographic analysis of genetic data from northeast Pacific harbor porpoise did not show complete concordance between DNA sequence types and geographic location (Rosel 1992). However, an analysis of molecular variance (AMOVA) of the same data with additional samples found significant genetic differences for four of the six pair-wise comparisons between the four areas investigated: California, Washington, British Columbia, and Alaska (Rosel et al. 1995). These results demonstrate that harbor porpoise along the west coast of North America are not panmictic or migratory, and movement is sufficiently restricted that genetic differences have evolved. Subsequent genetic analyses of samples ranging from Monterey Bay, California to Vancouver Island, British Columbia indicate that there is small-scale subdivision within the U.S. portion of this range (Chivers *et al.*, 2002, 2007).

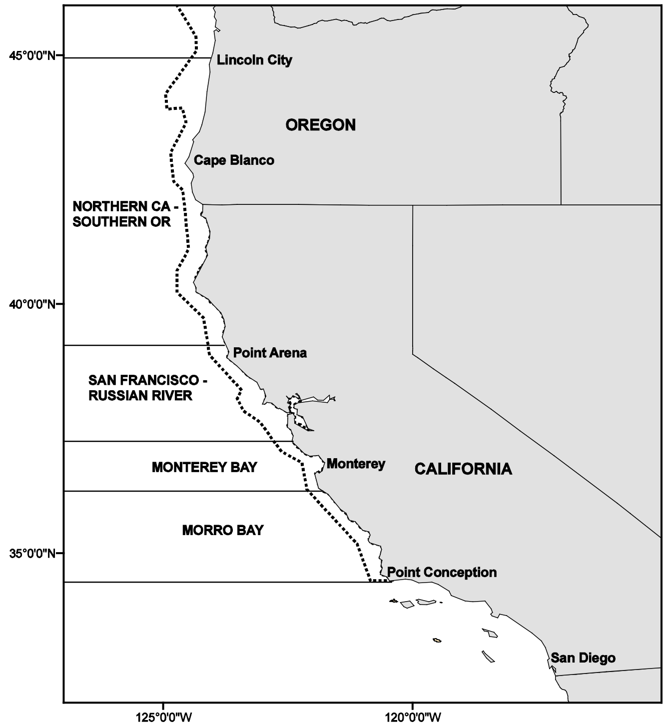

Figure 1. Stock boundaries and distributional range of harbor porpoise along the California and southern Oregon coasts. Dashed line represents harbor porpoise habitat (0-200 m) along the U.S. west coast.

In their assessment of harbor porpoise, Barlow and Hanan (1995) recommended that the animals inhabiting central California (defined to be from Point Conception to the Russian River) be treated as a separate stock. Their justifications for this were: 1) fishery mortality of harbor porpoise was limited to central California, 2) movement of individual animals appears to be restricted within California, and consequently 3) fishery mortality could cause the local depletion of harbor porpoise if central California is not managed separately. Although geographic structure exists along an almost continuous distribution of harbor porpoise from California to Alaska, stock boundaries are difficult to draw because any rigid line is (to a greater or lesser extent) arbitrary from a biological perspective. Nonetheless, failure to recognize geographic structure by defining management stocks can lead to depletion of local populations. Based on more recent genetic findings (Chivers *et al.*, 2002, 2007), California coast stocks were re-evaluated, and significant genetic differences were found among 4 identified sampling sites. Revised stock boundaries are presented here based on these genetic data and density discontinuities identified from aerial surveys, resulting in six California/Oregon/Washington stocks where previously there had been four (Carretta *et al.*

2001a). The stock boundaries for animals that occur in California/southern Oregon waters are shown in Figure 1. For the 2002 Marine Mammal Protection Act (MMPA) Stock Assessment Reports, other Pacific coast harbor porpoise stocks include: 1) a Morro Bay stock, 2) a Monterey Bay stock, 3) a northern California/southern Oregon stock, 4) a northern Oregon/Washington coast stock, 5) an Inland Washington stock, 6) a Southeast Alaska stock, 7) a Gulf of Alaska stock, and 8) a Bering Sea stock. Stock assessment reports for harbor porpoise stocks within waters of California, Oregon, and Washington appear in this volume. The three Alaska harbor porpoise stocks are reported separately in the Stock Assessment Reports for the Alaska Region.

POPULATION SIZE

Previous estimates of abundance for California harbor porpoise were based on aerial surveys conducted between the coast and the 50-fm isobath during 1988-95 (Barlow and Forney 1994, Forney 1999). These estimates did not include an unknown number of animals found in deeper waters. Barlow (1988) found that the vast majority of harbor porpoise in California were within the 0-50-fm depth range; however, Green et al. (1992) found that 24% of harbor porpoise seen during aerial surveys of Oregon and Washington were between the 100m and 200m isobaths (55 to 109 fathoms). A systematic ship survey of depth strata out to 90 m in northern California showed that porpoise abundance declined significantly in waters deeper than 60 m (Carretta *et al.* 2001b). Since 1999, aerial surveys extended farther offshore (to the 200m depth contour or a minimum of 15 nmi from shore in the region of the San Francisco-Russian River stock) to provide a more complete abundance estimate. The most recent estimate of abundance for the San Francisco-Russian River stock, based on 2007-2011 aerial surveys is 9,886 (CV=0.51) harbor porpoises (Forney et al. 2013). This estimate includes a correction factor of 3.42 (1/g(0); g(0)=0.292, CV=0.366) (Laake *et al*. 1997), to adjust for groups missed by aerial observers.

Minimum Population Estimate

The minimum population estimate for the San Francisco-Russian River harbor porpoise stock is taken as the lower 20th percentile of the log-normal distribution of the abundance estimated from 2007-2011 aerial surveys, or 6,625 animals.

Current Population Trend

The latest abundance estimate is very similar to the previous 2002-2007 estimate of 9,189 harbor porpoises (see previous stock assessment reports), and no recent trend is apparent. Further analyses will be required to estimate long-term population trends from the available abundance estimates, particularly because the abundance estimates are derived using common parameters and some shared survey data.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Based on what are argued to be biological limits of the species (i.e. females give birth first at age 4 and produce one calf per year until death), the theoretical, maximum-conceivable growth rate of a closed harbor porpoise population was estimated as 9.4% per year based on a human survivorship curve (Barlow and Boveng 1991). This maximum theoretical rate represents maximum survival in a protected environment and may not be achievable for any wild population (Barlow and Boveng 1991). Woodley and Read (1991) calculate a maximum growth rate of approximately 5% per year, but their argument for this being a maximum (i.e. that porpoise survival rates cannot exceed those of Himalayan thar) is not well justified. Population growth rates have not actually been measured for any harbor porpoise population. Because a reliable estimate of the maximum net productivity rate is not available for harbor porpoise, we use the default maximum net productivity rate (R_{MAX}) of 4% for cetaceans (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (6,625) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.5 (for a stock of unknown status; Wade and Angliss 1997), resulting in a PBR of 66.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Although coastal gillnets are prohibited throughout this stock's range, there have been fishery-related strandings in past years. In the most recent five-year period for which data are available (2007-2011), no fishery-related mortality or injury of harbor porpoise within the range of the San Francisco-Russian River stock has been documented.

Table 1. Summary of available information on incidental mortality and injury of harbor porpoise (San Francisco-Russian River stock) in commercial fisheries that might take this species. No fishery takes or fishery-related strandings were reported in this region between 2007 and 2011. n/a indicates that data are not available.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality	Kill/Day	Estimated Mortality (CV in parentheses)	Mean Annual Takes (CV in parentheses)
Unknown fishery	2007-2011	stranding	n/a	none	n/a	n/a	0 (n/a)
Minimum total annual takes							0 (n/a)

STATUS OF STOCK

Harbor porpoise in California are not listed as threatened or endangered under the Endangered Species Act nor as depleted under the Marine Mammal Protection Act. Barlow and Hanan (1995) calculate the status of harbor porpoise relative to historic carrying capacity (K) using a technique called back-projection. They calculate that the central California population (including Morro Bay, Monterey Bay, and San Francisco-Russian River stocks) could have been reduced to between 30% and 97% of K by incidental fishing mortality, depending on the choice of input parameters. They conclude that there is no practical way to reduce the range of this estimate. New information does not change this conclusion, and the status of central California harbor porpoise populations relative to their Optimum Sustainable Population (OSP) levels must be treated as unknown. Because the known human-caused mortality or serious injury (zero harbor porpoise per year) is less than the PBR (66), this stock is not considered a "strategic" stock under the MMPA, and fishery mortality can be considered insignificant and approaching zero mortality and serious injury rate. There are no known habitat issues that are presently of concern for this stock, although harbor porpoise are sensitive to disturbance by anthropogenic sound sources, such as those generated during the installation and operation of marine renewable energy facilities (Teilmann and Carstensen 2012).

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HARBOR PORPOISE (*Phocoena phocoena*): Northern California/Southern Oregon Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the Pacific, harbor porpoise are found in coastal and inland waters from Point Conception, California to Alaska and across to Kamchatka and Japan (Gaskin 1984). Harbor porpoise appear to have more restricted movements along the western coast of the continental U.S. than along the eastern coast. Regional differences in pollutant residues in harbor porpoise indicate that they do not move extensively between California, Oregon, and Washington (Calambokidis and Barlow 1991). That study also showed some regional differences within California (although the sample size was small). This pattern stands as a sharp contrast to the eastern coast of the U.S. and Canada where harbor porpoise are believed to migrate seasonally from as far south as the Carolinas to the Gulf of Maine and Bay of Fundy (Polacheck et al. 1995). A phylogeographic analysis of genetic data from northeast Pacific harbor porpoise did not show complete concordance between DNA sequence types and geographic location (Rosel 1992). However, an analysis of molecular variance (AMOVA) of the same data with additional samples found significant genetic differences for four of the six pair-wise comparisons between the four areas investigated: California, Washington, British Columbia, and Alaska (Rosel et al. 1995). These results demonstrate that harbor porpoise along the west coast of North America are not panmictic or migratory, and movement is sufficiently restricted that genetic differences have evolved. Subsequent genetic analyses of samples ranging from Monterey Bay, California to Vancouver Island, British Columbia indicate that there is small-scale subdivision within the U.S. portion of this range Chivers *et al.*, 2002, 2007).

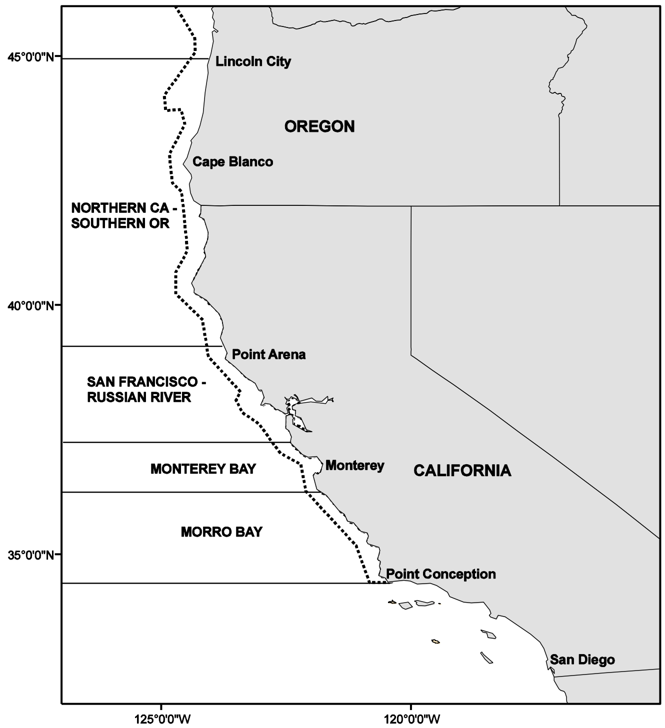

Figure 1. Stock boundaries and distributional range of harbor porpoise along the California/southern Oregon coasts. Dashed line represents harbor porpoise habitat (0-200 m) along the U.S. west coast.

In their assessment of harbor porpoise, Barlow and Hanan (1995) recommended that the animals inhabiting central California (defined to be from Point Conception to the Russian River) be treated as a separate stock. Their justifications for this were: 1) fishery mortality of harbor porpoise was limited to central California, 2) movement of individual animals appears to be restricted within California, and consequently 3) fishery mortality could cause the local depletion of harbor porpoise if central California is not managed separately. Although geographic structure exists along an almost continuous distribution of harbor porpoise from California to Alaska, stock boundaries are difficult to draw because any rigid line is (to a greater or lesser extent) arbitrary from a biological perspective. Nonetheless, failure to recognize geographic structure by defining management stocks can lead to depletion of local populations. Based on more recent genetic findings (Chivers *et al.*, 2002, 2007), California coast stocks were re-evaluated and significant genetic differences were found among four identified sampling sites. Revised stock boundaries were identified based on these genetic data and density discontinuities identified from aerial surveys (Figure 1). For the 2002 Marine Mammal Protection Act (MMPA) Stock Assessment Reports, other

Pacific coast harbor porpoise stocks include: 1) a Morro Bay stock, 2) a Monterey Bay stock, 3) a San Francisco-Russian River stock, 4) a northern Oregon/Washington coast stock, 5) an Inland Washington stock, 6) a Southeast Alaska stock, 7) a Gulf of Alaska stock, and 8) a Bering Sea stock. The stock assessment reports for harbor porpoise stocks within waters of California, Oregon, and Washington appear in this volume. The three Alaska harbor porpoise stocks are reported separately in the Stock Assessment Reports for the Alaska Region.

POPULATION SIZE

Previous estimates of abundance for California harbor porpoise were based on aerial surveys conducted between the coast and the 50-fm isobath during 1988-95 (Barlow and Forney 1994, Forney 1999). These estimates did not include an unknown number of animals found in deeper waters. Barlow (1988) found that the vast majority of harbor porpoise in California were within the 0-50-fm depth range; however, Green et al. (1992) found that 24% of harbor porpoise seen during aerial surveys of Oregon and Washington were between the 100m and 200m isobaths (55 to 109 fathoms). A systematic ship survey of depth strata out to 90 m in northern California showed that porpoise abundance declined significantly in waters deeper than 60 m (Carretta et al. 2001b). Since 1999, aerial surveys extended farther offshore (to the 200m depth contour or 15 nmi distance, whichever is farther) to provide a more complete abundance estimate. The most recent estimate of abundance for the northern California/southern Oregon stock, based on 2007-2011 aerial surveys is 35,769 (CV=0.52) harbor porpoises (Forney et al. 2013). This estimate includes a correction factor of 3.42 (1/g(0); g(0)=0.292, CV=0.366) (Laake *et al*. 1997), to adjust for groups missed by aerial observers.

Minimum Population Estimate

The minimum population estimate for harbor porpoise in northern California/southern Oregon is taken as the lower 20th percentile of the log-normal distribution of the abundance estimate obtained from 2007-2011 aerial surveys, or 23,749 animals.

Current Population Trend

The latest abundance estimate is similar to the previous 2002-2007 estimate of 39,581 harbor porpoises (see previous stock assessment reports), and no recent trend is apparent. Further analyses will be required to estimate long-term population trends from the available abundance estimates, particularly because the abundance estimates are derived using common parameters and some shared survey data.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Based on what are argued to be biological limits of the species (i.e. females give birth first at age 4 and produce one calf per year until death), the theoretical, maximum-conceivable growth rate of a closed harbor porpoise population was estimated as 9.4% per year based on a human survivorship curve (Barlow and Boveng 1991). This maximum theoretical rate represents maximum survival in a protected environment and may not be achievable for any wild population (Barlow and Boveng 1991). Woodley and Read (1991) calculate a maximum growth rate of approximately 5% per year, but their argument for this being a maximum (i.e. that porpoise survival rates cannot exceed those of Himalayan thar) is not well justified. Population growth rates have not actually been measured for any harbor porpoise population. Because a reliable estimate of the maximum net productivity rate is not available for harbor porpoise, we use the default maximum net productivity rate (R_{MAX}) of 4% for cetaceans (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (23,749) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 1.0 (for a species within its Optimal Sustainable Population; Wade and Angliss 1997), resulting in a PBR of 475.

HUMAN-CAUSED MORTALITY

Fishery Information

There were three harbor porpoise strandings in this stock's range that showed evidence of interactions with entangling net fisheries during 2007. Two of these were reported to be entangled in lost river salmon gillnet gear, while the third was an unidentified fishery interaction.

Table 1. Summary of available information on incidental mortality and injury of harbor porpoise (northern California/southern Oregon stock) in commercial fisheries that might take this species during 2007-2011. n/a indicates that data are not available.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality	Estimated Mortality (CV in parentheses)	Mean Annual Takes (CV in parentheses)
Unknown fishery	2007-2011	Stranding	n/a	3	n/a	≥0.6 (n/a)
Minimum total annual takes						≥0.6 (n/a)

STATUS OF STOCK

Harbor porpoise in northern California/southern Oregon are not listed as threatened or endangered under the Endangered Species Act nor as depleted under the Marine Mammal Protection Act. The northern California portion of this harbor porpoise stock was determined to be within their Optimum Sustainable Population (OSP) level in the mid-1990s (Barlow and Forney 1994), based on a lack of significant anthropogenic mortality. The amount of anthropogenic mortality as documented through fishery-related strandings appears to be negligible compared with the population size and the stock is still considered to be within the range of OSP. Because the known human-caused mortality or serious injury (≥0.6 harbor porpoise per year) is less than the PBR (475), this stock is not considered a "strategic" stock under the MMPA. Because average annual fishery mortality is less than 10% of the PBR, the fishery mortality can be considered insignificant and approaching zero mortality and serious injury rate. There are no known habitat issues that are presently of concern for this stock, although harbor porpoise are sensitive to disturbance by anthropogenic sound sources, such as those generated during the installation and operation of marine renewable energy facilities (Teilmann and Carstensen 2012).

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HARBOR PORPOISE (*Phocoena phocoena*): Northern Oregon/Washington Coast Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the eastern North Pacific Ocean, harbor porpoise are found in coastal and inland waters from Point Barrow, along the Alaskan coast, and down the west coast of North America to Point Conception, California (Gaskin 1984). Harbor porpoise are known to occur year-round in the inland trans-boundary waters of Washington and British Columbia, Canada (Osborne *et al*. 1988) and along the Oregon/Washington coast (Barlow 1988, Barlow *et al*. 1988, Green *et al*. 1992). Aerial survey data from coastal Oregon and Washington, collected during all seasons, suggest that harbor porpoise distribution varies by depth (Green *et al*. 1992). Although distinct seasonal changes in abundance along the west coast have been noted, and attributed to possible shifts in distribution to deeper offshore waters during late winter (Dohl *et al*. 1983, Barlow 1988), seasonal movement patterns are not fully understood.

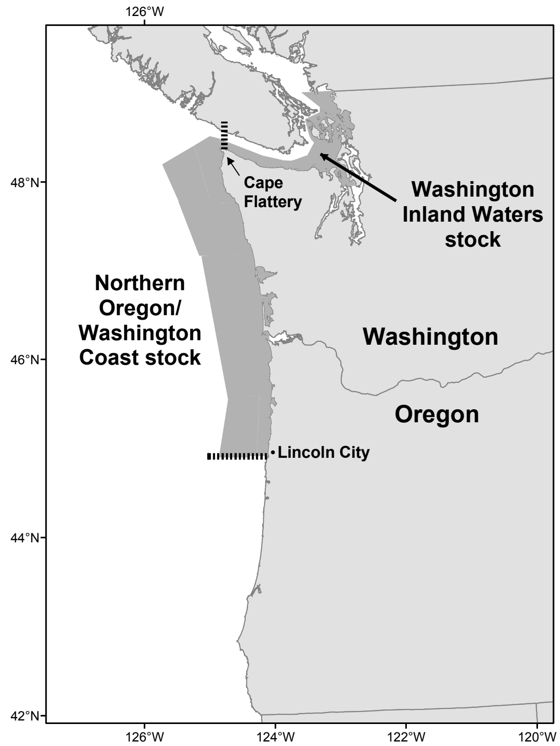

Figure 1. Stock boundaries (dashed lines) and approximate distribution (shaded areas) of harbor porpoise along the coasts of Washington and northern Oregon.

Investigation of pollutant loads in harbor porpoise ranging from California to the Canadian border suggests restricted harbor porpoise movements (Calambokidis and Barlow 1991). Stock discreteness in the eastern North Pacific was analyzed using mitochondrial DNA from samples collected along the west coast (Rosel 1992) and is summarized in Osmek *et al*. (1994). Two distinct mtDNA groupings or clades exist. One clade is present in California, Washington, British Columbia, and Alaska (no samples were available from Oregon), while the other is found only in California and Washington. Although these two clades are not geographically distinct by latitude, the results may indicate a low mixing rate for harbor porpoise along the west coast of North America. Further genetic testing of the same data, along with additional samples, found significant genetic differences for four of the six pair-wise comparisons between the four areas investigated: California, Washington, British Columbia, and Alaska (Rosel *et al*. 1995). These results demonstrate that harbor porpoise along the west coast of North America are not panmictic or migratory and that movement is sufficiently restricted that genetic differences have evolved. Recent preliminary genetic analyses of samples ranging from Monterey Bay, California, to Vancouver Island, British Columbia, indicate that there is small-scale subdivision within the U.S. portion of this range (Chivers *et al*. 2002, 2007). This is consistent with low movement suggested by genetic analysis of harbor porpoise specimens from the North Atlantic, where numerous stocks have been delineated with clinal differences over areas as small as the waters surrounding the British Isles.

Using the 1990-1991 aerial survey data of Calambokidis *et al*. (1993) for water depths <50 fathoms, Osmek *et al*. (1996) found significant differences in harbor porpoise mean densities ($Z=6.9$, $P<0.001$) between the waters of coastal Oregon/Washington and inland Washington/southern British Columbia, Canada (i.e., Strait of Juan de Fuca/San Juan Islands). Following a risk-averse management strategy, two stocks were recognized in the waters of Oregon and Washington, with a boundary at Cape Flattery, Washington. Based on recent genetic evidence, which suggests that the population of eastern

North Pacific harbor porpoise is more finely structured (Chivers *et al*. 2002, 2007), stock boundaries on the Oregon/Washington coast have been revised, resulting in three stocks in Oregon/Washington waters: a Northern California/Southern Oregon stock (Point Arena, CA, to Lincoln City, OR), a Northern Oregon/Washington Coast stock (Lincoln City, OR, to Cape Flattery, WA), and the Washington Inland Waters stock (in waters east of Cape Flattery). Additional analyses are needed to determine whether to adjust the stock boundaries for harbor porpoise in Washington inland waters (Chivers *et al*. 2007).

In their assessment of California harbor porpoise, Barlow and Hanan (1995) recommended two stocks be recognized in California, with the stock boundary at the Russian River. Based on recent genetic findings (Chivers *et al*. 2002, 2007), California coast stocks were re-evaluated and significant genetic differences were found among four identified sampling sites. Revised stock boundaries, based on these genetic data and density discontinuities identified from aerial surveys, resulted in six California/Oregon/Washington stocks where previously there had been four (e.g., Carretta *et al*. 2001): 1) the Washington Inland Waters stock, 2) the Northern Oregon/Washington Coast stock, 3) the Northern California/Southern Oregon stock, 4) the San Francisco-Russian River stock, 5) the Monterey Bay stock, and 6) the Morro Bay stock. The stock boundaries for animals that occur in northern Oregon/Washington waters are shown in Figure 1. This report considers only the Northern Oregon/Washington Coast stock. Stock assessment reports for Washington Inland Waters, Northern California/Southern Oregon, San Francisco-Russian River, Monterey Bay, and Morro Bay harbor porpoise also appear in this volume. Stock assessment reports for the three harbor porpoise stocks in the inland and coastal waters of Alaska, including 1) the Southeast Alaska stock, 2) the Gulf of Alaska stock, and 3) the Bering Sea stock, are reported separately in the Stock Assessment Reports for the Alaska Region. The harbor porpoise occurring in British Columbia have not been included in any of the U.S. stock assessment reports.

POPULATION SIZE

Two separate aerial surveys for leatherback turtles were conducted during 2010 and 2011 from the coast approximately to the 2,000 m isobath between Cape Blanco, Oregon, and Cape Flattery, Washington. Some additional adaptive surveys were conducted in areas of special interest for leatherback turtles; although these transects were not included in the analysis, the corresponding harbor porpoise sightings were included for estimation of the detection function in this study. Using a correction factor of 3.42 (1/g(0); g(0)=0.292, CV=0.366) (Laake *et al*. 1997a), to adjust for groups missed by aerial observers, the corrected estimate of abundance for harbor porpoise in the coastal waters of northern Oregon (north of Lincoln City) and Washington in 2010-2011 is 21,487 (CV = 0.44) (Forney et al. 2013).

Minimum Population Estimate

The minimum population estimate for this stock is calculated as the lower 20th percentile of the log-normal distribution (Wade and Angliss 1997) of the 2010-2011 population estimate of 21,487, which is 15,123 harbor porpoise.

Current Population Trend

There are no reliable data on population trends of harbor porpoise for coastal Oregon, Washington, or British Columbia waters; however, the uncorrected estimates of abundance for the Northern Oregon/Washington Coast stock in 1997 (6,406; SE=826.5) and 2002 (4,583) were not significantly different (Z=-1.73, P=0.08), although the survey area in 1997 (Regions I-S through III) was slightly larger than in 2002 (Strata D-G) (Laake *et al*. 1998a; J. Laake, unpublished data). The 2010-2011 Northern Oregon/Washington Coast stock estimate (21,487, CV = 0.44) is greater than the previous 2002 estimate of 15,674 (CV = 0.39), but the previous estimate is within the confidence limit of the current abundance estimate (Forney et al. 2013).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Based on what are argued to be biological limits of the species (i.e. females give birth first at age 4 and produce one calf per year until death), the theoretical, maximum-conceivable growth rate of a closed harbor porpoise population was estimated as 9.4% per year based on a human survivorship curve (Barlow and Boveng 1991). This maximum theoretical rate represents maximum survival in a protected environment and may not be achievable for any wild population (Barlow and Boveng 1991). Woodley and Read (1991) calculate a maximum growth rate of approximately 5% per year, but their argument for this being a maximum (i.e. that porpoise survival rates cannot exceed those of Himalayan thar) is not well justified. Population growth rates have not actually been measured for any harbor porpoise population. Because a reliable estimate of the maximum net productivity rate is not available for harbor porpoise, we use the default maximum net productivity rate (R_{MAX}) of 4% for cetaceans (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (15,123) times one-half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.5 (for a stock of unknown status, Wade and Angliss 1997), resulting in a PBR of 151 harbor porpoise per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Within the EEZ boundaries of the coastal waters of northern Oregon and Washington, harbor porpoise deaths are known to occur in the northern Washington marine set gillnet tribal fishery. Total fishing effort in this fishery is conducted within the range of both harbor porpoise stocks (Northern Oregon/Washington Coast and Washington Inland Waters) occurring in Washington State waters (Gearin *et al.* 1994). Some movement of harbor porpoise between Washington's coastal and inland waters is likely, but it is currently not possible to quantify the extent of such movements. For the purposes of this stock assessment report, the animals taken in waters south and west of Cape Flattery, WA, are assumed to have belonged to the Northern Oregon/Washington Coast stock, and Table 1 includes data only from that portion of the fishery. Fishing effort in the coastal marine set gillnet tribal fishery has declined since 2004. A test set gillnet fishery, with 100% observer coverage, was conducted in coastal waters in 2008 and 2011. This test fishery required the use of nets equipped with acoustic alarms, and no harbor porpoise deaths were reported (Makah Fisheries Management, unpublished data). The mean estimated mortality for this fishery in 2007-2011 is 0 (CV=0) harbor porpoise per year from observer data.

Table 1. Summary of incidental mortality and serious injury of harbor porpoise (Northern Oregon/Washington Coast stock) in commercial and tribal fisheries that might take this species and calculation of the mean annual mortality rate; n/a indicates that data are not available. Mean annual takes are based on 2007-2011 data unless noted otherwise.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean annual takes (CV in parentheses)
Northern WA marine set gillnet (tribal test fishery in coastal waters)[1]	2007 2008 2009 2010 2011	observer	no fishery 100% no fishery 100% no fishery	0 0 0 0 0	0 (0) 0 (0) 0 (0) 0 (0) 0 (0)	0 (0)
Unknown West Coast fisheries	2007-2011	stranding		2, 1, 3, 3, 6	n/a	>3.0 (n/a)
Minimum total annual takes						>3.0 (n/a)

[1]This is a tribal fishery; therefore, it is not listed in the NMFS list of commercial fisheries.

In 1995-1997, data were collected for the coastal portions (areas 4 and 4A) of the northern Washington marine set gillnet fishery as part of an experiment, conducted in cooperation with the Makah Tribe, designed to explore the merits of using acoustic alarms to reduce bycatch of harbor porpoise in salmon gillnets. Results in 1995-1996 indicated that the nets equipped with acoustic alarms had significantly lower entanglement rates, as only 2 of the 49 deaths occurred in alarmed nets (Gearin *et al.* 1996, 2000; Laake *et al.* 1997b). In 1997, 96% of the sets were equipped with acoustic alarms and 13 deaths were observed (Gearin *et al.* 2000; P. Gearin, unpublished data). Harbor porpoise were displaced by an acoustic buffer around the alarmed nets, but it is unclear whether the porpoise or their prey were repelled by the alarms (Kraus *et al.* 1997, Laake *et al.* 1998b). However, the acoustic alarms did not appear to affect the target catch (chinook salmon and sturgeon) in the fishery (Gearin *et al.* 2000). For the past decade, Makah tribal regulations have required nets set in coastal waters (areas 4 and 4A) to be equipped with acoustic alarms.

According to Northwest Marine Mammal Stranding Network records, maintained by the NMFS Northwest Region (NMFS, Northwest Regional Office, unpublished data), there were 15 fishery-related strandings of harbor porpoise from this stock reported on the northern Oregon/Washington coast in 2007-2011 (2 in 2007, 1 in 2008, 3 in 2009, 3 in 2010, and 6 in 2011), resulting in a mean annual mortality of 3.0 harbor porpoise in 2007-2011. Evidence of fishery interactions included net marks, rope marks, and knife cuts (Carretta et al. 2013). Since these deaths could not be attributed to a particular fishery, and were the only confirmed fishery-related deaths in this area in 2007-2011, they are listed in Table 1 as occurring in unknown West Coast fisheries. Seven additional strandings reported in 2007-2011 (2 in 2007, 1 in 2008, 1 in 2009 , and 3 in 2011) were considered possible fishery-related strandings but were not included in the estimate of mean annual mortality. This estimate is considered a minimum because not all stranded animals are found, reported, or examined for cause of death (via necropsy by trained personnel).

Other Mortality

A significant increase in the number of harbor porpoise strandings reported throughout Oregon and Washington in 2006 prompted the Working Group on Marine Mammal Unusual Mortality Events to declare an Unusual Mortality Event (UME) on 3 November 2006 (Huggins 2008). A total of 114 harbor porpoise strandings were reported and confirmed throughout Oregon/Washington coast and Washington inland waters in 2006 and 2007 (Huggins 2008). The cause of the UME has not been determined, and several factors, including contaminants, genetics, and environmental conditions, are still being investigated. Cause of death, determined for 48 of 81 porpoise that were examined in detail, was attributed mainly to trauma and infectious disease. Suspected or confirmed fishery interactions were the primary cause of adult/subadult traumatic injuries, while birth-related trauma was responsible for the neonate deaths. Although six of the Northern Oregon/Washington Coast harbor porpoise deaths examined as part of the UME were suspected to have been caused by fishery interactions, only two could be confirmed as fishery-related deaths; these two deaths are listed in Table 1 as occurring in unknown West Coast fisheries in 2007.

STATUS OF STOCK

Harbor porpoise are not listed as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act. Based on currently available data, the minimum annual level of total human-caused mortality and serious injury (3.0 per year) does not exceed the PBR (151). Therefore, the Northern Oregon/Washington Coast stock of harbor porpoise is not classified as "strategic." The minimum annual fishery mortality and serious injury for this stock (3.0) is not known to exceed 10% of the calculated PBR (15.1) and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate The status of this stock relative to its Optimum Sustainable Population (OSP) level and population trends is unknown.

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HARBOR PORPOISE (*Phocoena phocoena vomerina*): Washington Inland Waters Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the eastern North Pacific Ocean, harbor porpoise are found in coastal and inland waters from Point Barrow, along the Alaskan coast, and down the west coast of North America to Point Conception, California (Gaskin 1984). Harbor porpoise are known to occur year-round in the inland trans-boundary waters of Washington and British Columbia, Canada (Osborne et al. 1988), and along the Oregon/Washington coast (Barlow 1988, Barlow et al. 1988, Green et al. 1992). Aerial survey data from coastal Oregon and Washington, collected during all seasons, suggest that harbor porpoise distribution varies by depth (Green et al. 1992). Although distinct seasonal changes in abundance along the west coast have been noted, and attributed to possible shifts in distribution to deeper offshore waters during late winter (Dohl et al. 1983, Barlow 1988), seasonal movement patterns are not fully understood.

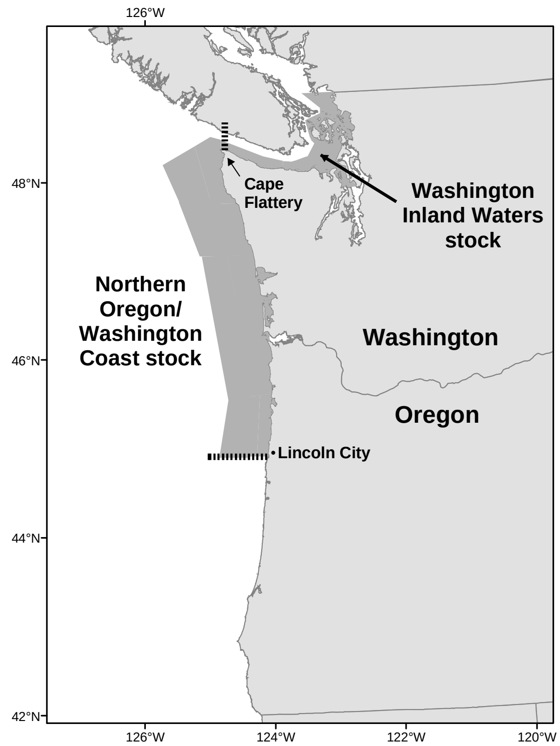

Figure 1. Stock boundaries (dashed lines) and approximate distribution (dark shaded areas) of harbor porpoise along the coasts of Washington and northern Oregon. The range of the Northern California/Southern Oregon stock of harbor porpoise (not shown), extends from Lincoln City. OR, south to Pt. Arena, CA.

Investigation of pollutant loads in harbor porpoise ranging from California to the Canadian border suggests restricted harbor porpoise movements (Calambokidis and Barlow 1991). Stock discreteness in the eastern North Pacific was analyzed using mitochondrial DNA from samples collected along the west coast (Rosel 1992) and is summarized in Osmek et al. (1994). Two distinct mtDNA groupings or clades exist. One clade is present in California, Washington, British Columbia, and Alaska (no samples were available from Oregon), while the other is found only in California and Washington. Although these two clades are not geographically distinct by latitude, the results may indicate a low mixing rate for harbor porpoise along the west coast of North America. Further genetic testing of the same data, along with additional samples, found significant genetic differences for four of the six pair-wise comparisons between the four areas investigated: California, Washington, British Columbia, and Alaska (Rosel et al. 1995). These results demonstrate that harbor porpoise along the west coast of North America are not panmictic or migratory and that movement is sufficiently restricted that genetic differences have evolved. Subsequent genetic analyses of samples ranging from Monterey Bay, California, to Vancouver Island, British Columbia, indicate that there is small-scale subdivision within the U.S. portion of this range (Chivers et al. 2002, 2007). This is consistent with low movement suggested by genetic analysis of harbor porpoise specimens from the North Atlantic, where numerous stocks have been delineated with clinal differences over areas as small as the waters surrounding the British Isles.

Using the 1990-1991 aerial survey data of Calambokidis et al. (1993) for water depths <50 fathoms, Osmek et al. (1996) found significant differences in harbor porpoise mean densities ($Z=6.9$, $P<0.001$) between the waters of coastal Oregon/Washington and inland Washington/southern British Columbia, Canada (i.e., Strait of Juan de Fuca/San Juan Islands). Following a risk averse management strategy, two stocks were recognized in the waters of Oregon and Washington, with a boundary at Cape Flattery, Washington. Based on more recent genetic evidence, which suggests that the population of eastern North Pacific harbor porpoise is more finely structured (Chivers et al. 2002, 2007), stock boundaries on the Oregon/Washington coast have been revised, resulting in three stocks in Oregon/Washington waters: a Northern California/Southern Oregon stock (Point Arena, CA, to Lincoln City, OR), a

Northern Oregon/Washington Coast stock (Lincoln City, OR, to Cape Flattery, WA), and the Washington Inland Waters stock (in waters east of Cape Flattery). Additional analyses are needed to determine whether to adjust the stock boundaries for harbor porpoise in Washington inland waters (Chivers et al. 2007).

Barlow and Hanan (1995) recommended two stocks of harbor porpoise be recognized in California, with the stock boundary at the Russian River. Based on more recent genetic findings (Chivers et al. 2002, 2007), California coast stocks were re-evaluated and significant genetic differences were found among four identified sampling sites. Revised stock boundaries, based on these genetic data and density discontinuities identified from aerial surveys, resulted in six California/Oregon/Washington stocks where previously there had been four (e.g., Carretta et al. 2001): 1) the Washington Inland Waters stock, 2) the Northern Oregon/Washington Coast stock, 3) the Northern California/Southern Oregon stock, 4) the San Francisco-Russian River stock, 5) the Monterey Bay stock, and 6) the Morro Bay stock. The stock boundaries for animals that occur in northern Oregon/Washington waters are shown in Figure 1. This report considers only the Washington Inland Waters stock. Stock assessment reports for Northern Oregon/Washington Coast, Northern California/Southern Oregon, San Francisco-Russian River, Monterey Bay, and Morro Bay harbor porpoise also appear in this volume. Stock assessment reports for the three harbor porpoise stocks in the inland and coastal waters of Alaska, including 1) the Southeast Alaska stock, 2) the Gulf of Alaska stock, and 3) the Bering Sea stock, are reported separately in the Stock Assessment Reports for the Alaska Region. The harbor porpoise occurring in British Columbia have not been included in any of the U.S. stock assessment reports.

POPULATION SIZE

Aerial surveys of the inside waters of Washington and southern British Columbia were conducted from 2013 to 2015 (Smultea *et al.* 2015a, 2015b). These aerial surveys included the Strait of Juan de Fuca, San Juan Islands, Gulf Islands, Strait of Georgia, Puget Sound, and Hood Canal. These are the waters inhabited by the Washington Inland Waters stock of harbor porpoise as well as harbor porpoise from British Columbia. Harbor porpoise abundance estimates were corrected for trackline animals missed by aerial observers using $g(0)$ from prior studies in the same area and using similar methods (Laake *et al*. 1997). For U.S. waters, the current estimate of abundance is 11,233 porpoise (CV=0.37) (Smultea *et al*. 2015a).

Minimum Population Estimate

The minimum population estimate for the Washington Inland Waters stock of harbor porpoise is calculated as the lower 20th percentile of the log-normal distribution (Wade and Angliss 1997) of the 2015 population estimate of 11,233 harbor porpoise, or 8,308 animals.

Current Population Trend

Estimates of population size for Washington Inland waters from 1990-1991 aerial surveys were 3,298 (CV=0.26) animals, corrected for diving animals not seen by observers (Calambokidis *et al.* 1993). Estimates of harbor porpoise abundance for the same region from 2013-2015 surveys (11,233; CV=0.37, Smultea *et al.* 2015a), are considerably higher, however a formal trend analysis has not been performed for this stock.

In southern Puget Sound, harbor porpoise were common in the 1940s (Scheffer and Slipp 1948), but marine mammal surveys (Everitt et al. 1980), stranding records since the early 1970s (Osmek et al. 1995), and harbor porpoise surveys in 1991 (Calambokidis et al. 1992) and 1994 (Osmek et al. 1995) indicated that harbor porpoise abundance had declined in southern Puget Sound. In 1994, a total of 769 km of vessel survey effort and 492 km of aerial survey effort conducted during favorable sighting conditions produced no sightings of harbor porpoise in southern Puget Sound. Reasons for the apparent decline are unknown, but it may have been related to fishery interactions, pollutants, vessel traffic, or other factors (Osmek et al. 1995). Annual winter aerial surveys conducted by the Washington Department of Fish and Wildlife from 1995 to 2015 revealed an increasing trend in harbor porpoise in Washington inland waters, including the return of harbor porpoise to Puget Sound. The data suggest that harbor porpoise were already present in Juan de Fuca, Georgia Straits, and the San Juan Islands from the mid-1990s to mid-2000s, and then expanded into Puget Sound and Hood Canal from the mid-2000s to 2015, areas they had used historically but abandoned. Changes in fishery-related entanglement was suspected as the cause of their previous decline and more recent recovery, including a return to Puget Sound (Evenson *et al*. 2016). Seasonal surveys conducted in spring, summer, and fall 2013-2015 in Puget Sound and Hood Canal documented substantial numbers of harbor porpoise in Puget Sound. Observed porpoise numbers were twice as high in spring as in fall or summer, indicating a seasonal shift in distribution of harbor porpoise (Smultea 2015b). The reasons for the seasonal shift and for the increase in sightings is unknown.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is not available for harbor porpoise. Therefore, until additional data become available, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% (Wade and Angliss 1997) be employed for the Washington Inland Waters harbor porpoise stock.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) for this stock is calculated as the minimum population size (8,308) times one-half the default maximum net growth rate for cetaceans (1/2 of 4%) times a recovery factor of 0.4 (for a stock of unknown status and high uncertainty in the mortality and injury estimate), resulting in a PBR of 66 harbor porpoise per year. Although no CV is available for the mortality and serious injury estimate, there is large uncertainty because the available data are limited to stranding information, which is known to have a substantial downward bias (Carretta *et al*. 2016a, Williams *et al.* 2014). For this reason, the recovery factor was set equal to the value for a stock of unknown status with mortality and serious injury CV > 0.80 (Wade and Angliss 1997).

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Fishing effort in the northern Washington marine gillnet tribal fishery is conducted within the range of both harbor porpoise stocks (Northern Oregon/Washington Coast and Washington Inland Waters) occurring in Washington State waters (Gearin et al. 1994). Some movement of harbor porpoise between Washington's coastal and inland waters is likely, but it is currently not possible to quantify the extent of such movements. For the purposes of this stock assessment report, animals taken in waters east of Cape Flattery, WA, are assumed to have belonged to the Washington Inland Waters stock. Between 2010 and 2014, no harbor porpoise deaths or serious injuries were reported in this fishery (Makah Fisheries Management, unpublished data).

Table 1. Summary of incidental mortality and serious injury of harbor porpoise (Washington Inland Waters stock) in commercial and tribal fisheries that might take this species and calculation of the mean annual mortality rate; n/a indicates that data are not available. Mean annual takes are based on 2010-2014 data unless noted otherwise.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean annual takes (CV in parentheses)
WA Puget Sound Region salmon set/drift gillnet (observer programs listed below covered segments of this fishery):						
Puget Sound non-treaty salmon gillnet (all areas and species)	1993	observer data	1.3%	0	0	see text[1]
Puget Sound non-treaty chum salmon gillnet (areas 10/11 and 12/12B)	1994	observer data	11%	0	0	see text[1]
Puget Sound treaty chum salmon gillnet (areas 12, 12B, and 12C)	1994	observer data	2.2%	0	0	see text[1]
Puget Sound treaty chum and sockeye salmon gillnet (areas 4B, 5, and 6C)	1994	observer data	7.5%	0	0	see text[1]
Puget Sound treaty and non-treaty sockeye salmon gillnet (areas 7 and 7A)	1994	observer data	7%	1	15	see text[1]
Unknown Puget Sound Region fishery	2010-2014	stranding data		2, 0, 7, 1, 2	n/a	$\geq$ 2.4 (n/a)
Minimum total annual takes						$\geq$2.4 (n/a)

[1]This fishery has not been observed since 1994 (see text); these data are not included in the calculation of recent minimum total annual takes.

Commercial salmon drift gillnet fisheries in Washington inland waters were last observed in 1993 and 1994, with observer coverage levels typically <10% (Pierce et al. 1994, 1996; NWIFC 1995; Erstad et al. 1996). Drift gillnet fishing effort in the inland waters has declined considerably since 1994 because far fewer vessels participate today (NMFS WC Region, unpublished data), but entanglements of harbor porpoise likely continue to occur. The most recent data on harbor porpoise mortality from commercial gillnet fisheries is included in Table 1.

Strandings of dead or seriously injured harbor porpoise entangled in fishing gear are another source of fishery-related mortality. There were 12 fishery-related strandings of harbor porpoise from this stock in 2010-2014 (2 in 2010, 7 in 2012, 1 in 2013, and 2 in 2014), resulting in an average annual mortality and serious injury rate of 2.4 harbor porpoise per year (Carretta *et al.* 2016b). Evidence of fishery interactions included observed entanglements, net marks, and line marks. Since these deaths could not be attributed to a particular fishery, and were the only confirmed fishery-related deaths in this area in 2010-2014, they are listed in Table 1 as occurring in an unknown Puget Sound Region fishery. There are no observed fisheries in Washington inland waters, and the estimate of human-caused mortality of harbor porpoise (2.4/yr) is based solely on stranding data, which are uncorrected for negative biases in cetacean carcass recovery (Williams *et al.* 2014). The only published carcass recovery rate for harbor porpoise (<0.01) is from an oceanic-coast habitat in the NE United States (Moore and Read 2008), but due to the confined nature of inland waterways, recovery rates in Washington State inland waters are likely higher than that estimated by Moore and Read (2008). Wells *et al*. (2015) reported a carcass recovery rate (0.33) for bottlenose dolphins that inhabit the densely populated Sarasota Bay area. If this recovery rate of 0.33 is applied to Washington Inland Waters harbor porpoise fishery-related strandings for the period 2010-2014, annual mortality would be estimated at 7.2 (12 documented fishery-related strandings, times a correction factor of 3, divided by 5 years), which is less than the PBR of 66. In the absence of a carcass recovery correction factor for Washington inland waters harbor porpoise, a minimum correction factor of 3 from the Wells *et al*. (2015) coastal bottlenose dolphin study is applied to fishery-related strandings here, resulting in an estimate of 7.2 porpoise annually. Additional data are required to estimate a carcass recovery rate for harbor porpoise in Washington inland waters.

Although commercial gillnet fisheries in Canadian waters are known to have taken harbor porpoise in the past (Barlow et al. 1994, Stacey et al. 1997), few data are available because the fisheries were not monitored. In 2001, the Department of Fisheries and Oceans, Canada, conducted a federal fisheries observer program and a survey of license holders to estimate the incidental mortality of harbor porpoise in selected salmon fisheries in southern British Columbia (Hall et al. 2002). Based on the observed bycatch of porpoise (2 harbor porpoise deaths) in the 2001 fishing season, the estimated mortality for southern British Columbia in 2001 was 20 porpoise per 810 boat days fished or a total of 80 harbor porpoise. However, it is not known how many harbor porpoise from the Washington Inland Waters stock are currently taken in the waters of southern British Columbia.

Other Mortality

A significant increase in harbor porpoise strandings reported throughout Oregon and Washington in 2006 prompted the Working Group on Marine Mammal Unusual Mortality Events to declare an Unusual Mortality Event (UME) on 3 November 2006 (Huggins 2008). A total of 114 harbor porpoise strandings were reported and confirmed along the Oregon and Washington outer coasts and Washington inland waters in 2006 and 2007 (Huggins 2008). A more recent analysis of strandings before and after the suspected UME indicates that no UME occurred (Huggins *et al*. 2015). The perceived increase in mortality was the result of multiple factors: an increase in the population of harbor porpoise, a shift of the population into Washington inland waters, and a well-established stranding network with improved response and reporting (Huggins *et al*. 2015).

STATUS OF STOCK

Harbor porpoise are not listed as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act. Based on currently available data, the minimum annual level of total human-caused mortality and serious injury (7.2) harbor porpoise per year (corrected for undetected strandings) does not exceed the PBR of 66 animals. Therefore, the Washington Inland Waters harbor porpoise stock is not classified as "strategic." The minimum annual fishery mortality and serious injury for this stock (7.2 harbor porpoise per year) exceeds 10% of PBR (6.6) and, therefore, cannot be considered to be insignificant and approaching zero mortality and serious injury rate. The status of this stock relative to its Optimum Sustainable Population (OSP) and population trends is unknown. Although harbor porpoise sightings in southern Puget Sound declined from the 1940s through the 1990s, harbor porpoise sightings have increased seasonally in this area in the last 10 years.

This stock is not recognized as "strategic," however, the current mortality rate is based on stranding data, since the Washington Puget Sound Region salmon set/drift gillnet fishery has not been observed since 1994.

Evaluation of the estimated take level is complicated by a lack of knowledge about the extent to which harbor porpoise from U.S. waters frequent the waters of British Columbia and are, therefore, subject to fishery-related mortality. It is appropriate to consider whether the current take level is different from the take level in 1994, when the fishery was last observed. No new information is available about mortality per set, but 1) fishing effort has decreased since 1994. Based on surveys conducted in between 1991/1992 and 2015 (Calambokidis *et al.* 1993, Smultea *et al.* 2015a, 2015b), the population appears to have increased, but a statistical trend analysis has not been performed with existing data. However, an increase in harbor porpoise use of southern Puget Sound in recent years is apparent (Evenson *et al*. 2016).

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DALL'S PORPOISE (*Phocoenoides dalli dalli*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Dall's porpoises are endemic to temperate waters of the North Pacific Ocean. Off the U.S. west coast, they are commonly seen in shelf, slope and offshore waters (Figure 1; Morejohn 1979). Sighting patterns from aerial and shipboard surveys conducted in California, Oregon and Washington (Green et al. 1992, 1993; Forney and Barlow 1998; Barlow 2016) suggest that north-south movement between these states occurs as oceanographic conditions change, both on seasonal and inter-annual time scales. The southern end of this population's range is not well-documented, but they are commonly seen off Southern California in winter, and during cold-water periods they probably range into Mexican waters off northern Baja California. The stock structure of eastern North Pacific Dall's porpoises is not known, but based on patterns of stock differentiation in the western North Pacific, where they have been more intensively studied, it is expected that separate stocks will emerge when data become available (Perrin and Brownell 1994). Although Dall's porpoises are not restricted to U.S. territorial waters, there are no cooperative management agreements with Mexico or Canada for fisheries which may take this species (e.g. gillnet fisheries). For the Marine Mammal Protection Act (MMPA) stock assessment reports, Dall's porpoises within the Pacific U.S. Exclusive Economic Zone are divided into two discrete, non-contiguous areas: 1) waters off California, Oregon and Washington (this report), and 2) Alaskan waters.

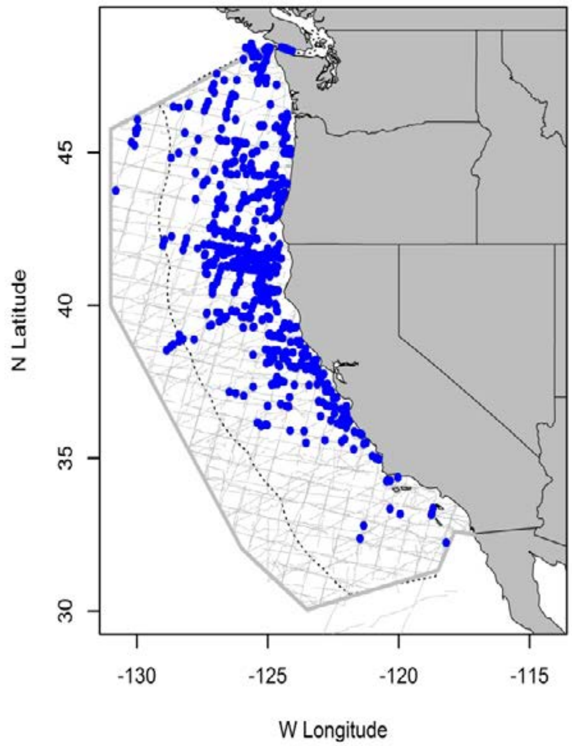

Figure 1. Dall's porpoise sightings based on shipboard surveys off California, Oregon, and Washington, 1991-2014 (Barlow 2016). Dashed line represents the U.S. EEZ, thin gray lines represent the completed transect effort of all surveys combined.

POPULATION SIZE

Dall's porpoise distribution in this region is highly variable between years and appears to be affected by oceanographic conditions (Forney 1997; Forney and Barlow 1998, Barlow 2016). Because animals may spend time outside the U.S. Exclusive Economic Zone as oceanographic conditions change, a multi-year average abundance estimate is the most appropriate for management within U.S. waters. The most recent estimate of Dall's porpoise abundance is the geometric mean of estimates from 2008 and 2014 summer/autumn vessel-based line-transect surveys of California, Oregon, and Washington waters, or 25,750 (CV=0.45) animals (Barlow 2016). This estimate includes new correction factors for animals missed during the surveys. Additional numbers of Dall's porpoises occur in the inland waters of Washington state, but the most recent abundance estimate obtained in 1996 (900 animals, CV=0.40) is over 8 years old (Calambokidis et al. 1997) and is not included in the overall estimate of abundance for this stock.

Minimum Population Estimate

The log-normal 20th percentile of the 2008-2014 average abundance estimate for the outer coast of California, Oregon and Washington waters is 17,954 Dall's porpoises.

Current Population Trend

The distribution and abundance of Dall's porpoise off California, Oregon and Washington varies considerably at both seasonal and interannual time scales (Forney and Barlow 1998, Becker *et al*. 2012, Barlow 2016), but no longterm trends have been identified.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No information on current or maximum net productivity rates is available for Dall's porpoise off the U.S. west coast.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (17,954) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.48 (for a species of unknown status and mortality rate CV between 0.3 and 0.6; Wade and Angliss 1997), resulting in a PBR of 172 Dall's porpoises per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

A summary of recent fishery mortality and injury information for this stock of Dall's porpoises is given in Table 1. More detailed information on these fisheries is provided in Appendix 1. The estimate of mortality and serious injury for Dall's porpoise in the California drift gillnet fishery for the five most recent years of monitoring, 2010-2014, averages 0.3 animals per year (Carretta *et al*. 2017). Although Dall's porpoises have been incidentally killed in West Coast groundfish fisheries in the past, no takes of this species were observed during the five most recent years for which data are available, 2009-2013 (Jannot et al. 2011; NWFSC unpublished data). Gillnets have been documented to entangle marine mammals off Baja California (Sosa-Nishizaki et al. 1993), where Dall's porpoise may occasionally be found, but no recent bycatch data from Mexico are available.

Table 1. Summary of available information on the incidental mortality and serious injury of Dall's porpoises (California/ Oregon/Washington Stock) in commercial fisheries that might take this species (Carretta *et al*. 2017; Jannot *et al*. 2011). All observed entanglements of Dall's porpoises resulted in the death of the animal. Coefficients of variation for mortality estimates are provided in parentheses; n/a = not available. Mean annual takes are based on 2010-2014 data for the CA/OR swordfish drift gillnet fishery and 2005-2009 for groundfish fisheries.

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality	Estimated Annual Mortality (CV)	Mean Annual Takes (CV)
CA/OR thresher shark/swordfish drift gillnet fishery	observer	2010 2011 2012 2013 2014	12% 20% 19% 37% 24%	0 0 0 0 1	0 0 0 0.2 (2.3) 1.1 (0.29)	0.3 (0.53)
WA/OR/CA groundfish (bottom trawl)[a]	observer	2009-2013	23% (2009) 18% (2010) 100% (2011-2013)	0	0	0

WA/OR/CA groundfish (midwater trawl - at-sea hake sector)	observer	2009-2013	100%	0	0	0
WA/OR/CA groundfish (midwater trawl - shoreside hake sector)[b]	observer	2011-2013	100%	0	0	0
Minimum total annual takes						0.3 (0.53)

[a]The bottom trawl fishery was a limited entry fishery in 2010 and a catch shares fishery in 2011-2013.
[b]Fishery observers began monitoring the shoreside hake sector of the fishery in 2011.

STATUS OF STOCK

The status of Dall's porpoises in California, Oregon and Washington relative to OSP is not known, and there are insufficient data to evaluate potential trends in abundance. No habitat issues are known to be of concern for this species. It is not listed as "threatened" or "endangered" under the Endangered Species Act nor as "depleted" under the MMPA. The average annual human-caused mortality of Dall's porpoise (0.3 animals) is estimated to be less than the PBR (172), and they are not classified as a "strategic" stock under the MMPA. The total fishery mortality and serious injury for this stock is less than 10% of the calculated PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate.

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PACIFIC WHITE-SIDED DOLPHIN (*Lagenorhynchus obliquidens*): California/Oregon/Washington, Northern and Southern Stocks

STOCK DEFINITION AND GEOGRAPHIC RANGE

Pacific white-sided dolphins are endemic to temperate waters of the North Pacific Ocean, and common both on the high seas and along the continental margins (Brownell et al. 1999). Off the U.S. west coast, Pacific white-sided dolphins occur primarily in shelf and slope waters (Figure 1). Sighting patterns from aerial and shipboard surveys conducted in California, Oregon and Washington (Green et al. 1992; 1993; Forney and Barlow 1998; Barlow 2016) suggest seasonal north-south movements, with animals found primarily off California during the colder water months and shifting northward into Oregon and Washington as water temperatures increase in late spring and summer.

Stock structure throughout the North Pacific is poorly understood, but based on morphological evidence, two forms are known off the California coast (Walker et al. 1986). Specimens belonging to the northern form were collected from north of about 33ºN, (Southern California to Alaska), and southern specimens were obtained from about 36ºN southward along the coasts of California and Baja California. Samples of both forms have been collected in the Southern California Bight, but it is unclear whether this indicates sympatry in this region or whether they may occur there at different times (seasonally or interannually). Genetic analyses have confirmed the distinctness of animals found off Baja California from animals occurring in U.S. waters north of Point Conception, California and the high seas of the North Pacific (Lux et al. 1997). Based on these genetic data, an area of mixing between the two forms appears to be located off Southern California (Lux et al. 1997). Two types of echolocation have been documented for Pacific white-sided dolphins off Southern California and these have been hypothesized to reflect acoustic differences between the two forms (Soldevilla et al. 2008, 2011; Henderson et al. 2011).

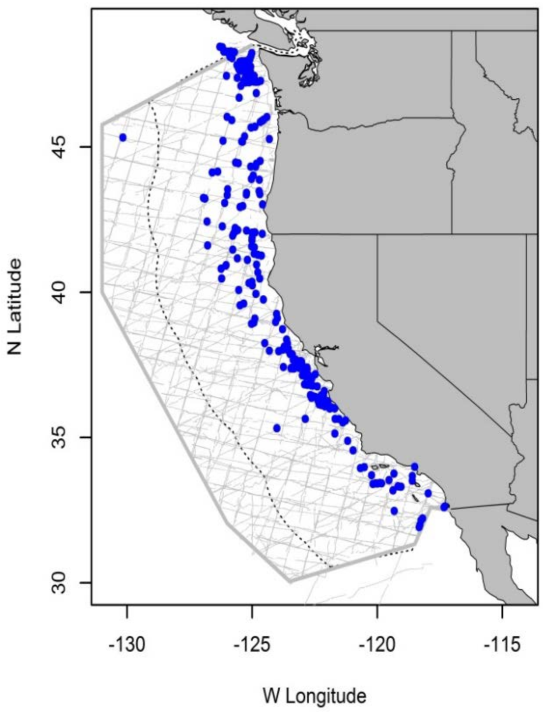

Figure 1. Pacific white-sided dolphin sightings based on shipboard surveys off California, Oregon, and Washington, 1991-2014 (Barlow 2016). Dashed line represents the U.S. EEZ, thin gray lines indicate completed transect effort of all surveys combined.

Although there is clear evidence that two forms of Pacific white-sided dolphins occur along the U.S. west coast, there are no known differences in color pattern, and it is not currently possible to distinguish the two stocks reliably during surveys. Geographic stock boundaries appear dynamic and are poorly understood, and therefore cannot be used to differentiate the two forms. Until means of differentiating the two forms for abundance and mortality estimation are developed, these two stocks are managed as a single unit. Pacific white-sided dolphins are not restricted to U.S. territorial waters, but there are no cooperative management agreements with Mexico or Canada for fisheries which may take this species (e.g. gillnet fisheries). For the Marine Mammal Protection Act (MMPA) stock assessment reports, Pacific white-sided dolphins within the Pacific U.S. Exclusive Economic Zone are divided into two discrete, non-contiguous areas: 1) waters off California, Oregon and Washington (this report), and 2) Alaskan waters.

POPULATION SIZE

The distribution of Pacific white-sided dolphins throughout this region is highly variable, apparently in response to oceanographic changes on both seasonal and interannual time scales (Forney and Barlow 1998, Barlow 2016). As oceanographic conditions vary, Pacific white-sided dolphins may spend time outside the U.S. Exclusive Economic Zone, and therefore a multi-year average abundance estimate including California, Oregon and Washington is the most appropriate for management within U.S. waters. The most recent estimate of Pacific white-sided dolphin abundance is the geometric mean of estimates from 2008 and 2014 summer/autumn vessel-based line-transect surveys of California, Oregon, and Washington waters, 26,814 (CV=0.28) animals (Barlow 2016). This estimate includes new correction factors for animals missed during the surveys.

Minimum Population Estimate

The log-normal 20th percentile of the 2008-2014 average abundance estimate is 21,195 Pacific white-sided dolphins.

Current Population Trend

The distribution and abundance of Pacific white-sided dolphins off California, Oregon and Washington varies considerably at both seasonal and interannual time scales (Forney and Barlow 1998, Becker et al. 2012, Barlow 2016), but no long-term trends have been identified.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No information on current or maximum net productivity rates is available for Pacific white-sided dolphins off the U.S. west coast.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (21,195) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.45 (for a species of unknown status with a mortality rate CV between 0.6 and 0.8; Wade and Angliss 1997), resulting in a PBR of 191 Pacific white-sided dolphins per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

A summary of recent fishery mortality and injury information for this stock of Pacific white-sided dolphin is shown in Table 1. More detailed information on these fisheries is provided in Appendix 1. The estimate of mortality and serious injury for Pacific white-sided dolphin in the California drift gillnet fishery for the five most recent years of monitoring, 2010-2014, is 1.1 animals (CV=0.97) per year (Carretta *et al*. 2017). Although some Pacific-white sided dolphins have been incidentally killed in West Coast groundfish fisheries in the past, no takes of this species were observed during 2009-2013 (Jannot et al. 2011, NWFSC unpublished data). Gillnets have been documented to entangle marine mammals off Baja California (Sosa-Nishizaki et al. 1993), but no recent bycatch data from Mexico are available.

Table 1. Summary of available information on the incidental mortality and injury of Pacific white-sided dolphins (California/ Oregon/Washington Stock) in commercial fisheries that might take this species (Carretta *et al*. 2017; Jannot *et al*. 2011). All observed entanglements of Pacific white-sided dolphins resulted in the death of the animal. Coefficients of variation for mortality estimates are provided in parentheses; n/a = not available. Mean annual takes are based on 2010-2014 data unless noted otherwise.

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality	Estimated Annual Mortality	Mean Annual Takes (CV in parentheses)
CA/OR thresher shark/swordfish drift gillnet fishery	observer	2010	12%	0	1.3 (2.5)	1.1 (0.97)
		2011	20%	0	1.4 (2)	
		2012	19%	0	0.8 (2.2)	
		2013	37%	0	0.9 (1.5)	
		2014	24%	0	0.9 (2)	

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality	Estimated Annual Mortality	Mean Annual Takes (CV in parentheses)
WA/OR/CA groundfish (bottom trawl)	observer	2009-2013	23% (2009) 18% (2010) 100% (2011-2013)	0	0	0
WA/OR/CA groundfish (midwater trawl - at-sea hake sector)	observer	2009-2013	100%	0	0	0
WA/OR/CA groundfish (midwater trawl - shoreside hake sector)	observer	2011-2013	100%	0	0	0
Minimum total annual takes						1.1 (0.97)

Other removals

Pacific white-sided dolphins have been seriously injured and killed in scientific research trawls for sardines and rockfish. From 2010 through 2014, there were 26 deaths and 2 serious injuries of Pacific white-sided dolphins in scientific research trawls, or an average of 5.6 annually (Carretta *et al*. 2016a). One Pacific white-sided dolphin stranded dead in Washington Inland waters during 2014, and the cause of death was determined to be a vessel strike (Carretta *et al*. 2016a). Human-caused mortality and injury documentation is often based on stranding data, where raw counts are negatively-biased because only a fraction of carcasses are detected. Carretta et al. (2016b) estimated the mean recovery rate of California coastal bottlenose dolphin carcasses to be 25% (95% CI 20% - 33%) and stated that given the extremely coastal habits of coastal bottlenose dolphins, carcass recovery rates for this stock represented a maximum, compared with more pelagic dolphin species in the region. Therefore, in this stock assessment report and others involving dolphins along the U.S. West Coast, human-related deaths and injuries counted from beach strandings along the outer U.S. West Coast are multiplied by a factor of 4 to account for the non-detection of most carcasses (Carretta et al. 2016b). Applying this correction factor to the one stranded Pacific white-sided dolphin yields a minimum estimate of 4 vessel strike-related deaths during 2010-2014, or 0.8 animals annually. The average annual mortality and serious injury of Pacific white-sided dolphin from other anthropogenic activities during 2010-2014 is 5.6 (research takes), plus 0.8 animals (vessel strikes, corrected for undetected carcasses), or 6.4 animals per year.

STATUS OF STOCK

The status of Pacific white-sided dolphins in California, Oregon and Washington relative to OSP is not known, and there is no indication of a trend in abundance for this stock. No habitat issues are known to be of concern for this species. They are not listed as "threatened" or "endangered" under the Endangered Species Act nor as "depleted" under the MMPA. The average annual human-caused mortality and serious injury from fisheries (1.1 animals), plus other anthropogenic sources (6.4) during 2010-2014 7.5 is estimated to be less than the PBR (191), and therefore this stock of Pacific white-sided dolphins is not classified as a "strategic" stock under the MMPA. The total commercial fishery mortality and serious injury for this stock (1.1/yr) is less than 10% of the calculated PBR and, therefore, is considered to be insignificant and approaching zero.

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RISSO'S DOLPHIN (*Grampus griseus*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Risso's dolphins are distributed world-wide in tropical and warm-temperate waters. Off the U.S. West coast, Risso's dolphins are commonly seen on the shelf in the Southern California Bight and in slope and offshore waters of California, Oregon and Washington. Based on sighting patterns from recent aerial and shipboard surveys conducted in these three states during different seasons (Figure 1), animals found off California during the colder water months are thought to shift northward into Oregon and Washington as water temperatures increase in late spring and summer (Green et al. 1992, 1993). The southern end of this population's range is not well-documented, but previous surveys have shown a conspicuous 500 nmi distributional gap between these animals and Risso's dolphins sighted south of Baja California and in the Gulf of California (Mangels and Gerrodette 1994). Thus this population appears distinct from animals found in the eastern tropical Pacific and the Gulf of California. Although Risso's dolphins are not restricted to U.S. waters, cooperative management agreements with Mexico exist only for the tuna purse seine fishery and not for other fisheries which may take this species (e.g. gillnet fisheries). For the Marine Mammal Protection Act (MMPA) stock assessment reports, Risso's dolphins within the Pacific U.S. Exclusive Economic Zone are divided into two discrete, non-contiguous areas: 1) waters off California, Oregon and Washington (this report), and 2) Hawaiian waters.

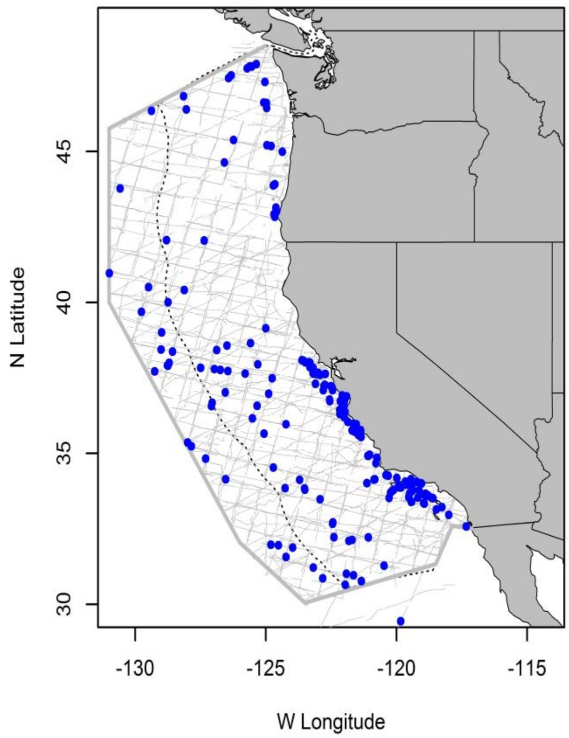

Figure 1. Risso’s dolphin sightings based on shipboard surveys off California, Oregon, and Washington, 1991-2014 (Barlow 2016). Dashed line represents the U.S. EEZ, thin gray lines indicate completed transect effort of all surveys combined.

POPULATION SIZE

The distribution of Risso’s dolphins throughout this region is highly variable, apparently in response to oceanographic changes on both seasonal and interannual time scales (Forney and Barlow 1998). As oceanographic conditions vary, Risso’s dolphins may spend time outside the U.S. Exclusive Economic Zone, and therefore a multi-year average abundance estimate is the most appropriate for management within U.S. waters. The most recent estimate of Risso’s dolphin abundance is the geometric mean of estimates from 2008 and 2014 summer/autumn vessel-based line-transect surveys of California, Oregon, and Washington waters, 6,336 (CV=0.32) animals (Barlow 2016). This estimate includes new correction factors for animals missed during the surveys.

Minimum Population Estimate

The log-normal 20th percentile of the 2008-2014 geometric mean abundance estimate is 4,817 Risso's dolphins.

Current Population Trend

The distribution and abundance of Risso's dolphins off California, Oregon and Washington varies considerably at both seasonal and interannual time scales (Forney and Barlow 1998, Becker *et al*. 2012, Barlow 2016), but no long-term trends have been identified.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No information on current or maximum net productivity rates is available for this stock.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (4,817) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.48 (for a species of unknown status with a mortality rate CV between 0.3 and 0.6; Wade and Angliss 1997), resulting in a PBR of 46 Risso's dolphins per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

A summary of recent fishery mortality and injury information for this stock of Risso's dolphin is shown in Table 1. More detailed information on these fisheries is provided in Appendix 1. The estimate of mortality and serious injury for Risso's dolphin in the California drift gillnet fishery for the five most recent years of monitoring, 2010-2014, is an average of 1.3 per year (Carretta *et al*. 2017, Table 1). Although some Risso's dolphins have been incidentally killed in West Coast groundfish fisheries in the past, no takes of this species were observed during 2009-2013 (Jannot *et al*. 2011, NWFSC unpublished data). Gillnets have been documented to entangle marine mammals off Baja California (Sosa-Nishizaki *et al*. 1993), but no recent bycatch data from Mexico are available.

Historically, Risso's dolphin mortality has been documented in the squid purse seine fishery off Southern California (Heyning et al. 1994). This mortality probably represented animals killed intentionally to protect catch or gear, rather than incidental mortality, and such intentional takes are now illegal under the 1994 Amendment to the MMPA. This fishery has expanded markedly since 1992 (California Department of Fish and Game, unpubl. data). An observer program in the squid purse seine fishery from 2004-2008 observed 377 sets (<10%) without an observed Risso's dolphin interaction.

Human-caused mortality and injury documentation is often based on stranding data, where raw counts are negatively-biased because only a fraction of carcasses are detected (Carretta *et al*. 2016a). Carretta *et al.* (2016b) estimated the mean recovery rate of California coastal bottlenose dolphin carcasses to be 25% (95% CI 20% - 33%) and stated that given the extremely coastal habits of coastal bottlenose dolphins, carcass recovery rates for this stock represented a maximum, compared with more pelagic dolphin species in the region. Therefore, in this stock assessment report and others involving dolphins along the U.S. West Coast, human-related deaths and injuries counted from beach strandings along the outer U.S. West Coast are multiplied by a factor of 4 to account for the non-detection of most carcasses (Carretta *et al*. 2016b). Three Risso's dolphins stranded during 2010-2014 with evidence of fishery interaction (Carretta *et al*. 2016a), yielding a minimum estimate of 12 fishery-related dolphin deaths.

Table 1. Summary of available information on the incidental mortality and serious injury of Risso's dolphin (California/ Oregon/Washington Stock) in commercial fisheries that might take this species (Carretta *et al*. 2016b, 2017; Jannot *et al*. 2011; NWFSC, unpublished data). All observed entanglements of Risso's dolphins resulted in the death of the animal. Human-caused mortality values based on strandings recovered along the outer U.S. West Coast are multiplied by a correction factor of 4 to account for undetected mortality (Carretta *et al*. 2016a). Coefficients of variation for mortality estimates are provided in parentheses; n/a = not available.

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality	Estimated AnnualMortality (CV)	Mean Annual Takes (CV)
CA/OR thresher shark/swordfish drift gillnet fishery	observer	2010	12%	0	1.5 (2.5)	1.3 (0.93)
		2011	20%	1	2.8 (1.3)	
		2012	19%	0	0.8 (2.8)	
		2013	37%	0	0.9 (1.9)	
		2014	24%	0	0.7 (2.8)	

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality	Estimated AnnualMortality (CV)	Mean Annual Takes (CV)
CA deep set longline fishery	observer	2005-2008	100%	0	0	0
Market squid purse seine	observer	2004-2008	<10%	0	0	0
Unknown fishery	Stranding	2007-2013	n/a	3	≥ 12	≥2.4 (0.46)[1]
WA/OR/CA groundfish (bottom trawl)[a]	observer	2009-2013	23% (2009) 18% (2010) 100% (2011-2013)	0	0	0
Minimum total annual takes (includes correction for unobserved beach strandings)						≥ 3.7 (0.44)

STATUS OF STOCK

The status of Risso's dolphins off California, Oregon and Washington relative to OSP is not known, and there are insufficient data to evaluate potential trends in abundance. No habitat issues are known to be of concern for this species. They are not listed as "threatened" or "endangered" under the Endangered Species Act nor as "depleted" under the MMPA. Over the last 5-year period (2010-2014), the average annual human-caused mortality (3.7 animals) is estimated to be less than the PBR (46), and therefore they are not classified as a "strategic" stock under the MMPA. The total fishery mortality and serious injury for this stock (3.7) is less than 10% of the calculated PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate.

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[1] The coefficient of variation (CV) for corrected carcass counts was derived from the results of Carretta *et al*. (2016b), who estimated that 25% (95% CI = 20% - 33%) of all available carcasses were recovered / documented.

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Revised 2/9/2017

COMMON BOTTLENOSE DOLPHIN (*Tursiops truncatus*): California Coastal Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Bottlenose dolphins are distributed world-wide in tropical and warm-temperate waters. In many regions, including California, separate coastal and offshore populations are known (Walker 1981; Ross and Cockcroft 1990; Van Waerebeek et al. 1990). The California coastal stock of bottlenose dolphins is distinct from the offshore stock, based on significant differences in genetics and cranial morphology (Perrin et al. 2011, Lowther-Thielking *et al*. 2015). Of 56 haplotypes found among coastal and offshore bottlenose dolphins in the region, only one is shared by both populations (Perrin et al. 2011). California coastal bottlenose dolphins are found within about one kilometer of shore (Hansen, 1990; Carretta et al. 1998; Defran and Weller 1999) from central California south into Mexican waters, at least as far south as San Quintin, Mexico (Figure 1). In southern California, animals are found within 500 m of the shoreline 99% of the time and within 250 m 90% of the time (Hanson and Defran 1993). Oceanographic events appear to influence the distribution of animals along the coasts of California and Baja California, Mexico, as indicated by a change in residency patterns along Southern California and a northward range extension into central California after the 1982-83 El Niño (Hansen and Defran 1990; Wells et al. 1990). Since the 1982-83 El Niño, which increased water temperatures off California, they have been consistently sighted in central California as far north as San Francisco. Photo-identification studies have documented north-south movements of coastal bottlenose dolphins (Hansen 1990; Defran et al. 1999), and monthly counts based on surveys between the U.S./Mexican border and Point Conception are variable (Carretta et al. 1998), indicating that animals are moving into and out of this area. There is little site fidelity of coastal bottlenose dolphins along the California coast; over 80% of the dolphins identified in Santa Barbara, Monterey, and Ensenada have also been identified off San Diego (Defran et al. 1999, Feinholz 1996, Defran *et al.* 2015). The area between Ensenada and San Quintin, Mexico may represent a southern boundary for the California coastal population, as very low rates of photo-ID overlap of individuals (3%) have been found between the two areas, compared to higher overlap rates to the north (Defran *et al.* 2015, Figure 1). Although coastal bottlenose dolphins are not restricted to U.S. waters, cooperative management agreements with Mexico exist only for the tuna purse seine fishery and not for other fisheries which may take this species. Therefore, the management stock includes only animals found within U.S. waters. For the Marine Mammal Protection Act (MMPA) stock assessment reports, bottlenose dolphins within the Pacific U.S. Exclusive Economic Zone are divided into seven stocks: 1) California coastal stock (this report), 2) California, Oregon and Washington offshore stock, and five stocks in Hawaiian waters: 3) Kauai/Niihau, 4) Oahu, 5) 4-Islands (Molokai, Lanai, Maui, Kahoolawe), 6) Hawaii Island and 7) the Hawaiian Pelagic Stock.

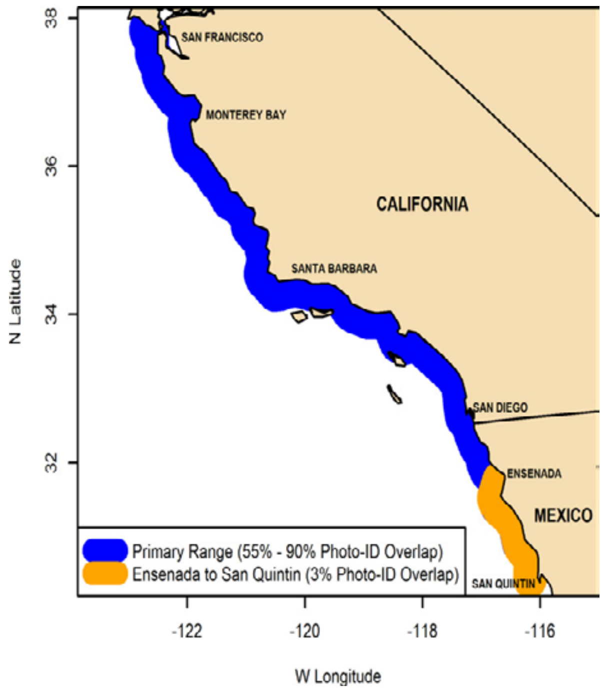

Figure 1. Approximate range of California coastal bottlenose dolphins, based on aerial and boat-based sighting surveys. This population of bottlenose dolphins is found within about 1 km of shore.

POPULATION SIZE

Based on photographic mark-recapture surveys conducted along the San Diego coast from 2009 to 2011 (Weller *et al*. 2016), two separate population size estimates were generated from open and closed mark-recapture models. The best open model generated an estimate of 515 (95% CI = 470–564, CV= 0.05) animals, while the best closed model produced an estimate of 453 (95% CI = 411–524, CV=0.06) animals. These estimates are for *marked animals only* and do not include an estimated ~ 40% of animals that are not individually recognizable (Weller *et al.* 2016). The estimated fraction of unmarked animals is highly uncertain because it is unknown how often unmarked animals are resighted. The new estimates are the largest obtained for this stock, dating back to the 1980s (Defran and Weller 1999, Dudzik 1999, Dudzik *et al.* 2006). For comparison with previous estimates of this stock, the closed population estimate of 453 (CV=0.06) animals is used as the best estimate of abundance.

Minimum Population Estimate

The minimum population size is based on the minimum number of individually identifiable animals documented during surveys in 2009-2011, or 346 animals (Weller *et al.* 2016). This number of individually recognizable dolphins exceeds the number recorded in previous survey periods: 1984-1986 (160 dolphins); 1987-1989 (284); 1996-1998 (260); and 2004-2005 (164) (Weller *et al.* 2016).

Current Population Trend

Based on a comparison of mark-recapture abundance estimates for the periods 1987-89 ($\hat{N}$= 354), 1996-98 ($\hat{N}$= 356), and 2004-05 ($\hat{N}$= 323), Dudzik et al. (2006) stated that the population size had remained stable over this period. New estimates of 450 – 515 animals based on 2009-2011 surveys are the highest to date and include a high proportion (~75%) of previously uncatalogued dolphins (Weller *et al.* 2016). The number of individually-identifiable animals from 2009-2011 surveys (346) is equal to or exceeds previous mark-recapture *abundance estimates* for this stock. This suggests that the population may be growing, although the movement of dolphins north from Mexican waters may also contribute to the observed increase in unique individuals.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No information on current or maximum net productivity rates is available for California coastal bottlenose dolphins.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (346) <u>times</u> one half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> a recovery factor of 0.48 (for a species of unknown status with mortality rate CV ≥ 0.3 and ≤ 0.6; Wade and Angliss 1997), resulting in a PBR of 3.3 coastal bottlenose dolphins per year. Not all California coastal bottlenose dolphins are present in U.S. waters at any given moment and approximately 18% of the stock's range occurs in Mexican waters. Thus, the PBR is prorated by a minimum factor of 0.82 to account for time that animals spend outside of U.S. waters. Without additional data on the residence times of dolphins in Mexican waters, this factor cannot be improved upon. Because this stock spends some of its time outside the U.S. EEZ, the PBR allocation for U.S. waters is 3.3 x 0.82 = 2.7 dolphins per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Due to its exclusive use of coastal habitats, this bottlenose dolphin population is susceptible to fishery-related mortality in coastal gillnet fisheries, such as the halibut and yellowtail set gillnet fishery, which was responsible for one documented coastal bottlenose dolphin death in 2003. Observer coverage in this fishery from 2010-2014 has been 9% (806 observed sets from an estimated 8,654 sets fished), with no observations of coastal bottlenose dolphin entanglements. Between 2010 and 2014, there were two fishery-related deaths of coastal bottlenose dolphins (stock ID confirmed via genetics, Lowther-Thielking *et al.* 2015). Both animals had evidence of entanglement with rope of unknown origin. A summary of information on fishery mortality and injury for this stock of bottlenose dolphin is shown in Table 1. Coastal gillnet fisheries exist in Mexico and may take animals from this population, but no details are available.

Human-caused mortality and injury documentation is often based on stranding data, where raw counts are negatively-biased because only a fraction of carcasses are detected (Williams *et al.* 2011), even for extremely coastal species (Wells *et al.* 2015). Carretta *et al.* (2016b) estimated the mean recovery rate of carcasses of California coastal bottlenose dolphins to be 25% (95% CI 20% - 33%). Given the extremely coastal habits of California coastal bottlenose dolphins, Carretta *et al.* (2016b) argue that carcass recovery rates for this population represent a maximum rate, compared to more pelagic dolphin species in the region. Therefore, in this stock assessment report and others involving dolphins along the U.S. west coast, human-related deaths and injuries counted from beach strandings are multiplied by a factor of 4 to account for the non-detection of most carcasses (Carretta *et al*. 2016b).

Other removals

Seven coastal bottlenose dolphins were collected during the late 1950s in the vicinity of San Diego (Norris and Prescott 1961). Twenty-seven additional bottlenose dolphins were captured off California between 1966 and 1982 (Walker 1975; Reeves and Leatherwood 1984), but based on the locations of capture activities, these animals probably were offshore bottlenose dolphins (Walker 1975). No additional captures of coastal bottlenose dolphins have been documented since 1982, and no live-capture permits are currently active for this species.

In 2012, a coastal bottlenose dolphin (stock ID confirmed via genetics) was found floating under a U.S. Navy marine mammal program dolphin pen enclosure dock and was assumed to have become entangled in the net curtain (Carretta *et al.* 2016a). Another, presumed coastal bottlenose dolphin (based on proximity to shore) became entrapped and drowned in a sea otter research net in 2012. The average annual non-fishery related mortality and serious injury of coastal bottlenose dolphins from 2010-2014 is 0.4 animals (2 animals / 5 years).

Table 1. Summary of available information on the incidental mortality and serious injury of bottlenose dolphins (California Coastal Stock) in commercial fisheries that might take this species. Human-caused mortality values based on strandings recovered on the outer U.S. West Coast are multiplied by a correction factor of 4 to account for undetected mortality (Carretta *et al*. 2016b).

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality	Estimated Annual Mortality	Mean Annual Takes (CV in parentheses)
CA angel shark/ halibut and other species large mesh (>3.5in) set gillnet fishery	observer	2010-2014	9%	0	0	0
Unknown fishery	stranding	2010-2014	Two strandings with evidence of entanglement in rope or braided material.			≥ 0.4 x 4 (correction factor) = 1.6 (0.46)[1]
Minimum total annual takes (includes correction for unobserved beach strandings)						≥ 1.6 (0.46)

STATUS OF STOCK

The status of coastal bottlenose dolphins in California relative to OSP is not known, and there is no evidence of a trend in abundance. They are not listed as "threatened" or "endangered" under the Endangered Species Act nor as "depleted" under the MMPA. Coastal bottlenose dolphins are not classified as a "strategic" stock under the MMPA because total annual fishery (1.6) and other anthropogenic mortality (0.4) and serious injury for this stock (≥ 2.0 per year) is less than the PBR (2.7). The total human-caused mortality and serious injury for this stock is not less than 10% of the calculated PBR and, therefore, cannot be considered to be insignificant and approaching zero. Recent population size estimates of 450 to 515 marked individuals are the highest recorded to date (Weller *et al.* 2016), but it is unknown how much of this increase is due to population growth versus immigration.

Habitat Issues

Pollutant levels, especially DDT residues, found in Southern California coastal bottlenose dolphins have been found to be among the highest of any cetacean examined (O'Shea et al. 1980; Schafer et al. 1984). Although the effects of pollutants on cetaceans are not well understood, they may affect reproduction or make the animals more prone to other mortality factors (Britt and Howard 1983; O'Shea et al. 1999). This population of bottlenose dolphins may also be vulnerable to the effects of morbillivirus

[1] The coefficient of variation (CV) for corrected carcass counts was derived from the results of Carretta *et al*. (2016b), who estimated that 25% (95% CI = 20% - 33%) of all available carcasses were recovered / documented.

outbreaks, which were implicated in the 1987-88 mass mortality of bottlenose dolphins on the U.S. Atlantic coast (Lipscomb et al. 1994).

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Revised 2/7/2017

COMMON BOTTLENOSE DOLPHIN (*Tursiops truncatus truncatus*): California/Oregon/Washington Offshore Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Bottlenose dolphins are distributed world-wide in tropical and warm-temperate waters. In many regions, including California, separate coastal and offshore populations are known (Walker 1981; Ross and Cockcroft 1990; Van Waerebeek et al. 1990; Lowther 2006). On surveys conducted off California, offshore bottlenose dolphins have been found at distances greater than a few kilometers from the mainland and throughout the Southern California Bight. They have also been documented in offshore waters as far north as about 41ºN (Figure 1), and they may range into Oregon and Washington waters during warm-water periods. Sighting records off California and Baja California (Lee 1993; Mangels and Gerrodette 1994) suggest that offshore bottlenose dolphins have a continuous distribution in these two regions. There is no apparent seasonality in distribution (Forney and Barlow 1998). Offshore bottlenose dolphins are not restricted to U.S. waters, but cooperative management agreements with Mexico exist only for the tuna purse seine fishery and not for other fisheries which may take this species (e.g. gillnet fisheries). Therefore, the management stock includes only animals found within U.S. waters. For the Marine Mammal Protection Act (MMPA) stock assessment reports, bottlenose dolphins within the Pacific U.S. Exclusive Economic Zone are divided into seven stocks: 1) California coastal stock, 2) California, Oregon and Washington offshore stock (this report), and five stocks in Hawaiian waters: 3) Kauai/Niihau, 4) Oahu, 5) 4-Islands (Molokai, Lanai, Maui, Kahoolawe), 6) Hawaii Island and 7) the Hawaiian Pelagic Stock.

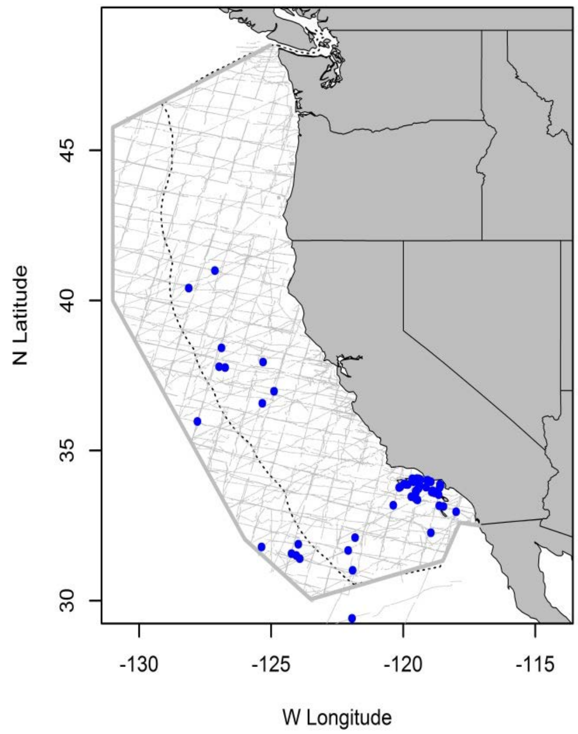

Figure 1. Offshore bottlenose dolphin sightings based on shipboard surveys off California, Oregon, and Washington, 1991-2014 (Barlow 2016). Dashed line represents the U.S. EEZ, thin gray lines indicate completed transect effort of all surveys combined.

POPULATION SIZE

The most recent estimate of bottlenose dolphin abundance is the geometric mean of estimates from 2008 and 2014 summer/autumn vessel-based line-transect surveys of California, Oregon, and Washington waters, 1,924 (CV=0.54) animals (Barlow 2016). This estimate includes new correction factors for animals missed during the surveys.

Minimum Population Estimate

The log-normal 20th percentile of the 2008-2014 geometric mean abundance estimate is 1,255 offshore bottlenose dolphins.

Current Population Trend

Trend analyses for this stock have not been performed to date, while other stocks with more urgent conservation concerns are analyzed (e.g., Moore and Barlow 2011, 2013).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No information on current or maximum net productivity rates is available for this population of offshore bottlenose dolphins.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (1,255) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.45 (for a species of unknown status with fishery mortality CV between 0.6 and 0.8; Wade and Angliss 1997), resulting in a PBR of 11 offshore bottlenose dolphins per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

A summary of known fishery mortality and serious injury for this stock of bottlenose dolphin is shown in Table 1. The estimate of mortality and serious injury for bottlenose dolphin in the California drift gillnet fishery for the five most recent years of monitoring, 2010-2014, is 6.9 (CV=0.74) individuals, or an average of 1.4 per year (CV=0.74) (Carretta *et al*. 2017). One bottlenose dolphin was seriously injured in the limited entry fixed gear sablefish fishery during 2009, but no other deaths or injuries were reported in West Coast groundfish fisheries for the period 2009-2013 (Jannot *et al*. 2011). Gillnets have been documented to entangle marine mammals off Baja California (Sosa-Nishizaki *et al*. 1993), but no recent bycatch data from Mexico are available. Gillnets have been documented to entangle marine mammals off Baja California (Sosa-Nishizaki et al. 1993), but no recent bycatch data from Mexico are available.

Table 1. Summary of available information on the incidental mortality and serious injury of bottlenose dolphins (California/ Oregon/Washington Offshore Stock) in commercial fisheries that might take this species (Carretta *et al*. 2016, 2017; Jannot *et al*. 2011). Coefficients of variation for mortality estimates are provided in parentheses; n/a = not available.

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality (and Serious Injury)	Estimated Mortality and Serious Injury (CV)	Mean Annual Takes (CV in parentheses)
CA/OR thresher shark/swordfish drift gillnet fishery	observer	2010 2011 2012 2013 2014	12% 20% 19% 37% 24%	1 0 0 0 0	6.8 (0.75) 0.1 (7.6) 0 (n/a) 0 (n/a) 0 (n/a)	1.4 (0.74)
CA halibut / white seabass and other species set gillnet fishery	observer	2010-2014	9%	0 0 0 0	0	0
California yellowtail, barracuda, and white seabass drift gillnet fishery	observer	2010-2012	~4%	0	0	0
CA lobster trap/pot	At-sea disentanglement	2008	n/a	0 (1)	1 (n/a)	0.2 (n/a)
Limited entry fixed gear (longline) sablefish fishery	At-sea disentanglement	2005 2006 2007 2008 2009	0.5% 1.5% 3.4% 1.5% 2.4%	0 (1)	1 (n/a)*	0.2 (n/a)
Minimum total annual takes						≥1.6 (0.74)

*No estimate of bycatch was derived from the one observation of a bottlenose dolphin released injured from sablefish gear (Jannot *et al*. 2011).

STATUS OF STOCK

The status of offshore bottlenose dolphins in California relative to OSP is not known, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this species. They are not listed as "threatened" or "endangered" under the Endangered Species Act nor as "depleted" under the MMPA. Because average annual fishery takes (1.6 /yr) are less than the calculated PBR (11), offshore bottlenose dolphins are not classified as a "strategic" stock under the MMPA. The total fishery mortality and serious injury for this stock is less than 10% of the PBR and, therefore, can be considered to be insignificant and approaching zero.

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Revised 02/09/2017

STRIPED DOLPHIN (*Stenella coeruleoalba*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Striped dolphins are distributed world-wide in tropical and warm-temperate pelagic waters. Striped dolphins are commonly encountered in warm offshore waters of California, and a few sightings have been made off Oregon (Figure 1, Barlow 2016). Striped dolphins are also commonly found in the central North Pacific, but sampling between this region and California has been insufficient to determine whether the distribution is continuous. Based on sighting records off California and Mexico, striped dolphins appear to have a continuous distribution in offshore waters of these two regions (Perrin et al. 1985; Mangels and Gerrodette 1994). No information on possible seasonality in distribution is available, because the California surveys which extended 300 nmi offshore were conducted only during the summer/fall period. Although striped dolphins are not restricted to U.S. waters, cooperative management agreements with Mexico exist only for the tuna purse seine fishery and not for other fisheries which may take this species (e.g. gillnet fisheries). Therefore, the management stock includes only animals found within U.S. waters. For the Marine Mammal Protection Act (MMPA) stock assessment reports, striped dolphins within the Pacific U.S. Exclusive Economic Zone are divided into two discrete, non-contiguous areas: 1) waters off California, Oregon and Washington (this report), and 2) waters around Hawaii.

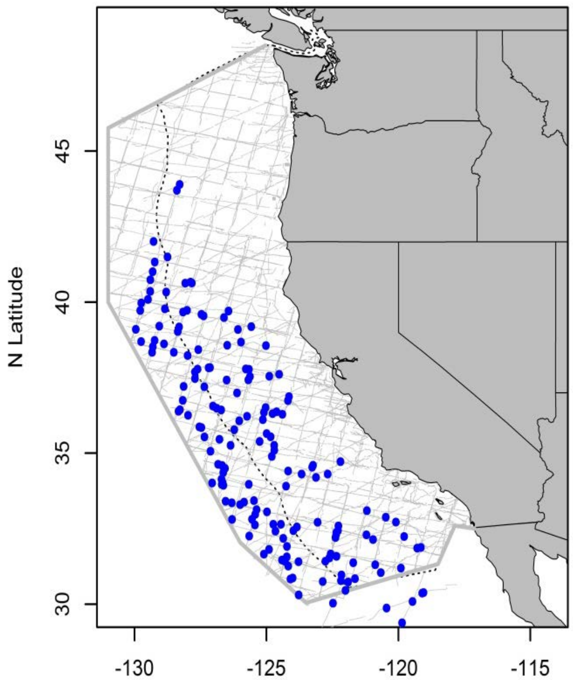

Figure 1. Striped dolphin sightings based on shipboard surveys off California, Oregon, and Washington, 1991-2014 (Barlow 2016). Dashed line represents the U.S. EEZ, thin gray lines indicate the completed transect effort of all surveys combined.

POPULATION SIZE

The abundance of striped dolphins in this region appears to be variable between years and may be affected by oceanographic conditions, as with other odontocete species (Forney 1997, Becker et al. 2012, Barlow 2016). Because animals may spend time outside the U.S. Exclusive Economic Zone as oceanographic conditions change, a multi-year average abundance estimate is the most appropriate for management within U.S. waters. The most recent estimate of striped dolphin abundance is the geometric mean of estimates from 2008 and 2014 summer/autumn vessel-based line-transect surveys of California, Oregon, and Washington waters, 29,211 (CV=0.20) animals (Barlow 2016). This estimate includes new correction factors for animals missed during the surveys.

Minimum Population Estimate

The log-normal 20th percentile of the 2008-2014 average abundance estimate is 24,782 striped dolphins.

Current Population Trend

The distribution and abundance of striped dolphins off California, Oregon and Washington varies interannually (Becker et al. 2012, Barlow 2016), but no long-term trends have been identified.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No information on current or maximum net productivity rates is available for striped dolphins off California.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (24,782) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.48 (for a species of unknown status with fishery mortality CV > 0.3 and < 0.6; Wade and Angliss 1997), resulting in a PBR of 238 striped dolphins per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

A summary of recent fishery mortality and injury for this stock of striped dolphin is shown in Table 1. More detailed information on these fisheries is provided in Appendix 1. The estimate of mortality and serious injury for striped dolphin in the California drift gillnet fishery for the five most recent years of monitoring, 2010-2014, is zero animals per year (Carretta et al. 2017). Human-caused mortality and injury documentation is often based on stranding data, where raw counts are negatively-biased because only a fraction of carcasses are detected. Carretta *et al*. (2016a) estimated the mean recovery rate of California coastal bottlenose dolphin carcasses to be 25% (95% CI 20% - 33%) and stated that given the extremely coastal habits of coastal bottlenose dolphins, carcass recovery rates for this stock represented a maximum, compared with more pelagic dolphin species in the region. Therefore, in this stock assessment report and others involving dolphins along the U.S. West Coast, human-related deaths and injuries counted from beach strandings along the outer U.S. West Coast are multiplied by a factor of 4 to account for the non-detection of most carcasses (Carretta *et al*. 2016a). One striped dolphin stranded during 2010-2014 with evidence of fishery interaction (Carretta *et al*. 2016b), yielding a minimum estimate of four fishery-related dolphin deaths. Gillnets have been documented to entangle marine mammals off Baja California (Sosa-Nishizaki et al. 1993), but no recent bycatch data from Mexico are available.

Table 1. Summary of available information on the incidental mortality and serious injury of striped dolphins (California/ Oregon/Washington Stock) in commercial fisheries that might take this species (Carretta *et al*. 2016a, 2016b, 2017.). Human-caused mortality values based on strandings recovered along the outer U.S. West Coast are multiplied by a correction factor of 4 to account for undetected mortality (Carretta *et al*. 2016a). Coefficients of variation for mortality estimates are provided in parentheses.

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality	Estimated Mortality	Mean Annual Takes (CV in parentheses)
CA/OR thresher shark/swordfish drift gillnet fishery	observer	2010 2011 2012 2013 2014	12% 20% 19% 37% 24%	0 0 0 0 0	0 (n/a)	0 (n/a)
Unidentified fishery	Stranding	2010-2014	-	1	≥ 4	≥ 0.8 (0.46)[1]
Minimum total annual takes (includes correction for unobserved beach strandings)						≥ 0.8 (0.46)

STATUS OF STOCK

The status of striped dolphins in California relative to OSP is not known, and there are insufficient data to evaluate potential trends in abundance. No habitat issues are known to be of concern for this species. They are not listed as "threatened" or "endangered" under the Endangered Species Act nor as "depleted" under the MMPA. Because recent fishery and human-caused mortality (≥0.80) is less than 10% of the PBR (238), striped dolphins are not classified as a "strategic" stock under the MMPA, and the total fishery mortality and serious injury for this stock can be considered to be insignificant and approaching zero.

[1] The coefficient of variation (CV) for corrected carcass counts was derived from the results of Carretta *et al*. (2016a), who estimated that 25% (95% CI = 20% - 33%) of all available carcasses were recovered / documented.

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SHORT-BEAKED COMMON DOLPHIN (*Delphinus delphis*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Short-beaked common dolphins are the most abundant cetacean off California, and are widely distributed between the coast and at least 300 nmi distance from shore (Figure 1). The abundance of this species off California has been shown to change on both seasonal and inter-annual time scales (Dohl *et al.* 1986; Forney and Barlow 1998; Barlow 2016). Significant seasonal shifts in the abundance and distribution of common dolphins have been identified based on winter/spring 1991-92 and summer/fall 1991 surveys (Forney and Barlow 1998). The distribution of short-beaked common dolphins is continuous southward into Mexican waters to about 13ºN (Perrin *et al.* 1985; Wade and Gerrodette 1993; Mangels and Gerrodette 1994), and short-beaked common dolphins off California may be an extension of the "northern common dolphin" stock defined for management of eastern tropical Pacific tuna fisheries (Perrin *et al.* 1985). However, preliminary data on variation in dorsal fin color patterns suggest there may be multiple stocks in this region, including at least two possible stocks in California (Farley 1995). Although short-beaked common dolphins are not restricted to U.S. waters, cooperative management agreements with Mexico exist only for the tuna purse seine fishery and not for other fisheries which may take this species. Under the Marine Mammal Protection Act (MMPA), short-beaked common dolphins involved in tuna purse seine fisheries in international waters of the eastern tropical Pacific are managed separately, and they are not included in the assessment reports. For the MMPA stock assessment reports, there is a single Pacific management stock including only animals found within the U.S. Exclusive Economic Zone of California, Oregon and Washington.

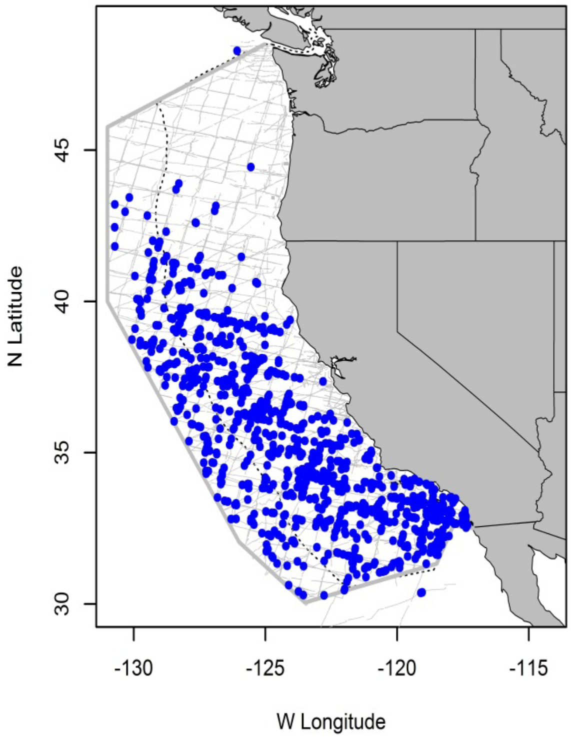

Figure 1. Short-beaked common dolphin sightings based on shipboard surveys off California, Oregon, and Washington, 1991-2014 (Barlow 2016). Dashed line represents the U.S. EEZ, thin gray lines indicate completed transect effort of all surveys combined.

POPULATION SIZE

The distribution of short-beaked common dolphins throughout this region is highly variable, apparently in response to oceanographic changes on both seasonal and interannual time scales (Heyning and Perrin 1994; Forney 1997; Forney and Barlow 1998). As oceanographic conditions vary, short-beaked common dolphins may spend time outside the U.S. Exclusive Economic Zone, and therefore a multi-year average abundance estimate is the most appropriate for management within U.S. waters. The most recent estimate of short-beaked common dolphin abundance is the geometric mean of estimates from 2008 and 2014 summer/autumn vessel-based line-transect surveys of California, Oregon, and Washington waters, 969,861 (CV = 0.17) animals (Barlow 2016). This estimate includes new correction factors for animals missed during the surveys.

Minimum Population Estimate

The log-normal 20th percentile of the 2008-2014 average abundance estimate is 839,325 short-beaked common dolphins.

Current Population Trend

Short-beaked common dolphin abundance off the U.S. West Coast is known to increase during warm-water periods (Dohl *et al.* 1986, Forney and Barlow 1998, Barlow 2016). The most recent 2014 survey was conducted during extremely warm ocean conditions (Bond *et al*. 2015) and resulted in the largest abundance estimate since large-scale surveys began in 1991. The increase in short-beaked common dolphin abundance is likely a result of northward movement of this transboundary stock from waters off Mexico (Barlow 2016).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

There are no estimates of current or maximum net productivity rates for short-beaked common dolphins.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (839,325) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a species of unknown status with a mortality rate CV< 0.30; Wade and Angliss 1997), resulting in a PBR of 8,393 short-beaked common dolphins per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

A summary of recent fishery mortality and injury for short-beaked common dolphins is shown in Table 1. The summed estimate of mortality and serious injury for short-beaked common dolphin in the California drift gillnet fishery for the five most recent years of monitoring, 2010-2014, is approximately 100 individuals, or an average of 20 (CV=0.18) per year (Carretta *et al*. 2017) (Table 1). No takes were documented by observers during the most recent five years of monitoring for other gillnet and purse seine fisheries that have interacted with short-beaked common dolphins in the past. However, two short-beaked common dolphins stranded with evidence of fishery interaction with an unidentified gillnet fishery. Human-caused mortality and injury documentation is often based on stranding data, where raw counts are negatively-biased because only a fraction of carcasses are detected. Carretta *et al*. (2016a) estimated the mean recovery rate of California coastal bottlenose dolphin carcasses to be 25% (95% CI 20% - 33%) and stated that given the extremely coastal habits of coastal bottlenose dolphins, carcass recovery rates for this stock represented a maximum, compared with more pelagic dolphin species in the region. Therefore, in this stock assessment report and others involving dolphins along the U.S. West Coast, human-related deaths and injuries counted from beach strandings along the outer U.S. West Coast are multiplied by a factor of 4 to account for the non-detection of most carcasses (Carretta *et al*. 2016a). Applying this correction factor to the two stranded short-beaked common dolphins yields a minimum estimate of 8 fishery-related dolphin deaths.

Table 1. Summary of available information on the incidental mortality and injury of short-beaked common dolphins (California/Oregon/Washington Stock) in commercial fisheries that might take this species (Carretta *et al*. 2016b, 2017). All entanglements resulted in the death of the animal. Coefficients of variation for mortality estimates are provided in parentheses; n/a = not available. Human-caused mortality values based on strandings recovered along the outer U.S. West Coast are multiplied by a correction factor of 4 to account for undetected mortality (Carretta *et al.* 2016a).

Fishery Name	Data Type	Year	Percent Observer Coverage	Observed Mortality (and Serious Injury)	Estimated Mortality and Serious Injury	Mean Annual Takes (CV in parentheses)
CA/OR thresher shark/swordfish drift gillnet fishery	observer	2010 2011 2012 2013 2014	12% 20% 19% 37% 24%	3 2 5 6 6	21.2 (0.53) 15.2 (0.46) 21.3 (0.41) 16.5 (0.25) 23.5 (0.31)	20 (0.18)

Fishery Name	Data Type	Year	Percent Observer Coverage	Observed Mortality (and Serious Injury)	Estimated Mortality and Serious Injury	Mean Annual Takes (CV in parentheses)
CA squid purse seine	observer	2004 2005 2006 2007 2008	unknown 1.1% unknown <5% <5%	0 1 0 (1) 0 0	0 87 (0.98) ≥ 1 (n/a)0 0	18 (0.98)
CA halibut / white seabass and other species set gillnet fishery	observer	2010-2014	9%	0	0	0 (n/a)
Hawaii Shallow Set Longline fishery	observer	2010-2014	100%	0 0 (1) 0 0 0 (1)	0 (2)	0.4 (n/a)
Unidentified gillnet fishery	Stranding	2010-2014	-	2	≥8	≥1.6 (0.46)[1]
Minimum total annual takes (includes correction for unobserved beach strandings)						≥ 40 (0.45)

The California squid purse seine fishery has not been observed since 2008. Between 2004 and 2008, there were 377 sets observed in the squid purse seine fishery and one short-beaked common dolphin mortality was observed in 2005, with a resulting mortality estimate of 87 (CV=0.98) animals (Carretta and Enriquez 2006). It is likely, due to the low observer coverage that year (~1%), combined with a relatively rare entanglement event, that this estimate is positively-biased (Carretta and Moore 2014). In addition, there was one squid purse seine set in 2006 where 8 unidentified dolphins were encircled. Seven were released alive and the eighth was seriously injured. For purposes of this stock assessment report, it is assumed that the unidentified seriously injured dolphin was a short-beaked common dolphin, due to its high abundance within the fishing area and a previous record of this species having been killed in the fishery.

Two short-beaked common dolphins were reported released injured from the Hawaii shallow set longline fishery (one each in 2011 and 2014 with 100% observer coverage, Table 1). These interactions occurred outside of the U.S. EEZ just west of the California Current and likely involved dolphins from the CA/OR/WA stock of short-beaked common dolphins (NOAA Pacific Islands Regional Office 2017).

Other Mortality

In the eastern tropical Pacific, 'northern common dolphins' have been incidentally killed in international tuna purse-seine fisheries since the late 1950's and are managed separately under a section of the MMPA written specifically for the management of dolphins involved in eastern tropical Pacific tuna fisheries. Cooperative international management programs have dramatically reduced overall dolphin mortality in these fisheries in recent decades (IATTC 2015). Between 2007 and 2014, annual fishing mortality of northern common dolphins (potentially including both short-beaked and long-beaked common dolphins) ranged between 35 and 124 animals, with an average of 75 (IATTC, 2015). Although it is unclear whether these animals are part of the same population as short-beaked common dolphins found off California, the distributions of both of the species that comprise the 'northern common dolphins' appear to shift into U.S. waters during certain oceanographic conditions (IATTC 2006).

STATUS OF STOCK

The status of short-beaked common dolphins in Californian waters relative to OSP is not known. The observed increase in abundance of this species off California probably reflects a distributional shift

[1] The coefficient of variation (CV) for corrected carcass counts was derived from the results of Carretta *et al*. (2016a), who estimated that 25% (95% CI = 20% - 33%) of all available carcasses were recovered / documented.

(Anganuzzi *et al.* 1993; Forney and Barlow 1998, Barlow 2016), rather than an overall population increase due to growth. No habitat issues are known to be of concern for this species. They are not listed as "threatened" or "endangered" under the Endangered Species Act nor as "depleted" under the MMPA. The average annual human-caused mortality in 2010-2014 (40 animals) is estimated to be less than the PBR (8,393), and therefore they are not classified as a "strategic" stock under the MMPA. The total estimated fishery mortality and injury for short-beaked common dolphins is less than 10% of the calculated PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate.

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Revised 2/10/2017

LONG-BEAKED COMMON DOLPHIN (*Delphinus capensis*): California Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Long-beaked common dolphins were recognized as a distinct species in the 1990s (Heyning and Perrin 1994; Rosel *et al.* 1994). Along the U.S. west coast, their distribution overlaps with that of the short-beaked common dolphin. Long-beaked common dolphins are commonly found within about 50 nmi of the coast, from Baja California (including the Gulf of California) northward to about central California (Figure 1). Along the west coast of Baja California, long-beaked common dolphins primarily occur inshore of the 250 m isobath, with very few sightings (<15%) in waters deeper than 500 meters (Gerrodette and Eguchi 2011). Stranding and sighting records indicate that the abundance of this species off California changes both seasonally and inter-annually (Heyning and Perrin 1994, Forney and Barlow 1998, Barlow 2016). Although long-beaked common dolphins are not restricted to U.S. waters, cooperative management agreements with Mexico exist only for the tuna purse seine fishery and not for other fisheries which may take this species (e.g. gillnet fisheries). For the MMPA stock assessment reports, there is a single Pacific management stock including only animals found within the U.S. Exclusive Economic Zone off California.

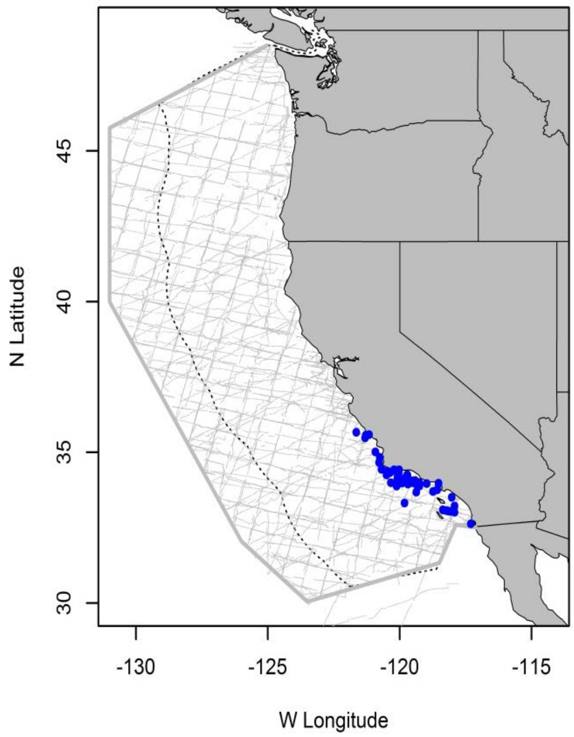

Figure 1. Long-beaked common dolphin sightings based on shipboard surveys off California, Oregon, and Washington, 1991- 2014 (Barlow 2016). Dashed line represents the U.S. EEZ, thin gray lines indicate completed transect effort of all surveys combined.

POPULATION SIZE

The distribution and abundance of long-beaked common dolphins off California varies inter-annually and seasonally (Heyning and Perrin 1994). As oceanographic conditions change, long-beaked common dolphins may move between Mexican and U.S. waters, and therefore a multi-year average abundance estimate is the most appropriate for management within the U.S. waters. The geometric mean abundance estimate for California, Oregon and Washington waters based on two ship surveys conducted in 2008 and 2014 (Barlow 2016) is 101,305 (0.49) long-beaked common dolphins. This estimate includes new correction factors for animals missed during the surveys. Although Carretta *et al.* (2011) also estimated abundance of this stock from a 2009 survey, that estimate did not include the correction factors and had high imprecision for one of the geographic strata, so it is not included in the multi-year average.

Minimum Population Estimate

The log-normal 20th percentile of the weighted 2008-2014 abundance estimate is 68,432 long-beaked common dolphins.

Current Population Trend

California waters represent the northern limit for this stock and animals likely move between U.S. and Mexican waters. While no formal statistical trend analysis exists for this stock of long-beaked common dolphin, abundance estimates for California waters from vessel-based line-transect surveys have been greater in recent years as water conditions have been warmer (Barlow 2016). The ratio of strandings of long-beaked to short-beaked common dolphin in southern California has varied, suggesting that the proportions of each species present change as ocean conditions vary (Heyning and Perrin 1994, Danil *et al*. 2010). During a 2009 ship-based survey of California and Baja California waters, the ratio of long-beaked to short-beaked common dolphin sightings was nearly 1:1, whereas during previous surveys conducted from 1986 to 2008 in the same geographic strata, the ratio was approximately 1:3.5 (Carretta *et al*. 2011). There appears to be an increasing trend of long-beaked common dolphins in California waters over the last 30 years, but a trend analysis for this stock has not been performed to date, while other stocks with more urgent conservation concerns are analyzed (e.g., Moore and Barlow 2011, 2013).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

There are no estimates of current or maximum net productivity rates for long-beaked common dolphins.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (68,432) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.48 (for a species of unknown status with a mortality rate CV of 0.3 to 0.6 ; Wade and Angliss 1997), resulting in a PBR of 657 long-beaked common dolphins per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

A summary of recent fishery mortality and injury for long-beaked common dolphins is shown in Table 1. More detailed information on these fisheries is provided in Appendix 1. The estimate of mortality and serious injury for long-beaked common dolphin in the California drift gillnet fishery for the five most recent years of monitoring, 2010-2014, averages 2.0 (CV=0.99) per year (Carretta *et al*. 2017). One interaction with the halibut set gillnet fishery was observed during 2010-2014, resulting in an estimate of 7 (CV=1.17) dolphins (Carretta and Enriquez 2012). No mortality or serious injury has been documented by observers during the most recent five years of monitoring for the small mesh gillnet fishery, which has interacted with long-beaked common dolphins in the past. However, 36 long-beaked common dolphins stranded with evidence of interaction with unidentified fisheries. Human-caused mortality and injury documentation is often based on stranding data, where raw counts are negatively-biased because only a fraction of carcasses are detected. Carretta *et al*. (2016a) estimated the mean recovery rate of California coastal bottlenose dolphin carcasses to be 25% (95% CI 20% - 33%) and stated that given the extremely coastal habits of coastal bottlenose dolphins, carcass recovery rates for this stock represented a maximum, compared with more pelagic dolphin species in the region. Therefore, in this stock assessment report and others involving dolphins along the U.S. West Coast, human-related deaths and injuries counted from beach strandings along the outer U.S. West Coast are multiplied by a factor of 4 to account for the non-detection of most carcasses (Carretta *et al*. 2016a). Applying this correction factor to the 36 stranded long-beaked common dolphins yields a minimum estimate of 144 fishery-related dolphin deaths, or an average of 29 per year. Gillnets have been documented to entangle marine mammals off Baja California (Sosa-Nishizaki *et al*. 1993), but no recent bycatch data from Mexico are available.

Table 1. Summary of available information on the incidental mortality and serious injury of long-beaked common dolphins (California Stock) in commercial fisheries that might take this species (Carretta *et al*. 2016b, 2017). All observed entanglements resulted in the death of the animal. Coefficients of variation for mortality estimates are provided in parentheses, when available. n/a = information not available. Human-caused mortality values based on strandings recovered along the outer U.S. West Coast are multiplied by a correction factor of 4 to account for undetected mortality (Carretta *et al*. 2016a).

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed (or self-reported)	Estimated Annual Mortality (CV)	Mean Annual Takes (CV

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed (or self-reported)	Estimated Annual Mortality (CV)	Mean Annual Takes (CV
CA thresher shark/swordfish drift gillnet fishery	observer	2010 2011 2012 2013 2014	12% 20% 19% 37% 24%	1 1 0 0 0	1.9 (1.1) 5.1 (1.3) 0 (n/a) 0.2 (2.2) 2.8 (1.4)	2.0 (0.99)
CA small mesh drift gillnet fishery for white seabass, yellowtail, barracuda, and tuna	observer	2010-2012	~4%	0	0	0 (n/a)
CA halibut/white seabass and other species set gillnet fishery	observer	2010-2014	9%	1	7 (1.17)	1.4 (1.17)
Unidentified fishery interaction	Strandings	2010-2014	-	36	≥144	≥29 (0.46)[1]
Minimum total annual takes (includes correction for unobserved beach strandings)						≥32 (0.42)

Other Mortality

Three long-beaked common dolphins died near San Diego in 2011 as the result of blast trauma associated with underwater detonations conducted by the U.S. Navy. Three days later, a fourth animal stranded approximately 70 km north of that location with similar injuries (Danil and St. Leger 2011). One long-beaked common dolphin was incidentally killed during fishery research during 2013 (Carretta *et al*. 2016b). Stranding records from 2010-2014 include three additional human-related long-beaked common dolphin deaths, including one animal that was struck by a vessel, one animal that had ingested marine debris, and one animal that had been cut in half (Carretta *et al*. 2016b). Applying the minimum correction factor to account for undetected mortality (Carretta *et al*. 2016a), this yields an estimated 12 human-caused long-beaked common dolphin deaths. From all sources combined, this results in a total of 17 non-fishery human-caused deaths between 2010 and 2014, or an average of 3.4 dolphins per year.

'Unusual mortality events' of long-beaked common dolphins off California due to domoic acid toxicity have been documented by NMFS as recently as 2007. One study suggests that increasing anthropogenic CO_2 levels and ocean acidification may increase the toxicity of the diatom responsible for these mortality events (Tatters *et al*. 2012).

In the eastern tropical Pacific, 'northern common dolphins' have been incidentally killed in international tuna purse-seine fisheries since the late 1950's and are managed separately under a section of the MMPA written specifically for the management of dolphins involved in eastern tropical Pacific tuna fisheries. Cooperative international management programs have dramatically reduced overall dolphin mortality in these fisheries (Joseph 1994). Between 2007 and 2014, annual fishing mortality of northern common dolphins (potentially including both short-beaked and long-beaked common dolphins) ranged between 35 and 124 animals, with an average of 75 (IATTC 2015). The distributions of both of the species that comprise the 'northern common dolphins' appear to shift into U.S. waters during certain oceanographic conditions (IATTC 2006).

STATUS OF STOCK

The status of long-beaked common dolphins in California waters relative to OSP is not known, and there are insufficient data to evaluate potential trends in abundance. Exposure to blast trauma resulting from underwater detonations is a local concern for this stock, but population level impacts from such activities are unclear. In response to the 2011 event, the U.S. Navy has implemented new training protocols to reduce the probability of blast trauma events occurring (Danil and St. Leger 2011). Long-

[1] The coefficient of variation (CV) for corrected carcass counts was derived from the results of Carretta *et al*. (2016a), who estimated that 25% (95% CI = 20% - 33%) of all available carcasses were recovered / documented.

beaked common dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act nor as "depleted" under the MMPA. The average annual human-caused mortality from commercial fisheries (≥32 dolphins /year) and other sources (3.4 dolphins/year) is 35.4 long-beaked common dolphins. This does not exceed the PBR (657), and therefore they are not classified as a "strategic" stock under the MMPA. The average total fishery mortality and injury for long-beaked common dolphins (32/yr) is less than 10% of the PBR and therefore, is considered to be insignificant and approaching zero mortality and serious injury rate.

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NORTHERN RIGHT-WHALE DOLPHIN (*Lissodelphis borealis*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Northern right-whale dolphins are endemic to temperate waters of the North Pacific Ocean. Off the U.S. west coast, they have been seen primarily in shelf and slope waters (Figure 1), with seasonal movements into the Southern California Bight (Leatherwood and Walker 1979; Dohl et al. 1980; 1983). Sighting patterns from recent aerial and shipboard surveys conducted in California, Oregon and Washington during different seasons (Green et al. 1992; 1993; Forney and Barlow 1998; Barlow 2016) suggest seasonal north-south movements, with animals found primarily off California during the colder water months and shifting northward into Oregon and Washington as water temperatures increase in late spring and summer. The southern end of this population's range is not well-documented, but during cold-water periods, they probably range into Mexican waters off northern Baja California. Genetic analyses have not found statistically significant differences between northern right-whale dolphins from the U.S. West coast and other areas of the North Pacific (Dizon et al. 1994); however, power analyses indicate that the ability to detect stock differences for this species is poor, given traditional statistical error levels (Dizon et al. 1995). Although northern right-whale dolphins are not restricted to U.S. territorial waters, there are currently no international agreements for cooperative management. For the Marine Mammal Protection Act (MMPA) stock assessment reports, there is a single management stock including only animals found within the U.S. Exclusive Economic Zone of California, Oregon and Washington.

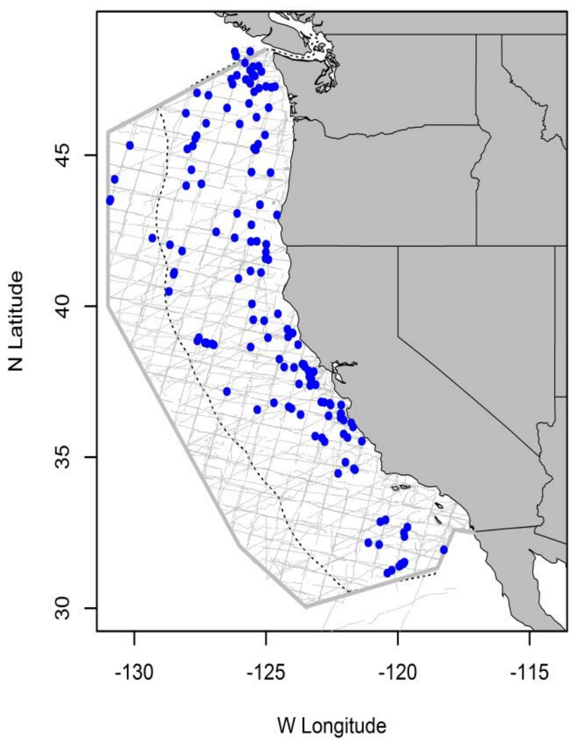

Figure 1. Northern right whale dolphin sightings based on shipboard surveys off California, Oregon, and Washington, 1991-2014 (Barlow 2016). Dashed line represents the U.S. EEZ, thin gray lines indicate completed transect effort of all surveys combined.

POPULATION SIZE

The distribution of northern right-whale dolphins throughout this region is highly variable, apparently in response to oceanographic changes on both seasonal and interannual time scales (Forney and Barlow 1998, Barlow 2016). As oceanographic conditions vary, northern right-whale dolphins may spend time outside the U.S. Exclusive Economic Zone, and therefore a multi-year average abundance estimate is the most appropriate for management within U.S. waters. The most recent estimate of northern right whale dolphin abundance is the geometric mean of estimates from 2008 and 2014 summer/autumn vessel-based line-transect surveys of California, Oregon, and Washington waters, 26,556 (CV=0.44) animals (Barlow 2016). This estimate includes new correction factors for animals missed during the surveys.

Minimum Population Estimate

The log-normal 20th percentile of the 2008-2014 average abundance estimate is 18,608 northern right-whale dolphins.

Current Population Trend

The distribution and abundance of northern right whale dolphins off California, Oregon and Washington varies considerably at both seasonal and interannual time scales (Forney and Barlow 1998, Becker *et al*. 2012, Barlow 2016), but no long term trends have been identified.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No information on current or maximum net productivity rates is available for northern right-whale dolphins off the U.S. west coast.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (18,608) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.48 (for a species of unknown status with a mortality rate CV between 0.3 and 0.6; Wade and Angliss 1997), resulting in a PBR of 179 northern right-whale dolphins per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

A summary of recent fishery mortality and injury information for this stock of northern right-whale dolphin is shown in Table 1. More detailed information on these fisheries is provided in Appendix 1. The estimate of mortality and serious injury for northern right whale dolphin in the California drift gillnet fishery for the five most recent years of monitoring, 2010-2014, is 17.6 (CV=0.36) individuals, or an average of 3.5 per year (Carretta *et al*. 2016). Gillnets have been documented to entangle marine mammals off Baja California (Sosa-Nishizaki *et al*. 1993), but no recent bycatch data from Mexico are available.

Table 1. Summary of available information on the incidental mortality and serious injury of northern right-whale dolphins (California/Oregon/Washington Stock) in commercial fisheries that might take this species (Carretta *et al*. 2017). All observed entanglements of northern right-whale dolphins resulted in the death of the animal. Coefficients of variation for mortality estimates are provided in parentheses.

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality	Estimated Annual Mortality (CV)	Mean Annual Takes (CV)
CA/OR thresher shark/swordfish drift gillnet fishery	observer data	2010 2011 2012 2013 2014	12% 20% 19% 37% 24%	1 1 1 2 1	3.9 (1) 5.5 (0.85) 3.7 (0.95) 3.3 (0.45) 2.5 (0.83)	3.8 (0.40)
Minimum total annual takes						3.8 (0.40)

STATUS OF STOCK

The status of northern right-whale dolphins in California, Oregon and Washington relative to OSP is not known, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this species. They are not listed as "threatened" or "endangered" under the Endangered Species Act nor as "depleted" under the MMPA. The average annual human-caused mortality in 2010-2014 (3.8 animals) is estimated to be less than the PBR (179), and therefore they are not classified as a "strategic" stock under the MMPA. The total fishery mortality and serious injury for northern right-whale dolphins does not exceed 10% of the calculated PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate.

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Revised 01/15/2011

KILLER WHALE (*Orcinus orca*): Eastern North Pacific Offshore Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Killer whales have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Although reported from tropical and offshore waters, killer whales prefer the colder waters of both hemispheres, with greatest abundances found within 800 km of major continents (Mitchell 1975). Along the west coast of North America, killer whales occur along the entire Alaskan coast (Braham and Dahlheim 1982), in British Columbia and Washington inland waterways (Bigg et al. 1990), and along the outer coasts of Washington, Oregon and California (Green et al. 1992; Barlow 1995, 1997; Forney et al. 1995; Barlow and Forney 2007). Seasonal and year-round occurrence have been noted for killer whales throughout Alaska (Braham and Dahlheim 1982) and in the intracoastal waterways of British Columbia and Washington, where pods have been labeled as 'resident', 'transient' and 'offshore' (Bigg et al. 1990, Ford et al. 1994) based on aspects of morphology, ecology, genetics and behavior (Ford and Fisher 1982; Baird and Stacey 1988; Baird et al. 1992, Hoelzel et al. 1998). Through examination of photographs of recognizable individuals and pods, movements of whales between geographical areas have been documented. For example, whales identified in Prince William Sound have been observed near Kodiak Island (Heise et al. 1991) and whales identified in Southeast Alaska have been observed in Prince William Sound, British Columbia, and Puget Sound (Leatherwood et al. 1990, Dahlheim et al. 1997). Movements of killer whales between the waters of Southeast Alaska and central California have also been documented (Goley and Straley 1994).

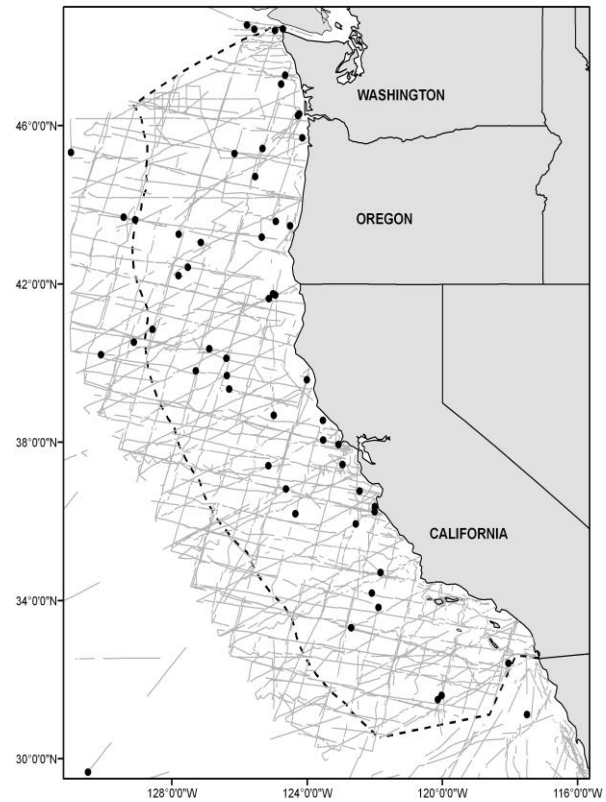

Figure 1. Killer whale sightings based on shipboard surveys off California, Oregon and Washington, 1991-2008 (see Appendix 2 for data sources and information on timing and location of survey effort). Sightings include killer whales from all stocks found in this region. Dashed line represents the U.S. EEZ, thin lines indicate completed transect effort of all surveys combined.

Offshore killer whales have more recently also been identified off the coasts of California, Oregon, and rarely, in Southeast Alaska (Ford et al. 1994, Black et al. 1997, Dahlheim et al. 1997). They apparently do not mix with the transient and resident killer whale stocks found in these regions (Ford et al. 1994, Black et al. 1997). Studies indicate the 'offshore' type, although distinct from the other types ('resident' and 'transient'), appears to be more closely related genetically, morphologically, behaviorally, and vocally to the 'resident' type killer whales (Black et al. 1997, Hoelzel et al. 1998; J. Ford, pers. comm.; L. Barrett-Lennard, pers. comm.). Based on data regarding association patterns, acoustics, movements, genetic differences and potential fishery interactions, eight killer whale stocks are recognized within the Pacific U.S. EEZ: 1) the Eastern North Pacific Alaska Resident stock - occurring from Southeast Alaska to the Bering Sea, 2) the Eastern North Pacific Northern Resident stock - occurring from British Columbia through Alaska, 3) the Eastern North Pacific Southern Resident stock - occurring mainly within the inland waters of Washington State and southern British Columbia but extending from central California into southern Southeast Alaska, 4) the West Coast Transient stock - occurring from Alaska through California, 5) the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock - occurring from southeast Alaska to the Bering Sea, 6) the AT1 Stock – found only in Prince William Sound, 7) the Eastern North Pacific Offshore stock - occurring from Southeast Alaska through California, 8) the Hawaiian stock. The Stock Assessment Reports for the Alaska Region contain information concerning the Eastern North Pacific Alaska Resident, Eastern North Pacific Northern Resident and the Gulf of Alaska, Aleutian Islands, and Bering Sea, AT1, and West Coast Transient stocks.

POPULATION SIZE

Off British Columbia, approximately 200 offshore killer whales were identified between 1989 and 1993 (Ford et al. 1994), and 20 of these individuals have also been seen off California (Black et al. 1997). Using only good quality photographs that clearly show characteristics of the dorsal fin and saddle patch region, an additional 11 offshore killer whales that were not previously known have been identified off the California coast, bringing the total number of known individuals in this population to 211. This is certainly an underestimate of the total population size, because not all animals in this population have been photographed. In the future, it may be possible estimate the total abundance of this transboundary stock using mark-recapture analyses based on individual photographs. Based on summer/fall shipboard line-transect surveys in 2005 (Forney 2007) and 2008 (Barlow 2010), the total number of killer whales within 300 nmi of the coasts of California, Oregon and Washington is estimated to be 691 animals (CV=0.49). There is currently no way to reliably distinguish the different stocks of killer whales from sightings at sea, but photographs of individual animals can provide a rough estimate of the proportion of whales in each stock. A total of 161 individual killer whales photographed off California and Oregon have been determined to belong to the transient (105 whales) and offshore (56 whales) stocks (Black et al. 1997). Using these proportions to prorate the line transect abundance estimate yields an estimate of 56/161 * 691 = 240 offshore killer whales along the U.S. west coast. This is expected to be a conservative estimate of the number of offshore killer whales, because offshore whales apparently are less frequently seen near the coast (Black et al. 1997), and therefore photographic sampling may be biased towards transient whales. For stock assessment purposes, this combined value is currently the best available estimate of abundance for offshore killer whales off the coasts of California, Oregon and Washington.

Minimum Population Estimate

The total number of known offshore killer whales along the U.S. West coast, Canada and Alaska is 211 animals, but it is not known what proportion of time this transboundary stock spends in U.S. waters, and therefore this number is difficult to work with for PBR calculations. A minimum abundance estimate for all killer whales along the coasts of California, Oregon and Washington can be estimated from the 2005-2008 line-transect surveys as the 20th percentile of the geometric mean 2005-2008 abundance estimate, or 466 killer whales. Using the same prorating as above, a minimum of 56/161 * 466 = 162 offshore killer whales are estimated to be in U.S. waters off California, Oregon and Washington.

Current Population Trend

No information is available regarding trends in abundance of Eastern North Pacific offshore killer whales.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No information on current or maximum net productivity rates is available for killer whales in this region.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (162) <u>times</u> one half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> a recovery factor of 0.50 (for a species of unknown status with no known fishery mortality; Wade and Angliss 1997), resulting in a PBR of 1.6 offshore killer whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

A summary of information on fisheries that may take animals from this killer whale stock is shown in Table 1 (Carretta et al. 2005, Carretta and Enriquez 2006, 2007, 2009a, 2009b). More detailed information on these fisheries is provided in Appendix 1. In the California drift gillnet fishery, no offshore killer whales have been observed entangled (Julian 1997; Julian and Beeson 1998; Cameron and Forney 1999, 2000; Carretta and Chivers 2004, Carretta et al. 2005a, 2005b, Carretta and Enriquez 2006, 2007, 2009a, 2009b), but one killer whale from the Eastern North Pacific Transient Stock was observed taken in 1995, and offshore killer whales may also occasionally be entangled. Additional potential sources of killer whale mortality are set gillnets and longlines. In California, an observer program between July 1990 and December 1994 and additional observations between 2000 and 2008 monitored 5-15% of all sets in the large mesh (>3.5") set gillnet fishery for halibut , and no killer whales were observed taken. Based on observations for longline fisheries in other regions (i.e. Alaska; Yano and Dahlheim 1995), fishery interactions may also occur with U.S. West coast pelagic longline fisheries, but no such interactions have been documented to date.

Table 1. Summary of available information on the incidental mortality and injury of killer whales (Eastern North Pacific Offshore Stock) in commercial fisheries that might take this species. Mean annual takes are based on 2004-2008 data unless noted otherwise.

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality	Estimated Annual Mortality	Mean Annual Takes (CV in parentheses)
CA/OR thresher shark/swordfish drift gillnet fishery	observer data	2004 2005 2006 2007 2008	20.6% 20.9% 18.5% 16.4% 13.5%	0 0 0 0 0	0 0 0 0 0	0
Minimum total annual takes						0

Drift gillnet fisheries for swordfish and sharks exist along the entire Pacific coast of Baja California, Mexico and may take animals from this population. Quantitative data are available only for the Mexican swordfish drift gillnet fishery, which uses vessels, gear, and operational procedures similar to those in the U.S. drift gillnet fishery, although nets may be up to 4.5 km long (Holts and Sosa-Nishizaki 1998). The fleet increased from two vessels in 1986 to 31 vessels in 1993 (Holts and Sosa-Nishizaki 1998). The total number of sets in this fishery in 1992 can be estimated from data provided by these authors to be approximately 2700, with an observed rate of marine mammal bycatch of 0.13 animals per set (10 marine mammals in 77 observed sets; Sosa-Nishizaki et al. 1993). This overall mortality rate is similar to that observed in California driftnet fisheries during 1990-95 (0.14 marine mammals per set; Julian and Beeson, 1998), but species-specific information is not available for the Mexican fisheries. Previous efforts to convert the Mexican swordfish driftnet fishery to a longline fishery have resulted in a mixed-fishery, with 20 vessels alternately using longlines or driftnets, 23 using driftnets only, 22 using longlines only, and seven with unknown gear type (Berdegué 2002).

STATUS OF STOCK

The status of killer whales in California in relation to OSP is unknown, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this stock. They are not listed as "threatened" or "endangered" under the Endangered Species Act nor as "depleted" under the MMPA. There has been no documented human-caused mortality of this stock, and therefore they are not classified as a "strategic" stock under the MMPA. The total fishery mortality and serious injury for offshore killer whales is zero and can be considered to be insignificant and approaching zero mortality and serious injury rate.

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KILLER WHALE (*Orcinus orca*): Eastern North Pacific Southern Resident Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Killer whales have a cosmopolitan distribution, ranging from equatorial to polar waters, with highest densities found in coastal temperate waters (Forney and Wade 2006). Along the west coast of North America, killer whales occur along the entire Alaskan coast as far north as Barrow (George *et al.* 1994, Lowry *et al.* 1987, Clarke *et al.* 2013), in British Columbia and Washington inland waterways (Bigg *et al.* 1990), and along the outer coasts of Washington, Oregon, and California (Barlow and Forney 2007). Seasonal and year-round occurrence has been noted for killer whales throughout Alaska (Braham and Dahlheim 1982) and in the intra-coastal waterways of British Columbia and Washington State, where pods have been labeled as 'resident,' 'transient,' and 'offshore' (Bigg *et al.* 1990, Ford *et al.* 1994) based on aspects of morphology, ecology, genetics, and behavior (Ford and Fisher 1982, Baird and Stacey 1988, Baird *et al.* 1992, Hoelzel *et al.* 1998). Through examination of photographs of recognizable individuals and pods, movements of whales between Prince William Sound and Kodiak Island have been observed (Matkin *et al.* 1999) and whales identified in Southeast Alaska have been observed in Prince William Sound, British Columbia, and Puget Sound (Leatherwood *et al.* 1990, Dahlheim *et al.* 1997).

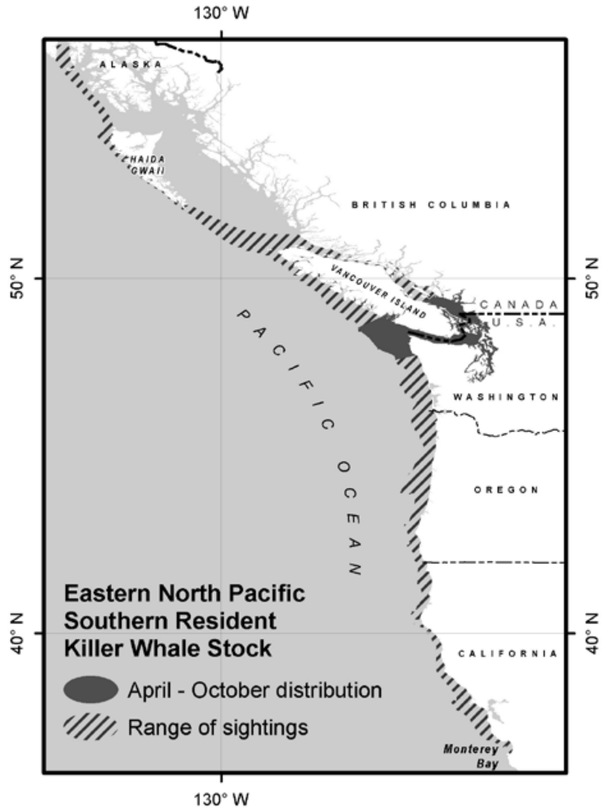

Figure 1. Approximate April - October distribution of the Eastern North Pacific Southern Resident killer whale stock (shaded area) and range of sightings (diagonal lines).

Genetic studies provide evidence that the 'resident' and 'transient' types are distinct (Stevens *et al.* 1989, Hoelzel 1991, Hoelzel and Dover 1991, Hoelzel *et al.* 1998, Morin *et al.* 2010). Analyses of complete mitochondrial genomes indicates that transient killer whales should be recognized as a separate species, and that, pending additional data, resident killer whales should be recognized as a separate subspecies (Morin *et al.* 2010). The genetic data results support previous lines of evidence for separation of the transient and resident ecotypes, including differences in 1) acoustic dialects; 2) skull features; 3) morphology; 4) feeding specializations; and 5) a lack of interbreeding between the two sympatric ecotypes (Krahn *et al.* 2004).

Most sightings of the Eastern North Pacific Southern Resident stock of killer whales have occurred in the summer in inland waters of Washington and southern British Columbia. However, pods belonging to this stock have also been sighted in coastal waters off southern Vancouver Island and Washington (Bigg *et al.* 1990, Ford *et al.* 2000, NWFSC unpubl. data). The complete winter range of this stock is uncertain. Of the three pods comprising this stock, one (J1) is commonly sighted in inshore waters in winter, while the other two (K1 and L1) apparently spend more time offshore (Ford *et al.* 2000). These latter two pods have been sighted as far south as Monterey Bay and central California in recent years. They sometimes have also been seen entering the inland waters of Vancouver Island through Johnstone Strait in the spring (Ford *et al.* 2000), suggesting that they may spend time along the outer coast of Vancouver Island during the winter. In June 2007, whales from L-pod were sighted off Chatham Strait, Alaska, the farthest north they have ever been documented (J. Ford, pers. comm.). Passive autonomous acoustic recorders have recently provided more information on the seasonal occurrence of these pods along the west coast of the U.S. (Hanson *et al.* 2013). In addition, satellite-linked tags were recently deployed in winter months on members of J, K, and L pods. Results were consistent with previous data, but provided much greater detail, showing wide-ranging use of inland waters by J Pod whales and extensive movements in U.S. coastal waters by K and L Pods.

Based on data regarding association patterns, acoustics, movements, genetic differences and potential fishery interactions, eight killer whale stocks are recognized within the Pacific U.S. EEZ: 1) the Eastern North Pacific Alaska Resident stock - occurring from Southeast Alaska to the Bering Sea, 2) the Eastern North Pacific Northern Resident stock - occurring from British Columbia through Alaska, 3) the Eastern North Pacific Southern Resident stock - occurring mainly within the inland waters of Washington State and southern British Columbia but extending from central California into southern Southeast Alaska (see Fig. 1), 4) the West Coast Transient stock - occurring from Alaska through California, 5) the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock - occurring from southeast Alaska to the Bering Sea, 6) the AT1 Stock – found only in Prince William Sound, 7) the Eastern North Pacific Offshore stock - occurring from Southeast Alaska through California, 8) the Hawaiian stock. The Stock Assessment Reports for the Alaska Region contain information concerning the Eastern North Pacific Alaska Resident, Eastern North Pacific Northern Resident and the Gulf of Alaska, Aleutian Islands, and Bering Sea, AT1, and Eastern North Pacific Transient stocks.

POPULATION SIZE

The Eastern North Pacific Southern Resident stock is a trans-boundary stock including killer whales in inland Washington and southern British Columbia waters. Photo-identification of individual whales through the years has advanced knowledge of this stock's structure, behaviors, and movements. In 1993, the three pods comprising this stock totaled 96 killer whales (Ford *et al.* 1994). The population increased to 99 whales in 1995, then declined to 79 whales in 2001, and most recently numbered 81 whales in 2015 (Fig. 2; Ford *et al.* 2000; Center for Whale Research 2016). The 2001-2005 counts included a whale born in 1999 (L-98) that was listed as missing during the annual census in May and June 2001 but was subsequently discovered alone in an inlet off the west coast of Vancouver Island. L-98 remained separate from L pod until 10 March 2006 when he died due to injuries associated with a vessel interaction in Nootka Sound. L-98 has been subtracted from the official 2006 and subsequent population censuses. The most recent census spanning 1 July 2014 through 1 July 2015 includes 5 new calves (3 presumed male, one female) and the deaths of one reproductive age adult female (that was pregnant with a female neonate), and a calf of unknown sex. This does not include 5 additional calves born between September 2015 and January 2016. In addition, a young adult female was observed pushing a dead neonate (not one of the recently born calves) in January 2016.

Minimum Population Estimate

The abundance estimate for this stock of killer whales is a direct count of individually identifiable animals. It is thought that the entire population is censused every year. This estimate therefore serves as both a best estimate of abundance and a minimum estimate of abundance. Thus, the minimum population estimate (N_{min}) for the Eastern North Pacific Southern Resident stock of killer whales is 81 animals.

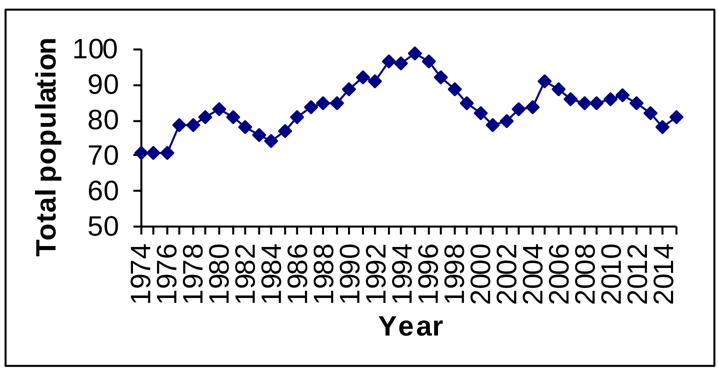

Figure 2. Population of Eastern North Pacific Southern Resident stock of killer whales, 1974-2015. Each year's count includes animals first seen and first missed; a whale is considered first missed the year after it was last seen alive (Ford *et al.* 2000; Center for Whale Research 2015).

Current Population Trend

During the live-capture fishery that existed from 1967 to 1973, it is estimated that 47 killer whales, mostly immature, were taken out of this stock (Ford *et al.* 1994). Since the first complete census of this stock in 1974 when 71 animals were identified, the number of southern resident killer whales has fluctuated annually. Between 1974 and the mid-1990s, the Southern Resident stock increased approximately 35% (Ford *et al.* 1994), representing a net annual growth rate of 1.8% during those years. Following the peak census count of 99 animals in 1995, the population size has declined and currently stands at 81 animals as of the 2015 census (Ford *et al.* 2000; Center for Whale Research 2015).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for this stock of killer whales. Matkin *et al.* (2014) estimated a maximum population annual growth rate of 1.035 for southern Alaska resident killer whales. The authors noted that the 3.5% annual rate estimated for southern Alaska residents is higher than previously measured rates for British Columbia northern residents (2.9%, Olesiuk *et al.* 1990) and "probably represents a population at r-max (maximum rate of growth)." In the absence of published estimates of R_{max} for southern resident killer whales, the maximum annual rate of 3.5% found for southern Alaska residents is used for this stock of southern resident killer whales. This reflects more information about the known life history of resident killer whales than the default R_{max} of 4% and results in a more conservative estimate of potential biological removal (PBR).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (81) <u>times</u> one-half the maximum net growth rate for *Alaska* resident killer whales (½ of 3.5%) <u>times</u> a recovery factor of 0.1 (for an endangered stock, Wade and Angliss 1997), resulting in a PBR of 0.14 whales per year, or approximately 1 animal every 7 years.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Salmon drift gillnet fisheries in Washington inland waters were last observed in 1993 and 1994 and no killer whale entanglements were documented, though observer coverage levels were less than 10% (Erstad *et al.* 1996, Pierce *et al.* 1994, Pierce *et al.* 1996, NWIFC 1995). Fishing effort in the inland waters drift gillnet fishery has declined considerably since 1994 because far fewer vessels participate today (NOAA West Coast Region). Past marine mammal entanglements in this fishery included harbor porpoise, Dall's porpoise, and harbor seals. Coastal marine tribal set gillnets also occur along the outer Washington coast and no killer whale interactions have been reported in this fishery since the inception of the observer program in 1988, though the fishery is not active every year (Gearin *et al.* 1994, Gearin *et al.* 2000, Makah Fisheries Management,).

An additional source of information on killer whale mortality and injury incidental to commercial fishery operations is the self-reported fisheries information required of vessel operators by the MMPA. No self-report records of killer whale mortality have been reported.

Due to a lack of observer programs, there are few data concerning the mortality of marine mammals incidental to Canadian commercial fisheries. Since 1990, there have been no reported fishery-related strandings of killer whales in Canadian waters. However, in 1994 one killer whale was reported to have contacted a salmon gillnet but did not entangle (Guenther *et al.* 1995). Data regarding the level of killer whale mortality related to commercial fisheries in Canadian waters are not available.

The known total fishery mortality and serious injury for this stock is zero.

Other Mortality

No human-caused killer whale mortality or serious injuries were reported from non-fisheries sources in 2010-2014 (Carretta *et al.* 2016). In 2012, a moderately decomposed juvenile female southern resident killer whale (L-112) was found dead near Long Beach, WA. A full necropsy was performed and the cause of death was determined to be blunt force trauma to the head, however the source of the trauma (vessel strike, intraspecific aggression, or other unknown source) could not be established (NOAA 2014). There was documentation of a whale-boat collision in Haro Strait in 2005 which resulted in a minor injury to a whale. In 2006, whale L98 was killed during a vessel interaction. It is important to note that L98 had become habituated to regularly interacting with vessels during its isolation in Nootka Sound. The annual known level of non-fishery human-caused mortality for this stock over the past five years (2010-2014) is zero animals per year.

STATUS OF STOCK

Total annual fishery mortality and serious injury for this stock (0) is not known to exceed 10% of the calculated PBR (0.14) and, therefore, appears to be insignificant and approaching zero mortality and serious injury rate. The estimated annual level of human-caused mortality and serious injury of zero animals per year does not exceed the PBR (0.14). Southern Resident killer whales were formally listed as "endangered" under the ESA in 2005 and consequently the stock is automatically considered as a "strategic" stock under the MMPA. This stock was considered "depleted" prior to its 2005 listing under the ESA.

Habitat Issues

Several potential risk factors identified for this population have habitat implications. The summer range of this population, the inland waters of Washington and British Columbia, are home to a large commercial whale watch industry, and high levels of recreational boating and commercial shipping. Potential for acoustic masking effects on the whales' communication and foraging due to vessel traffic remains a concern (Erbe 2002, Clark *et al.* 2009). In 2011 vessel approach regulations were implemented to restrict vessels from approaching closer than 200m. Oil tankers also regularly transit these inland waters and as such the risk of oil spills to this population is of concern. This population appears to be Chinook salmon specialists (Ford and Ellis 2006, Hanson *et al.* 2010), although other species, such as chum, pink, and coho salmon also appear to be important elements of the diet (Ford *et al.* 1998). There is evidence that changes in Chinook abundance have affected this population (Ford *et al.* 2009, Ward *et al.* 2009). In addition, the high trophic level and longevity of the animals has predisposed them to accumulate levels of contaminants that are high enough to cause potential health impacts. In particular, there is recent evidence of extremely high levels of flame retardants in young animals (Krahn *et al.* 2007, 2009). The recovery plan for southern resident killer whales highlights risk factors related to high PCB levels found in southern resident killer whales, including possible immune suppression and reproductive impairment (NOAA 2008).

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Revised 02/06/2017

SHORT-FINNED PILOT WHALE (*Globicephala macrorhynchus*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Two genetically and morphologically distinct short-finned pilot whale types are described in the Pacific ('Shiho' and 'Naisa') by Van Cise *et al*. (2016), which correspond to the northern and southern types (respectively) described off Japan (Kasuya *et al.* 1988; Wada 1988; Miyazaki and Amano 1994). Shiho type animals are largely confined to the California Current and eastern tropical Pacific, while Naisa type pilot whales occur in the central Pacific and Japan. Differences in body size, head shape, coloration, and number of teeth characterize Shiho and Naisa morphotypes, with the larger eastern Pacific Shiho type characterized by a rounder melon and distinct light saddle patch. Short-finned pilot whales were once common off Southern California, with an apparently resident population around Santa Catalina Island, as well as seasonal migrants (Dohl et al. 1980). After a strong El Niño event in 1982-83, short-finned pilot whales virtually disappeared from this region, and despite increased survey effort along the entire U.S. west coast, sightings and fishery takes are rare and have primarily occurred during warm-water years (Julian and Beeson 1998, Carretta *et al*. 2004, Barlow 2016). Figure 1 summarizes the sightings of short-finned pilot whales off the U.S. west coast from 1991-2014. Pilot whales in the California Current and eastern tropical Pacific likely represent a single population, based on a lack of differentiation in mtDNA (Van Cise *et al.* 2016), while animals in Hawaiian waters are characterized by unique haplotypes that are absent from eastern and southern Pacific samples, despite relatively large sample sizes from Hawaiian waters. For the Marine Mammal Protection Act (MMPA) stock assessment reports, short-finned pilot whales within the Pacific U.S. Exclusive Economic Zone are divided into two discrete, non-contiguous areas: 1) waters off California, Oregon and Washington (this report), and 2) Hawaiian waters. Shiho-type short-finned pilot whales comprise the California, Oregon and Washington stock, and are covered in this report. Naisa-type short-finned pilot whales comprise the Hawaiian stock.

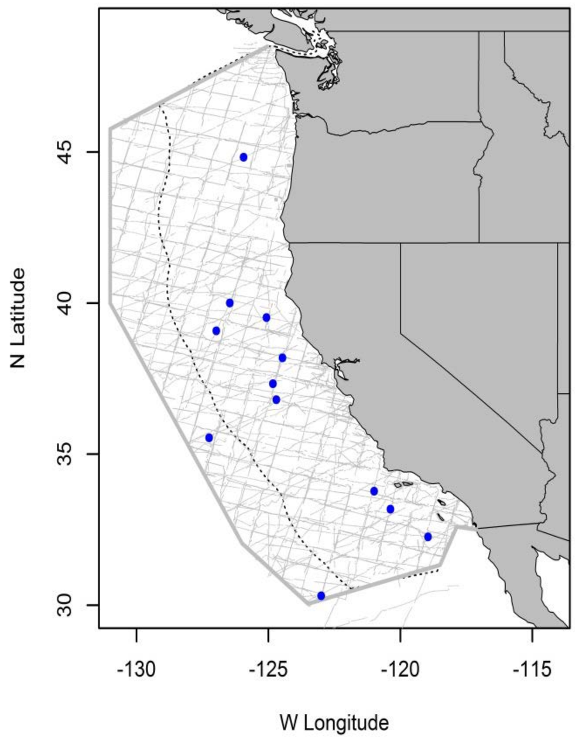

Figure 1. Short-finned pilot whale sightings made during shipboard surveys conducted off California, Oregon, and Washington, 1991-2014 (Barlow 2016). Dashed line represents the U.S. EEZ, thin gray lines indicate completed transect effort of all surveys combined.

POPULATION SIZE

The abundance of short-finned pilot whales in this region is variable and may be influenced by prevailing oceanographic conditions (Forney 1997, Forney and Barlow 1998, Barlow 2016). Because animals may spend time outside the U.S. Exclusive Economic Zone as oceanographic conditions change, a multi-year average abundance estimate is the most appropriate for management within U.S. waters. The most recent estimate of short-finned pilot whale abundance is the geometric mean of estimates from 2008 and 2014 summer/autumn vessel-based line-transect surveys of California, Oregon, and Washington waters, or 836 (CV=0.79) animals (Barlow 2016). This estimate includes new correction factors for animals missed during the surveys.

Minimum Population Estimate

The log-normal 20th percentile of the 2008-2014 geometric mean abundance estimate is 466 short-finned pilot whales.

Current Population Trend

Following the virtual disappearance of short-finned pilot whales from California after the 1982-83 El Niño, they have been encountered infrequently and primarily during warm-water years, such as 1991, 1993, 1997, 2014, and 2015 (e.g., Carretta et al. 1995, Julian and Beeson 1998, Carretta et al. 2004, Barlow 2016). These patterns likely reflect large-scale, long-term movements of this species in response to changing oceanographic conditions. It is not known whether the animals sighted more recently are part of the same population that was documented off Southern California before the mid-1980s or a different wide-ranging pelagic population. Therefore, no inferences can be drawn regarding trends in abundance of short-finned pilot whales off California, Oregon and Washington.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No information on current or maximum net productivity rates is available for short-finned pilot whales off California, Oregon and Washington.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (466) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.48 (for a species of unknown status with bycatch mortality rate CV between 0.3 and 0.6; Wade and Angliss 1997), resulting in a PBR of 4.5 short-finned pilot whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

A summary of known fishery mortality and injury for this stock of short-finned pilot whale is shown in Table 1. More detailed information on these fisheries is provided in Appendix 1. The estimate of mortality and serious injury for short-finned pilot whale in the California drift gillnet fishery for the five most recent years of monitoring, 2010-2014, is 6 (CV= 0.39) individuals, or an average of 1.2 per year (Carretta *et al*. 2017). Bycatch of short-finned pilot whales in the drift gillnet fishery is rarely-observed (14 animals in 8,711 observed sets), but high multivariate El Niño index values associated with warm-water years (Wolter and Timlin 2011) were identified as a significant predictor of bycatch in a recent analysis (Carretta et al. 2017).

Historically, short-finned pilot whales were also killed in squid purse seine operations off Southern California (Miller et al. 1983; Heyning et al. 1994), but these deaths occurred when pilot whales were still common in the region. An observer program in the squid purse seine fishery was initiated in 2004 and a total of 377 sets (<10% of effort) were observed through 2008 without a pilot whale interaction. Gillnets have been documented to entangle marine mammals off Baja California (Sosa-Nishizaki et al. 1993), but no recent bycatch data from Mexico are available.

Table 1. Summary of available information on the incidental mortality and serious injury of short-finned pilot whales (California/Oregon/Washington Stock) in commercial fisheries that might take this species (Carretta *et al*. 2017). Coefficients of variation for mortality estimates are provided in parentheses; n/a = not available.

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality	Estimated Mortality	Mean Annual Takes (CV in parentheses)

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality	Estimated Mortality	Mean Annual Takes (CV in parentheses)
CA/OR thresher shark/swordfish drift gillnet fishery	observer	2010 2011 2012 2013 2014	12% 20% 19% 37% 24%	0 0 0 0 2	0 0 0 0 6 (0.39)	1.2 (0.39)
Market squid purse seine	observer	2004-2008	<10%	0	0	0
Minimum total annual takes						1.2 (0.39)

STATUS OF STOCK

The status of short-finned pilot whales off California, Oregon and Washington in relation to OSP is unknown. They have declined in abundance in the Southern California Bight, since the 1982-83 El Niño, but the nature of these changes and potential habitat issues are not adequately understood. Short-finned pilot whales are not listed as "threatened" or "endangered" under the Endangered Species Act nor as "depleted" under the MMPA. The average annual human-caused mortality, 1.2 animals, is less than the PBR of 4.5, and therefore they are not classified as a "strategic" stock under the MMPA. Total annual human-caused mortality and serious injury for this stock is greater than 10 % of PBR; therefore, mortality and serious injury cannot be considered to be approaching a zero mortality and serious injury rate.

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BAIRD'S BEAKED WHALE (*Berardius bairdii*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Baird's beaked whales are distributed throughout deep waters and along the continental slopes of the North Pacific Ocean (Balcomb 1989, Macleod et al. 2006). They have been harvested and studied in Japanese waters, but little is known about this species elsewhere (Balcomb 1989). Along the U.S. west coast, Baird's beaked whales have been seen primarily along the continental slope (Figure 1) from late spring to early fall. They have been seen less frequently and are presumed to be farther offshore during the colder water months of November through April. For the Marine Mammal Protection Act (MMPA) stock assessment reports, Baird's beaked whales within the Pacific U.S. Exclusive Economic Zone are divided into two discrete, non-contiguous areas: 1) waters off California, Oregon and Washington (this report), and 2) Alaskan waters.

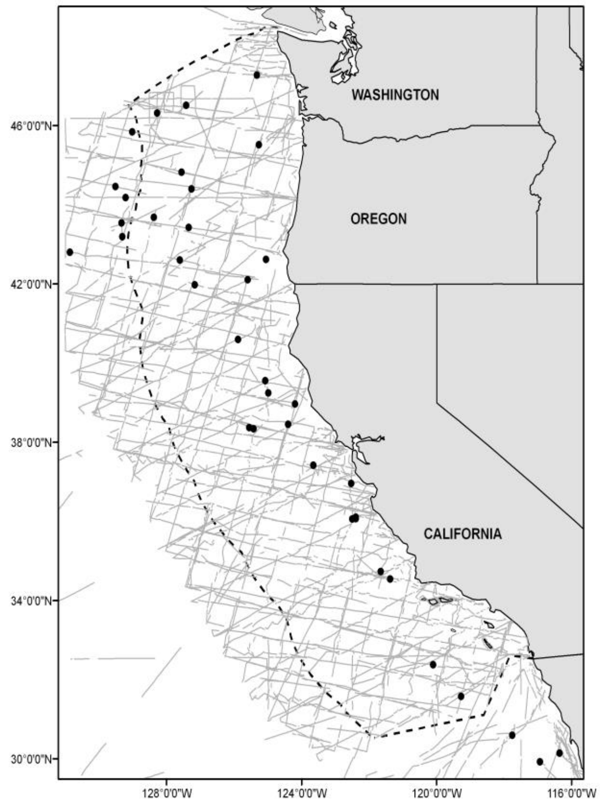

Figure 1. Baird's beaked whale sightings based on shipboard surveys off California, Oregon and Washington, 1991-2008 (see Appendix 2 for data sources and information on timing and location of survey effort). Dashed line represents the U.S. EEZ, thin lines indicate completed transect effort of all surveys combined.

POPULATION SIZE

Two summer/fall shipboard surveys were conducted within 300 nmi of the coasts of California, Oregon and Washington 2005 (Forney 2007) and 2008 (Barlow 2010). Because the distribution of Baird's beaked whale varies and animals probably spend time outside the U.S. Exclusive Economic Zone, a multi-year average abundance estimate is the most appropriate for management within U.S. waters. A geometric mean abundance estimate for California, Oregon and Washington waters based on ship surveys from 2005 and 2008 was 907 (CV=0.49) Baird's beaked whales (Forney 2007, Barlow 2010). This abundance estimate included correction factors for the proportion of animals missed, based on a model of their diving behavior, detection distances, and the searching behavior of observers (Barlow 1999). About 96% of all trackline groups are estimated to be seen. A trend-based analysis of line-transect data from surveys conducted between 1991 and 2008 yielded new estimates of abundance (Moore and Barlow 2013). Based on this analysis and a lack of a detected trend in abundance, a multi-year average of the 2005 and 2008 trend estimates is the most appropriate estimate for this stock. The geometric mean of the best (50th percentile) estimates of abundance for Baird's beaked whales in 2005 (767, CV=1.29) and 2008 (937, CV=1.34) in waters off California, Oregon and Washington is 847 (CV=0.81).

Minimum Population Estimate

The log-normal 20th percentile of the 2005-2008 geometric mean abundance estimate is 466 Baird's beaked whales.

Current Population Trend

The analysis by Moore and Barlow (2013) did not suggest evidence of an abundance trend during 1991–2008 for Baird's beaked whale in waters off the U.S. west coast (Figure 2).

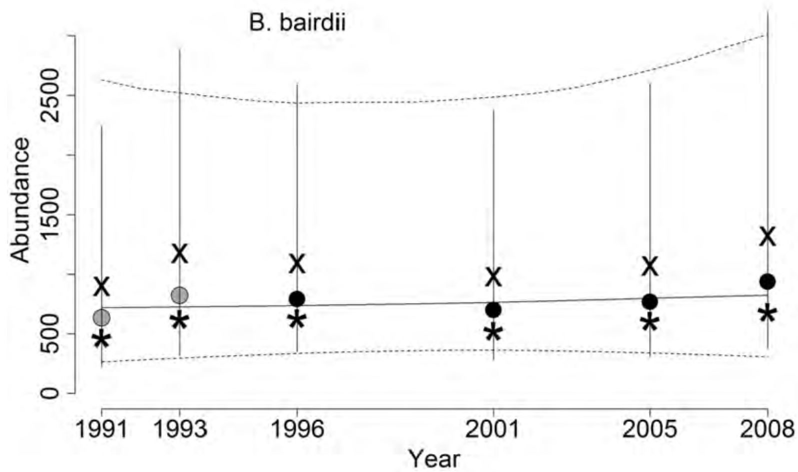

Figure 2. Abundance and trend estimates for Baird's beaked whales in the California Current, 1991-2008 (Moore and Barlow 2013). For each year, the Bayesian posterior median (●), mean (x) and mode (*) abundance estimates are shown, along with 90% CRIs.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No information on current or maximum net productivity rates is available for this species.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (466) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a species of unknown status with no fishery mortality; Wade and Angliss 1997), resulting in a PBR of 4.7 Baird's beaked whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

The California large mesh drift gillnet fishery has been the only fishery known to interact with this stock. One Baird's beaked whale was incidentally killed in this fishery in 1994 (Julian and Beeson 1998), before acoustic pingers were first used in the fishery in 1996 (Barlow and Cameron 2003). Since 1996, no beaked whale of *any* species have been observed entangled or killed in this fishery (Carretta et al. 2008, Carretta and Enriquez 2009a, 2009b, Carretta and Barlow 2011, Carretta and Enriquez 2012a, 2012b). Mean annual takes in Table 1 are based on 2007-2011 data. This results in an average estimated annual mortality of zero Baird's beaked whales. Gillnets have been documented to entangle marine mammals off Baja California (Sosa-Nishizaki et al. 1993), but no recent bycatch data from Mexico are available.

Table 1. Summary of available information on the incidental mortality and injury of Baird's beaked whales (California/Oregon/Washington Stock) in commercial fisheries that might take this species. The single observed entanglement resulted in the death of the animal. Coefficients of variation for mortality estimates are provided in parentheses. Mean annual takes are based on 2007-2011 data unless noted otherwise.

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality	Estimated Annual Mortality	Mean Annual Takes (CV in parentheses)
CA/OR thresher shark/swordfish drift gillnet fishery	observer data	2007 2008 2009 2010 2011	16.4% 13.5% 13.3% 11.9% 19.5%	0 0 0 0 0	0 0 0 0 0	0

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality	Estimated Annual Mortality	Mean Annual Takes (CV in parentheses)
Minimum total annual takes						0

Other mortality

California coastal whaling operations killed 15 Baird's beaked whales between 1956 and 1970, and 29 additional Baird's beaked whales were taken by whalers in British Columbian waters (Rice 1974). One Baird's beaked whale stranded in Washington state in 2003 and the cause of death was attributed to a ship strike. No other human-caused mortality has been reported for this stock for the period 2007-2011.

Anthropogenic sound sources, such as military sonar and seismic testing have been implicated in the mass strandings of beaked whales, including atypical events involving multiple beaked whale species (Simmonds and Lopez-Jurado 1991, Frantiz 1998, Anon. 2001, Jepson et al. 2003, Cox et al. 2006). While D'Amico et al. (2009) note that most mass strandings of beaked whales are unassociated with documented sonar activities, lethal or sub-lethal effects of such activities would rarely be documented, due to the remote nature of such activities and the low probability that an injured or dead beaked whale would strand. Filadelpho et al. (2009) reported statistically significant correlations between military sonar use and mass strandings of beaked whales in the Mediterranean and Caribbean Seas, but not in Japanese and Southern California waters, and hypothesized that regions with steep bathymetry adjacent to coastlines are more conducive to stranding events in the presence of sonar use. In Hawaiian waters, Faerber & Baird (2010) suggest that the probability of stranding is lower than in some other regions due to nearshore currents carrying animals away from beaches, and that stranded animals are less likely to be detected due to low human population density near many of Hawaii's beaches. Actual and simulated sonar are known to interrupt the foraging dives and echolocation activities of tagged beaked whales (Tyack et al. 2011). Blainville's beaked whale presence was monitored on hydrophone arrays before, during, and after sonar activities on a Caribbean military range, with evidence of avoidance behavior: whales were detected throughout the range prior to sonar exposure, not detected in the center of the range coincident with highest sonar use, and gradually returned to the range center after the cessation of sonar activity (Tyack et al. 2011). Fernández et al. (2013) report that there have been no mass strandings of beaked whales in the Canary Islands following a 2004 ban on sonar activities in that region. The absence of beaked whale bycatch in California drift gillnets following the introduction of acoustic pingers into the fishery implies additional sensitivity of beaked whales to anthropogenic sound (Carretta et al. 2008, Carretta and Barlow 2011).

STATUS OF STOCK

The status of Baird's beaked whales in California, Oregon and Washington waters relative to OSP is not known, and no abundance trend is evident. They are not listed as "threatened" or "endangered" under the Endangered Species Act nor as "depleted" under the MMPA. The average annual human-caused mortality during 2007-2011 is zero animals/year. Because recent fishery and human-caused mortality is less than the PBR (4.7), Baird's beaked whales are not classified as a "strategic" stock under the MMPA. The total fishery mortality and serious injury for this stock is zero and can be considered to be insignificant and approaching zero. The impacts of anthropogenic sound on beaked whales remains a concern (Barlow and Gisiner 2006, Cox et al. 2006, Hildebrand et al. 2005, Weilgart 2007).

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MESOPLODONT BEAKED WHALES (*Mesoplodon* spp.): California/Oregon/Washington Stocks

STOCK DEFINITION AND GEOGRAPHIC RANGE

Mesoplodont beaked whales are distributed throughout deep waters and along the continental slopes of the North Pacific Ocean. The six species known to occur in this region are: Blainville's beaked whale (*M. densirostris*), Perrin's beaked whale (*M. perrini*), Lesser beaked whale (*M. peruvianus*), Stejneger's beaked whale (*M. stejnegeri*), Gingko-toothed beaked whale (*M. gingkodens*), and Hubbs' beaked whale (*M. carlhubbsi*) (Mead 1989, Henshaw *et al.* 1997, Dalebout *et al.* 2002, MacLeod et al. 2006). Based on bycatch and stranding records in this region, it appears that Hubb's beaked whale is most commonly encountered (Carretta et al. 2008, Moore and Barlow 2013). Insufficient sighting records exist off the U.S. west coast (Figure 1) to determine any possible spatial or seasonal patterns in the distribution of mesoplodont beaked whales.

Until methods of distinguishing these six species at-sea are developed, the management unit must be defined to include all *Mesoplodon* stocks in this region. However, in the future, species-level management is desirable, and a high priority should be placed on finding means to obtain species-specific abundance information. For the Marine Mammal Protection Act (MMPA) stock assessment reports, three *Mesoplodon* stocks are defined: 1) all *Mesoplodon* species off California, Oregon and Washington (this report), 2) *M. stejnegeri* in Alaskan waters, and 3) *M. densirostris* in Hawaiian waters.

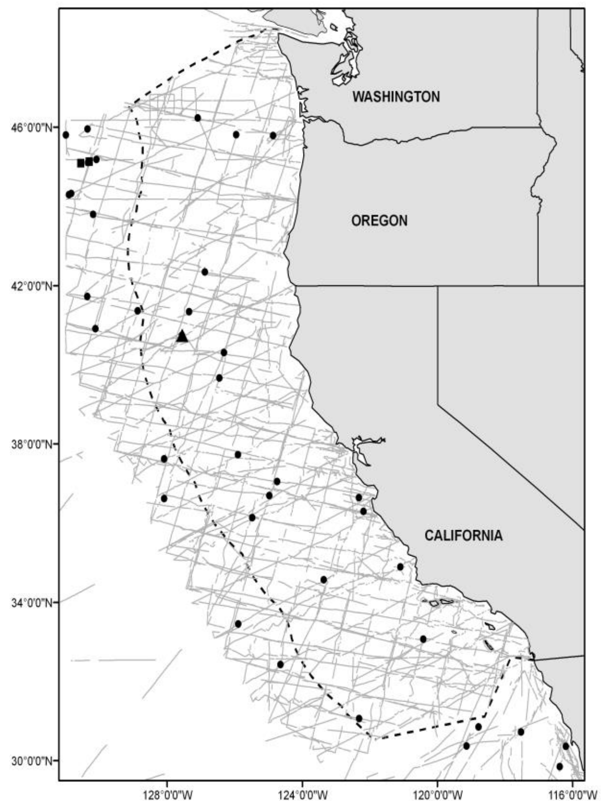

Figure 1. *Mesoplodon* beaked whale sightings based on shipboard surveys off California, Oregon and Washington, 1991-2008 (see Appendix 2 for data sources and information on timing and location of survey effort). Key: • = *Mesoplodon* spp.; ▲= identified *Mesoplodon densirostris*; ■ = identified *Mesoplodon carlhubbsi*. Dashed line represents the U.S. EEZ, thin lines indicate completed transect effort of all surveys combined.

POPULATION SIZE

Although mesoplodont beaked whales have been sighted along the U.S. west coast on several line transect surveys utilizing both aerial and shipboard platforms, the rarity of sightings has historically precluded reliable population estimates. Early abundance estimates are imprecise and biased low by an unknown amount because of the large proportion of time this species spends submerged, and because the ship surveys before 1996 covered only California waters, and thus did not include animals off Oregon/Washington. Furthermore, survey data include a large number of unidentified beaked whale sightings that are probably either *Mesoplodon* sp. or Cuvier's beaked whales (*Ziphius cavirostris*). An abundance estimate of 1,024 (CV = 0.77) for all species of *Mesoplodon* beaked whales in the California Current was obtained based on combining data from the two most recent surveys (2005, 2008) conducted within 300 nmi of the coasts of California, Oregon and Washington (Forney 2007, Barlow and Forney 2007, Barlow 2010). This estimate was based in part on a correction factor to account for the proportion of animals on the survey trackline that were likely to missed by observers (0.55), calculated from a model of beaked whale diving behavior, detection distances and searching behavior by the observers (Barlow 1999). Of the 5 sightings of *Mesoplodon* made during 2005-2008 surveys [all 5 sightings were made during the 2005 survey] two were identified to the 'probable' species level (one *Mesoplodon densirostris* and one *Mesoplodon carlhubbsi*). An estimate of Blainville's beaked whale abundance (603, CV = 1.16) was based on this one probable sighting, while the Hubb's beaked whale sighting was not recorded during standard survey effort, and thus there is no estimate of abundance. The abundance estimate for mesoplodont beaked whales of unknown species, based on the same 2005-2008 surveys was 421 (CV=0.88). A trend-based analysis of line-transect data from surveys conducted between 1991 and 2008 yielded new estimates of *Mesoplodon* species abundance (Moore and Barlow 2013). The new estimate accounts for the proportion of unidentified beaked whale sightings likely to be *Mesoplodon* beaked whales and uses a correction factor for missed animals adjusted to account for the fact that the proportion of animals on the trackline missed by observers increases in rough observing conditions. The trend-model analysis incorporates information from the entire 1991-2008 time series for each annual estimate of abundance, and given the strong evidence of a decreasing abundance trend over that time (Moore and Barlow 2013), the best estimate of abundance is represented by the model-averaged estimate for 2008. Based on this analysis, the best (50th percentile) estimate of abundance for all species of *Mesoplodon* species combined in 2008 in waters off California, Oregon and Washington is 694 (CV=0.65).

Minimum Population Estimate

The minimum population estimate (defined as the log-normal 20th percentile of the abundance estimate) for mesoplodont beaked whales in California, Oregon, and Washington is 389 animals.

Current Population Trend

There is strong evidence, based on line-transect survey data and the historical stranding record off the U.S. west coast, that the abundance of *Mesoplodon* beaked whales has recently declined in waters off California, Oregon and Washington (Moore and Barlow 2013, Figure 2). Statistical analysis of line-transect survey data from 1991 - 2008 indicates a 0.96 probability of decline during this period, with the mean annual rate of population change estimated to have been −7.0% per year (95% CRI: −16.7% to +1.0%). Patterns in the historical stranding record alone provide limited information about beaked whale abundance trends, but the stranding record appears generally consistent rather than at-odds with results of the line-transect survey analysis. Regional stranding networks along the Pacific coast of the U.S. and Canada originated during the 1980s, and beach coverage and reporting rates are thought to have increased throughout the 1990s and in to the early 2000s. Therefore, for a stable or increasing population, an overall increasing trend in stranding reports between the 1980s and 2000s would be expected. In contrast, reported strandings for *M. carlhubbsi* and *M. stejnegeri* in the California Current region have declined monotonically since the 1980s.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No information on current or maximum net productivity rates is available for mesoplodont beaked whales.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (389) <u>times</u> one half the default maximum net growth rate

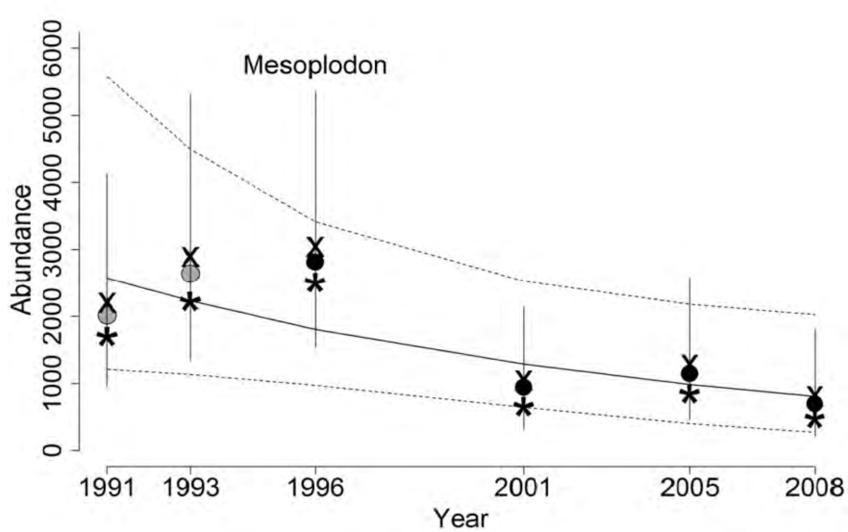

Figure 2. Abundance and trend estimates for mesoplodont beaked whales in the California Current, 1991-2008 (Moore and Barlow 2013). For each year, the Bayesian posterior median (●), mean (x) and mode (*) abundance estimates are shown, along with 90% CRIs.

for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a species of unknown status with no known recent fishery mortality; Wade and Angliss 1997), resulting in a PBR of 3.9 mesoplodont beaked whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

The California large mesh drift gillnet fishery has been the only fishery historically known to interact with *Mesoplodon* beaked whales in this region. Between 1990 and 1995, a total of eight *Mesoplodon* beaked whales (5 Hubb's beaked whales (*Mesoplodon carlhubbsi*), one Stejneger's beaked whale (*Mesoplodon stejnegeri*), and two unidentified whales of the genus *Mesoplodon* were observed entangled in approximately 3,300 sets (Julian and Beeson 1998, Carretta *et al*. 2008). Following the introduction of acoustic pingers into this fishery (Barlow and Cameron 2003), no beaked whales of any species have been observed entangled in over 4,000 observed sets (Carretta *et al*. 2008, Carretta and Enriquez 2009a, 2009b, 2010, 2012a, 2012b, Carretta and Barlow 2011). Mean annual takes in Table 1 are based on 2007-2011 data. This results in an average estimated annual mortality of zero mesoplodont beaked whales.

Gillnets have been documented to entangle marine mammals off Baja California (Sosa-Nishizaki et al. 1993), but no recent bycatch data from Mexico are available.

Table 1. Summary of available information on the incidental mortality and injury of *Mesoplodon* beaked whales (California/Oregon/Washington Stocks) in commercial fisheries that might take these species. Mean annual takes are based on 2007-2011 data unless noted otherwise.

Fishery Name	Data Type	Year	Percent Observer Coverage	Observed Mortality	Estimated Annual Mortality	Mean Annual Takes (CV in parentheses)
CA/OR thresher shark/swordfish drift gillnet fishery	observer	2007 2008 2009 2010 2011	16.4% 13.5% 13.3% 11.9% 19.5%	0 0 0 0 0	0 0 0 0 0	0
Minimum total annual takes of *Mesoplodon* beaked whales						0

Other mortality

Anthropogenic sound sources, such as military sonar and seismic testing have been implicated in the mass strandings of beaked whales, including atypical events involving multiple beaked whale species (Simmonds and Lopez-Jurado 1991, Frantiz 1998, Anon. 2001, Jepson et al. 2003, Cox et al. 2006). While D'Amico et al. (2009) note that most mass strandings of beaked whales are unassociated with documented sonar activities, lethal or sub-lethal effects of such activities would rarely be documented, due to the remote nature of such activities and the low probability that an injured or dead beaked whale would strand. Filadelpho et al. (2009) reported statistically significant correlations between military sonar use and mass strandings of beaked whales in the Mediterranean and Caribbean Seas, but not in Japanese and Southern California waters, and hypothesized that regions with steep bathymetry adjacent to coastlines are more conducive to stranding events in the presence of sonar use. In Hawaiian waters, Faerber & Baird (2010) suggest that the probability of stranding is lower than in some other regions due to nearshore currents carrying animals away from beaches, and that stranded animals are less likely to be detected due to low human population density near many of Hawaii's beaches. Actual and simulated sonar are known to interrupt the foraging dives and echolocation activities of tagged beaked whales (Tyack et al. 2011, DeRuiter et al. 2013). Cuvier's beaked whales tagged and tracked during simulated mid-frequency sonar exposure showed avoidance reactions, including prolonged diving, cessation of echolocation click production associated with foraging, and directional travel away from the simulated sonar source (DeRuiter et al. 2013). Blainville's beaked whale presence was monitored on hydrophone arrays before, during, and after sonar activities on a Caribbean military range, with evidence of avoidance behavior: whales were detected throughout the range prior to sonar exposure, not detected in the center of the range coincident with highest sonar use, and gradually returned to the range center after the cessation of sonar activity (Tyack et al. 2011). Fernández et al. (2013) report that there have been no mass strandings of beaked whales in the Canary Islands following a 2004 ban on sonar activities in that region. The absence of beaked whale bycatch in California drift gillnets following the introduction of acoustic pingers into the fishery implies additional sensitivity of beaked whales to anthropogenic sound (Carretta et al. 2008, Carretta and Barlow 2011).

STATUS OF STOCKS

The status of mesoplodont beaked whales in California, Oregon and Washington waters relative to OSP is not known, but evidence suggests a high likelihood of population decline in the California Current since the early 1990s, at a mean rate of −7.0% per year, which corresponds to trend-fitted abundance levels in 2008 (most recent survey) being at approximately 30% of 1991 levels. Moore and Barlow (2013) ruled out bycatch as a cause of the decline in mesoplodont beaked whale abundance and suggest that impacts from anthropogenic sound such as naval sonar and deepwater ecosystem changes within the California Current are plausible hypotheses warranting further investigation. None of the six species is listed as "threatened" or "endangered" under the Endangered Species Act, but given the long-term decline in mesoplodont beaked whale abundance in the California Current reported by Moore and Barlow (2013), these stocks are considered strategic. The degree of decline (trend-fitted 2008 abundance at approximately 30% of 1991 levels) also suggests that these stocks are likely well below their carrying capacity and may be depleted. The average annual known human-caused fishery mortality between 2007 and 2011 is zero. It is likely that the difficulty in identifying these animals in the field will remain a critical obstacle to obtaining species-specific abundance estimates and stock assessments in the future. The impacts of anthropogenic sound on beaked whales remains a concern (Barlow and Gisiner 2006, Cox et al. 2006, Hildebrand et al. 2005, Weilgart 2007).

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CUVIER'S BEAKED WHALE (*Ziphius cavirostris*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Cuvier's beaked whales are distributed widely throughout deep waters of all oceans (MacLeod et al. 2006). Off the U.S. west coast, this species is the most commonly encountered beaked whale (Figure 1). No seasonal changes in distribution are apparent from stranding records, and morphological evidence is consistent with the existence of a single eastern North Pacific population from Alaska to Baja California, Mexico (Mitchell 1968). For the Marine Mammal Protection Act (MMPA) stock assessment reports, Cuvier's beaked whales within the Pacific U.S. Exclusive Economic Zone are divided into three discrete, non-contiguous areas: 1) waters off California, Oregon and Washington (this report), 2) Alaskan waters, and 3) Hawaiian waters.

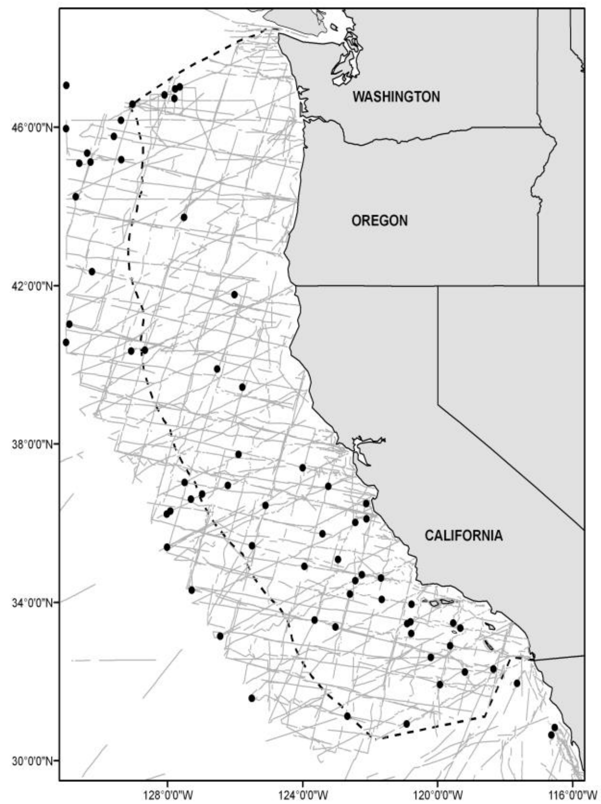

Figure 1. Cuvier's beaked whale sightings based on shipboard surveys off California, Oregon and Washington, 1991-2008 (see Appendix 2, for data sources and information on timing and location of survey effort). Dashed line represents the U.S. EEZ, thin lines indicate completed transect effort of all surveys combined.

POPULATION SIZE

Although Cuvier's beaked whales have been sighted along the U.S. west coast on several line transect surveys utilizing both aerial and shipboard platforms, the rarity of sightings has historically precluded reliable population estimates. Early abundance estimates were imprecise and biased low by an unknown amount because of the large proportion of time this species spends submerged, and because ship surveys before 1996 covered only California waters, and thus did not include animals off Oregon/Washington. Furthermore, survey data include a large number of unidentified beaked whale sightings that are probably either *Mesoplodon* sp. or Cuvier's beaked whales (*Ziphius cavirostris*). An abundance estimate of 2,143 (CV = 0.65) was obtained based on combining data from the two most recent surveys (2005, 2008) conducted within 300 nmi of the coasts of California, Oregon and Washington (Forney 2007, Barlow and Forney 2007, Barlow 2010). This estimate was based in part on a correction factor to account for the proportion of animals on the survey trackline that were likely to missed by observers (0.67), calculated from a model of Cuvier's beaked whale diving behavior, detection distances and searching behavior by the observers (Barlow 1999). A trend-based analysis of line-transect data from surveys conducted between 1991 and 2008 yielded new estimates of Cuvier's beaked whale abundance (Moore and Barlow 2013). The new estimate is substantially higher than previous estimates in part because it accounts for the proportion of unidentified beaked whale sightings likely to be Cuvier's beaked whales and because the correction factor for missed animals was adjusted to account for the fact that the proportion of animals on the trackline missed by observers increases in rough observing conditions. The trend-model analysis incorporates information from the entire

1991-2008 time series for each annual estimate of abundance, and given the strong evidence of a decreasing abundance trend over that time (Moore and Barlow 2013), the best estimate of abundance is represented by the model-averaged estimate for 2008. Based on this analysis, the best (50^{th} percentile) estimate of abundance for Cuvier's beaked whales in 2008 in waters off California, Oregon and Washington was 6,590 (CV=0.55).

Minimum Population Estimate

Based on the analysis by Moore and Barlow (2013), the minimum population estimate (defined as the log-normal 20th percentile of the abundance estimate) for Cuvier's beaked whales in California, Oregon, and Washington is 4,481 animals.

Current Population Trend

There is substantial evidence, based on line-transect survey data and the historical stranding record off the U.S. west coast, that the abundance of Cuvier's beaked whales has recently declined in waters off California, Oregon and Washington (Moore and Barlow 2013, Figure 2). Statistical analysis of line-transect survey data from 1991 - 2008 indicates a 0.84 probability of decline during this period, with the mean annual rate of population change estimated to have been −2.9% per year (95% CRI: −8.8% to +3.3%). Patterns in the historical stranding record alone provide limited information about beaked whale abundance trends, but the stranding record appears generally consistent rather than at-odds with results of the line-transect survey analysis. Regional stranding networks along the Pacific coast of the U.S. and Canada originated during the 1980s, and beach coverage and reporting rates are thought to have increased throughout the 1990s and in to the early 2000s. Therefore, for a stable or increasing population, an overall increasing trend in stranding reports between the 1980s and 2000s would be expected. Patterns of Cuvier's beaked whale strandings data are highly variable across stranding network regions, but an overall increasing trend from the 1980s through 2000s is not evident within the California Current area, contrary to patterns for Baird's beaked whales (Moore and Barlow 2013) and for cetaceans in general (e.g., Norman et al. 2004, Danil et al. 2010).

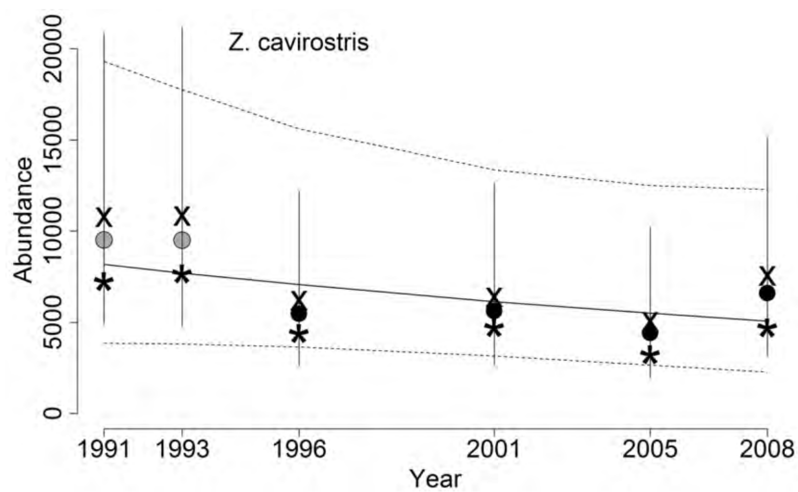

Figure 2. Abundance and trend estimates for Cuvier's beaked whales in the California Current, 1991-2008 (Moore and Barlow 2013). For each year, the Bayesian posterior median (●), mean (x) and mode (*) abundance estimates are shown, along with 90% CRIs.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No information on current or maximum net productivity rates is available for this species.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (4,481) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a species of unknown status with no known fishery mortality; Wade and Angliss 1997), resulting in a PBR of 45 Cuvier's beaked whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

A summary of recent fishery mortality and injury for Cuvier's beaked whales in this region is shown in Table 1. The California large mesh drift gillnet fishery has been the only fishery historically known to interact with this stock. There have been no Cuvier's beaked whales observed entangled in over 4,000 drift gillnet fishery sets since acoustic pingers were first used in this fishery in 1996 (Barlow and Cameron 2003, Carretta et al. 2008, Carretta and Enriquez 2009a, 2009b, 2010, 2012a, 2012b, Carretta and Barlow 2011). Prior to 1996, there were a total of 21 Cuvier's beaked whales entangled in approximately 3,300 drift gillnet fishery sets: 1992 (six animals), 1993 (three), 1994 (six) and 1995 (six) (Julian and Beeson 1998). Mean annual takes in Table 1 are based only on 2007-2011 data. This results in an average estimated annual mortality of zero Cuvier's beaked whales.

Table 1. Summary of available information on the incidental mortality and injury of Cuvier's beaked whales (California/ Oregon/Washington Stock) in commercial fisheries that might take this species. Mean annual takes are based on 2007-2011 data unless noted otherwise.

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality + ReleasedAlive	Estimated Annual Mortality / Mortality + Entanglements	Mean Annual Takes (CV in parentheses)
CA/OR thresher shark/swordfish drift gillnet fishery	observer data	2007 2008 2009 2010 2011	16.4% 13.5% 13.3% 11.9% 19.5%	0 0 0 0 0	0 0 0 0 0	0
Minimum total annual takes						0

Gillnets have been documented to entangle marine mammals off Baja California (Sosa-Nishizaki et al. 1993), but no recent bycatch data from Mexico are available.

Other mortality

Anthropogenic sound sources, such as military sonar and seismic testing have been implicated in the mass strandings of beaked whales, including atypical events involving multiple beaked whale species (Simmonds and Lopez-Jurado 1991, Frantiz 1998, Anon. 2001, Jepson et al. 2003, Cox et al. 2006). While D'Amico et al. (2009) note that most mass strandings of beaked whales are unassociated with documented sonar activities, lethal or sub-lethal effects of such activities would rarely be documented, due to the remote nature of such activities and the low probability that an injured or dead beaked whale would strand. Filadelpho et al. (2009) reported statistically significant correlations between military sonar use and mass strandings of beaked whales in the Mediterranean and Caribbean Seas, but not in Japanese and Southern California waters, and hypothesized that regions with steep bathymetry adjacent to coastlines are more conducive to stranding events in the presence of sonar use. In Hawaiian waters, Faerber & Baird (2010) suggest that the probability of stranding is lower than in some other regions due to nearshore currents carrying animals away from beaches, and that stranded animals are less likely to be detected due to low human population density near many of Hawaii's beaches. Actual and simulated sonar are known to interrupt the foraging dives and echolocation activities of tagged beaked whales (Tyack et al. 2011, DeRuiter et al. 2013). Cuvier's beaked whales tagged and tracked during simulated mid-frequency sonar exposure showed avoidance reactions, including prolonged diving, cessation of echolocation click production associated with foraging, and directional travel away from the simulated sonar source (DeRuiter et al. 2013). Blainville's beaked whale presence was monitored on hydrophone arrays before, during, and after sonar activities on a Caribbean military range, with evidence of avoidance behavior: whales were detected throughout the range prior to sonar exposure, not detected in the center of the range coincident with highest sonar use, and gradually returned to the range center after the cessation of sonar activity (Tyack et al. 2011). Fernández et al. (2013) report that there have been no mass strandings of beaked whales in the Canary Islands following a 2004 ban on sonar activities in that region. The absence of beaked whale bycatch in California drift gillnets following the introduction of acoustic pingers into the fishery implies additional sensitivity of beaked whales to anthropogenic sound (Carretta et al. 2008, Carretta and Barlow 2011).

STATUS OF STOCK

The status of Cuvier's beaked whales in California, Oregon and Washington waters relative to OSP is not known, but evidence suggests a substantial likelihood of population decline in the California

Current since the early 1990s, at a mean rate of -2.9% per year, which corresponds to trend-fitted abundance levels in 2008 (most recent survey) being at 61% of 1991 levels. They are not listed as "threatened" or "endangered" under the Endangered Species Act nor as "depleted" under the MMPA, but given the long-term decline in Cuvier's beaked whale abundance in the California Current reported by Moore and Barlow (2013), this stock is considered strategic. The degree of decline (trend-fitted 2008 abundance at approximately 61% of 1991 levels) also suggests that this stock is likely below its carrying capacity and may be depleted. Moore and Barlow (2013) ruled out bycatch as a cause of the decline in Cuvier's beaked whale abundance and suggest that impacts from anthropogenic sounds such as naval sonar and deepwater ecosystem changes within the California Current are plausible hypotheses warranting further investigation. The average annual known human-caused mortality between 2007 and 2011 is zero. The total fishery mortality and serious injury for this stock is less than 10% of the PBR and thus can be considered to be insignificant and approaching zero. The impacts of anthropogenic sound on beaked whales remains a concern (Barlow and Gisiner 2006, Cox et al. 2006, Hildebrand et al. 2005, Weilgart 2007).

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PYGMY SPERM WHALE (*Kogia breviceps*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Pygmy sperm whales are distributed throughout deep waters and along the continental slopes of the North Pacific and other ocean basins (Ross 1984; Caldwell and Caldwell 1989). Along the U.S. west coast, sightings of this species and of animals identified only as *Kogia* sp. have been rare (Figure 1). However, this probably reflects their pelagic distribution, small body size and cryptic behavior, rather than a measure of rarity. Strandings of pygmy sperm whales in this region are known from California, Oregon and Washington (Roest 1970; Caldwell and Caldwell 1989; NMFS, Northwest Region, unpublished data; NMFS, Southwest Region, unpublished data), while strandings of dwarf sperm whales (*Kogia sima*) are rare in this region. At-sea sightings in this region have all been either of pygmy sperm whales or unidentified *Kogia* sp. Available data are insufficient to identify any seasonality in the distribution of pygmy sperm whales, or to delineate possible stock boundaries. For the Marine Mammal Protection Act (MMPA) stock assessment reports, pygmy sperm whales within the Pacific U.S. Exclusive Economic Zone are divided into two discrete, non-contiguous areas: 1) waters off California, Oregon and Washington (this report), and 2) Hawaiian waters.

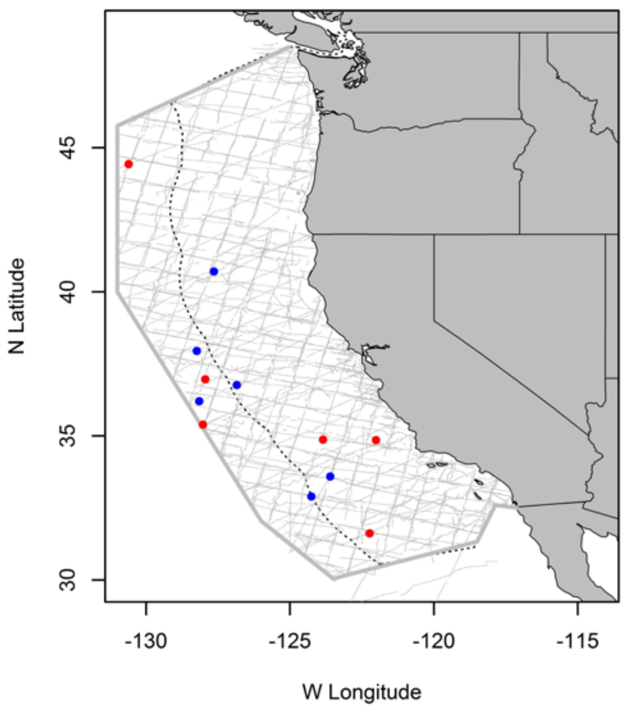

Figure 1. *Kogia* sightings based on shipboard surveys off California, Oregon and Washington, 1991-2014. Key: ● = *Kogia breviceps*, ● = *Kogia* spp. Dashed line represents the U.S. EEZ, thin lines indicate completed transect effort of all surveys combined.

POPULATION SIZE

Most sightings of *Kogia* in the California Current are only identified to genus due to their cryptic nature, but based on positively-identified sightings from previous surveys and historical stranding data, most of these sightings were probably pygmy sperm whales; *K. breviceps*. The rarity of sightings likely reflects the cryptic nature of this species (they are detected almost exclusively in extremely calm sea conditions), rather than an absence of animals in the region. The best estimate of abundance for this stock is the geometric mean of 2008 and 2014 shipboard line-transect surveys, or 4,111 (CV=1.12) animals. This estimate is considerably higher than previous abundance estimates for the genus *Kogia* and results from a new and lower estimate of *g(0)*, the trackline detection probability (Barlow 2015). Only 3% of *Kogia* groups were estimated to have been detected on the trackline during 1991-2014 surveys (Barlow 2016).

Minimum Population Estimate

The minimum population estimate is taken as the log-normal 20th percentile of the 2008 and 2014 average abundance estimate for California, Oregon, and Washington waters, or 1,924 animals.

Current Population Trend

Due to the rarity of sightings of this species on surveys along the U.S. West coast, no information exists regarding trends in abundance of this population.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No information on current or maximum net productivity rates is available for this species.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (1,924) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a species of unknown status with no known fishery mortality during the last five years; Wade and Angliss 1997), resulting in a PBR of 19 pygmy sperm whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

A summary of recent fishery mortality and injury for pygmy sperm whales and unidentified *Kogia*, which may have been pygmy sperm whales, is shown in Table 1. In the California swordfish drift gillnet fishery (the only U.S. west coast fishery likely to interact with *Kogia*), no mortality of pygmy sperm whales or unidentified *Kogia* was observed during the most recent five years of monitoring (Carretta *et al*. 2017). Over 8,600 fishing sets have been monitored in the California swordfish drift gillnet fishery between 1990 and 2014 and only 2 pygmy sperm whales were observed entangled (Carretta et al. 2017). Both animals were entangled in years that predated the use of acoustic pingers in the fishery to reduce bycatch (Barlow and Cameron 2003), but the small sample size of *Kogia breviceps* bycatch in the fishery precludes any conclusions regarding the effectiveness of acoustic pingers in reducing bycatch of this species (Carretta and Barlow 2011). Mean annual takes in Table 1 are based on 2010-2014 data. This results in an average estimated annual mortality of zero pygmy sperm whales.

One pygmy sperm whale stranded in California in 2002 with evidence that it died as a result of a shooting (positive metal detector scan). Due to the cryptic and pelagic nature of this species, it is likely that the shooting resulted from an interaction with an unknown entangling net fishery. Although there are no records of fishery-related strandings of pygmy sperm whales along the U.S. west coast in recent years (Carretta *et al*. 2013, 2014, 2015, 2016a), compared with other more coastal cetaceans, the probability of a pygmy sperm whale carcass coming ashore and being detected would be quite low (Carretta *et al*. 2016b).

Other mortality

Unknown levels of injuries and mortality of pygmy sperm whales may occur as a result of anthropogenic sound, such as military sonars. Atypical multispecies mass strandings, sometimes involving pygmy and/or dwarf sperm whales have been associated with military sonar use. One 1988 event from the Canary Islands included 2 pygmy sperm whales and the species *Ziphius cavirostris* and *Hyperoodon ampullatus* (reviewed in D'Amico *et al*. 2009). Another mass stranding and unusual mortality event (UME) in North Carolina, USA in 2005 included 2 dwarf sperm whales, in addition to 33 short-finned pilot whales and a minke whale (Hohn *et al*. 2006). This UME coincided in time and space with military activity using mid-frequency active sonar, although the authors note that a definitive association between the UME and sonar use is lacking (Hohn *et al*. 2006). Such injuries or mortality to pygmy sperm whales would rarely be documented, due to the remote nature of many of these activities and the low probability that an injured or dead pygmy sperm whale would strand.

STATUS OF STOCK

The status of pygmy sperm whales in California, Oregon and Washington waters relative to OSP is not known, and there are insufficient data to evaluate potential trends in abundance. Although the impacts of anthropogenic sounds such as sonar are often focused on beaked whales (Barlow and Gisiner 2006), the impacts of such sounds on deep-diving pygmy beaked whales also warrants concern. They are not listed as "threatened" or "endangered" under the Endangered Species Act nor as "depleted" under the MMPA. Given the rarity of sightings and lack of recent documented fishery interactions in U.S. west coast waters, pygmy sperm whales are not classified as a "strategic" stock under the MMPA.

Table 1. Summary of available information on the incidental mortality and injury of pygmy sperm whales and unidentified *Kogia* sp. (California/Oregon/Washington Stock) in commercial fisheries that might take this species. Coefficients of variation for mortality estimates are provided in parentheses. Mean annual takes are based on 2010-2014 data unless noted otherwise (Carretta *et al.* 2017).

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality *K. breviceps* /*Kogia* sp.	*Estimated Annual Mortality of K. breviceps/Kogia sp.*	*Mean Annual Takes (CV in parentheses)*

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality *K. breviceps /Kogia* sp.	*Estimated Annual Mortality of K. breviceps/Kogia* sp.	*Mean Annual Takes (CV in parentheses)*
CA/OR thresher shark/swordfish drift gillnet fishery	observer data	2010 2011 2012 2013 2014	12% 20% 19% 37% 24%	0 0 0 0 0	0	0
Minimum total annual takes						0

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DWARF SPERM WHALE (*Kogia sima*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Dwarf sperm whales are distributed throughout deep waters and along the continental slopes of the North Pacific and other ocean basins (Caldwell and Caldwell 1989; Ross 1984). This species was only recognized as being distinct from the pygmy sperm whale in 1966 (Handley, 1966), and early records for the two species are confounded. Along the U.S. west coast, no at-sea sightings of this species have been reported; however, this may be partially a reflection of their pelagic distribution, small body size and cryptic behavior. A few sightings of animals identified only as *Kogia* sp. have been reported (Figure 1), and some of these may have been dwarf sperm whales. At least five dwarf sperm whales stranded in California between 1967 and 2000 (Roest 1970; Jones 1981; J. Heyning, pers. comm.; NMFS, Southwest Region, unpublished data), and one stranding is reported for western Canada (Nagorsen and Stewart 1983). It is unclear whether records of dwarf sperm whales are so rare because they are not regular inhabitants of this region, or merely because of their cryptic habits and offshore distribution. Available data are insufficient to identify any seasonality in the distribution of dwarf sperm whales, or to delineate possible stock boundaries. For the Marine Mammal Protection Act (MMPA) stock assessment reports, dwarf sperm whales within the Pacific U.S. Exclusive Economic Zone are divided into two discrete, non-contiguous areas: 1) waters off California, Oregon and Washington (this report), and 2) Hawaiian waters.

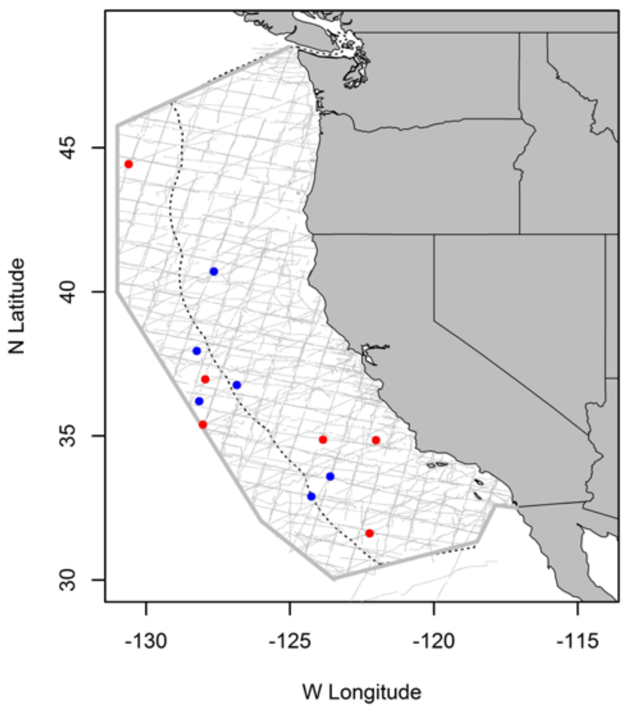

Figure 1. *Kogia* sightings based on shipboard surveys off California, Oregon and Washington, 1991-2014. Key: ● = *Kogia breviceps*; ● = *Kogia* spp. Dashed line represents the U.S. EEZ, thin lines indicate completed transect effort of all surveys combined.

POPULATION SIZE

No information is available to estimate the population size of dwarf sperm whales off the U.S. west coast, as no sightings of this species have been documented despite numerous vessel surveys of this region (Barlow 1995; Barlow and Gerrodette 1996; Barlow and Forney 2007; Forney 2007; Barlow 2010, Barlow 2016). Based on previous sighting surveys and historical stranding data, it is likely that recent ship survey sightings were of pygmy sperm whales; *K. breviceps.*

Minimum Population Estimate

No information is available to obtain a minimum population estimate for dwarf sperm whales.

Current Population Trend

Due to the rarity of records for this species along the U.S. West coast, no information exists regarding trends in abundance of this population.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No information on current or maximum net productivity rates is available for this species.

POTENTIAL BIOLOGICAL REMOVAL

Based on this stock's unknown status and growth rate, the recovery factor (F_r) is 0.5, and ½R_{max} is the default value of 0.02. However, due to the lack of abundance estimates for this species, no potential biological removal (PBR) can be calculated.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

The fishery most likely to interact with dwarf sperm whales in the California Current is the swordfish drift gillnet fishery. There have been no observed dwarf sperm whale entanglements in over 8,600 monitored fishing sets from 1990 to 2014 (Carretta *et al.* 2017). Although there are no records of fishery-related strandings of dwarf sperm whales along the U.S. west coast in recent years (Carretta *et al.* 2013, 2014, 2015, 2016a), compared with other more coastal cetaceans, the probability of a dwarf sperm whale carcass coming ashore and being detected would be quite low (Carretta *et al*. 2016b).

Table 1. Summary of available information on the incidental mortality and injury of dwarf sperm whales and unidentified *Kogia* sp. (California/Oregon/Washington Stock) in commercial fisheries that might take this species. Coefficients of variation for mortality estimates are provided in parentheses. Mean annual takes are based on 2010-2014 data.

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality *K. breviceps /Kogia* sp.	*Estimated Annual Mortality of K. breviceps/Kogia* sp.	*Mean Annual Takes (CV in parentheses)*
CA/OR thresher shark/swordfish drift gillnet fishery	observer data	2010-2014	12% to 37%	0	0	0
Minimum total annual takes						0

Other Mortality

Unknown levels of injuries and mortality of dwarf sperm whales may occur as a result of anthropogenic sound, such as military sonars. Atypical multispecies mass strandings, sometimes involving dwarf and/or pygmy sperm whales have been associated with military sonar use. One 1988 event from the Canary Islands included 2 pygmy sperm whales and the species *Ziphius cavirostris* and *Hyperoodon ampullatus* (reviewed in D'Amico *et al.* 2009). Another mass stranding and unusual mortality event (UME) in North Carolina, USA in 2005 included 2 dwarf sperm whales, in addition to 33 short-finned pilot whales and a minke whale (Hohn *et al.* 2006). This UME coincided in time and space with military activity using mid-frequency active sonar, although the authors note that a definitive association between the UME and sonar use is lacking (Hohn *et al*. 2006). Such injuries or mortality would rarely be documented, due to the remote nature of many of these activities and the low probability that an injured or dead dwarf sperm whale would strand.

STATUS OF STOCK

The status of dwarf sperm whales in California, Oregon and Washington waters relative to OSP is not known, and there are insufficient data to evaluate potential trends in abundance. Although the impacts of anthropogenic sounds such as sonar are often focused on beaked whales (Barlow and Gisiner 2006), the impacts of such sounds on deep-diving dwarf beaked whales also warrants concern. They are not listed as "threatened" or "endangered" under the Endangered Species Act nor as "depleted" under the MMPA. Given that this species rarely occurs off the U.S. west coast and a lack of recent documented fishery mortality, dwarf sperm whales off California, Oregon and Washington are not classified as a "strategic" stock under the MMPA.

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SPERM WHALE (*Physeter macrocephalus*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Sperm whales are distributed across the entire North Pacific and into the southern Bering Sea in summer, but the majority are thought to be south of 40°N in winter (Rice 1974; Rice 1989; Gosho et al. 1984; Miyashita et al. 1995). The International Whaling Commission (IWC) historically divided the North Pacific into two management regions (Donovan 1991) defined by a zig-zag line which starts at 150°W at the equator, is 160°W between 40-50°N, and ends up at 180°W north of 50°N; however, the IWC has not reviewed this stock boundary recently (Donovan 1991). Sperm whales are found year-round in California waters (Dohl et al. 1983; Barlow 1995; Forney et al. 1995), but they reach peak abundance from April through mid-June and from the end of August through mid-November (Rice 1974). Sperm whales are seen off Washington and Oregon in every season except winter (Green et al. 1992). Of 176 sperm whales that were marked with Discovery tags off southern California in winter 1962-70, only three were recovered by whalers: one off northern California in June, one off Washington in June, and another far off British Columbia in April (Rice 1974). Recent summer/fall surveys in the eastern tropical Pacific (Wade and Gerrodette 1993) show that although sperm whales are widely distributed in the tropics, their relative abundance declines westward towards the middle of the tropical Pacific (near the IWC stock boundary at 150°W) and declines northward towards the tip of Baja California. Sperm whale population structure in the eastern tropical Pacific is unknown, but the only photographic matches of known individuals from this area have been between the Galapagos Islands and coastal waters of South America (Dufault and Whitehead 1995) and between the Galapagos Islands and the southern Gulf of California (Jaquet et al. 2003), suggesting that eastern tropical Pacific animals constitute a distinct stock. No apparent distributional hiatus was found between the U.S. EEZ off California and Hawaii during a survey designed specifically to investigate stock structure and abundance of sperm whales in the northeastern temperate Pacific (Barlow and Taylor 2005). Sperm whales in the California Current have been identified as demographically independent from animals in Hawaii and the Eastern Tropical Pacific, based on genetic analyses of single-nucleotide polymorphisms (SNPs), microsatellites, and mtDNA (Mesnick *et al.* 2011). For the Marine Mammal Protection Act (MMPA) stock assessment reports, sperm whales within the Pacific U.S. EEZ are divided into three

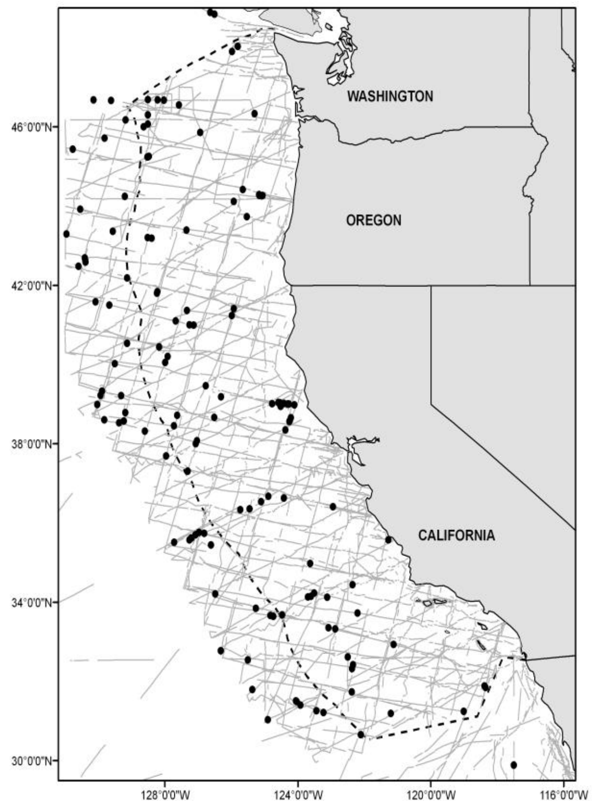

Figure 1. Sperm whale sighting locations from shipboard surveys off California, Oregon, and Washington, 1991-2008. Dashed line represents the U.S. EEZ, thin lines indicate completed transect effort of all surveys combined. See Appendix 2 for data sources and information on timing and location of survey effort.

discrete, non-contiguous areas: 1) California, Oregon and Washington waters (this report), 2) waters around Hawaii, and 3) Alaska waters.

POPULATION SIZE

Previous estimates of sperm whale abundance from 2005 (3,140, CV=0.40, Forney 2007) and 2008 (300, CV=0.51, Barlow 2010) show a ten-fold difference that cannot be attributed to human-caused or natural population declines and likely reflect inter-annual variability in movement of animals into and out of the study area. New estimates of sperm whale abundance in California, Oregon, and Washington waters out to 300 nmi are available from a trend-model analysis of line-transect data collected from six surveys conducted from 1991 to 2008 (Moore and Barlow 2014), using methods similar to previous abundance trend analyses for fin whales (Moore and Barlow 2011) and beaked whales (Moore and Barlow 2013). Abundance trend models incorporate information from the entire 1991-2008 time series to obtain each annual abundance estimate, yielding estimates with less inter-annual variability. The trend model also uses improved estimates of group size and trackline detection probability (Moore and Barlow 2014). Sperm whale abundance estimates based on the trend-model ranged between 2,000 and 3,000 animals for the 1991-2008 time series (Moore and Barlow 2014). The best estimate of sperm whale abundance in the California Current is the trend-based estimate corresponding to the most recent survey (2008), or 2,106 animals (CV=0.58). This estimate is corrected for diving animals not seen during surveys.

Minimum Population Estimate

The minimum population estimate for sperm whales is taken as the lower 20th percentile of the posterior distribution of abundance estimated from 2008 or 1,332 whales (Moore and Barlow 2014).

Current Population Trend

Moore and Barlow (2014) report that sperm whale abundance appeared stable from 1991 to 2008 (Figure 2), but that reliable conclusions on population trends could not be made because the precision of estimated growth rates was poor. However, they also reported that trends in the detection of single animals (presumably large, solitary males) apparently doubled over this time period. The authors could not determine if the apparent increase in sightings of single animals reflected an increase in the number of adult male sperm whales in the population or merely increased use of the U.S. west coast waters by adult males in recent years.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

There are no published estimates of the growth rate for any sperm whale population (Best 1993).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (1,332) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.1 (for an endangered stock with N_{min} <1,500; Taylor et al. 2003), resulting in a PBR of 2.7 animals per year.

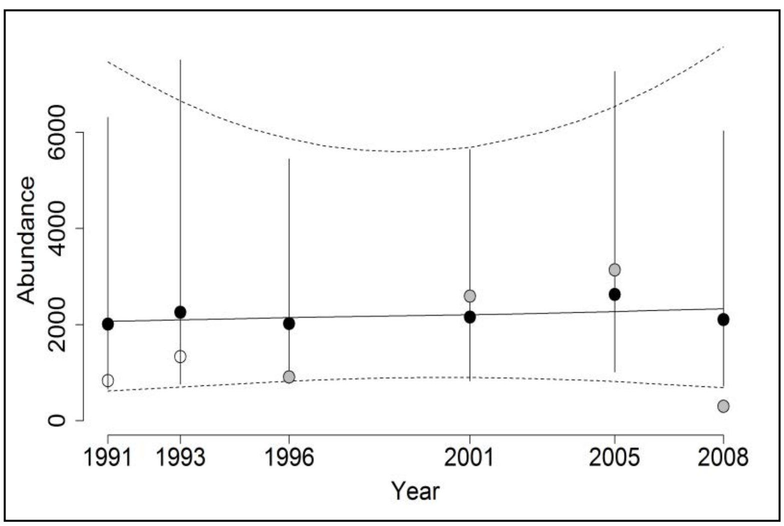

Figure 2. Trend-based estimates of sperm whale abundance in the California Current, 1991-2008 (Moore and Barlow 2014). Abundance estimates (posterior medians [●] and 95% CRIs) from the trend model, with fitted trend line and 95% CRIs for trend. For comparison, open and gray circles depict earlier published estimates from Barlow and Forney (2007) and Barlow (2010), with those for 1991 and 1993 [○] being for a smaller surveyed area.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Serious Injury Guidelines

NMFS uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to distinguis serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "injury that is more likely than not to result in mortality".

Fishery Information

The fishery most likely to directly take sperm whales from this stock is the California thresher shark/swordfish drift gillnet fishery (Julian and Beeson 1998, Carretta and Enriquez 2012). Observed serious injury and mortality has been rarely documented in the gillnet fishery (10 animals observed during ~8,500 observed sets between 1990 and 2014). Given the historic long-term average observer coverage of ~15% for this fishery (Carretta and Barlow 2011), annual estimates of bycatch will always be either zero (if no sperm bycatch is observed) or at least 7 (if ≥ 1 observed), for estimates made using within-year ratio methods [*e.g.,* estimated bycatch = observed bycatch/percent observer coverage]. If the true average annual mortality and serious injury is > 0, but less than a few animals per year, and if observer coverage generally remains low, then multiple years of data need to be pooled to for unbiased estimation of a mean annual bycatch rates (Carretta and Moore, 2014). Pooling more years reduces bias (estimates of mean annual bycatch approaches the true rate) and provides increased precision of bycatch estimates to better estimate long-term annual mortality and serious injury. Most marine mammal stock assessment reports utilize a 5-year time period for pooling bycatch estimates (NMFS 2005), but in the case of rare events, this 5-year time frame will yield biased estimates (systematic over- or underestimation of true bycatch) with insufficient precision (Carretta and Moore 2014, Moore and Merrick 2011). Since 2001, the drift gillnet fishery has been subject to a time/area closure that restricts most fishing to south of Point Conception, California, in waters generally shallower than 2,000 m, where bycatch risk to sperm whales is lower. The post-2000 time period best represents the current spatial state of the fishery and is used to calculate mean annual bycatch for sperm whales. Between 2001 and 2013, two sperm whales (one death and one serious injury in the same set) were entangled during 2,392 observed sets, resulting in a mean bycatch rate of 0.84 per 1,000 sets. Annual bycatch estimates for the 12-year period of 2001-2012 are presented for the drift gillnet fishery in Table 1 and are based on previously published estimates (Carretta et al. 2004, 2014a, Carretta and Chivers 2004, Carretta et al. 2005, Carretta and Enriquez 2006, 2007, 2009a, 2009b, 2010, 2012).

Although acoustic pingers are known to reduce the entanglement of cetaceans in the California drift gillnet swordfish fishery (Barlow and Cameron 2003, Carretta et al. 2008, Carretta and Barlow 2011), it is unknown whether pingers have any effect on sperm whale entanglement in this fishery due to low sample sizes. Sperm whales have been observed entangled 10 times in approximately 8,500 observed drift gillnet sets since 1990 (Carretta and Enriquez 2012). Six entanglements occurred prior to pinger use in this fishery. Two entanglements (1996 and 1998) occurred in sets that did not use a full complement of pingers, and two animals were entangled in 2010 in a single net where a full complement of 40 pingers was used (Carretta and Enriquez 2012).

Other fisheries may injure or kill sperm whales through entanglement or ingestion of marine debris. Three separate sperm whale strandings in 2008 showed evidence of fishery interactions (Jacobsen et al. 2010; NMFS, unpublished stranding data). Two whales died from gastric impaction as a result of ingesting multiple types of floating polyethylene netting (Jacobsen *et al*. 2010). The variability in size and age of the ingested net material suggests that it was ingested as surface debris and was not the result of fishery depredation (Jacobsen *et al*. 2010). Net types recovered from the whales' stomachs included portions of gillnet, bait nets, and fish/shrimp trawl nets. A third whale in 2008 showed evidence of entanglement scars (NMFS, unpublished stranding data). Two sperm whales also died in 2004 as a result of marine debris ingestion (NMFS, unpublished data): one animal had monofilament gillnet in its stomach and the second animal had nets of differing types in its stomach. Mean annual takes for all fisheries (Table 1) are based on 2001-2012 observer and stranding data (Carretta and Enriquez 2006, 2007, 2009a, 2009b, 2010, 2012, Carretta et al. 2005, Carretta and Chivers 2004, Carretta et al. 2004, 2014a, Jacobsen et al. 2010, NMFS unpublished stranding data). Including estimates from fishery observer programs (16 animals/12 years = 1.3/yr) and strandings data (5 animals/12 years = 0.4/yr), results in an average estimate of 1.7 sperm whale deaths per year due to fishery-related causes for the period 2001 to 2012. The mean annual mortality from strandings represents a minimum value, as not all carcasses come ashore or are detected.

Table 1. Summary of available information on the incidental mortality and injury of sperm whales (CA/OR/WA stock) for commercial fisheries that might take this species. n/a indicates that data are not available. Mean annual takes are based on 2001-2012 data unless noted otherwise.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed mortality (and serious injury in parentheses)	Estimated mortality and serious injury (CV in parentheses)	Mean annual takes (CV in parentheses)
CA thresher shark/swordfish drift gillnet fishery	2001	observer	20.4%	0	0	1.3 (0.95)
	2002		22.1%	0	0	
	2003		20.0%	0	0	
	2004		21.0%	0	0	
	2005		21.0%	0	0	
	2006		18.5%	0	0	
	2007		16.4%	0	0	
	2008		13.5%	0	0	
	2009		13.3%	0	0	
	2010		11.9%	1 (1)	16 (0.95)	
	2011		19.5%	0	0	
	2012		18.7%	0	0	
Unknown fishery	2001-2012	stranding	n/a	5	≥5	≥ 0.4
Total annual takes						≥ 1.7 (0.95)

Sperm whales from the North Pacific stock are known to depredate on longline sablefish catch in the Gulf of Alaska and sometimes incur serious injuries from becoming entangled in gear (Sigler et al. 2008, Allen and Angliss 2011). An unknown number of whales from the CA/OR/WA stock probably venture into waters where Alaska longline fisheries operate, but the amount of temporal and spatial overlap is unknown. Thus, the risk of serious injury to CA/OR/WA stock sperm whales resulting from longline fisheries cannot be quantified.

Ship Strikes

One sperm whale died as the result of a ship strike in Oregon in 2007 (NMFS Northwest Regional Stranding data, unpublished). Another sperm whale was struck by a 58-foot sablefish longline vessel in 2007 while at idle speed (Jannot et al. 2011). The observer noted no apparent injuries to the whale. Based on the size and speed of the vessel relative to the size of a sperm whale, this incident was categorized as a non-serious injury (Carretta et al. 2013). For the most recent 5-year period of 2008 to 2012 for which data are available, no ship strikes of sperm whales were documented (Carretta et al. 2014b) and the mean annual average mortality and serious injury is zero whales. Ship strikes are assessed over the most recent 5-year period to reflect the degree of shipping risk to large whales since ship traffic routes changed in response to new ship pollution rules implemented in 2009 (McKenna *et al*. 2012, Redfern *et al*. 2013).

STATUS OF STOCK

The only estimate of the status of North Pacific sperm whales in relation to carrying capacity (Gosho et al. 1984) is based on a CPUE method which is no longer accepted as valid. Whaling removed at least 436,000 sperm whales from the North Pacific between 1800 and the end of legal commercial whaling for this species in 1987 (Best 1976; Ohsumi 1980; Brownell 1998; Kasuya 1998). Of this total, an estimated 33,842 were taken by Soviet and Japanese pelagic whaling operations in the eastern North Pacific from the longitude of Hawaii to the U.S. West coast, between 1961 and 1976 (Allen 1980), and approximately 1,000 were reported taken in land-based U.S. West coast whaling operations between 1919 and 1971 (Ohsumi 1980; Clapham et al. 1997). There has been a prohibition on taking sperm whales in the North Pacific since 1988, but large-scale pelagic whaling stopped in 1980. Sperm whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently the California to Washington stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. The status of sperm whales with respect to carrying capacity and optimum sustainable population (OSP) is unknown. Including both fishery and ship-strike mortality, the annual rate of kill and serious injury (1.7 per year) is less than the calculated PBR for this stock (2.7). Total human-caused mortality is greater than 10% of the calculated PBR and, therefore, cannot be considered to be insignificant and approaching zero mortality and serious injury rate. Increasing levels of anthropogenic sound in the world's oceans has been suggested to be a habitat concern for whales, particularly for deep-diving whales like sperm whales that feed in the ocean's "sound channel".

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Revised 7/31/2015

GRAY WHALE (*Eschrichtius robustus*): Eastern North Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Once common throughout the Northern Hemisphere, the gray whale was extinct in the Atlantic by the early 1700s (Fraser 1970; Mead and Mitchell 1984), though one anomalous sighting occurred in the Mediterranean Sea in 2010 (Scheinin *et al.* 2011) and another off Namibia in 2013 (Elwen and Gridley 2013). Gray whales are now only commonly found in the North Pacific. Genetic comparisons indicate there are distinct "Eastern North Pacific" (ENP) and "Western North Pacific" (WNP) population stocks, with differentiation in both mtDNA haplotype and microsatellite allele frequencies (LeDuc et al. 2002; Lang et al. 2011a; Weller et al. 2013).

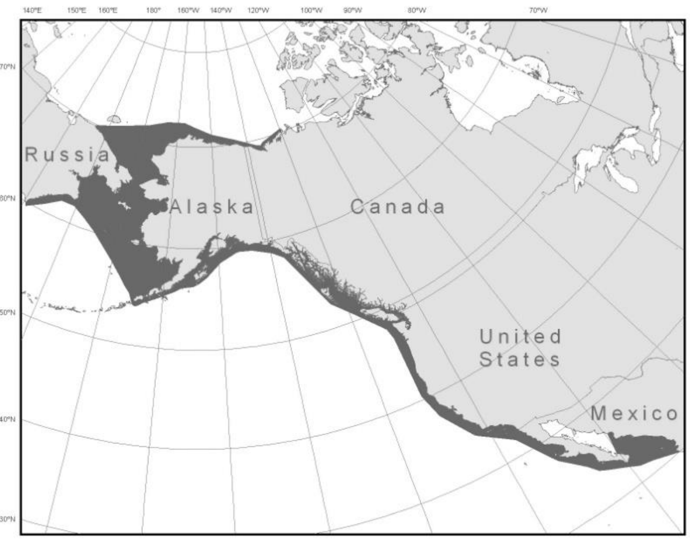

Figure 1. Approximate distribution of the Eastern North Pacific stock of gray whales (shaded area).

During summer and fall, most whales in the ENP population feed in the Chukchi, Beaufort and northwestern Bering Seas (Fig. 1). An exception to this is the relatively small number of whales (approximately 200) that summer and feed along the Pacific coast between Kodiak Island, Alaska and northern California (Darling 1984, Gosho *et al.* 2011, Calambokidis *et al.* 2012), referred to as the "Pacific Coast Feeding Group" (PCFG). Three primary wintering lagoons in Baja California, Mexico are utilized, and some females are known to make repeated returns to specific lagoons (Jones 1990). Genetic substructure on the wintering grounds is indicated by significant differences in mtDNA haplotype frequencies between females (mothers with calves) using two of the primary calving lagoons and females sampled in other areas (Goerlitz *et al*. 2003). Other research identified a small, but significant departure from panmixia between two of the lagoons using nuclear data, although no significant differences were identified using mtDNA (Alter *et al.* 2009).

Tagging, photo-identification and genetic studies show that some whales identified in the WNP off Russia have been observed in the ENP, including coastal waters of Canada, the U.S. and Mexico (Lang 2010; Mate et al. 2011; Weller et al. 2012; Urbán et al. 2013, Mate et al. 2015). In combination, these studies have recorded a total of 27 gray whales observed in both the WNP and ENP. Despite this overlap, significant mtDNA and nDNA differences are found between whales in the WNP and those summering in the ENP (Lang *et al*. 2011a).

In 2010, the IWC Standing Working Group on Aboriginal Whaling Management Procedure noted that different names had been used to refer to gray whales feeding along the Pacific coast, and agreed to designate animals that spend the summer and autumn feeding in coastal waters of the Pacific coast of North America from California to southeast Alaska as the "Pacific Coast Feeding Group" or PCFG (IWC 2012). This definition was further refined for purposes of abundance estimation, limiting the geographic range to the area from northern California to northern British Columbia (from 41°N to 52°N), limiting the temporal range to the period from June 1 to November 30, and counting only those whales seen in more than one year within this geographic and temporal range (IWC 2012). The IWC adopted this definition in 2011, but noted that "not all whales seen within the PCFG area at this time will be PCFG whales and some PCFG whales will be found outside of the PCFG area at various times during the year." (IWC 2012).

Photo-identification studies between northern California and northern British Columbia provide data on the abundance and population structure of PCFG whales (Calambokidis *et al*. 2012). Gray whales using the study area in summer and autumn include two components: **1)** whales that frequently return to the area, display a high degree of intra-seasonal " fidelity" and account for a majority of the sightings between 1 June and 30 November. Despite movement and interchange among sub-regions of the study area, some whales are more likely to return to the same sub-region where they were observed in previous years; **2)**"visitors" from the northbound migration that are sighted only in one year, tend to be seen for shorter time periods in that year, and are encountered in more limited areas. Photo-identification (Gosho *et al*. 2011; Calambokidis *et al*. 2012) and satellite tagging (Mate *et al*. 2010; Ford *et al.*

2012) studies have documented some PCFG whales off Kodiak Island, the Gulf of Alaska and Barrow, Alaska, well to the north of the pre-defined 41°N to 52°N boundaries used in some PCFG-related analyses (e.g. abundance estimation).

Frasier *et al.* (2011) found significant differences in mtDNA haplotype distributions between PCFG and ENP gray whale sequences, in addition to differences in long-term effective population size, and concluded that the PCFG qualifies as a separate management unit under the criteria of Moritz (1994) and Palsbøll *et al.* (2007). The authors noted that PCFG whales probably mate with the rest of the ENP population and that their findings were the result of maternally-directed site fidelity of whales to different feeding grounds.

Lang *et al.* (2011b) assessed stock structure of ENP whales from different feeding grounds using both mtDNA and eight microsatellite markers. Significant mtDNA differentiation was found when samples from individuals (n=71) sighted over two or more years within the seasonal range of the PCFG were compared to samples from whales feeding north of the Aleutians (n=103), and when PCFG samples were compared to samples collected off Chukotka, Russia (n=71). No significant differences were found when these same comparisons were made using microsatellite data. The authors concluded that (1) the significant differences in mtDNA haplotype frequencies between the PCFG and whales sampled in northern areas indicates that use of some feeding areas is being influenced by internal recruitment (e.g., matrilineal fidelity), and (2) the lack of significance in nuclear comparisons suggests that individuals from different feeding grounds may interbreed. The level of mtDNA differentiation identified, while statistically significant, was low and the mtDNA haplotype diversity found within the PCFG was similar to that found in the northern strata. Lang *et al*. (2011b) suggested this could indicate recent colonization of the PCFG but could also be consistent with external recruitment into the PCFG. An additional comparison of whales sampled off Vancouver Island, British Columbia (representing the PCFG) and whales sampled at the calving lagoon at San Ignacio also found no significant differences in microsatellite allele frequencies, providing further support for interbreeding between the PCFG and the rest of the ENP stock (D'Intino et al. 2012). Lang and Martien (2012) investigated potential immigration levels into the PCFG using simulations and produced results consistent with the empirical (mtDNA) analyses of Lang et al. (2011b). Simulations indicated that immigration of >1 and <10 animals per year into the PCFG was plausible, and that annual immigration of 4 animals/year produced results most consistent with the empirical study.

While the PCFG is recognized as a distinct feeding aggregation (Calambokidis et al. 2012; Mate et al. 2010; Frasier et al. 2011; Lang et al. 2011b; IWC 2012), the status of the PCFG as a population stock remains unresolved (Weller et al. 2013). A NMFS gray whale stock identification workshop held in 2012 included a review of available photo-identification, genetic, and satellite tag data. The report of the workshop states "there remains a substantial level of uncertainty in the strength of the lines of evidence supporting demographic independence of the PCFG." (Weller et al. 2013). The NMFS task force, charged with evaluating stock status of the PCFG, noted that "both the photo-identification and genetics data indicate that the levels of internal versus external recruitment are comparable, but these are not quantified well enough to determine if the population dynamics of the PCFG are more a consequence of births and deaths within the group (internal dynamics) rather than related to immigration and/or emigration (external dynamics)." Further, given the lack of significant differences found in nuclear DNA markers between PCFG whales and other ENP whales, the task force found no evidence to suggest that PCFG whales breed exclusively or primarily with each other, but interbreed with ENP whales, including potentially other PCFG whales. Additional research is needed to better identify recruitment levels into the PCFG and further assess the stock status of PCFG whales (Weller et al. 2013). In contrast, the task force noted that WNP gray whales should be recognized as a population stock under the MMPA, and NMFS prepared a separate report for WNP gray whales in 2014. Because the PCFG appears to be a distinct feeding aggregation and may warrant consideration as a distinct stock in the future, separate PBRs are calculated for the PCFG to assess whether levels of human-caused mortality are likely to cause local depletion.

POPULATION SIZE

Systematic counts of gray whales migrating south along the central California coast have been conducted by shore-based observers at Granite Canyon most years since 1967 (Fig. 2). The most recent estimate of abundance for the ENP population is from the 2010/2011 southbound survey and is 20,990 (CV=0.05) whales (Durban *et al*. 2013) (Fig. 2).

Photographic mark-recapture abundance estimates for PCFG gray whales between 1998 and 2012, including estimates for a number of smaller geographic areas within the IWC-defined PCFG region (41°N to 52°N), are reported in Calambokidis *et al*. (2014). The 2012 abundance estimate for the defined range of the PCFG between 41°N to 52°N is 209 (SE=15.4; CV= 0.07).

Eastern North Pacific gray whales experienced an unusual mortality event (UME) in 1999 and 2000, when large numbers of emaciated animals stranded along the west coast of North America (Moore *et al*., 2001; Gulland *et al*., 2005). Over 60% of the dead whales were adults, compared with previous years when calf strandings were more common. Several factors following this UME suggest that the high mortality rate observed was a short-term, acute event and not a chronic situation or trend: 1) in 2001 and 2002, strandings decreased to levels below UME levels (Gulland *et al*., 2005); 2) average calf production returned to levels seen before 1999; and 3) in 2001, living whales no longer appeared emaciated. Oceanographic factors that limited food availability for gray whales were identified as likely causes of the UME (LeBouef et al. 2000; Moore et al. 2001; Minobe 2002; Gulland et al. 2005), with resulting declines in survival rates of adults during this period (Punt and Wade 2012). The population has recovered to levels seen prior to the UME of 1999-2000 (Fig. 2).

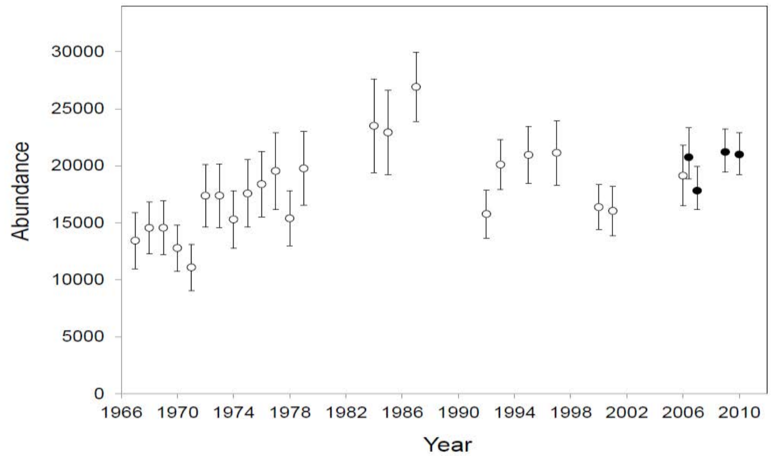

Figure 2. Estimated abundance of Eastern North Pacific gray whales from NMFS counts of migrating whales past Granite Canyon, California. Open circles represent abundance estimates and 95% confidence intervals reported by Laake et al. (2012). Closed circles represent estimates and 95% posterior highest density intervals reported by Durban et al. (2013) for the 2006/7, 2007/8, 2009/10, and 2010/11 migration seasons.

Gray whale calves have been counted from Piedras Blancas, a shore site in central California, in 1980-81 (Poole 1984a) and each year from 1994 to 2012 (Perryman *et al*. 2002; Perryman and Weller 2012). In 1980 and 1981, calves comprised 4.7% to 5.2% of the population (Poole 1984b). Calf production indices, as calculated by dividing northbound calf estimates by estimates of population abundance (Laake *et al*. 2012), ranged between 1.3 - 8.8% (mean=4.2%) during 1994-2012. Annual indices of calf production include impacts of early postnatal mortality but may overestimate recruitment because they exclude possibly significant levels of killer whale predation on gray whale calves north of the survey site (Barrett-Lennard et al. 2011). The relatively low reproductive output reported is consistent with little or no population growth over the time period (Laake *et al*. 2012; Punt and Wade 2012).

Minimum Population Estimate

The minimum population estimate (N_{MIN}) for the ENP stock is calculated from Equation 1 from the PBR Guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842\times[\ln(1 + [CV(N)]^2)]^{½})$. Using the 2010/11 abundance estimate of 20,990 and its associated CV of 0.05 (Durban et al. 2013), N_{MIN} for this stock is 20,125.

The minimum population estimate for PCFG gray whales is calculated as the lower 20th percentile of the log-normal distribution of the 2012 mark-recapture estimate of 209 (CV=0.07), or 197 animals.

Current Population Trend

The population size of the ENP gray whale stock has increased over several decades despite an UME in 1999 and 2000 and has been relatively stable since the mid-1990s (see Fig. 2).

Abundance estimates of PCFG gray whales reported by Calambokidis et al. (2014) show a high rate of increase in the late 1990s and early 2000s, but have been relatively stable since 2003.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Using abundance data through 2006/07, an analysis of the ENP gray whale population led to an estimate of R_{max} of 0.062, with a 90% probability the value was between 0.032 and 0.088 (Punt and Wade 2012). This value of R_{max} is also applied to PCFG gray whales, as it is currently the best estimate of R_{max} available for gray whales in the ENP.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the ENP stock of gray whales is calculated as the minimum population size (20,125), times one-half of the maximum theoretical net population growth rate (½ x 6.2% = 3.1%), times a recovery factor of 1.0 for a stock above MNPL (Punt and Wade 2012), or 624 animals per year.

The potential biological removal (PBR) level for PCFG gray whales is calculated as the minimum population size (197 animals), times one half the maximum theoretical net population growth rate (½ x 6.2% = 3.1%), times a recovery factor of 0.5 (for a population of unknown status), resulting in a PBR of 3.1 animals per year. Use of the recovery factor of 0.5 for PCFG gray whales, rather than 1.0 used for ENP gray whales, is based on uncertainty regarding stock structure (Weller et al. 2013) and guidelines for preparing marine mammal stock assessments which state that "Recovery factors of 1.0 for stocks of unknown status should be reserved for cases where there is assurance that N_{min}, R_{max}, and the kill are unbiased and where the stock structure is unequivocal" (NMFS 2005). Given uncertainties in the levels of external versus internal recruitment of PCFG whales described above, the equivocal nature of the stock structure, and the small estimated population size of the PCFG, NMFS will continue to use the default recovery factor of 0.5 for PCFG gray whales.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Serious Injury Guidelines

NMFS uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases todistinguishserious from non-serious injury (Angliss and DeMaster 1998, Andersen *et al*. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*".

Fisheries Information

No gray whales were observed entangled in California gillnet fisheries between 2008 and 2012 (Carretta and Enriquez 2009, 2010, 2012a, 2012b, Carretta *et al*., 2014a.), but previous mortality in the swordfish drift gillnet fishery has been observed (Carretta et al. 2004) and there have been recent sightings of free-swimming gray whales entangled in gillnets (Table 1). Alaska gillnet fisheries largely lack observer programs, including those in Bristol Bay known to interact with gray whales. Most data on human-caused mortality and serious injury of gray whales are from strandings, including at-sea reports of entangled animals alive or dead (Carretta et al. 2013, 2014b). Strandings represent only a fraction of actual gray whale deaths (natural or human-caused), as reported by Punt and Wade (2012), who estimated that only 3.9% to 13.0% of gray whales that die in a given year end up stranding and being reported.

A summary of human-caused mortality and serious injury resulting from unknown fishery and marine debris sources (mainly pot/trap or net fisheries) is given in Table 1 for the most recent 5-year period of 2008 to 2012. Total observed human-caused fishery mortality and serious injury for ENP gray whales is 22.25 animals (8 serious injuries, 8.25 prorated serious injuries, and 6 deaths), or 4.45 whales per year (Table 1). Total observed human-caused fishery mortality and serious injury for gray whales observed in the PCFG range and season for the period 2008 to 2012 is 0.75 animals (0.75 prorated serious injuries), or 0.15 whales per year (Table 1). Three gray whales from Table 1 (one death and two serious injuries) were detected in California waters during the known PCFG season, but were south of the area recognized by the IWC as the PCFG management area. It is possible that some of these whales could be PCFG whales, but no photographic identifications were available to establish their identity. They are included in ENP gray whale serious injury and death totals.

Table 1. Human-caused deaths and serious injuries (SI) of gray whales from fishery-related and marine debris sources for the period 2008 to 2012 as recorded by NMFS stranding networks and observer programs.

Date of observation	Location	PCFG range N 41- N 52 AND season?	Description	Determination (SI Prorate value)
13-Oct-2012	Fort Bragg, CA	No	Entangled animal report; animal reported with rope around the peduncle which wasn't seen in photographs but photos did show green gillnet with cuts to the head; animal disappeared and final status is unknown.	SI
31-Aug-2012	Los Angeles, CA	No	Animal first detected near San Diego. Subadult gray whale reported entangled with small gauge, dark-colored line deeply embedded around its tail stock. Little gear trails. Entanglement was once more involved as indicated by scars on the animal's body. Animal in very poor condition - emaciated, scarred and a heavy load of cyamid	Dead

			amphipods. Black line around peduncle, 20 ft trailing; observed off san San Diego on 8/31, completely disentangled off L.A. 9/6, stranded dead 9/14/12.	
22-Aug-2012	Prince William Sound, AK	No	Whale sighted by tour boat. Few details, other than part of a fishing net was observed being trailed from a gray whale's fin. Photos apparently available, but have not been located. Prince william William Sound. Extent and severity of entanglement unknown.	SI (0.75)
16-Jun-2012	Prince William Sound, AK	No	30' gray whale in prince william Prince William Sound entangled in gear. Thrashing at surface and moving at 4-5 knots. No wounds or chafing was observed. Gillnet, corkline (at least 12 floats), and leadline observed over animal's rostrum, body, and tailstock. Both pectoral flippers appeared pinned to body. Animal later appeared tired and was swimming at 2 knots. It was not relocated. Assigned serious injury because gear appears to be constricting movement of whale's flippers.	SI
13-May-2012	Monterey, CA	No	Animal entangled through mouth in at least two sets of suspected pot gear that that hang below. Animal anchored with a short scope in 28 feet of water to suspected pots. Bundle of gear, including 4 buoys lie under animal. Animal having some difficulty getting to surface. Animal eventually disentangled, but results of entanglement may still be life-threatening.	SI
8-May-2012	Eureka, CA	No	Entangled animal report; deep cuts from rope around peduncle and lacerations at fluke notch and lateral edge of fluke; successfully disentangled but long-term survival noted as questionable. Gear was collected and identified as Dungeness crab pot gear. Animal entirely freed of gear. Animal in fair condition and slightly emaciated. Deep cuts (~ 2 inches) from the rope around the peduncle remained. Gear was recovered. Results of entanglement may still be life threatening.	SI
5-May-2012	Monterey, CA	No	Whale watch vessel noticed from images taken of a 20 - 25 foot gray whale they had been observing earlier in the day, that animal was actually entangled. A small gauge line, likely from right side of mouth goes over the animal's back, and over blowholes, to left side of mouth. No buoys or trailing line were observed. Animal in fair condition. Animal sighted next day by whale watch vessel. Confirmed mouth entanglement, appears to be strapping material.	SI (0.75)
28-Apr-2012	Fort Bragg, CA	No	Small gray whale off fort bragg Fort Bragg, CA, in company of two other animals, trailing two buoys.	SI (0.75)
21-Apr-2012	San Simeon, CA	No	Rope like marks on caudal peduncle. Rope impression on pectoral fin. Photos taken.	Dead
17-Apr-2012	Laguna Beach, CA	No	40-foot gray whale reported entangled with approximately 150 feet of line trailing. Four spongex bullet buoys lie along the left side of the animal. Entanglement involves the mouth, a wrap over the head, and the left pectoral flipper. Entanglement appears recent. Partially disentangled on 5/3/12 by fishermen.	SI (0.75)
24-Mar-2012	San Diego, CA	No	Entangled animal report; gillnet gear around peduncle; response effort resulted in successful disentanglement with >100 ft of pink gillnet removed from animal, but animal subsequently observed dead on 03/27 (floating, skin sample taken, no necropsy). Net removed on 03/24 found to contain one dead ca sea lion and three dead sharks.	Dead
28-Jan-2012	San Diego, CA	No	Entangled animal report; towing two orange buoys and at least 150 feet of line; unknown fishery, reported as possible gillnet; no response effort.	SI (0.75)
17-Jan-2012	Unimak Pass, AK	No	A 40' whale was caught in cod pot gear near Unimak Pass. Lines were cut by boat crew and buoys were recovered, however, the pot and some line remained in the water. Any line possibly remaining on animal thought to be minimal. Gray whale species determination made following extensive questioning by local biologist. Determination: prorated serious injury because gear possibly remains on animal.	SI (0.75)
25-Aug-2011	San Mateo, CA	No	One white "crab pot" buoy next to body by left pectoral fin; float stayed next to body and did not change position; animal remained in same position - possibly anchored; only observed for ~2 min; not resighted, no rescue, outcome unknown.	SI
12-Sep-2010	Central Bering Sea	No	Bering Sea / Aleutian Islands flatfish trawl fishery: 12 m animal caught in gear. Photos taken.	Dead
11-May-2010	Orange County CA	No	Free-swimming animal entangled in gillnet; animal first observed inside Dana Point Harbor on 5/11/10; animal successfully	Dead

			disentangled on 5/12/10 & swam out of harbor; animal observed alive in surf zone for several hours on 5/14/10 off Doheny State Beach before washing up dead on beach	
7-May-2010	Cape Foulweather OR	No	Entangled in 3 crab pots, whale not relocated.	SI (0.75)
16-Apr-2010	Seaside OR	No	27-ft long gray whale stranded dead, entangled in crab pot gear	Dead
8-Apr-2010	San Francisco CA	No	Rope wrapped around caudal peduncle; identified as gray whale from photo. Free-swimming, diving. No rescue effort, no resightings, final status unknown	SI
5-Mar-2010	San Diego	No	Free-swimming entangled whale reported by member of the public; no rescue effort initiated; no resightings reported; final status unknown.	SI (0.75)
21-Jul-2009	Trinidad Head CA	Yes	Free-swimming animal with green gillnet, rope & small black floats wrapped around caudal peduncle; report received via HSU researcher on scene during research cruise; animal resighted on 3 Aug; no rescue effort initiated. Photos show rope cutting into caudal peduncle. This whale was re-sighted in 2010 and 2011, still trailing gear. Whale was resighted in 2013 and had shed gear, and was apparently in good health (Jeff Jacobsen, pers. comm.).	NSI
24-Jun-2009	Clallam County, WA	Yes	Whale found entangled in tribal set gillnet in morning. Net had been set 8 pm previous day. Whale able to breath, but not swim freely and was stationary in net. Right pectoral flipper and head were well-wrapped in net webbing. In response to disentanglement attempts, whale reacted violently and swam away. The net was retrieved and found to be torn in two. No confirmation on whether whale was completely free of netting.	SI (0.75)
9-Apr-2009	Sitka, AK	No	Thick black line wrapped twice around whale's body posterior to the eyes was cut and pulled away by private citizen. Animal swam away and dove.	SI (0.75)
25-Mar-2009	Seal Beach CA	No	Free-swimming animal with pink gillnet wrapped around head, trailing 4 feet of visible netting; report received via naturalist on local whale watch vessel; no rescue effort initiated; final status unknown	SI (0.75)
31-Jan-2009	San Diego CA	No	Free-swimming animal towing unidentified pot/trap gear; report received via USCG on scene; USCG reported gear as 4 lobster pots; final status unknown	SI (0.75)
16-Apr-2008	Eel River CA	No	Observed 12 miles west of Eel River by Humboldt State University personnel. It was unknown sex, with an estimated length of 20 ft and in emaciated condition. The animal was described as towing 40-50 feet of line & 3 crab pot buoys from the caudal peduncle and moving very slowly. Vessel retrieved the buoys, pulled them and ~20 ft of line onto the deck and cut it loose from the whale. The whale swam away slowly with 20-30 feet of line still entangling the peduncle, outcome unknown. Identification numbers on buoy traced to crab pot fishery gear that was last fished in Bering Sea in December 2007.	SI

Subsistence/Native Harvest Information

Subsistence hunters in Russia and the United States have traditionally harvested whales from the ENP stock in the Bering Sea, although only the Russian hunt has persisted in recent years (Huelsbeck 1988; Reeves 2002). In 2005, the Makah Indian Tribe requested authorization from NOAA/NMFS, under the MMPA and the Whaling Convention Act, to resume limited hunting of gray whales for ceremonial and subsistence purposes in the coastal portion of their usual and accustomed (U&A) fishing grounds off Washington State (NMFS 2008). The spatial overlap of the Makah U&A and the summer distribution of PCFG whales has management implications. The proposal by the Makah Tribe includes time/area restrictions designed to reduce the probability of killing a PCFG whale and to focus the hunt on whales migrating to/from feeding areas to the north. The Makah proposal also includes catch limits for PCFG whales that result in the hunt being terminated if these limits are met. Also, observations of gray whales moving between the WNP and ENP highlight the need to estimate the probability of a gray whale observed in the WNP being taken during a hunt by the Makah Tribe (Moore and Weller 2013). NMFS has published a notice of intent to prepare an environmental impact statement (EIS) on the proposed hunt (NMFS 2012) and the IWC has evaluated the potential impacts of the proposed hunt and other sources of human-caused mortality on PCFG whales and concluded, with certain qualifications, that the proposed hunt meets the Commission’s conservation objectives (IWC 2013). The Scientific Committee has not scheduled an implementation review of the impacts of the Makah hunt on whales using summering feeding areas in the WNP, but is continuing to investigate stock structure of north Pacific gray whales and may schedule such a review in the future (IWC 2013). In 2012, the IWC approved a 6-year quota (2013-2018) of 744 gray whales, with an annual cap of 140, for Russian and U.S. (Makah Indian Tribe) aboriginals based on the joint request and needs statements submitted by the U.S. and Russian federation. The U.S. and Russia have agreed that the quota will be shared with an average annual harvest of 120 whales by the Russian Chukotka people and 4 whales by the Makah Indian Tribe. Total takes by the Russian hunt during the past five years were: 130 in 2008,116 in 2009, 118 in 2010, 128 in 2011, and 143 in 2012 (source: http://iwc.int/table_aboriginal). Based on this information, the annual subsistence take averaged 127 whales during the 5-year period from 2008 to 2012.

Other Mortality

Ship strikes are a source of mortality for gray whales (Table 2). For the most recent five-year period, 2008-2012, the total serious injury and mortality of ENP gray whales attributed to ship strikes is 9.8 animals (including 7 deaths, 2 serious injuries, and 0.8 prorated serious injuries, or 2.0 whales per year (Table 2, Carretta et al. 2013, Carretta et al. 2014b.). The total ship strike serious injury and mortality of gray whales observed in the PCFG range and season during this same period is 0.52 animals, or 0.1 whales per year (Table 2). One gray whale ship strike in Table 2 was detected in California waters during the known PCFG season, but was south of the area recognized by the IWC as the PCFG management area. It is possible that this animal could be a PCFG whale, but no photographic identification was available to establish its identity. It is included in ENP gray whale serious injury and death totals. Additional mortality from ship strikes probably goes unreported because the whales either do not strand or do not have obvious signs of trauma.

In February 2010, a gray whale stranded dead near Humboldt, CA with parts of two harpoons embedded in the body. Since this whale was likely harpooned during the aboriginal hunt in Russian waters, it would have been counted as "struck and lost" in the harvest data.

HABITAT CONCERNS

Near shore industrialization and shipping congestion throughout the migratory corridors of the ENP gray whale stock represent risks by increasing the likelihood of exposure to pollutants and ship strikes, as well as a general degradation of the habitat.

Evidence indicates that the Arctic climate is changing significantly, resulting in a reductions in sea ice cover (Johannessen et al. 2004, Comiso et al. 2008). These changes are likely to affect gray whales. For example, the summer range of gray whales has greatly expanded in the past decade (Rugh et al. 2001). Bluhm and Gradinger (2008) examined the availability of pelagic and benthic prey in the Arctic and concluded that pelagic prey is likely to increase while benthic prey is likely to decrease in response to climate change. They noted that marine mammal species that exhibit trophic plasticity (such as gray whales which feed on both benthic and pelagic prey) will adapt better than trophic specialists.

Global climate change is also likely to increase human activity in the Arctic as sea ice decreases, including oil and gas exploration and shipping (Hovelsrud et al. 2008). Such activity will increase the chance of oil spills and ship strikes in this region. Gray whales have demonstrated avoidance behavior to anthropogenic sounds associated with oil and gas exploration (Malme et al. 1983, 1984) and low-frequency active sonar during acoustic playback experiments (Buck and Tyack 2000, Tyack 2009). Ocean acidification could reduce the abundance of shell-forming organisms (Fabry et al. 2008, Hall-Spencer et al. 2008), many of which are important in the gray whales' diet (Nerini 1984).

Table 2. Summary of gray whale serious injuries (SI) and deaths attributed to vessel strikes for the five-year period 2008-2012. No vessel strikes were reported in 2012.

Date of observation	Location	PCFG range N 41 - N 52 AND season?	Description	Determination (SI prorate value)
6-Jun-2011	San Mateo CA	No	Massive hemorrhage into the thorax, blood clots around lungs. Lesions indicate massive trauma. Due to carcass position, the skeleton could not be completely examined (lying on back, top of skull in sand).	Dead
8-Apr-2011	San Francisco CA	No	Crushed mandible.	Dead
12-Feb-2011	Los Angeles CA	No	Private recreational vessel collided with free-swimming animal; animal breached just prior to contact, bouncing off side of vessel; dove immediately following contact & was not resighted; no blood observed in water; final status unknown; skin sample collected from vessel and genetically identified	SI (0.14)

			as a female gray whale. Vessel size assumed less than 65 ft and speed unknown.	
22-Jan-2011	San Diego CA	No	Pleasure sailboat collided with free-swimming animal; animal dove immediately following contact & was not resighted; no blood observed in water; final status unknown. Vessel size assumed less than 65 ft. And speed unknown.	SI (0.14)
12-Mar-2010	Santa Barbara CA	No	21 meter sailboat underway at 13 kts collided with free-swimming animal; whale breached shortly after collision; no blood observed in water; minor damage to lower portion of boat's keel; final status unknown; DNA analysis of skin sample confirmed species.	SI
16-Feb-2010	San Diego CA	No	Free-swimming animal with propeller-like wounds to dorsum.	SI (0.52)
9-Sep-2009	Quileute River WA	Yes	USCG vessel reported to be traveling at 10 knots when they hit the gray whale at noon on 9/9/2009. The animal was hit with the prop and was reported alive after being hit, blood observed in water.	SI (0.52)
1-May-2009	Los Angeles CA	No	Catalina island transport vessel collided with free-swimming calf accompanied by adult animal; calf was submerged at time of collision; pieces of flesh & blood observed in water; calf never surfaced; presumed mortality.	SI
27-Apr-2009	Whidbey Is. WA	No	Large amount of blood in body cavity, bruising in some areas of blubber layer and in some internal organs. Findings suggestive of blunt force trauma likely caused by collision with a large ship.	Dead
5-Apr-2009	Sunset Beach CA	No	Dead stranding; 3 deep propeller-like cuts on right side, just anterior of genital opening; carcass towed out to sea	Dead
4-Apr-2009	Ilwaco WA	No	Necropsied, broken bones in skull; extensive hemorrhage head and thorax; sub-adult male	Dead
1-Mar-2008	Mexico	No	Carcass brought into port on bow of cruise ship; collision occurred betweeen ports of San Diego and Cabo San Lucas between 5:00 p.m. On 2/28 & 7:20 a.m. On 3/1	Dead
7-Feb-2008	Orange County CA	No	Carcass; propeller-like wounds to left dorsum from mid-body to caudal peduncle; deep external bruising on right side of head; field necropsy revealed multiple cranial fractures	Dead

STATUS OF STOCK

In 1994, the ENP stock of gray whales was removed from the List of Endangered and Threatened Wildlife (the List), as it was no longer considered endangered or threatened under the Endangered Species Act (NMFS 1994). Punt and Wade (2012) estimated the ENP population was at 85% of carrying capacity (K) and at 129% of the maximum net productivity level (MNPL), with a probability of 0.884 that the population is above MNPL and therefore within the range of its optimum sustainable population (OSP).

Even though the stock is within OSP, abundance will fluctuate as the population adjusts to natural and human-caused factors affecting carrying capacity (Punt and Wade 2012). It is expected that a population close to or at carrying capacity will be more susceptible to environmental fluctuations (Moore et al. 2001). The correlation between gray whale calf production and environmental conditions in the Bering Sea may reflect this (Perryman et al. 2002; Perryman and Weller 2012). Overall, the population nearly doubled in size over the first 20 years of monitoring and has fluctuated for the last 30 years around its average carrying capacity. This is consistent with a population approaching K.

Based on 2008-2012 data, the estimated annual level of human-caused mortality and serious injury for ENP gray whales includes Russian harvest (127), mortality and serious injury from commercial fisheries (4.45), and ship strikes (2.0), totals 133 whales per year, which does not exceed the PBR (624). The IWC completed an implementation review for ENP gray whales (including the PCFG) in 2012 (IWC 2013) and concluded that harvest levels (including the proposed Makah hunt) and other human caused mortality are sustainable, given the current population abundance (Laake et al. 2012, Punt and Wade 2012). Therefore, the ENP stock of gray whales is not classified as a strategic stock.

PCFG gray whales do not currently have a formal status under the MMPA, though the population size appears to have been stable since 2003, based on photo-ID studies (Calambokidis et al. 2014, IWC 2012). Total annual human-caused mortality of PCFG gray whales during the period 2008 to 2012 includes deaths due to commercial fisheries (0.15/yr), and ship strikes (0.1/yr), or 0.25 whales annually. This does not exceed the PBR level of 3.1 whales for this population. Levels of human-caused mortality and serious injury resulting from commercial fisheries and ship strikes for both ENP and PCFG whales represent minimum estimates as recorded by stranding networks or at-sea sightings.

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GRAY WHALE (*Eschrichtius robustus*): Western North Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Gray whales occur along the eastern and western margins of the North Pacific. In the western North Pacific (WNP), gray whales feed during summer and fall in the Okhotsk Sea off northeast Sakhalin Island, Russia, and off southeastern Kamchatka in the Bering Sea (Weller et al. 1999, 2002; Vertyankin et al. 2004; Tyurneva et al. 2010; Burdin et al. 2013; Figure 1). Some gray whales observed feeding off Sakhalin and Kamchatka migrate during the winter to the west coast of North America in the eastern North Pacific (Mate et al. 2011; Weller et al. 2012; Urbán *et al*. 2013), while others, including at least one whale first identified as a calf off Sakhalin, migrate to areas off Asia in the WNP (Weller et al. 2008; Weller et al. 2013a). Despite the observed movements between the WNP and eastern North Pacific (ENP), genetic comparisons show significant mitochondrial and nuclear genetic differences between whales sampled in the ENP and those sampled on the feeding ground off Sakhalin Island in the WNP (LeDuc et al. 2002; Lang et al. 2011). While a few previously unidentified non-calves are identified annually, a recent population assessment using photo-identification data from 1994 to 2011 fitted to an individually-based model found that whales feeding off Sakhalin Island have been demographically self-contained, at least in recent years, as new recruitment to the population is almost exclusively a result of calves born to mothers from within the group (Cooke et al. 2013).

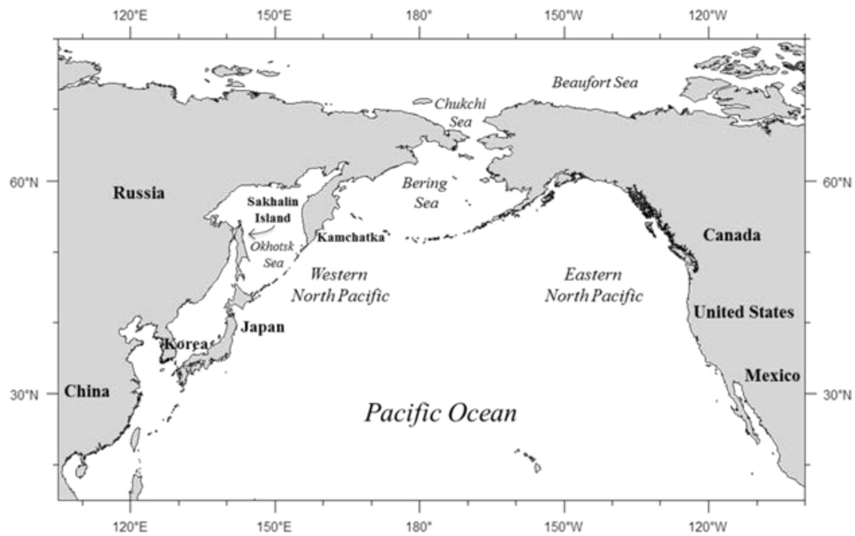

Figure 1. Range map of the Western North Pacific Stock of gray whales, including summering areas off Russia and wintering areas in the western and eastern Pacific.

Historical evidence indicates that the coastal waters of eastern Russia, the Korean Peninsula and Japan were once part of the migratory route in the WNP and that areas in the South China Sea may have been used as wintering grounds (Weller et al. 2002; Weller et al. 2013a). However, contemporary records of gray whales off Asia are rare, with only 13 from Japanese waters between 1990 and 2007 (Nambu *et al*. 2010) and 24 from Chinese waters since 1933 (Wang 1984; Zhu 2002). The last known record of a gray whale off Korea was in 1977 (Park 1995; Kim et al. 2013). While recent observations of gray whales off the coast of Asia are infrequent, they nevertheless continue to occur, including: (1) March/April 2014 - one or possibly two gray whales were sighted and photographed off the Shinano River in Teradomari (Niigata Prefecture) on the Sea of Japan coast of Honshu, Japan (Kato et al. 2014), (2) March 2012 - a gray whale was sighted and photographed in Mikawa Bay (Aichi Prefecture), on the Pacific coast of Honshu, Japan (Kato *et al*. 2012), and (3) November 2011 - a 13 m female gray whale was taken in fishing gear offshore of Baiqingxiang, China, in the Taiwan Strait (Zhu 2012).

Information from tagging, photo-identification and genetic studies show that some whales identified in the WNP off Russia have been observed in the ENP, including coastal waters of Canada, the U.S. and Mexico (Lang 2010; Mate et al. 2011; Weller et al. 2012; Urbán et al. 2013, Mate et al. 2015). In combination, these studies have recorded a total of 27 gray whales observed in both the WNP and ENP. Some whales that feed off Sakhalin Island in summer migrate east across the Pacific to the west coast of North America in winter, while others migrate south to waters off Japan and China. Taken together, these observations indicate that not all gray whales in the WNP share a common wintering ground (Weller et al. 2013a).

In 2012, the National Marine Fisheries Service convened a scientific task force to appraise the currently recognized and emerging stock structure of gray whales in the North Pacific (Weller et al. 2013b). The charge of the task force was to evaluate gray whale stock structure as defined under the Marine Mammal Protection Act (MMPA) and implemented through the National Marine Fisheries Service's Guidelines for Assessing Marine Mammal Stocks (GAMMS; NMFS 2005). Significant differences in both mitochondrial and nuclear DNA between whales sampled off Sakhalin Island (WNP) and whales sampled in the ENP provided convincing evidence that resulted in the task force advising that WNP gray whales should be recognized as a population stock under the MMPA and GAMMS guidelines. Given the interchange of some whales between the WNP and ENP, including seasonal occurrence of WNP whales in U.S. waters, the task force agreed that a stand-alone WNP gray whale population stock assessment report was warranted.

POPULATION SIZE

Photo-identification data collected between 1994 and 2011 on the gray whale summer feeding ground off Sakhalin Island in the WNP were used to calculate an abundance estimate of 140 (SE = ± 6, CV=0.043) whales for the age 1-plus (non-calf) population size in 2012 (Cooke et al. 2013). Some whales (approximately 70 individuals) sighted during the summer off southeastern Kamchatka have not been sighted off Sakhalin Island, but it is as yet unclear whether those whales are part of the WNP stock (IWC 2014).

Minimum Population Estimate

The minimum population estimate (N_{min}) for the WNP stock is calculated from Equation 1 from the PBR Guidelines (Wade and Angliss 1997): $N_{min} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$ and the abundance estimate of 140 (CV=0.043) whales from Cooke et al. (2013), resulting in a minimum population estimate of 135 gray whales on the summer feeding ground off Sakhalin Island in the WNP.

Current Population Trend

The WNP gray whale stock has increased over the last 10 years (2002-2012). The estimated realized average annual rate of population increase during this period is 3.3% per annum (± 0.5%) (Cooke et al. 2013).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

An analysis of the ENP gray whale population led to an estimate of R_{max} of 0.062, with a 90% probability the value was between 0.032 and 0.088 (Punt and Wade 2012). This value of R_{max} is also applied to WNP gray whales, as it is currently the best estimate of R_{max} available for any gray whale population.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (135), times one-half the estimated maximum annual growth rate for a gray whale population (½ of 6.2% for the Eastern North Pacific Stock, Punt and Wade 2012), times a recovery factor of 0.1 (for an endangered stock with N_{min} < 1,500, Taylor et al. 2003), and also multiplied by estimates for the proportion of the stock that uses U.S. EEZ waters (0.575) and the proportion of the year that those animals are in the U.S. EEZ (3 months, or 0.25 years) (Moore and Weller 2013), resulting in a PBR of 0.06 WNP gray whales per year, or approximately 1 whale every 17 years (if abundance and other parameters in the PBR equation remained constant over that time period).

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Serious Injury Guidelines

NMFS uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to distinguis serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "injury that is more likely than not to result in mortality".

Fisheries Information

The decline of gray whales in the WNP is attributable to commercial hunting off Korea and Japan between the 1890s and 1960s. The pre-exploitation abundance of WNP gray whales is unknown, but has been estimated to be between 1,500 and 10,000 individuals (Yablokov and Bogoslovskaya 1984). By 1910, after some commercial exploitation had already occurred, it is estimated that only 1,000 to 1,500 gray whales remained in the WNP population (Berzin and Vladimirov 1981). The basis for how these two estimates were derived, however, is not apparent (Weller et al. 2002). By the 1930s, gray whales in the WNP were considered by many to be extinct (Mizue 1951; Bowen 1974).

Today, a significant threat to gray whales in the WNP is incidental catches in coastal net fisheries (Weller et al. 2002; Kato et al. 2012; Weller et al. 2008; Weller et al. 2013a). Between 2005 and 2007, four female gray whales (including one mother-calf pair and one yearling) died in fishing nets on the Pacific coast of Japan. In addition, one adult female gray whale died as a result of a fisheries interaction in November 2011 off Pingtan County, China (Zhu 2012). An analysis of anthropogenic scarring of gray whales photographed off Sakhalin Island found that at least 18.7% (n=28) of 150 individuals identified between 1994 and 2005 had evidence of previous entanglements in fishing gear (Bradford et al. 2009), further highlighting the overall risks coastal fisheries pose to WNP gray whales.

In summer 2013, salmon net fishing was observed for the first time on the gray whale feeding ground off Sakhalin Island. Observations of whales within 100 m of salmon fishing nets have been made and a male gray whale was observed dragging fishing gear (rope), with a related injury on the caudal peduncle at the dorsal insertion point with the flukes (Weller et al. 2014).

Given that some WNP gray whales occur in U.S. waters, there is some probability of WNP gray whales being killed or injured by ship strikes or entangled in fishing gear within U.S. waters.

Subsistence/Native Harvest Information

In 2005, the Makah Indian Tribe requested authorization from NOAA/NMFS, under the Marine Mammal Protection Act of 1972 (MMPA) and the Whaling Convention Act, to resume limited hunting of gray whales for ceremonial and subsistence purposes in the coastal portion of their usual and accustomed (U&A) fishing grounds off Washington State (NOAA 2008). Observations of gray whales moving between the WNP and ENP highlight the need to estimate the probability of a gray whale observed in the WNP being taken during a hunt by the Makah Tribe (Moore and Weller 2013). Given conservation concerns for the WNP population, the Scientific Committee of the International Whaling Commission (IWC) emphasized the need to estimate the probability of a WNP gray whale being struck during aboriginal gray whale hunts (IWC 2012). Additionally, NOAA is required by the National Environmental Policy Act (NEPA) to prepare an Environmental Impact Statement (EIS) pertaining to the Makah's request. The EIS needs to address the likelihood of a WNP whale being taken during the proposed Makah gray whale hunt.

To estimate the probability that a WNP whale might be taken during the proposed Makah gray whale hunt, four alternative models were evaluated. These models made different assumptions about the proportion of WNP whales that would be available for the hunt or utilized different types of data to inform the probability of a WNP whale being taken (Moore and Weller 2013). Based on the preferred model, the probability of striking at least one WNP whale in a single year was estimated to range from 0.006 – 0.012 across different scenarios for the annual number of total gray whales that might be struck. This corresponds to an expectation of ≥ 1 WNP whale strike in one of every 83 to 167 years.

HABITAT CONCERNS

Near shore industrialization and shipping congestion throughout the migratory corridors of the WNP gray whale stock represent risks by increasing the likelihood of exposure to pollutants and ship strikes as well as a general degradation of the habitat. In addition, the summer feeding area off Sakhalin Island is a region rich with offshore oil and gas reserves. Two major offshore oil and gas projects now directly overlap or are in near proximity to this important feeding area, and more development is planned in other parts of the Okhotsk Sea that include the migratory routes of these whales. Operations of this nature have introduced new sources of underwater noise, including seismic surveys, increased shipping traffic, habitat modification, and risks associated with oil spills (Weller et al. 2002). During the past decade, a Western Gray Whale Advisory Panel, convened by the International Union for Conservation of Nature (IUCN), has been providing scientific advice on the matter of anthropogenic threats to gray whales in the WNP (see http://www.iucn.org/wgwap/). Ocean acidification could reduce the abundance of shell-forming organisms (Fabry et al. 2008, Hall-Spencer et al. 2008), many of which are important in the gray whales' diet (Nerini 1984).

STATUS OF STOCK

The WNP stock is listed as "Endangered" under the U.S. Endangered Species Act of 1973 (ESA) and is therefore also considered "strategic" and "depleted" under the MMPA. At the time the ENP stock was delisted, the WNP stock was thought to be geographically isolated from the ENP stock. Recent documentation of some whales moving between the WNP and ENP seems to indicate otherwise (Lang 2010; Mate et al. 2011; Weller et al. 2012; Urbán et al. 2013). Other research findings, however, provide continued support for identifying two separate stocks of North Pacific gray whales, including: (1) significant mitochondrial and nuclear genetic differences between whales that feed in the WNP and those that feed in the ENP (LeDuc et al. 2002; Lang et al. 2011), (2) recruitment into the WNP stock is almost exclusively internal (Cooke et al. 2013), and (3) the abundance of the WNP stock remains low while the abundance of the ENP stock grew steadily following the end of commercial whaling (Cooke et al. 2013). As long as the WNP stock remains listed as endangered under the ESA, it will continue to be considered as depleted under the MMPA.

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Revised 9/21/2016

HUMPBACK WHALE (*Megaptera novaeangliae*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

NMFS has conducted a global Status Review of humpback whales (Bettridge *et al.* 2015), and recently revised the ESA listing of the species (81 FR 62259, September 8, 2016). NMFS is evaluating the stock structure of humpback whales under the MMPA, but no changes to current stock structure are presented at this time. However, effects of the ESA listing final rule on the status of the stock are discussed below. Northern Hemisphere humpback whales (*M. novaeangliae kuzira*) comprise a distinct subspecies based on mtDNA and DNA relationships and distribution compared to North Atlantic humpback whales (*M. n. novaeangliae*) and those in the Southern Hemisphere (*M. n. australis*) (Jackson *et al*. 2014). Humpback whales occur throughout the North Pacific, with multiple populations currently recognized based on low-latitude winter breeding areas (Baker *et al*. 1998, Calambokidis *et al*. 2001, Calambokidis *et al*. 2008, Barlow *et al*. 2011, Fleming and Jackson 2011). North Pacific breeding areas fall broadly into three regions, including the 1) western Pacific (Japan and Philippines); 2) central Pacific (Hawaiian Islands); and 3) eastern Pacific (Central America and Mexico) (Calambokidis *et al*. 2008). Exchange of animals between breeding areas rarely occurs, based on photo-identification data of individual whales (Calambokidis *et al*. 2001, Calambokidis *et al*. 2008). Photo-identification evidence also suggests strong site fidelity to feeding areas, but animals from multiple feeding areas converge on common winter breeding areas (Calambokidis *et al*. 2008). Baker *et al*. (2008) reported significant differences in mtDNA haplotype frequencies among different breeding and feeding areas in the North Pacific, reflecting strong matrilineal site fidelity to the respective migratory destinations. The most significant differences in haplotype frequencies were found between the California/Oregon feeding area and Russian and Southeastern Alaska feeding areas (Baker *et al*. 2008). Among breeding areas, the greatest level of differentiation was found between Okinawa and Central America and most other breeding grounds (Baker *et al*. 2008). Genetic differences between feeding and breeding grounds were also found, even for areas where regular exchange of animals between feeding and breeding grounds is confirmed by photo-identification (Baker *et al*. 2008).

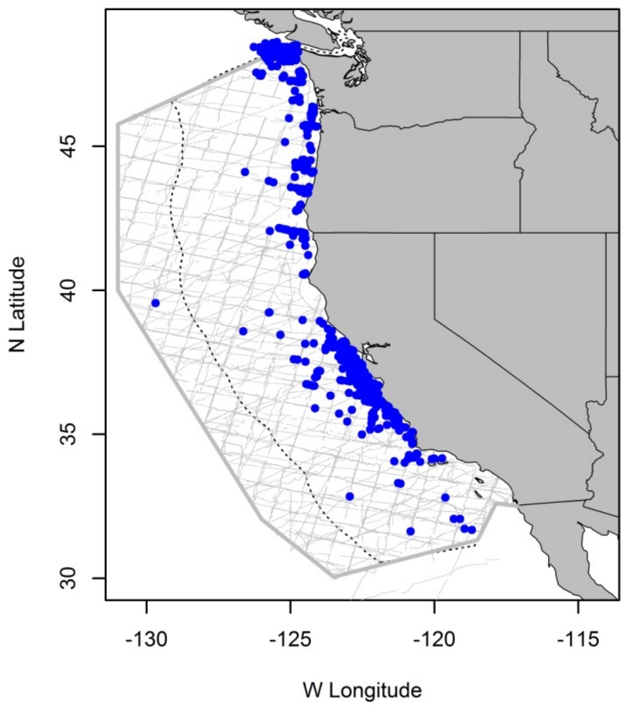

Figure 1. Humpback whale sightings based on shipboard surveys off California, Oregon, and Washington, 1991-2014. Dashed line represents the U.S. EEZ, thin lines indicate completed transect effort of all surveys combined. See Appendix 2 for data sources and information on timing and location of survey effort.

Along the U.S. west coast, one stock is currently recognized, which includes animals that appear to be part of two separate feeding groups, a California and Oregon feeding group and a northern Washington and southern British Columbia feeding group (Calambokidis *et al*. 2008, Barlow *et al*. 2011). Very few photographic matches between these feeding groups have been documented (Calambokidis *et al*. 2008). Humpbacks from both groups have been photographically matched to breeding areas off Central America, mainland Mexico, and Baja California, but whales from the northern Washington and southern British Columbia feeding group also winter near the Hawaiian Islands and the Revillagigedo Islands off Mexico (Barlow *et al*. 2011). Seven 'biologically important areas' for humpback whale feeding are identified off the U.S. west coast by Calambokidis *et al*. (2015), including 5 in California, 1 in Oregon, and 1 in Washington.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, the California/Oregon/Washington Stock is defined to include humpback whales that feed off the west coast of the United States, including animals from both the California-Oregon and Washington-southern British Columbia feeding groups (Calambokidis *et al*. 1996, Calambokidis *et al*. 2008, Barlow *et al*. 2011). Three other stocks are recognized in the U.S. MMPA Pacific stock assessment reports: the Central North Pacific Stock (with feeding areas from Southeast Alaska to the Alaska Peninsula), the Western North Pacific Stock (with feeding areas from the Aleutian Islands, the Bering Sea, and Russia), and the American Samoa Stock in the South Pacific (with largely undocumented feeding areas as far south as the Antarctic Peninsula).

POPULATION SIZE

Based on whaling statistics, the pre-1905 population of humpback whales in the North Pacific was estimated to be 15,000 (Rice 1978), but this population was reduced by whaling to approximately 1,200 by 1966 (Johnson and Wolman 1984). A photo-identification study in 2004-2006 estimated the abundance of humpback whales in the entire Pacific Basin to be 21,808 (CV=0.04) (Barlow *et al*. 2011). Barlow (2016) recently estimated 3,064 (CV= 0.82) humpback whales from a 2014 summer/fall ship line-transect survey of California, Oregon, and Washington waters. Abundance estimates from photographic mark-recapture surveys conducted in California and Oregon waters every year from 1991 through 2011 represent the most precise estimates (Calambokidis 2013). These estimates include only animals photographed in California and Oregon waters and not animals that are part of the separate feeding group found off Washington state and southern British Columbia (Calambokidis *et al*. 2009). California and Oregon estimates range from approximately 1,100 to 2,600 animals, depending on the choice of recapture model and sampling period (Figure 2). The best estimate of abundance for California and Oregon waters is taken as the 2008-2011 Darroch estimate of 1,729 (CV = 0.03) whales, which is also the most precise estimate (Calambokidis and Barlow 2013).

Calambokidis *et al*. (2008) reported a range of photographic mark-recapture abundance estimates (145 – 469) for the northern Washington and southern British Columbia feeding group most recently in 2005. The best model estimate from that study (lowest AIC_c score) was reported as 189 (CV not reported) animals. This estimate is more than 8 years old and is outdated for use in stock assessments; however, because west-coast humpback whale populations are growing (Calambokidis and Barlow 2013), this is still a valid minimum population estimate.

Combining abundance estimates from both the California/Oregon and Washington/southern British Columbia feeding groups (1,729 + 189) yields an estimate of 1,918 (CV≈0.03) animals for the California/Oregon/Washington stock. The approximate CV of 0.03 for the combined estimate reflects that a vast majority of the variance is derived from the California and Oregon estimate (CV=0.03) and that no CV was provided for the Washington state and southern British Columbia estimate.

Minimum Population Estimate

The minimum population estimate for humpback whales in the California/Oregon/Washington stock is taken as the lower 20th percentile of the log-normal distribution of the combined mark-recapture estimate for both feeding groups given above, or 1,876 animals.

Current Population Trend

Ship surveys provide some indication that humpback whales increased in abundance in California coastal waters between 1979/80 and 1991 (Barlow 1994) and between 1991 and 2014 (Barlow 2016), but this increase was not steady, and estimates showed slight dips in 2001 and 2008. Mark-recapture population estimates had shown a long-term increase of approximately 7.5% per year (Calambokidis *et al*. 2009, Figure 2), but more recent estimates show variable trends (Figure 2), depending on the choice of model and time frame used (Calambokidis and Barlow 2013). Population estimates for the entire North Pacific have also increased substantially from 1,200 in 1966 to approximately 18,000 - 20,000 whales in 2004 to 2006 (Calambokidis *et al*. 2008). Although these estimates are based on different methods and the earlier estimate is extremely uncertain, the growth rate implied by these estimates (6-7%) is consistent with growth rate of the California/Oregon/Washington stock.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

The proportion of calves in the California/Oregon/Washington stock from 1986 to 1994 appeared much lower than previously measured for humpback whales in other areas (Calambokidis and Steiger 1994), but in 1995-97 a greater proportion of calves were identified, and the 1997 reproductive rates for this population are closer to those reported for humpback whale populations in other regions (Calambokidis et al. 1998). Despite the apparently low proportion of calves, two independent lines of evidence indicate that this stock was growing in the 1980s and early 1990s (Barlow 1994; Calambokidis *et al*. 2003) with a best estimate of 8% growth per year (Calambokidis *et al*. 1999). The current net productivity rate is unknown.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (1,876) times one half the estimated population growth rate for this stock of humpback whales (½ of 8%) times a recovery factor of 0.3 (for an endangered species; see Status of Stock section below regarding ESA listing status) with N_{min} > 1,500 and CV (N_{min}) < 0.50), resulting in a PBR of 22. Because this stock spends approximately half its time outside the U.S. EEZ, the PBR allocation for U.S. waters is 11 whales per year.

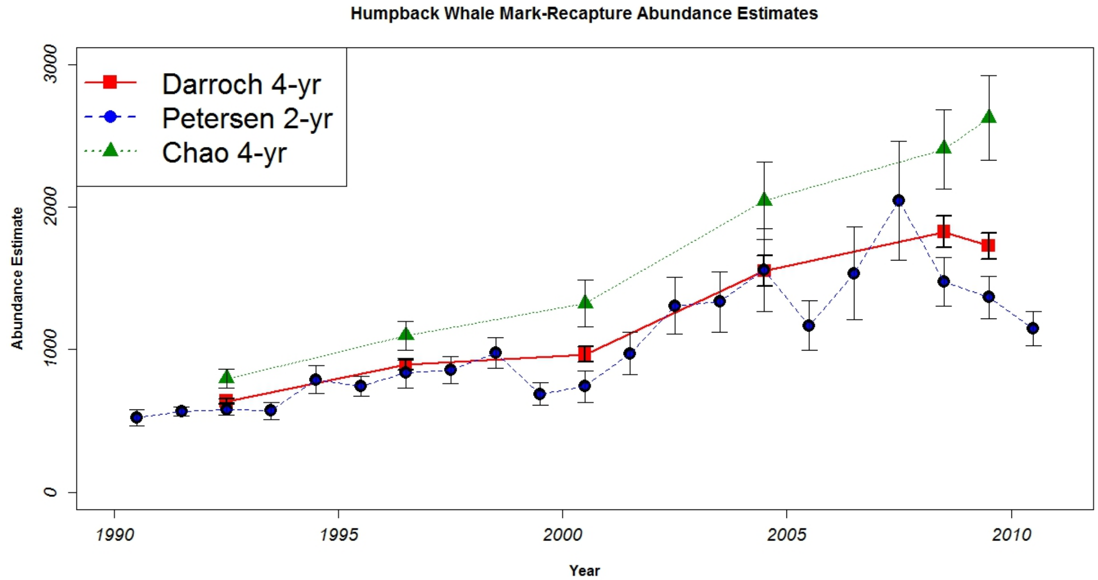

Figure 2. Mark-recapture estimates of humpback whale abundance in California and Oregon, 1991-2011, based on 3 different mark-recapture models and sampling periods (Calambokidis and Barlow 2013). Vertical bars indicate ±2 standard errors of each abundance estimate. Darroch and Chao models use 4 consecutive non-overlapping sample years, except for the last estimates, which use the four most recent years, but overlap with the next-to-last estimate (Calambokidis and Barlow 2013).

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Pot and trap fisheries are the most commonly documented source of serious injury and mortality of humpback whales in U.S. west coast waters (Carretta *et al*. 2013, 2015, 2016a). From 2010 to 2014, there were 27 documented interactions associated with pot and trap fisheries (Carretta *et al.* 2016a, Jannot *et al.* 2016). Five records (3 CA spot prawn pot + 2 unidentified pot/trap fisheries) involved non-serious injuries resulting from human intervention to remove gear, or cases where animals were able to free themselves. Four records involved dead whales, including one case where a pair of severed humpback flukes were found in southern California waters with 2 sets of California Dungeness crab gear attached (Carretta *et al.* 2016a). The remaining 18 cases involved serious injuries (prorated and non-prorated) attributed to unidentified pot/trap fisheries (12 total serious injuries), WA coastal Dungeness crab pot (1), CA Dungeness crab pot (1), and CA spot prawn pot (0.75), for a total of 14.75 serious injuries / 5 years, or 2.95 humpback whales annually (Table 1). Including the 4 deaths attributed to pot/traps, the minimum level of annual mortality and serious injury across all pot/trap fisheries is 14.75 + 4 = 18.75 / 5 years = 3.75 whales annually (Table 1).

Table 1. Summary of available information on the incidental mortality and serious injury of humpback whales (California/Oregon/Washington stock) for commercial fisheries that are likely to take this species (Carretta *et al*. 2015, Carretta *et al.* 2016a, Carretta *et al.* 2016b). Mean annual takes are based on 2010-2014 data unless noted otherwise. Serious injuries may include prorated serious injuries with values less than one (NOAA 2012), thus the sum of serious injury and mortality may not be a whole number.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality (and serious injury)	Estimated mortality and serious injury (CV)	Mean Annual Takes (CV)
CA swordfish and thresher shark drift gillnet fishery	2010-2014	observer	22%	0[1]	0.5 (2.2)	0.1 (2.2)
CA halibut/white seabass and other species large mesh (≥3.5") set gillnet fishery	2010-2014	observer	9%	0	0	0 (n/a)
CA spot prawn pot	2010-2014	Strandings / sightings	n/a	0 (0.75)	n/a	≥ 0.15
Unspecified pot or trap fisheries (includes generic 'Dungeness' crab gear not attributed to a specific state fishery)	2010-2014	Strandings / sightings	n/a	1 (12)	n/a	≥ 2.6
CA Dungeness crab pot	2010-2014	Strandings / sightings	n/a	1 (1)	n/a	≥ 0.4
OR Dungeness crab pot	2010-2014	Strandings / sightings	n/a	1 (0)	n/a	≥ 0.2
WA coastal Dungeness crab pot	2010-2014	Strandings / sightings	n/a	0 (1)	n/a	≥ 0.2
WA/OR/CA limited entry sablefish pot	2014	observer	31%	1 (0)	n/a[2]	≥ 0.2
unidentified fisheries	2010-2014	Strandings / sightings	n/a	2 (5.5)	n/a	≥ 1.5
Total Annual Takes						≥ 5.3

Gillnet and unidentified fisheries accounted for 8 interactions with humpback whales between 2010 and 2014 (Carretta *et al.* 2016a). Two interactions involved dead whales, both with evidence of recent entanglements around the tailstock. Three interactions involved at-sea sightings of seriously injured humpback whales with constricting gear (rope and/or netting) that was cutting into the animal. Three interactions involved at-sea sightings of whales trailing gear of unknown type and configuration. The latter 3 cases were prorated as 0.75 serious injuries each according to NMFS serious injury policy guidelines (NOAA 2012). The total annual mortality and serious injury due to unidentified fisheries from 2010 to 2014 is based on 2 deaths + 3 serious injuries + 3 prorated serious injuries (0.75 x 3 = 2.25), or 7.25 whales. The 5-year annual mean serious injury and mortality due to unidentified fisheries during this period is 7.25 / 5 = 1.5 whales. Three humpback whale entanglements (all released alive) were observed in the CA swordfish drift gillnet fishery from over 8,600 fishing sets monitored between 1990 and 2014 (Carretta *et al.* 2016b). Some opportunistic sightings of free-swimming humpback whales entangled in gillnets may also originate from this fishery. The most recent model-based estimate of humpback whale bycatch in this fishery for 2010-2014 is 0.5 whales (CV=2.2). The corresponding ratio estimate of bycatch for the same time period is zero (Carretta *et al.* 2016b). The model-based estimate is considered superior because it utilizes all 25 years of data for estimation, in contrast to the ratio estimate that uses only 2010-2014 data. The model-based estimate does not distinguish between non-serious injuries and mortality and no proration is applied because of small observed sample sizes and the likelihood that whales may swim away with sections of gillnet and not be recorded by the observer program. The average annual estimated bycatch in the CA swordfish drift gillnet fishery is 0.1 whales (0.5 total whales / 5 years).

Total commercial fishery serious injury and mortality of humpback whales for the period 2010-2014 is the sum of pot/trap fishery records (18.75), plus unidentified fishery records (7.5), plus estimates from the CA swordfish drift gillnet fishery (0.5), or 26.75 total whales. The mean annual serious injury and mortality from commercial fisheries during 2010-2014 is 26.75 whales / 5 years = 5.3 whales (Table 1). Most serious injury and mortality records from commercial fisheries reflect opportunistic stranding and at-sea sighting data and thus, represent minimum counts of impacts, for which no correction factor is currently available.

[1] There were no observations of humpback whales in this fishery during 2010-2014, but the model-based estimate of bycatch for this period results in a positive estimate of bycatch (Carretta *et al.* 2016b).
[2] No estimate of total bycatch has been generated for this fishery.

Ship Strikes

Seven humpback whales (4 deaths, 1 serious injury, and 2 non-serious injuries) were reported struck by vessels between 2010 and 2014 (Carretta *et al.* 2015, Carretta *et al.* 2016a). In addition, there was one serious injury to an unidentified large whale from a ship strike during this time. The average annual serious injury and mortality of humpback whales attributable to ship strikes during 2010-2014 is 1.0 whale per year (4 deaths, plus one serious injury = 5 deaths/injuries / 5 years = 1 whale).).

Other human-caused mortality and serious injury

A humpback whale was entangled in a research wave rider buoy in 2014. The whale is estimated to have been entangled for 3 weeks and had substantial necrotic tissue around the caudal peduncle. Although the whale was fully disentangled by a whale entanglement team, this animal was categorized as a serious injury[3] because of the necrotic condition of the caudal peduncle and the possibility that the whale would lose its flukes due to the severity of the entanglement (NOAA 2012, Carretta *et al.* 2016a).

Habitat Concerns

Increasing levels of anthropogenic sound in the world's oceans (Andrew *et al*. 2002), such as those produced by shipping traffic, or LFA (Low Frequency Active) sonar, have been identified as a habitat concern for whales, as it can reduce acoustic space used for communication (masking) (Clark *et al.* 2009, NOAA 2016). This can be particularly problematic for baleen whales that may communicate using low-frequency sound (Erbe 2016). Based on vocalizations (Richardson *et al*. 1995; Au *et al*. 2006), reactions to sound sources (Lien *et al*. 1990, 1992; Maybaum 1993), and anatomical studies (Hauser *et al*. 2001), humpback whales also appear to be sensitive to mid-frequency sounds, including those used in active sonar military exercises (U.S. Navy 2007).

STATUS OF STOCK

Approximately 15,000 humpback whales were taken from the North Pacific from 1919 to 1987 (Tonnessen and Johnsen 1982), and, of these, approximately 8,000 were taken from the west coast of Baja California, California, Oregon and Washington (Rice 1978), presumably from this stock. Shore-based whaling apparently depleted the humpback whale stock off California twice: once prior to 1925 (Clapham *et al*. 1997) and again between 1956 and 1965 (Rice 1974). There has been a prohibition on taking humpback whales since 1966. As a result of commercial whaling, humpback whales were listed as "endangered" under the Endangered Species Conservation Act of 1969. This protection was transferred to the Endangered Species Act (ESA) in 1973. The humpback whale ESA listing final rule (81 FR 62259, September 8, 2016) established 14 distinct population segments (DPSs) with different listing statuses. The DPSs that occur in waters under the jurisdiction of the United States do not necessarily equate to the existing MMPA stocks. Some of the listed DPSs partially coincide with the currently defined CA/OR/WA stock. Until such time as the MMPA stock delineations are reviewed in light of the DPS designations, NMFS considers this stock to be endangered and depleted for MMPA management purposes (e.g., selection of a recovery factor, stock status). Consequently, the California/Oregon/Washington stock is automatically considered as a "strategic" stock under the MMPA. The estimated annual mortality and serious injury due to commercial fishery entanglements (5.3/yr), and non-fishery entanglements (0.2/yr), plus ship strikes (1.0/yr), equals 6.5 animals, and is less than the PBR allocation of 11 for U.S. waters. Most data on human-caused serious injury and mortality for this population is based on opportunistic stranding and at-sea sighting data and represents a minimum count of total impacts. There is currently no estimate of the fraction of anthropogenic injuries and deaths to humpback whales that are undocumented on the U.S. west coast. Based on strandings and at sea observations, annual humpback whale mortality and serious injury in commercial fisheries (5.3/yr) is greater than 10% of the PBR; therefore, total fishery mortality and serious injury is not approaching zero mortality and serious injury rate. The California/Oregon/Washington stock showed a long-term increase in abundance from 1990 through approximately 2008 (Figure 2), but more recent estimates have shown variable trends.

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[3] This whale was initially listed as a non-serious injury in Carretta *et al.* (2016a) due to insufficient detail in the preliminary reporting. It is considered a serious injury for purposes of this stock assessment report.

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Revised 12/31/2015

BLUE WHALE (*Balaenoptera musculus musculus*): Eastern North Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

North Pacific blue whales were once thought to belong to as many as five separate populations (Reeves *et al.* 1998), but acoustic evidence suggests only two populations, in the eastern and western north Pacific, respectively (Stafford *et al*. 2001, Stafford 2003, McDonald *et al*. 2006, Monnahan *et al*. 2014). North Pacific blue whales produce two distinct acoustic calls, referred to as "northwestern" and "northeastern" types, and it has been proposed that these represent distinct populations with some degree of geographic overlap (Stafford *et al*. 2001, Stafford 2003, Monnahan *et al*. 2014). The northeastern call predominates in the Gulf of Alaska, the U.S. West Coast, and the eastern tropical Pacific, while the northwestern call predominates from south of the Aleutian Islands to the Kamchatka Peninsula in Russia, though both call types have been recorded concurrently in the Gulf of Alaska (Stafford *et al*. 2001, Stafford 2003). Both call types occur in lower latitudes in the central North Pacific, but differ in their seasonal patterns (Stafford *et al*. 2001). Blue whales satellite-tagged off California in late summer have been found to travel to the eastern tropical Pacific and the Costa Rica Dome area in winter (Mate *et al*. 1999, Bailey *et al.* 2009). Photographs of blue whales in California have also been matched to individuals photographed off the Queen Charlotte Islands in northern British Columbia and to one individual photographed in the northern Gulf of Alaska (Calambokidis *et al*. 2009a). Gilpatrick and Perryman (2008) showed that blue whales from California to Central America (the Eastern North Pacific stock) are on average, two meters shorter than blue whales measured from historic whaling records in the central and western north Pacific.

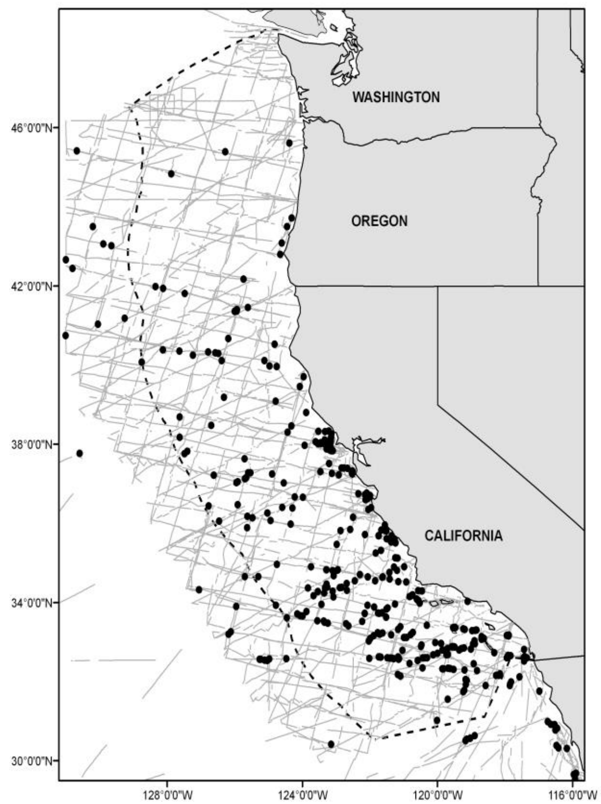

Figure 1. Blue whale sighting locations based on aerial and summer/autumn shipboard surveys off California, Oregon, and Washington, 1991-2008 (see Appendix 2 for data sources and information on timing and location of surveys). Dashed line represents the U.S. EEZ; thin lines represent completed transect effort for all surveys combined.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, the Eastern North Pacific Stock of blue whales includes animals found in the eastern North Pacific from the northern Gulf of Alaska to the eastern tropical Pacific. This definition is consistent with both the distribution of the northeastern call type, photogrammetric length determinations and with the known range of photographically identified individuals. Based on locations where the northeastern call type has been recorded, some individuals in this stock may range as far west as Wake Island and as far south as the Equator (Stafford *et al*. 1999, 2001). The U.S. West Coast is certainly one of the most important feeding areas in summer and fall (Figure 1), but, increasingly, blue whales from this stock have been found feeding to the north and south of this area during summer and fall. Nine 'biologically important areas' (BIAs) for blue whale feeding are identified off the California coast by Calambokidis *et al.* (2015), including six in southern California and three in central California. Most of this stock is believed to migrate south to spend the winter and spring in high productivity areas off Baja California, in the Gulf of California, and on the Costa Rica Dome. Given that these migratory destinations are areas of high productivity and given the observations of feeding in these areas, blue whales can be assumed to feed year round. Some individuals from this stock may be present year-round on the Costa Rica Dome (Reilly and Thayer 1990). However, it is also possible that some Southern Hemisphere blue whales might occur north of the equator during the austral winter. One other stock of North Pacific blue whales (the Central North Pacific stock) is recognized in the Pacific Marine Mammal Protection Act (MMPA) Stock Assessment Reports.

POPULATION SIZE

The size of the feeding stock of blue whales off the U.S. West Coast has been estimated recently by both line-transect and mark-recapture methods. Line-transect abundance estimates from summer/autumn research vessel surveys in the California Current ranged between approximately 400 and 800 animals from 2001 to 2008 (Barlow and Forney 2007, Barlow 2010). These estimates are considerably lower than previous line-transect estimates of approximately 1,900 animals obtained between 1991 and 1996 (Barlow 2010) (Figure 2). The lower abundance estimates appear to be related to a northward shift in the distribution of blue whales out of the study area (as far north as the Gulf of Alaska) and not a population decline (Barlow and Forney 2007, Calambokidis *et al*. 2009a). Mark-recapture estimates are often negatively biased by individual heterogeneity in sighting probabilities (Hammond 1986); however, Calambokidis *et al*. (2010) minimize such effects by selecting one sample that was taken randomly with respect to distance from the coast. Because some fraction of the population is always outside the survey area, the line-transect and mark recapture estimation methods provide different measures of abundance for this stock. Line transect estimates reflect the average density and abundance of blue whales in the study area during summer and autumn surveys, while mark recapture estimates provide an estimate of total population size. New photographic mark-recapture estimates of abundance for the period 2005 to 2011 presented by Calambokidis and Barlow (2013) range from approximately 1,000 to 2,300 animals, with the most consistent estimates represented by a 4-yr sampling period Chao model that incorporates individual capture heterogeneity over time. The Chao model consistently yielded estimates of approximately 1,500 whales (Figure 2). The best estimate of blue whale abundance is taken from the Chao model results of Calambokidis and Barlow (2013) for the period 2008 to 2011, or 1,647 (CV=0.07) whales.

Minimum Population Estimate

The minimum population estimate for blue whales is taken as the lower 20th percentile of the log-normal distribution of abundance estimated from the mark-recapture estimate, or approximately 1,551.

Current Population Trend

Mark-recapture estimates provide the best indicator of population trends for this stock, because of recent northward shifts in blue whale distribution that negatively bias line-transect estimates. Based on mark-recapture estimates shown in Figure 2, there is no evidence of a population size increase in this blue whale population since the early 1990s. While the Petersen mark-recapture estimates show an apparent increase in blue whale abundance since 1996, the estimation errors associated with these estimates are also much higher than for the Chao estimates (Figure 2). Monnahan *et al*. (2015) used a population dynamics model to estimate that the eastern Pacific blue whale population was at 97% of carrying capacity in 2013 and suggest that density dependence and not impacts from ship strikes, explains the observed lack of a population size increase since the early 1990s. The authors estimate that the eastern North Pacific population likely did not drop below 460 whales during the last century, despite being targeted by commercial whaling.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Based on mark-recapture estimates from the US West Coast and Baja California, Mexico, Calambokidis *et al*. (2009b) estimate a rate of increase just under 3% per year, but it is not known if that corresponds to the maximum growth rate of this stock.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (1,551) <u>times</u> one half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> a recovery factor of 0.3 (for an endangered species which has a minimum abundance greater than 1,500 and a CV_{Nmin}<0.5), resulting in a PBR of 9.3. Because whales in this stock spends approximately three quarters of their time outside the U.S. EEZ, the PBR allocation for U.S. waters is one-quarter of this total, or 2.3 whales per year.

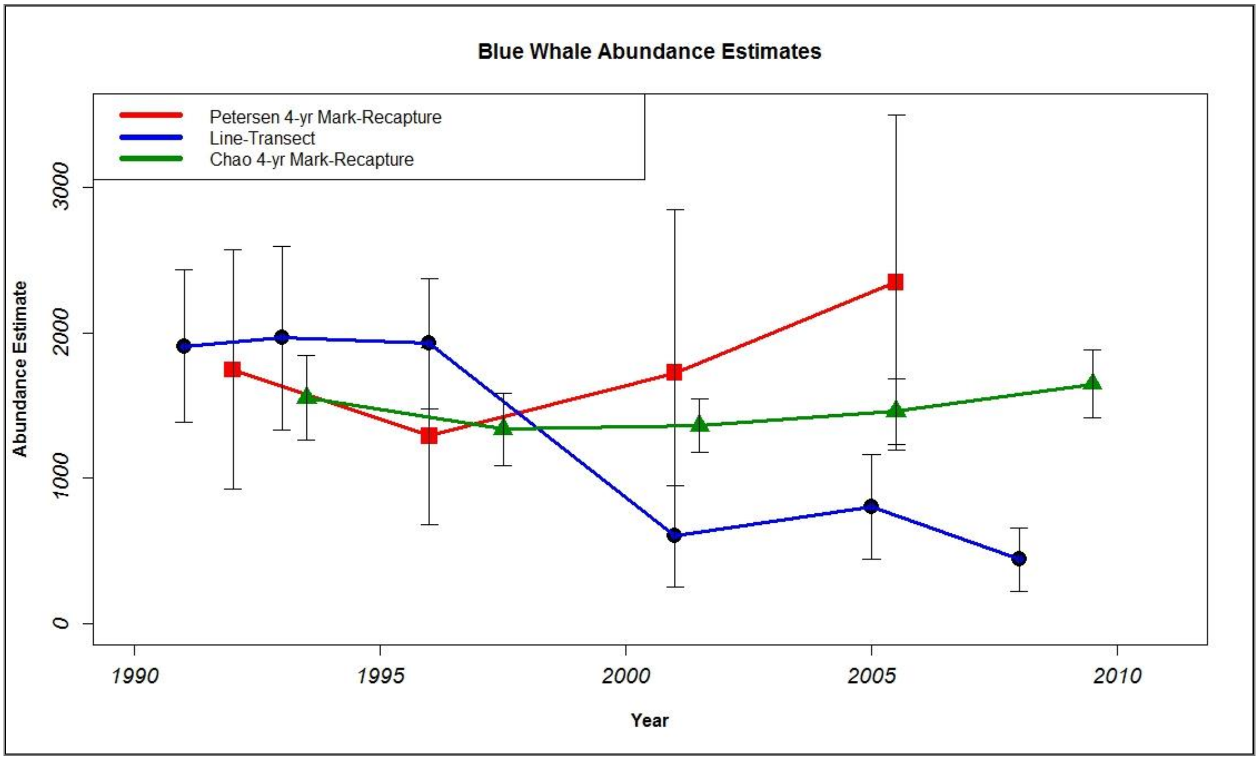

Figure 2. Estimates of blue whale abundance from line-transect and photographic mark-recapture surveys, 1991 to 2011 (Barlow and Forney 2007, Barlow 2010, Calambokidis and Barlow 2013). Vertical bars indicate ±2 standard errors of each abundance estimate.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

The California swordfish drift gillnet fishery is the only fishery that is likely to take blue whales from this stock, but no fishery mortality or serious injuries have been observed since the observer program was initiated in 1990 (Julian and Beeson 1998, Carretta *et al*. 2004, Carretta and Enriquez 2009a, 2009b, 2010, 2012a, 2012b). This results in an average estimate of zero blue whales taken annually (Table 1). Some gillnet mortality of large whales may go unobserved because whales swim away with a portion of the net; however, fishermen report that large rorquals usually swim through nets without entangling and with very little damage to the nets.

Gillnets have been documented to entangle marine mammals off Baja California (Sosa-Nishizaki *et al*. 1993), but no recent bycatch data from Mexico are available.

Table 1. Summary of available information on the incidental mortality and injury of blue whales (Eastern North Pacific stock) for commercial fisheries that might take this species (Carretta and Enriquez 2009a, 2009b, 2010, 2012a, 2012b).

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed Mortality (and injury)	Estimated mortality (CV in parentheses)	Mean Annual Takes (CV in parentheses)
CA/OR thresher shark/swordfish drift gillnet fishery	2001-2013	observer	19%	0	0	0 (n/a)
Total Annual Takes						0 (n/a)

Ship Strikes

Ship strikes were implicated in the deaths of four blue whales and the serious injury of a fifth whale between 2009 and 2013 (Carretta *et al*. 2015). Five deaths occurred in 2007, the highest number recorded for any year. The remaining four ship strike deaths occurred in 2009 (2) and 2010 (2). One additional whale was seriously injured in 2010 and its prorated serious injury value is 0.56 (Carretta *et al*. 2013, 2014). During 2009-2013, there were an additional two serious injuries of unidentified large whales attributed to ship strikes, some of which may have been blue whales (Carretta *et al*. 2015). No methods have been developed to prorate the number of unidentified ship strike cases to species, because identified cases are likely biased towards species that are large, easy to identify, and more likely to be detected, such as blue and fin whales. Most observed blue whale ship strikes have been in the southern California Bight, where large container ship ports overlap with seasonal blue whale distribution (Berman-Kowalewski *et al*. 2010). Several blue whales have been photographed in California with large gashes in their dorsal surface that appear to be from ship strikes. Including ship strike records identified to species and prorated serious injuries, blue whale mortality and injuries attributed to ship strikes in California waters averaged 0.9 per year during 2009-2013 (Carretta *et al*. 2015). NOAA previously implemented a mitigation plan that includes NOAA weather radio and U.S. Coast Guard advisory broadcasts to mariners entering the Santa Barbara Channel to be observant for whales, along with recommendations that mariners transit the channel at 10 knots or less. The Channel Islands National Marine Sanctuary also developed a blue whale/ship strike response plan, which involved weekly overflights to record whale locations. Additional plan information can be found at http://channelislands.noaa.gov/focus/alert.html. Documented ship strike deaths and serious injuries are derived from actual counts of whale carcasses and should be considered minimum values. Where evaluated, estimates of detection rates of cetacean carcasses are consistently quite low across different regions and species (<1% to 17%), highlighting that observed numbers are unrepresentative of true impacts (Kraus *et al*. 2005, Perrin *et al*. 2011, Williams *et al*. 2011, Prado *et al*. 2013). Due to this negative bias, Redfern *et al*. (2013) stress that the number of ship strike deaths of blue whales in the California Current likely exceeds PBR.

Impacts of ship strikes on population recovery of the eastern North Pacific blue whale population were recently assessed by Monnahan *et al*. (2015). Their population dynamics model incorporates data on historic whaling removals, levels of ship strikes, and projected numbers of vessels using the region through 2050. The authors conclude that this stock was at 97% of carrying capacity in 2013 and that current ship strike levels do not pose a threat to the status of this stock. Caveats to the carrying capacity analysis include the assumption that the population was already at carrying capacity prior to commercial whaling of this stock in the early 20th century and that carrying capacity has not changed appreciably since that time (Monnahan *et al*. 2015).

STATUS OF STOCK

The reported take of North Pacific blue whales by commercial whalers totaled 9,500 between 1910 and 1965 (Ohsumi and Wada 1972). Approximately 3,000 of these were taken from the west coast of North America from Baja California, Mexico to British Columbia, Canada (Tonnessen and Johnsen 1982; Rice 1992; Clapham *et al*. 1997; Rice 1974). Recently, Monnahan *et al*. (2014) estimated that 3,411 blue whales (95% range 2,593–4,114) were removed from the eastern North Pacific populations between 1905 and 1971. Blue whales in the North Pacific were given protected status by the IWC in 1966, but Doroshenko (2000) reported that a small number of blue whales were taken illegally by Soviet whalers after that date. As a result of commercial whaling, blue whales were listed as "endangered" under the Endangered Species Conservation Act of 1969. This protection was transferred to the Endangered Species Act (ESA) in 1973. Despite a current analysis suggesting that the Eastern North Pacific population is at 97% of carrying capacity (Monnahan *et al*. 2015), blue whales are listed as "endangered", and consequently the Eastern North Pacific stock is automatically considered a "depleted" and "strategic" stock under the MMPA. Conclusions about the population's current status relative to carrying capacity depend upon assumptions that the population was already at carrying capacity before commercial whaling impacted the population in the early 1900s, and that carrying capacity has remained relatively constant since that time (Monnahan *et al*. 2015). If carrying capacity has changed significantly in the last century, conclusions regarding the status of this population would necessarily change (Monnahan *et al*. 2015). The observed annual incidental mortality and injury rate (0.9/year) from ship strikes is less than the calculated PBR (2.3) for this stock, but this rate does not include unidentified large whales struck by vessels, some of which may have been blue whales, nor does it include undetected and unreported ship strikes of blue whales. The number of blue whales struck by ships in the California Current likely exceeds the PBR for this stock (Redfern *et al*. 2013). To date, no blue whale mortality has been associated with California gillnet fisheries; therefore, total fishery mortality is approaching zero mortality and serious injury rate.

Habitat Concerns

Increasing levels of anthropogenic sound in the world's oceans has been suggested to be a habitat concern for blue whales (Reeves *et al*. 1998, Andrew *et al*. 2002). Tagged blue whales exposed to simulated mid-frequency sonar and pseudo-random noise demonstrated a variety of behavioral responses, including no change in behavior, termination of deep dives, directed travel away from sound sources, and cessation of feeding (Goldbogen *et al*. 2013). Behavioral responses were highly dependent upon the type of sound source and the behavioral state of the animal at the time of exposure. Deep-feeding and non-feeding whales reacted more strongly to experimental sound sources than surface-feeding whales that typically showed no change in behavior. The authors stated that behavioral responses to such sounds are influenced by a complex interaction of behavioral state, environmental context, and prior exposure of individuals to such sound sources. One concern expressed by the authors is if blue whales did not habituate to such sounds near feeding areas that "repeated exposures could negatively impact individual feeding performance, body condition and ultimately fitness and potentially population health." Currently, no evidence indicates that such reduced population health exists, but such evidence would be difficult to differentiate from natural sources of reduced fitness or mortality in the population. Nine blue whale feeding areas identified off the California coast by Calambokidis *et al.* (2015) represent a diversity of nearshore and offshore habitats that overlap with a variety of anthropogenic activities, including shipping, oil and gas extraction, and military activities.

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Revised 4/7/2017

FIN WHALE (*Balaenoptera physalus physalus*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Northern Hemisphere fin whales (*B. physalus physalus*) likely comprise distinct Pacific and Atlantic subspecies (Archer *et al*. 2013). Mizroch *et al*. (2009) described eastern and western North Pacific populations, based on a review of sightings data, catch statistics, recaptures of marked whales, blood chemistry data, and acoustics. The two populations are thought to have separate wintering and mating grounds off of Asia and North America and during summer, whales from each population may co-occur near the Aleutian Islands and Bering Sea (Mizroch *et al*. 2009). Non-migratory populations exist in the Gulf of California (Tershy et al. 1993; Bérubé et al. 2002) and the East China Sea (Fujino 1960). Evidence of additional subpopulations near Sanriku-Hokkaido and the Sea of Japan exists, based on seasonal catch data and recaptures of marked animals (Mizroch *et al*. 2009). Fin whales occur throughout the North Pacific, from the southern Chukchi Sea to the Tropic of Cancer (Mizroch *et al*. 2009), but their wintering areas are poorly known. Fin whales are scarce in the eastern tropical Pacific in summer (Wade and Gerrodette 1993) and winter (Lee 1993). Fin whales occur year-round in the Gulf of Alaska (Stafford et al. 2007); the Gulf of California (Tershy et al. 1993; Bérubé et al. 2002); California (Dohl et al. 1983); and Oregon and Washington (Moore et al. 1998). Fin whales satellite-tagged in the Southern California Bight (SCB) appear to use the region year-round, although they seasonally range to central California and Baja California before returning to the SCB (Falcone and Schorr 2013). The longest satellite track reported by Falcone and Schorr (2013) was a fin whale tagged in the SCB in January 2014, with the whale moving south to central Baja California by February and north to the Monterey area by late June. Archer *et al*. (2013) present evidence for geographic separation of fin whale mtDNA clades near Point Conception, California: a significantly higher proportion of 'clade A' is composed of samples from the SCB and Baja California, while 'clade C' is largely represented by samples from central California, Oregon, Washington, and the Gulf of Alaska.

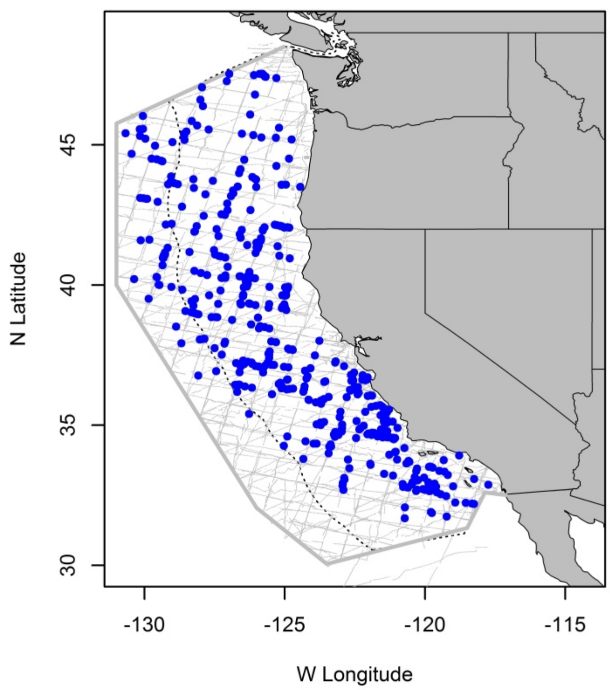

Figure 1. Fin whale sighting locations based on shipboard surveys off California, Oregon, and Washington, 1991-2014. Dashed line represents the U.S. EEZ; thin lines indicate completed transect effort of all surveys combined.

Insufficient information exists to determine population structure, but from a conservation perspective it may be risky to assume panmixia in the entire North Pacific. This report covers the stock of fin whales found along the coasts of California, Oregon, and Washington. Because fin whale abundance appears lower in winter/spring in California (Dohl *et al*. 1983; Forney *et al*. 1995) and in Oregon (Green *et al*. 1992), it is likely that the distribution of this stock extends seasonally outside these coastal waters. Fin whales are present year-round in southern California waters, as evidenced by individually-identified whales photographed in all four seasons (Falcone and Schorr 2013). The Marine Mammal Protection Act (MMPA) stock assessment reports recognize three stocks of fin whales in the North Pacific: 1) the California/Oregon/Washington stock (this report), 2) the Hawaii stock, and 3) the Northeast Pacific stock.

POPULATION SIZE

The pre-whaling population of fin whales in the North Pacific was estimated to be 42,000-45,000 (Ohsumi and Wada 1974). In 1973, the North Pacific population was estimated to have been reduced to 13,620-18,680 (Ohsumi and Wada 1974), of which 8,520-10,970 were estimated to belong to the eastern Pacific stock. The best estimate of fin whale abundance in California, Oregon, and Washington waters out to 300 nmi is from a trend-model analysis of line-transect data from 1991 through 2014 (Nadeem *et al*. 2016; Fig. 2), which generated an estimate for 2014 of 9,029 (CV=0.12) whales. The new estimates are based on similar methods to those first applied to this population by Moore and Barlow (2011). However, the new abundance estimates are substantially higher than earlier estimates because the new analysis incorporates lower estimates of *g(0)*, the trackline detection probability (Barlow 2015). The trend-model analysis incorporates information from the entire 1991-2014 time series for each annual estimate of abundance, and given the strong evidence of an increasing abundance trend over that time (Moore and Barlow 2011, Nadeem *et al.* 2016), the best estimate of abundance is represented by the estimate for the most recent year, or 2014. This is probably an underestimate because it excludes some fin whales that could not be identified in the field and were recorded as “unidentified rorqual” or “unidentified large whale”.

Minimum Population Estimate

The minimum population estimate for fin whales is taken as the lower 20th percentile of the posterior distribution of abundance estimated for 2014, or approximately 8,127 whales.

Current Population Trend

Indications of recovery in CA coastal waters date back to 1979/80 (Barlow 1994), but there is now strong evidence that fin whale abundance increased in the California Current between 1991 and 2008 based on analysis of abundance data from line transect surveys conducted in the California Current between 1991 and 2014 (Nadeem *et al*. 2016, Figure 2). Abundance in waters out to 300 nmi off the coast of California approximately doubled between 1991 and 1993, from approximately 1,744 (CV = 0.25) to 3,369 (CV= 0.21), suggesting probable dispersal of animals into this area. Across the entire study area (waters off California, Oregon, and Washington), the mean annual abundance increase was 7.5%, although abundance appeared stable between 2008 and 2014. In all, there has been a roughly 5-fold increase between 1991 and 2014. Since 2005, the abundance increase has been driven by increases off northern California, Oregon and Washington, while numbers off Central and Southern California have been stable (Nadeem *et al*. 2016). Zerbini *et al*. (2006) found similar evidence of increasing abundance trend for fin whales in Alaskan waters at a rate of 4.8% per year between 2001 and 2003.

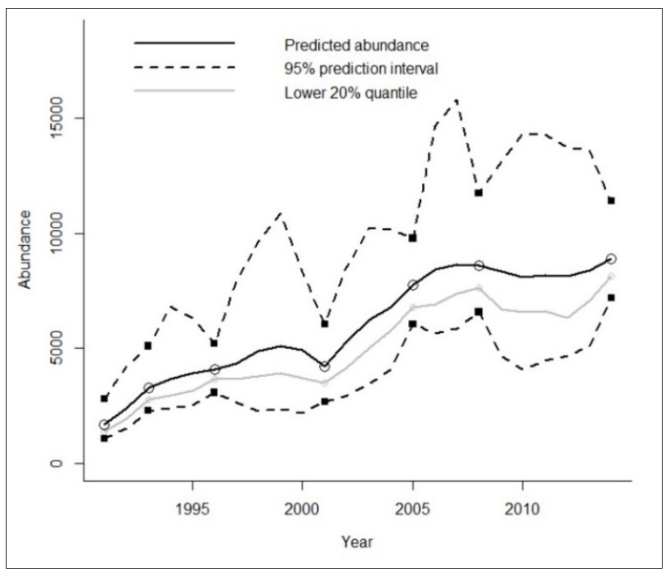

Figure 2. Trend-based estimates of fin whale abundance, 1991- 2014, with 95% Bayesian credible intervals (Nadeem *et al*. 2016).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Estimated annual rates of increase in the California Current (California, Oregon, and Washington waters) averaged 7.5% from 1991 to 2014 (Nadeem *et al*. 2016). However, it is unknown how much of this growth is due to immigration rather than birth and death processes. A doubling of the abundance estimate in California waters between 1991 and 1993 cannot be explained by birth and death processes alone, and movement of individuals between U.S. west coast waters and other areas (e.g., Alaska, Mexico) have been documented (e.g., Mizroch et al. 1984).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (8,127) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.5 (for an endangered species, with N_{min} > 5,000 and CV_{Nmin} < 0.50, Taylor *et al*. 2003), resulting in a PBR of 81 whales.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

One fin whale death (in 1999) was observed in the California swordfish drift gillnet fishery from over 8,600 observed sets between 1990 and 2014 (Carretta *et al*. 2016a.). Although no fin whales have been observed taken in the fishery since 1999, new model-based bycatch estimates include a very small estimate of 0.1 whales (CV=3) for the most recent 5-year period, 2010-2014 (Carretta *et al.* 2016a). The large CV of this bycatch estimate is a consequence of the mean estimate being very small. This estimate is based on inclusion of 25 years of observer data spanning 1990-2014 and reflects a very low long-term observed bycatch rate scaled up to levels of unobserved fishing effort. Mean annual takes (<0.1) for this fishery (Table 1) are based on 2010-2014 data. Some gillnet mortality of large whales may go unobserved because whales swim away with a portion of the net. One fin whale sighted at-sea was determined to be seriously injured (line cutting into the whale) as a result of interactions with unknown fishing gear during 2010-2014 (Carretta *et al.* 2016b). Including systematic fishery observations in the CA swordfish drift gillnet fishery and opportunistic sightings of fishery-related injuries, the mean annual serious injury and mortality of fin whales for 2010-2014 is ≥0.2 whales (Table 1). Gillnets have been documented to entangle marine mammals off Baja California (Sosa-Nishizaki et al. 1993), but no recent bycatch data from Mexico are available.

Table 1. Summary of available information on the incidental mortality and injury of fin whales (CA/OR/WA stock) for commercial fisheries that might take this species.

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed (or self-reported)	Estimated Mortality (and serious injury)	Mean Annual Takes (CV in parentheses)
CA swordfish and thresher shark drift gillnet fishery	2010-2014	observer	22%	0[1]	0.1 (CV=3)	<0.1 (CV=3)
Unidentified fishery interactions	2010-2014	at-sea sightings	n/a	1	0 (1)	≥ 0.2
Minimum total annual takes						≥ 0.2 (CV=3)

Ship Strikes

Ship strikes were implicated in the deaths of nine fin whales during 2010-2014 (Carretta *et al*. 2015, Carretta *et al.* 2016b). During 2010-2014, there was one additional serious injury to an unidentified large whale attributed to a ship strike. Additional mortality from ship strikes probably goes unreported because the whales do not strand or, if they do, they do not always have obvious signs of trauma. The average observed annual mortality and serious injury due to ship strikes is 1.8 fin whales per year during 2010-2014. Documented ship strike deaths and serious injuries are derived from actual counts of whale carcasses and should be considered minimum values. Where evaluated, estimates of detection rates of cetacean carcasses are consistently quite low across different regions and species (<1% to 33%), highlighting that observed numbers underestimate true impacts (Carretta *et al*. 2016c, Kraus *et al*. 2005, Williams *et al*. 2011, Prado *et al*. 2013, Wells *et al.* 2015).

STATUS OF STOCK

Fin whales in the North Pacific were given protected status by the IWC in 1976. Fin whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently the California

[1] There were no observations of fin whale entanglements in this fishery during 2010-2014, but the model-based estimate of bycatch for this period results in a positive estimate of bycatch (Carretta *et al*. 2016a).

to Washington stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. The total documented incidental mortality and serious injury (2.0/yr) due to fisheries (0.2/yr) and ship strikes (1.8/yr) is less than the calculated PBR (81). Total fishery mortality is less than 10% of PBR and, therefore, may be approaching zero mortality and serious injury rate. There is strong evidence that the population has increased since the early 1990s (Moore and Barlow 2011, Nadeem *et al.* 2016). Increasing levels of anthropogenic sound in the world's oceans has been suggested to be a habitat concern for whales, particularly for baleen whales that may communicate using low-frequency sound (Croll *et al.* 2002). Behavioral changes associated with exposure to simulated mid-frequency sonar, including no change in behavior, cessation of feeding, increased swimming speeds, and movement away from simulated sound sources has been documented in tagged *blue* whales (Goldbogen *et al*. 2013), but it is unknown if fin whales respond in the same manner to such sounds.

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Revised 2/8/2017

SEI WHALE (*Balaenoptera borealis borealis*): Eastern North Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The International Whaling Commission (IWC) only considers one stock of sei whales in the North Pacific (Donovan 1991), but some evidence exists for multiple populations (Masaki 1977; Mizroch *et al.* 1984; Horwood 1987). Sei whales are distributed far out to sea in temperate regions of the world and do not appear to be associated with coastal features. Whaling effort for this species was distributed continuously across the North Pacific between 45-55ºN (Masaki 1977). Two sei whales that were tagged off California were later killed off Washington and British Columbia (Rice 1974) and the movement of tagged animals has been noted in many other regions of the North Pacific. Sei whales are rare in the California Current (Dohl *et al.* 1983; Barlow 1997; Forney *et al.* 1995; Mangels and Gerrodette 1994, Barlow 2016), but were the fourth most common whale taken by California coastal whalers in the 1950s-1960s (Rice 1974). They are extremely rare south of California (Wade and Gerrodette 1993; Lee 1993). Lacking additional information on sei whale population structure, sei whales in the eastern North Pacific (east of longitude 180º) are considered as a separate stock.

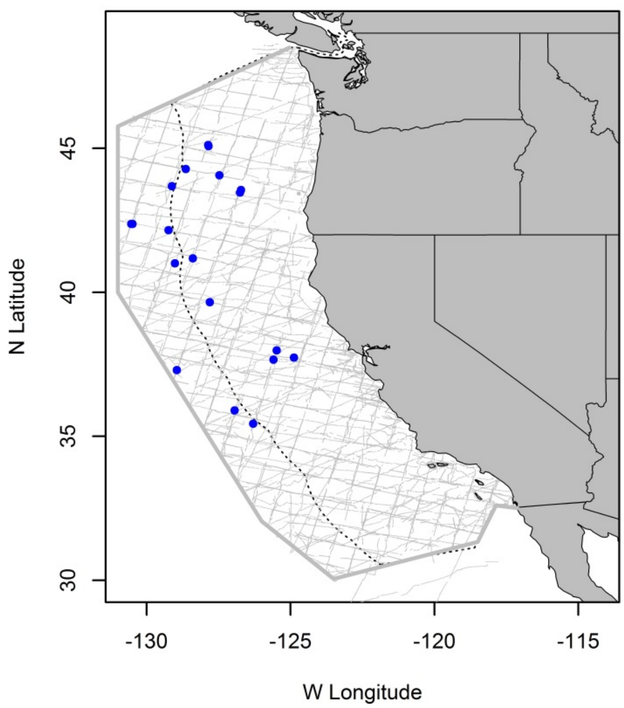

Figure 1. Sei whale sighting locations from shipboard surveys off California, Oregon, and Washington, 1991-2014. Dashed line represents the U.S. EEZ; thin lines indicate completed transect effort of all surveys combined.

POPULATION SIZE

Ohsumi and Wada (1974) estimate the pre-whaling abundance of sei whales to be 58,000-62,000 in the North Pacific. Later, Tillman (1977) used a variety of different methods to estimate the abundance of sei whales in the North Pacific and revised this pre-whaling estimate to 42,000. His estimates for the year 1974 ranged from 7,260 to 12,620. All methods depend on using the history of catches and trends in CPUE or sighting rates; there have been no direct estimates of sei whale abundance in the entire (or eastern) North Pacific based on sighting surveys. Sei whale sightings in California, Oregon, and Washington waters during extensive ship and aerial surveys between 1991- 2014 have been relatively rare (Figure 1, Hill and Barlow 1992; Carretta and Forney 1993; Mangels and Gerrodette 1994; VonSaunder and Barlow 1999; Barlow 2003; Forney 2007; Barlow 2010, Barlow 2016). Green *et al.* (1992) did not report any sightings of sei whales in aerial surveys of Oregon and Washington. Abundance estimates for the two most recent line transect surveys of California, Oregon, and Washington waters in 2008 and 2014 out to 300 nmi are 311 (0.76) and 864 (0.40) sei whales, respectively (Barlow 2016). The best estimate of abundance for California, Oregon, and Washington waters out to 300 nmi is the unweighted geometric mean of the 2008 and 2014 estimates, or 519 (CV=0.40) sei whales (Barlow 2016).

Minimum Population Estimate

The minimum population estimate for sei whales is taken as the lower 20th percentile of the log-normal distribution of abundance estimated from 2008 and 2014 shipboard line-transect surveys, or approximately 374 whales.

Current Population Trend

There are no data on trends in sei whale abundance in the eastern North Pacific waters. Although the population in the North Pacific is expected to have grown since being given protected status in 1976, the possible effects of continued unauthorized take (Yablokov 1994) and incidental ship strikes and gillnet mortality make this uncertain. Barlow (2016) noted that an increase in sei whale abundance observed in 2014 in the California Current is partly due to recovery of the population from commercial whaling, but may also involve distributional shifts in the population.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

There are no estimates of the growth rate of sei whale populations in the North Pacific (Best 1993).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (374) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.1 (for an endangered species), resulting in a PBR of 0.75 whales.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

The California swordfish drift gillnet fishery is the only fishery that is likely to take sei whales from this stock, but no fishery mortality or serious injuries have been observed from over 8,600 monitored fishing sets from 1990-2014 (Carretta *et al.* 2017, Table 1). Mean annual takes for this fishery (Table 1) are based on 2010-2014 data. This results in an average estimate of zero sei whales taken annually. However, some gillnet mortality of large whales may go unobserved because whales swim away with a portion of the net.

Table 1. Summary of available information on the incidental mortality and injury of sei whales (eastern North Pacific stock) for commercial fisheries that might take this species. n/a indicates that data are not available. Mean annual takes are based on 2010-2014 data unless noted otherwise.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed mortality (and injury in parentheses)	Estimated mortality (CV in parentheses)	Mean annual takes (CV in parentheses)
CA/OR thresher shark/swordfish drift gillnet fishery	2010-2014	observer	22%	0	0	0 (n/a)

Ship Strikes

There have been no documented ship strikes of sei whales in the most recent 5-year period, 2010-2014 (Carretta *et al.* 2016), although one ship strike death was reported in Washington in 2003 (NMFS Northwest Regional Office, unpublished data). During 2010-2014, there were an additional eight injuries of unidentified large whales attributed to ship strikes. Additional mortality from ship strikes probably goes unreported because the whales do not strand or, if they do, they do not always have obvious signs of trauma. The average observed annual mortality due to ship strikes is zero sei whales per year for the period 2010-2014.

STATUS OF STOCK

The NMFS recovery plan for the sei whale (NMFS 2011) notes that basic information such as distribution, abundance, trends and stock structure is of poor quality or largely unknown, owing to the rarity of sightings of this species. Sei whales were estimated to have been reduced to 20% (8,600 out of 42,000) of their pre-whaling abundance in the North Pacific (Tillman 1977). The initial abundance has never been reported separately for the eastern North Pacific stock, but this stock was also probably depleted by whaling. Sei whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently the eastern North Pacific stock is automatically considered as a "depleted" and "strategic" stock under the Marine Mammal Protection Act (MMPA). Total known estimated fishery mortality is zero and therefore is approaching zero mortality and serious injury rate. Although the current known rate of ship strike deaths and serious injuries is zero, it is likely that some sei whale ship strikes are unreported. Increasing levels of anthropogenic sound in the world's oceans has been suggested to be a habitat concern for whales, particularly for baleen whales that may communicate using low-frequency sound (Croll *et al.* 2002). Behavioral changes associated with exposure to simulated mid-frequency sonar, including no change in behavior, cessation of feeding, increased swimming speeds, and movement away from simulated sound sources has been documented in tagged blue whales (Goldbogen *et al.* 2013), but it is unknown if sei whales respond in the same manner to such sounds.

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Revised 8/16/2016

MINKE WHALE (*Balaenoptera acutorostrata scammoni*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The International Whaling Commission (IWC) recognizes 3 stocks of minke whales in the North Pacific: one in the Sea of Japan/East China Sea, one in the rest of the western Pacific west of 180ºN, and one in the "remainder" of the Pacific (Donovan 1991). The "remainder" stock only reflects the lack of exploitation in the eastern Pacific and does not imply that only one population exists in that area (Donovan 1991). In the "remainder" area, minke whales are relatively common in the Bering and Chukchi seas and in the Gulf of Alaska, but are not considered abundant in any other part of the eastern Pacific (Leatherwood et al. 1982; Brueggeman et al. 1990). In the Pacific, minke whales are usually seen over continental shelves (Brueggeman et al. 1990). In the extreme north, minke whales are believed to be migratory, but in inland waters of Washington and in central California they appear to establish home ranges (Dorsey et al. 1990). Minke whales occur year-round in California (Dohl et al. 1983; Forney et al. 1995; Barlow 1997) and in the Gulf of California (Tershy et al. 1990). Minke whales are present at least in summer/fall along the Baja California peninsula (Wade and Gerrodette 1993). Because the "resident" minke whales from California to Washington appear behaviorally distinct from migratory whales further north, minke whales in coastal waters of California, Oregon, and Washington (including Puget Sound) are considered as a separate stock. Minke whales in Alaskan waters are considered in a separate stock assessment report.

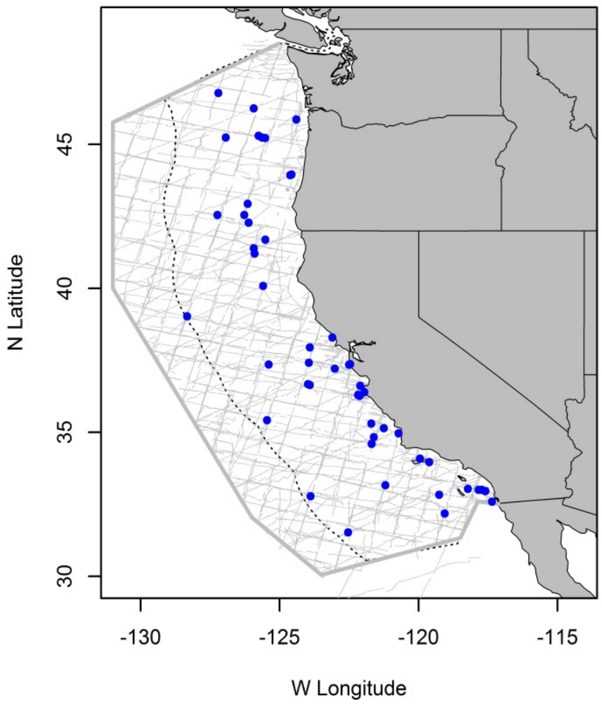

Figure 1. Minke whale sighting locations based on shipboard surveys off California, Oregon, and Washington, 1991-2014. Dashed line represents the U.S. EEZ; thin lines indicate completed transect effort of all surveys combined.

POPULATION SIZE

No estimates have been made for the number of minke whales in the entire North Pacific. The most recent abundance estimate for this stock is based on the geometric mean of estimates obtained from ship line transect surveys in summer and autumn in 2008 and 2014, or 636 (CV=0.72) whales (Barlow 2016).

Minimum Population Estimate

The minimum population estimate for minke whales is taken as the lower 20th percentile of the log-normal distribution of abundance estimated from 2008 and 2014 summer/fall ship surveys in California, Oregon, and Washington waters (Barlow 2016) or approximately 369 whales.

Current Population Trend

There are no data on trends in minke whale abundance in waters of California, Oregon and/or Washington.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

There are no estimates of the growth rate of minke whale populations in the North Pacific (Best 1993).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (369) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.48 (for a stock of unknown status with a mortality estimate CV > 0.30 and < 0.60), resulting in a PBR of 3.5 whales.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Table 1. Summary of available information on the incidental mortality and injury of minke whales (CA/OR/WA stock) for commercial fisheries that might take this species (Carretta *et al.* 2016a). Mean annual takes are based on 2010-2014 data.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed mortality (and serious injury)	Estimated mortality (CV)	Mean annual takes (CV)
CA/OR thresher shark/swordfish drift gillnet fishery	2010-2014	observer	22%	1[1]	4.5 (0.58)	0.9 (0.58)
CA halibut and other species large mesh (>3.5") set gillnet fishery	2010-2014	observer	9%	0	0	n/a
Unidentified fisheries	2010-2014	Sightings and strandings	n/a	1 (0.75)	1.75 (n/a)	≥ 0.35 (n/a)
Total annual takes						≥1.3 (0.58)

Fishery Information

Minke whales may occasionally be caught in coastal set gillnets off California, in salmon drift gillnet in Puget Sound, Washington, and in offshore drift gillnets off California. Four minke whales were observed entangled (2 dead, 2 released alive) between 1990-2014 in the California swordfish drift gillnet fishery from over 8,600 monitored fishing sets (Carretta *et al.* 2016a). One animal 'released alive' in 1999 occurred in a set with a large hole in the net from which a skin sample was collected and positively-identified as a minke whale with genetic sequencing. It is unknown whether or not gear remained on the whale. The estimate for the drift gillnet fishery in Table 1 (4.5 whales / 5 years = 0.9 annually) currently reflects total bycatch, regardless of animal condition (Carretta *et al.* 2016a). Two additional minke whale fishery interactions were recorded during 2010-2014: an entangled whale sighted at sea with rope and net material (=0.75 serious injury) and a live stranding of an animal that later died and appeared to have been previously entangled in unknown cable material (Carretta *et al.* 2016b). The mean annual mortality and serious injury of minke whales from this stock during 2010-2014 is 1.3 animals (Table 1).

Ship Strikes

No ship strikes of minke whales were reported during the most recent 5-year period of 2010-2014. Additional mortality from ship strikes probably goes unreported because the whales do not strand or, if they do, they do not always have obvious signs of trauma.

STATUS OF STOCK

Minke whales are not listed as "endangered" under the Endangered Species Act and are not considered "depleted" under the MMPA. The greatest uncertainty in their status is whether entanglement in commercial gillnets and ship strikes could have reduced this relatively small population. Because of this,

[1] One minke whale was observed entangled in this fishery during the 2010-2014 period. The entanglement occurred in 2011 (Carretta *et al.* 2016a).

the status of the west-coast stock is considered "unknown". The annual mortality and serious injury due to fisheries (1.3/yr) and ship strikes (0.0/yr) is less than the calculated PBR for this stock (3.5), so they are not considered a "strategic" stock under the MMPA. Fishery mortality is not less than 10% of the PBR; therefore, total fishery mortality is not approaching zero mortality and serious injury rate. There is no information on trends in the abundance of this stock. Harmful algal blooms are a habitat concern for minke whales and at least one death along the U.S. west coast has been attributed to domoic acid toxicity resulting from the consumption of northern anchovy prey items (Fire *et al.* 2010). Increasing levels of anthropogenic sound in the world's oceans has been suggested to be a habitat concern for whales, particularly for baleen whales that may communicate using low-frequency sound (Croll *et al*. 2002). Behavioral changes associated with exposure to simulated mid-frequency sonar, including no change in behavior, cessation of feeding, increased swimming speeds, and movement away from simulated sound sources has been documented in tagged blue whales (Goldbogen *et al*. 2013), but it is unknown if minke whales respond in the same manner to such sounds.

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BRYDE'S WHALE (*Balaenoptera edeni*): Eastern Tropical Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The International Whaling Commission (IWC) recognizes 3 stocks of Bryde's whales in the North Pacific (eastern, western, and East China Sea), 3 stocks in the South Pacific (eastern, western and Solomon Islands), and one cross-equatorial stock (Peruvian) (Donovan 1991). Bryde's whales are distributed widely across the tropical and warm-temperate Pacific (Leatherwood et al. 1982), and there is no justification for splitting stocks between the northern and southern hemispheres (Donovan 1991). Past surveys have shown them to be common and distributed throughout the eastern tropical Pacific with a concentration around the equator east of 110ºW (corresponding approximately to the IWC's "Peruvian stock") and a lower densities west of 140ºW (Lee 1993; Wade and Gerrodette 1993). They are also the most common baleen whale in the central Gulf of California (Tershy et al. 1990). Sightings and acoustic recordings of Bryde’s whales in southern California waters have increased in the past decade (Kerosky *et al*. 2012, Smultea *et al*. 2012), possibly signaling a northward range expansion (Kerosky *et al*. 2012). Acoustic recordings indicate Bryde’s whales are present in southern California waters from summer through early winter (Kerosky *et al*. 2012). At least seven sightings have been documented in southern / central California waters between 1991 and 2014 (Barlow and Forney 2007, Smultea *et al*. 2012, Barlow 2016). Bryde's whales in California waters likely belong to a larger population inhabiting at least the eastern part of the tropical Pacific. Acoustic call types of Bryde’s whales in southern California waters match a type found along the west coast of Baja California (Kerosky *et al*. 2012). For the Marine Mammal Protection Act (MMPA) stock assessment reports, Bryde's whales within the Pacific U.S. Exclusive Economic Zone are divided into two areas: 1) the eastern tropical Pacific (east of 150ºW and including the Gulf of California and waters off California; this report), and 2) Hawaiian waters.

POPULATION SIZE

In the western North Pacific, Bryde's whale abundance in the early 1980s was estimated independently by tag mark-recapture and ship survey methods to be 22,000 to 24,000 (Tillman and Mizroch 1982; Miyashita 1986). Bryde's whale abundance has never been estimated for the entire eastern Pacific; however, a portion of that stock in the eastern tropical Pacific was estimated as 13,000 (CV=0.20; 95% CI = 8,900-19,900) (Wade and Gerrodette 1993), and the minimum number in the Gulf of California was estimated at 160 based on individually-identified whales (Tershy et al. 1990). The most recent verified sighting in California waters occurred in 2014 during a systematic line-transect survey designed to estimate cetacean abundance (Barlow 2016). That sighting did not occur during standard search effort and thus, no estimate of abundance is available from the 2014 survey.

Minimum Population Estimate

The only minimum estimate of Bryde’s whale abundance for the eastern tropical Pacific (11,163; Wade and Gerrodette 1993) is over 8 years old and thus, no current estimate of minimum abundance is available.

Current Population Trend

There are no data on trends in Bryde's whale abundance in the eastern tropical Pacific.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

There are no estimates of the growth rate of Bryde's whale populations in the Pacific (Best 1993).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock cannot be calculated because a current abundance estimate is unavailable.

HUMAN CAUSED MORTALITY

Historic Whaling

The reported take of North Pacific Bryde's whales by commercial whalers totaled 15,076 in the western Pacific from 1946-1983 (Holt 1986) and 2,873 in the eastern Pacific from 1973-81 (Cooke 1983). In addition, 2,304 sei-or-Bryde's whales were taken in the eastern Pacific from 1968-72 (Cooke 1983) (based on subsequent catches, most of these were probably Bryde's whales). None were reported taken by shore-based whaling stations in central or northern California between 1919 and 1926 (Clapham et al. 1997) or 1958 and 1965 (Rice 1974). There has been a prohibition on taking Bryde's whales since 1988.

Table 1. Summary of available information on the incidental mortality and injury of Bryde’s whales (eastern tropical Pacific stock) for commercial fisheries that might take this species (Carretta *et al*. 2014a, 2012a, 2012b, Carretta and Enriquez 2009, 2010; Carretta *et al*. 2004). n/a indicates that data are not available. Mean annual takes are based on 2001-2013 data unless noted otherwise.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed mortality (and injury in parentheses)	Estimated mortality (CV in parentheses)	Mean annual takes (CV in parentheses)
CA/OR thresher shark/swordfish drift gillnet fishery	2001-2013	observer	19%	0	0	0
Total annual takes						0

Fishery Information

The California swordfish drift gillnet fishery is the only fishery that is likely to take Bryde’s whales from this stock, but no entanglements have been observed (Table 1). Detailed information on this fishery is provided in Appendix 1. Mean annual takes for this fishery are zero (Table 1) and are based on 2001-2013 data, the period during which a season/area closure has limited most fishing to southern California waters. Although Bryde’s whales have not been observed entangled in California gillnets, some gillnet mortality of large whales may go unobserved because whales swim away with a portion of the net.

Ship Strikes

One Bryde’s whale was documented to have been killed by a ship strike in 2010 (Carretta et al. 2014b, Carretta et al. 2015). The whale was initially sighted alive in Washington state waters with propeller marks and stranded dead about a week later. The mean annual serious injury and mortality rate of Bryde’s whales over the most recent 5-year period (2009-2013) is 0.2 whales annually.

STATUS OF STOCK

Commercial whaling of Bryde's whales was largely limited to the western Pacific. Bryde's whales are not listed as "threatened" or "endangered" under the Endangered Species Act (ESA). Bryde's whales in the eastern tropical Pacific would not be considered a strategic stock under the MMPA. The total human-caused mortality rate is 0.2 whales annually. Current abundance of this stock is unknown and therefore PBR cannot be calculated for this stock. Likewise, human-caused mortality cannot be evaluated in the context of PBR. Increasing levels of anthropogenic sound in the world’s oceans has been suggested to be a habitat concern for whales, particularly for baleen whales that may communicate using low-frequency sound.

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Revised 7/15/2014

ROUGH-TOOTHED DOLPHIN (*Steno bredanensis*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Rough-toothed dolphins are found throughout the world in tropical and warm-temperate waters (Perrin et al. 2009). They are present around all the main Hawaiian Islands, though they are uncommon near Maui and the 4-Islands region (Baird et al. 2013) and have been observed close to the islands and atolls at least as far northwest as Pearl and Hermes Reef (Bradford et al. 2013). Rough-toothed dolphins were occasionally seen offshore throughout the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands during both 2002 and 2010 surveys (Barlow 2006, Bradford et al. 2013; Figure 1).

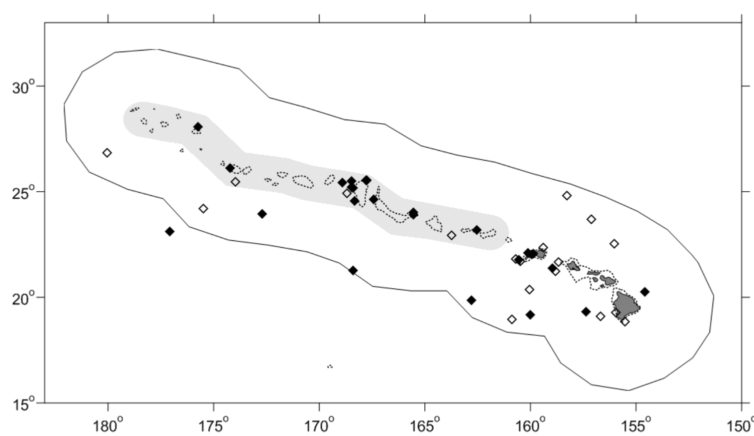

Figure 1. Rough-toothed dolphin sighting locations during the 2002 (open diamonds) and 2010 (black diamonds) shipboard cetacean surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2013; see Appendix 2 for details on timing and location of survey effort). Outer line represents approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument. Dotted line represents the 1000m isobath.

Little is known about stock structure for this species in the North Pacific. Photographic identification studies around the main Hawaiian Islands suggest that dispersal rates between the islands of Kauai/Niihau and Hawaii do not exceed 2% per year (Baird *et al*. 2008). Resighting rates off the island of Hawaii are high, with 75% of well-marked individuals resighted on two or more occasions, suggesting high site fidelity and low population size. Preliminary results of genetic studies of individuals sampled from Kauai/Niihau and Hawaii Island (Albertson, unpublished data), together with resighting data, suggest there may be at least two island-associated stocks of rough-toothed dolphins in main Hawaiian Islands (Oleson et al. 2013). Rough-toothed dolphins have also been documented in American Samoan waters (Oleson 2009).

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are two Pacific management stocks: 1) The Hawaii Stock (this report), and 2) the American Samoa Stock. The Hawaii stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from the U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

A population estimate for this species is available from the eastern tropical Pacific (Wade and Gerrodette 1993), but it is not known whether these animals are part of the same population that occurs around the Hawaiian Islands. Mark-recapture estimates for the islands of Kauai/Nihau and Hawaii were derived from identification photographs obtained between 2003 and 2006, resulting in estimates of 1,665 (CV=0.33) around Kauai/Niihau and 198 (CV=0.12) around the island of Hawaii (Baird *et al.* 2008). These estimates are specific to those island areas and do not represent the abundance of rough-toothed dolphins within the Hawaiian EEZ, as surveys were primarily conducted within 40km of shore. A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 8,709 (CV=0.45) rough-toothed dolphins (Barlow 2006). The recent 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 6,288 (CV = 0.39) rough-toothed dolphins (Bradford et al. 2013). This is currently the best available abundance estimate for this stock.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al. 1995) of the 2010 abundance estimate or 4,581 rough-toothed dolphins within the Hawaiian Islands

EEZ.

Current Population Trend

No data are available on current population trend. The broad and overlapping confidence intervals around the 2002 and 2010 estimates preclude assessment of trends with the available data.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii stock of rough-toothed dolphins is calculated as the minimum population size within the U.S. EEZ of the Hawaiian Islands (4,581) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no known fishery mortality or serious injury; Wade and Angliss 1997), resulting in a PBR of 46 rough-toothed dolphins per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Rough-toothed dolphins are known to take bait and catch from several Hawaiian sport and commercial fisheries operating near the main islands (Shallenberger 1981; Schlais 1984; Nitta and Henderson 1993). They have been specifically reported to interact with the day handline fishery for tuna (palu-ahi), the night handline fishery for tuna (ika-shibi), and the troll fishery for billfish and tuna (Schlais 1984; Nitta and Henderson 1993). Baird *et al.* (2008) reported increased vessel avoidance of boats by rough-toothed dolphins off the island of Hawaii relative to those off Kauai or Niihau and attributed this to possible shooting of dolphins that are stealing bait or catch from recreational fisherman off the island of Hawaii (Kuljis 1983). No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Between 2007 and 2011, no rough-toothed dolphins were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (McCracken 2013, Bradford & Forney 2013). However, eight unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been rough-toothed dolphins.

STATUS OF STOCK

The Hawaii stock of rough-toothed dolphins is not considered strategic under the 1994 amendments to the MMPA, The status of rough-toothed dolphins in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Rough-toothed dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. There have been no reports of recent mortality or serious injuries; however, there is no systematic monitoring for interactions with protected species within near-shore fisheries that may take this species, thus mean annual takes are undetermined. Insufficient information is available to determine whether the total fishery mortality and serious injury for rough-toothed dolphins is insignificant and approaching zero mortality and serious injury rate.

One rough-toothed dolphin stranded in the main Hawaiian Islands tested positive for *Brucella* (Chernov, 2010) and another for *Morbillivirus* (Jacob 2012). *Brucella* is a bacterial infection may limit recruitment by compromising male and female reproductive systems if it is common in the population, and can also cause neurological disorders that may result in death (Van Bressem et al. 2009). Although *morbillivus* is known to trigger lethal disease in cetaceans (Van Bressem et al. 2009), its impact on the health of the stranded animal is not known (Jacob 2012). The presence of *morbillivirus* in 10 species (Jacob 2012) and *Brucella* in 3 species (Chernov 2010, West unpublished data) raises concerns about the history and prevalence of these diseases in Hawaii and the potential population impacts on Hawaiian cetaceans. It is not known if *Brucella or Morbillivirus* are common in the Hawaii stock.

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Revised 01/15/2011

ROUGH-TOOTHED DOLPHIN *(Steno bredanensis)*: American Samoa Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Figure 1. Rough-toothed dolphin sightings during cetacean sighting surveys around Tutuila, American Samoa, 2003-2006 (Johnston et al, 2008).

Rough-toothed dolphins are found throughout the world in tropical and warm-temperate waters (Perrin et al. 2009). Rough-toothed dolphins are common in the South Pacific from the Solomon Islands, where they were taken by dolphin hunters, to French Polynesia and the Marquesas (reviewed by Reeves et al 1999). Rough-toothed dolphins have been observed during summer and winter surveys around the American Samoan island of Tutuila (Johnston et al. 2008) and are thought to be common throughout the Samoan archipelago (Craig 2005). Rough-toothed dolphins were among the most commonly-sighted cetaceans during small boat surveys conducted from 2003 to 2006 around Tutuila, though not observed during a 2006 survey of Swain's Island and the Manu'a Group (Johnston et al. 2008). Photo-identification data collected during the surveys suggest the presence of a resident population of rough-toothed dolphins in the waters surrounding Tutuila (Johnston et al. 2008). Approximately 1/3 of the individuals within the photo-id catalog were sighted in multiple years (Johnston et al. 2008). One rough-toothed dolphin was taken entangled near 40-fathom bank south of the islands by the American Samoa-based longline in 2008 (Oleson 2009), indicating some rough-toothed dolphins maintain a more pelagic distribution. Nothing is known about stock structure for this species in the South Pacific. For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are two Pacific management stocks: 1) The Hawaiian Stock, which includes animals found within the U.S. EEZ of the Hawaiian Islands, and 2) the American Samoa Stock, which include animals inhabiting the EEZ waters around American Samoa (this report).

POPULATION SIZE

No abundance estimates are currently available for rough-toothed dolphins in U.S. EEZ waters of American Samoa; however, density estimates for rough-toothed dolphins in other tropical Pacific regions can provide a range of likely abundance estimates in this unsurveyed region. Published estimates of rough-toothed dolphins (animals per km^2) in the Pacific are: 0.0035 (CV=0.45) for the U.S. EEZ of the Hawaiian Islands (Barlow 2006); 0.0017 (CV=0.63) for nearshore waters surrounding the main Hawaiian Islands (Mobley et al. 2000), 0.0076 (CV=0.32) and 0.0017 (CV=0.16) for the eastern tropical Pacific Ocean (Wade and Gerrodette 1993; Ferguson and Barlow 2003). Applying the lowest and highest of these density estimates to U.S. EEZ waters surrounding American Samoa (area size = 404,578 km^2) yields a range of plausible abundance estimates of 692 – 3,115 rough-toothed dolphins.

Minimum Population Estimate

No minimum population estimate is currently available for waters surrounding American Samoa, but the rough-toothed dolphin density estimates from other tropical Pacific regions (Barlow 2003, Mobley et al. 2000, Wade and Gerrodette 1993, Ferguson and Barlow 2003, see above) can provide a range of likely values. The lognormal 20^{th} percentiles of plausible abundance estimates for the American Samoa EEZ, based on the densities observed elsewhere, range from 426 – 2,731 rough-toothed dolphins.

Current Population Trend

No data are available on current population trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

No PBR can presently be calculated for rough-toothed dolphins within the American Samoa EEZ, but based on the range of plausible minimum abundance estimates (426 – 2,731), a recovery factor of 0.40 (for a species of unknown status with a fishery mortality and serious injury rate CV > 0.50 within the American Samoa EEZ; Wade and Angliss 1997), and the default growth rate (½ of 4%), the PBR would likely fall between 3.4 and 22 rough-toothed dolphins per year.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in American Samoan fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Gillnets appear to capture marine mammals wherever they are used, and float lines from lobster traps and longlines can be expected to occasionally entangle whales (Perrin et al. 1994). The primary fishery in American Samoa is the commercial pelagic longline fishery that targets tunas, which was introduced in 1995 (Levine and Allen 2009). In 2008, there were 28 federally permitted vessels within the longline fishery in American Samoa. The fishery has been monitored since March 2006 under a mandatory observer program, which records all interactions with protected species (Pacific Islands Regional Office 2009). One rough-toothed dolphin was seriously injured by the fishery in 2008 (Oleson 2009).

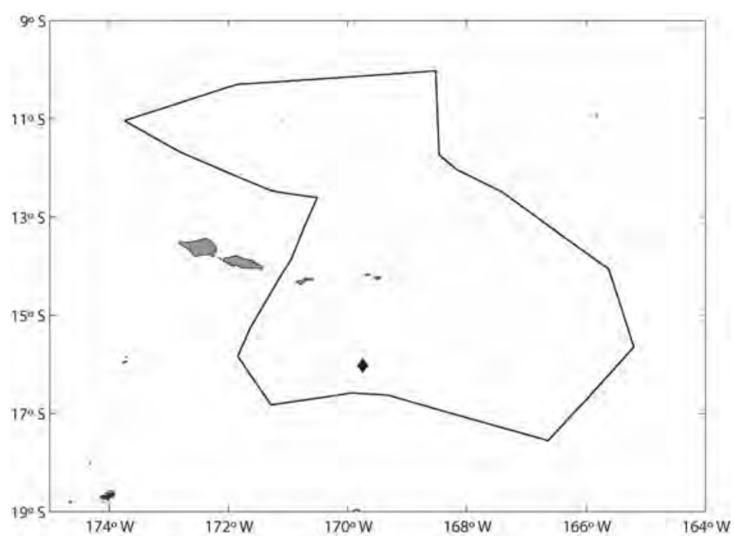

Figure 2. Locations of observed rough-toothed dolphin takes (filled diamonds) in the American Samoa longline fishery, 2006-2008. Solid lines represent the U.S. EEZ. Set locations in this fishery are summarized in Appendix 1.

Table 1. Summary of available information on incidental mortality and serious injury of rough-toothed dolphins (American Samoan stock) in commercial fisheries within the U.S. EEZ (Oleson 2009). Longline fishery take estimates represent only those trips with at least 10 sets/trip (Oleson 2009). Mean annual takes are based on 2006-2008 data unless otherwise indicated.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed and estimated mortality and serious injury of rough-toothed dolphins in the American Samoa EEZ		
				American Samoa EEZ		
				Obs.	Estimated (CV)	Mean Annual Takes (CV)
American Samoa-based longline fishery	2006 2007 2008	observer data	9.0% 7.7% 8.5%	0 0 1	0 (-) 0 (-) 10.9 (2.0)	3.6 (0.6)
Minimum total annual takes within U.S. EEZ waters						3.6 (0.6)

Prior to 1995, bottom fishing and trolling were the primary fisheries in American Samoa but they became less prominent after longlining was introduced (Levine and Allen 2009). Nearshore subsistence fisheries include spear fishing, rod and reel, collecting, gill netting, and throw netting (Craig 1993, Levine and Allen 2009). Information on fishery-related mortality of cetaceans in the nearshore fisheries is unknown, but the gear types used in American Samoan fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Gillnets appear to capture marine mammals wherever they are used. Although boat-based nearshore fisheries have been randomly monitored since 1991, by the American Samoa Department of Marine and Wildlife Sources (DMWR), no estimates of annual human-caused mortality and serious injury of cetaceans are available.

STATUS OF STOCK

The status of rough-toothed dolphins in American Samoan waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this species. It is not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor as "depleted" under the MMPA. The status of the American Samoan stock of rough-toothed dolphins under the 1994 amendments to the MMPA cannot be determined at this time because no abundance estimates are available and PBR cannot be calculated. However, the estimated rate of fisheries-related mortality or serious injury within the American Samoa EEZ (3.6 animals per year) is between the range of likely PBRs (3.4 – 22) for this region. Insufficient information is available to determine whether the total fishery mortality and serious injury for rough-toothed dolphins is insignificant and approaching zero mortality and serious injury rate.

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Revised 6/4/2014

RISSO'S DOLPHIN (*Grampus griseus*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Risso's dolphins are found in tropical to warm-temperate waters worldwide (Perrin et al. 2009). Risso’s dolphins represent less than 1% of all odontocete sightings in leeward surveys of the main Hawaii Islands from 2000 to 2012 (Baird et al. 2013); however, six sightings were made during a 2002 survey and 12 during a 2010 survey of the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands (Barlow 2006, Bradford et al. 2013; Figure 1).

For the Marine Mammal Protection Act (MMPA) stock assessment reports, Risso's dolphins within the Pacific U.S. EEZ are divided into two discrete areas: 1) Hawaiian waters (this report), and 2) waters off California, Oregon and Washington. The Hawaiian stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

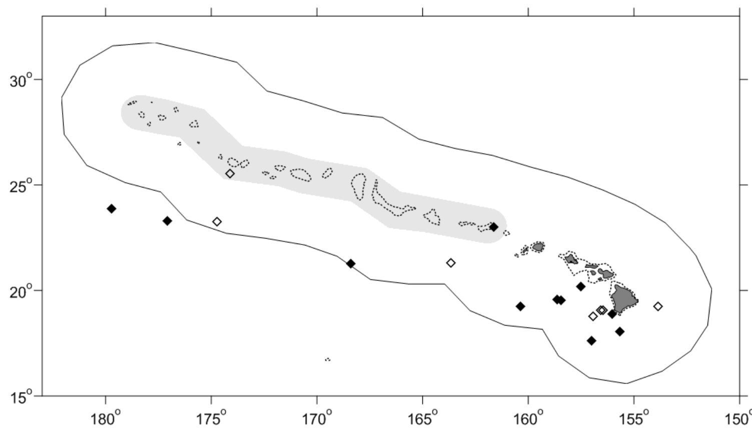

Figure 1. Risso's dolphin sighting locations during the 2002 (open diamonds) and 2010 (black diamonds) shipboard cetacean surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2013; see Appendix 2 for details on timing and location of survey effort). Outer line represents approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument. Dotted line is the 1000m isobath.

POPULATION SIZE

Population estimates are available from Japan (Miyashita 1993), the eastern tropical Pacific (Wade and Gerrodette 1993), and the U.S. West Coast (Barlow and Forney 2007), but it is not known whether these animals are part of the same population that occurs around the Hawaiian Islands and in the central North Pacific. A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 2,372 (CV=0.97) Risso’s dolphins (Barlow 2006). The recent 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 7,256 (CV=0.41) Risso’s dolphins (Bradford et al. 2013). This is currently the best available abundance estimate for this stock.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al. 1995) of the 2010 abundance estimate, or 5,207 Risso’s dolphins within the Hawaiian Islands EEZ.

Current Population Trend

The broad and overlapping confidence intervals around the 2002 and 2010 estimates preclude assessment of trends with the available data.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for Hawaiian animals.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii stock of Risso’s dolphins is calculated as the minimum population size within the U.S. EEZ of the Hawaiian Islands (5,207) <u>times</u> one half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> a recovery factor of 0.40 (for a stock of unknown status with a

Hawaiian Islands EEZ fishery mortality and serious injury rate CV greater than 0.80 ; Wade and Angliss 1997), resulting in a PBR of 42 Risso's dolphins per year.

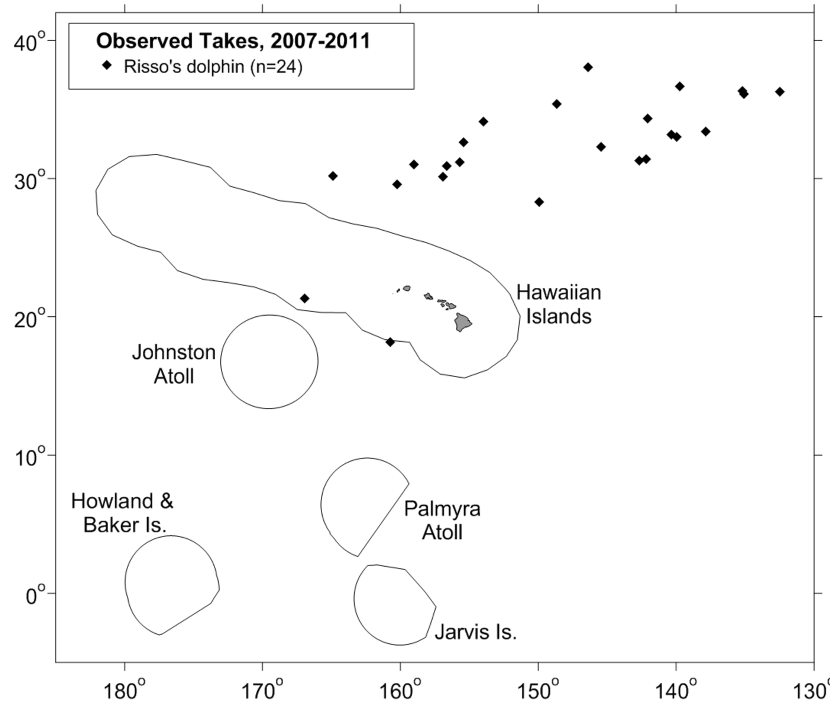

Figure 2. Locations of Risso's dolphin takes (filled diamonds) in Hawaii-based longline fisheries, 2007-2011. Solid lines represent the U.S. EEZs. Fishery descriptions are provided in Appendix 1.

HUMAN CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

Table 1. Summary of available information on incidental mortality and serious injury of Risso's dolphin (Hawaii stock) in commercial longline fisheries, within and outside of U.S. EEZs (McCracken 2013). Mean annual takes are based on 2007-2011 data unless indicated otherwise. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of Risso's dolphins			
				Outside U.S. EEZs		Hawaiian EEZ	
				Obs. T/MSI	Estimated M&SI (CV)	Obs. T/MSI	Estimated M&SI (CV)
Hawaii-based deep-set longline fishery	2007	Observer data	20%	1/1	3 (1.4)	0	0 (-)
	2008		22%	1/1	2 (1.5)	0	0 (-)
	2009		21%	0	0 (-)	0	0 (-)
	2010		21%	0	0 (-)	1/1	3 (0.7)
	2011		20%	0	0 (-)	0	0 (-)
Mean Estimated Annual Take (CV)					**0.9 (1.5)**		**0.6 (2.0)**
Hawaii-based shallow-set longline fishery	2007	Observer data	100%	3/3	3	0	0
	2008		100%	4/4	4	0	0
	2009		100%	3/2	2	0	0
	2010		100%	7/6	6	0	0
	2011		100%	4/3	3	0	0
Mean Annual Takes (100% coverage)					**3.6**		**0**
Minimum total annual takes within U.S. EEZ							**0.6 (2.0)**

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. No interactions between nearshore fisheries and Risso's dolphins have been reported in Hawaiian waters. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2007 and 2011, 21 Risso's dolphins were observed killed or seriously injured in the SSLL fishery (100% observer coverage), and 3 Risso's dolphins were observed killed or seriously injured in the DSLL fishery (20-22% observer coverage) (Bradford & Forney 2013, McCracken 2013). One Risso's dolphin in the DSLL fishery and two in the SSLL fishery were killed, 16 in the SSLL fishery and two in the DSLL fishery were considered to have been seriously injured, and the remaining three interactions in the SSLL fishery were determined to be not seriously injured (Bradford & Forney 2013) based on evaluation of the observer's description of the interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012). Average 5-yr estimates of annual mortality and serious injury for 2007-2011are 4.5 (CV = 1.5) Risso's dolphins outside of U.S. EEZs, and 0.6 (CV = 2.0) within the Hawaiian Islands EEZ (Table 1, McCracken 2013). Eight additional unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been Risso's dolphins.

STATUS OF STOCK

The Hawaii stock of Risso's dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of Risso's dolphins in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this stock. Risso's dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. The estimated rate of fisheries related mortality or serious injury within the Hawaiian Islands EEZ (0.6 animals per year) is less than the PBR (42).The total fishery mortality and serious injury can be considered to be insignificant and approaching zero because mortality and serious injury is less than 10% of PBR.

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Revised 6/4/2014

COMMON BOTTLENOSE DOLPHIN (*Tursiops truncatus truncatus*): Hawaiian Islands Stock Complex- Kauai/Niihau, Oahu, 4-Islands, Hawaii Island, Hawaii Pelagic

STOCK DEFINITION AND GEOGRAPHIC RANGE

Common bottlenose dolphins are widely distributed throughout the world in tropical and warm-temperate waters (Perrin et al. 2009). The species is primarily coastal in much of its range, but there are populations in some offshore deepwater areas as well. Bottlenose dolphins are common throughout the Hawaiian Islands, from the island of Hawaii to Kure Atoll (Shallenberger 1981, Baird et al 2013). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands resulted in 18 sightings in 2002 and 20 sightings in 2010 (Barlow 2006, Bradford et al. 2013; Figure 1). In the Hawaiian Islands, bottlenose dolphins are found in shallow inshore waters and deep water (Baird et al. 2009).

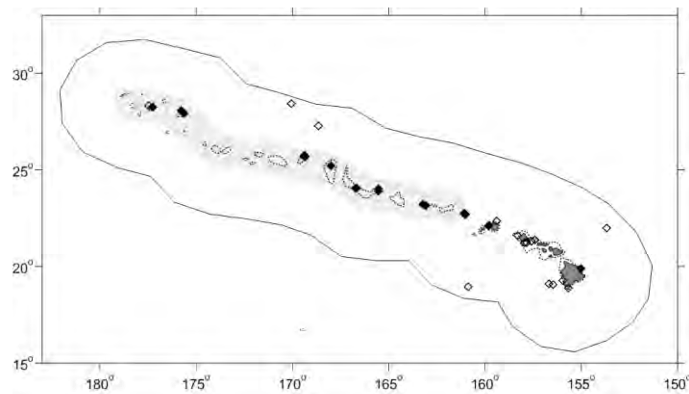

Figure 1. Bottlenose dolphin sighting locations during the 2002 (open diamonds) and 2010 (black diamonds) shipboard cetacean surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2013; see Appendix 2 for details on timing and location of survey effort). Outer line represents approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument. Dotted line represents the 1000m isobath. Insular stock boundaries are shown in Figure 2.

Separate offshore and coastal forms of bottlenose dolphins have been identified along continental coasts (Ross and Cockcroft 1990; Van Waerebeek et al. 1990), and there is evidence that similar onshore-offshore forms may exist in Hawaiian waters. In their analysis of sightings of bottlenose dolphins in the eastern tropical Pacific (ETP), Scott and Chivers (1990) noted a large hiatus between the westernmost sightings and the Hawaiian Islands. These data suggest that bottlenose dolphins in Hawaiian waters belong to a separate stock from those in the ETP. Furthermore, recent photo-identification and genetic studies off Oahu, Maui, Lanai, Kauai, Niihau, and Hawaii suggest limited movement of bottlenose dolphins between islands and offshore waters (Baird et al. 2009; Martien et al. 2012). These data suggest the existence of demographically distinct resident populations at each of the four main Hawaiian Island groups – Kauai & Niihau, Oahu, the '4-island' region (Molokai, Lanai, Maui, Kahoolawe), and Hawaii. Genetic data support inclusion of bottlenose dolphins in deeper waters surrounding the main Hawaiian Islands as part of the broadly distributed pelagic population (Martien et al 2012).

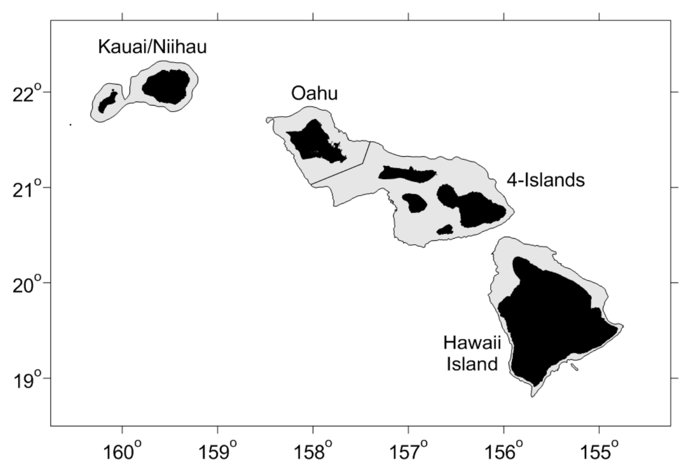

Figure 2. Main Hawaiian Islands insular bottlenose dolphin stock boundaries (gray shading). Areas beyond the 1000 m isobath represent the pelagic stock range.

Over 99% of the bottlenose dolphins linked through photo-identification to one of the insular populations around the main Hawaiian Islands (Baird et al. 2009) have been documented in waters of 1000 m or less (Martien & Baird 2009). Based on these data, Martien & Baird (2009) suggested that the boundaries between the insular stocks and the Hawaii Pelagic stock be placed along the 1000 m isobath. Since that isobath does not separate Oahu from the 4-Islands Region, the boundary between those stocks runs approximately equidistant between the 500 m isobaths around Oahu and the 4-

Islands Region, through the middle of Kaiwi Channel. These boundaries (Figure 2) are applied in this report to recognize separate insular and pelagic bottlenose dolphin stocks for management (NMFS 2005). These boundaries may be revised in the future as additional information becomes available. To date, no data are available regarding population structure of bottlenose dolphins in the Northwestern Hawaiian Islands (NWHI), though sightings during the 2010 survey indicate they are commonly found close to the islands and atolls there (Bradford et al 2013). Given the evidence of island resident populations in the main Hawaiian Islands, the larger distances between islands in the NWHI, and the finding of population structure within the NWHI in other dolphin species (Andrews 2010), it is likely that additional demographically independent populations of bottlenose dolphins exist in the NWHI. However, until data become available upon which to base stock designations in this area, the NWHI will remain part of the Hawaii Pelagic Stock. For the Marine Mammal Protection Act (MMPA) Pacific stock assessment reports, bottlenose dolphins within the Pacific U.S. EEZ are divided into seven stocks: 1) California, Oregon and Washington offshore stock, 2) California coastal stock, and five Pacific Islands Region management stocks (this report): 3) Kauai/Niihau, 4) Oahu, 5) 4-Islands (Molokai, Lanai, Maui, Kahoolawe), 6) Hawaii Island and 7) the Hawaiian Pelagic Stock, including animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of the Hawaii pelagic stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005). Estimates of abundance, potential biological removals, and status determinations for the five Hawaiian stocks are presented separately below.

HUMAN CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen *et al*. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

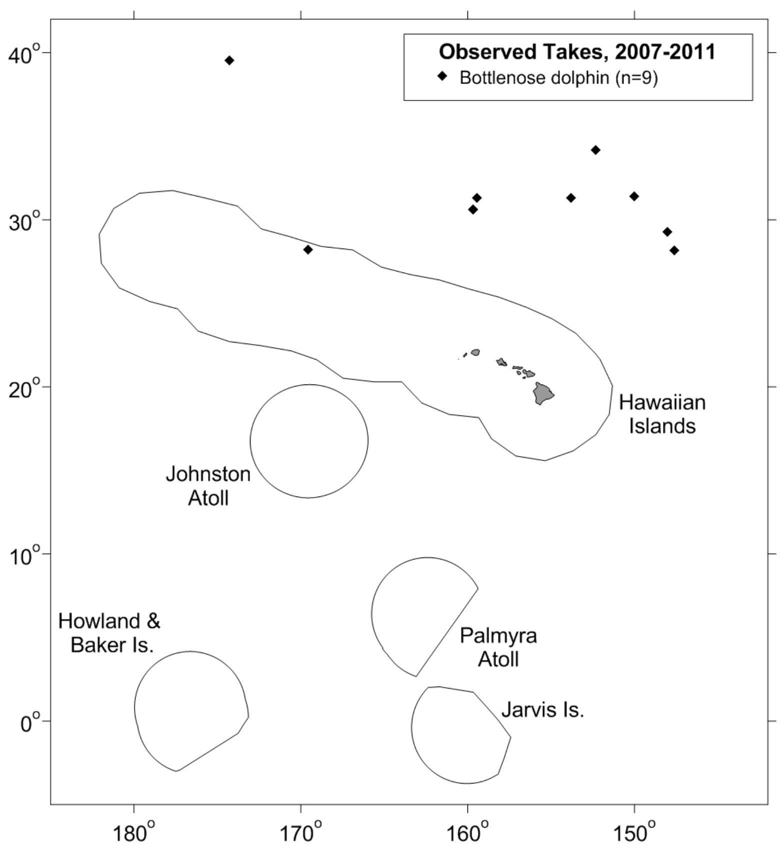

Figure 3. Locations of observed Pelagic Stock bottlenose dolphin takes (filled diamonds) in the Hawaii-based longline fishery, 2007-2011. Solid lines represent the U. S. EEZ. Fishery descriptions are provided in Appendix 1.

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaii fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. There are at least two reports of entangled bottlenose dolphins drowning in gillnets off Maui (Nitta and Henderson, 1993, Maldini 2003, Bradford & Lyman 2013). Although gillnet fisheries are not observed or monitored through any State or Federal program, State regulations now ban gillnetting around Maui and much of Oahu and require gillnet fishermen to monitor their nets for bycatch every 30 minutes in those areas where gillnetting is permitted. In 2009, one bottlenose dolphin, known to frequent aquaculture pens off the Kona Coast of the island of Hawaii, was seen with a hook and line trailing out of its mouth (Bradford & Lyman 2013). Based on the description and photographs, this injury was considered serious under the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012). The animal was resighted in February 2012 without the fish hook and in normal body condition, such that this injury is no longer considered serious. The responsible fishery is not known. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line or gillnet fisheries because these fisheries are not observed or monitored for protected species bycatch.

Bottlenose dolphins are one of the species commonly reported to steal bait and catch from several Hawaii sport and commercial fisheries (Nitta and Henderson 1993; Schlais 1984). Observations of bottlenose dolphins stealing bait or catch have been made in the day handline fishery (palu-ahi) for tuna, the night handline fishery for tuna (ika-shibi), the handline fishery for mackerel scad, the troll fishery for billfish and tuna, and the inshore set gillnet fishery (Nitta and Henderson 1993). Nitta and Henderson (1993) indicated that bottlenose dolphins remove bait and catch from handlines used to catch bottomfish off the island of Hawaii and Kaula Rock and formerly on several banks of the Northwestern Hawaiian Islands. Fishermen claim interactions with dolphins that steal bait and catch are increasing, including anecdotal reports of bottlenose dolphins getting "snagged" (Rizzuto 2007). Interaction rates between dolphins and the NWHI bottomfish fishery were estimated based on studies conducted in 1990-1993, indicating that an average of 2.67 dolphin interactions, defined as incidence of dolphins removing bait or catch from hooks, occurred for every 1000 fish brought on board (Kobayashi and Kawamoto 1995) These interactions generally involved bottlenose dolphins and it is not known whether these interactions result in serious injury or mortality of dolphins. This fishery was observed from 2003 through 2005 at 18-25% coverage, during which time, no incidental takes of cetaceans were reported. The bottomfish fishery is no longer permitted for the Northwestern Hawaiian Islands.

Table 1. Summary of available information on incidental mortality and serious injury of bottlenose dolphins (Hawaii Pelagic stock) in commercial longline fisheries, within and outside of the U.S. EEZs (McCracken 2013). Mean annual takes are based on 2007-2011 data unless otherwise indicated; n/a = not available. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of Hawaii Pelagic stock bottlenose dolphins			
				Outside U.S. EEZs		Hawaiian EEZ	
				Obs. T/MSI	Estimated M&SI (CV)	Obs. T/MSI	Estimated M&SI (CV)
Hawaii-based deep-set longline fishery	2007	Observer data	20%	0	0 (-)	0	0 (-)
	2008		22%	0	0 (-)	0	0 (-)
	2009		21%	1/1	5 (0.5)	0	0 (-)
	2010		21%	1/1	4 ().6)	0	0 (-)
	2011		20%	0	0 (-)	0	0 (-)
Mean Estimated Annual Take (CV)					**1.9 (0.6)**		**0 (-)**
Hawaii-based shallow-set longline fishery	2007	Observer data	100%	3/3	3	1/1	1
	2008		100%	0	0	0	0
	2009		100%	0	0	0	0
	2010		100%	2/2	2	0	0
	2011		100%	2/1	1	0	0
Mean Annual Takes (100% coverage)					**1.2**		**0.2**
Minimum total annual takes within U.S. EEZ							**0.2 (-)**

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2007 and 2011, seven bottlenose dolphins were observed hooked or entangled in the SSLL fishery (100% observer coverage), and two bottlenose dolphins were observed taken in the DSLL fishery (20-22% observer coverage) (Bradford & Forney 2013, McCracken 2013). Based on the locations, these takes are all considered to have been from the Pelagic Stock of bottlenose dolphins. Eight of the nine dolphins were considered to have been seriously injured (Bradford & Forney 2013), based on an evaluation of the observer's description of the interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012). Average 5-yr estimates of annual mortality and serious injury for the Pelagic Stock during 2007-2011 are 3.1 (CV = 0.6) bottlenose dolphins outside of U.S. EEZs, and 0.2 (CV = 0) within the Hawaiian Islands EEZ (Table 1, McCracken 2013). Eight unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been bottlenose dolphins.

KAUAI/NIIHAU STOCK

POPULATION SIZE

A photo-identification study conducted from 2003 to 2005 identified 102 individual bottlenose dolphins around Kauai and Niihau (Baird et al. 2009). A Lincoln-Peterson mark-recapture analysis of the photo-identification data resulted in an abundance estimate of 147 (CV=0.11), or 184 animals when corrected for the proportion of marked individuals (Baird et al. 2009). The CV of this estimate is likely negatively-biased, as it does not account for variation in the proportion of marked animals within groups.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al 1995) of the Baird et al. (2009) mark-recapture estimate, or 168 bottlenose dolphins. This is greater than the number of distinct individuals (102) identified during the photo-identification study.

Current Population Trend

Only one abundance estimate is available for this stock, such that there is insufficient information to assess population trends.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (168) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no reported fishery mortality or serious injury within the Kauai/Niihau stock range; Wade and Angliss 1997), resulting in a PBR of 1.7 bottlenose dolphins per year.

STATUS OF STOCK

The Kauai/Niihau Stock of bottlenose dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of bottlenose dolphins in the Kauai/Niihau stock relative to OSP is unknown, and there are insufficient data to evaluate abundance trends. No habitat issues are known to be of concern for this stock. Bottlenose dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. There have been no reports of recent mortality or serious injuries; however, there is no systematic monitoring for interactions with protected species within near-shore fisheries that may take this species, thus mean annual takes are undetermined. Insufficient information is available to determine whether the total fishery mortality and serious injury for bottlenose dolphins is insignificant and approaching zero mortality and serious injury rate.

OAHU STOCK

POPULATION SIZE

A photo-identification study conducted in 2002, 2003 and 2006 identified 67 individual bottlenose dolphins around Oahu (Baird et al. 2009). A Lincoln-Peterson mark-recapture analysis of the photo-identification data resulted in an abundance estimate of 594 (CV=0.54), or 743 animals when corrected for the proportion of marked individuals (Baird et al. 2009). The estimate does not include individuals from the Northeastern (windward) side of the island.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al 1995) of the Baird et al. (2009) mark-recapture estimate, or 485. This is substantially greater than the number of distinct individuals (67) identified during the photo-identification study.

Current Population Trend

Only one abundance estimate is available for this stock, such that there is insufficient information to assess population trends.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Oahu stock is calculated as the minimum population size (485) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no reported fishery mortality in the Oahu stock range; Wade and Angliss 1997), resulting in a PBR of 4.9 bottlenose dolphins per year.

STATUS OF STOCK

The Oahu stock of bottlenose dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of bottlenose dolphins in Oahu waters relative to OSP is unknown, and there are insufficient data to evaluate abundance trends. No habitat issues are known to be of concern for this stock. Bottlenose dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. There have been no reports of recent mortality or serious injuries; however, there is no systematic monitoring for interactions with protected species within near-shore fisheries that may take this species, thus mean annual takes are undetermined. Insufficient information is available to determine whether the total fishery mortality and serious injury for bottlenose dolphins is insignificant and approaching zero mortality and serious injury rate.

4-ISLANDS STOCK

POPULATION SIZE

A photo-identification study conducted from 2000-2006 identified 98 individual bottlenose dolphins around Maui and Lanai (Baird et al. 2009). A Lincoln-Peterson mark-recapture analysis of the photo-identification data resulted in an abundance estimate of 153 (CV=0.24), or 191 animals when corrected for the proportion of marked individuals (Baird et al. 2009). This abundance estimate likely underestimates the total number of bottlenose dolphins in the 4-islands region because it does not include individuals from the Northeastern (windward) sides of Maui and Molokai. The CV of this estimate is likely negatively-biased, as it does not account for variation in the proportion of marked animals within groups.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al 1995) of the Baird et al. (2009) mark-recapture estimate, or 156 bottlenose dolphins. This is greater than the number of distinct individuals (98) identified during the photo-identification study.

Current Population Trend

Only one abundance estimate is available for this stock, such that there is insufficient information to assess population trends.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the 4-Islands stock is calculated as the minimum population size (156) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no reported fishery mortality in the 4-Islands stock area; Wade and Angliss 1997), resulting in a PBR of 1.6 bottlenose dolphins per year.

STATUS OF STOCK

The 4-Islands Region Stock of bottlenose dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of bottlenose dolphins in 4-Islands waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this stock. Bottlenose dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor as "depleted" under the MMPA. There have been no reports of recent mortality or serious injuries of this stock; however, there is no systematic monitoring for interactions with protected species within near-shore fisheries that may take this species, thus mean annual takes are undetermined. Insufficient information is available to determine whether the total fishery mortality and serious injury for bottlenose dolphins is insignificant and approaching zero mortality and serious injury rate.

HAWAII ISLAND STOCK

POPULATION SIZE

A photo-identification study conducted from 2000-2006 identified 69 individual bottlenose dolphins around the island of Hawaii (Baird et al. 2009). A Lincoln-Peterson mark-recapture analysis of the photo-identification data resulted in an abundance estimate of 102 (CV=0.13), or 128 animals when corrected for the proportion of marked individuals (Baird et al. 2009). This abundance estimate likely underestimates the total number of bottlenose dolphins around the island of Hawaii because it does not include individuals from the Northeastern (windward) side of the island. The CV of this estimate is likely negatively-biased, as it does not account for variation in the proportion of marked animals within groups.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al 1995) of the Baird et al. (2009) mark-recapture estimate, or 115 bottlenose dolphins. This is greater than the number of distinct individuals (69) identified during the photo-identification study.

Current Population Trend

Only one abundance estimate is available for this stock, such that there is insufficient information to assess population trends.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii Island stock is calculated as the minimum population size (115) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no reported fishery mortality in the Hawaii Islands stock area; Wade and Angliss 1997), resulting in a PBR of 1.1 bottlenose dolphins per year.

STATUS OF STOCK

The Hawaii Island Stock of bottlenose dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of bottlenose dolphins in waters around Hawaii Island relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Hawaii Island bottlenose dolphins are regularly seen near aquaculture pens off the Kona coast, and aquaculture workers have been observed feeding bottlenose dolphins. Bottlenose dolphins in this region are also known to interact with divers. Bottlenose dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. There have been no reports of recent mortality or serious injuries; however, there is no systematic monitoring of takes in near-shore fisheries that may take this species, thus mean annual takes are undetermined. Insufficient information is available to determine whether the total fishery mortality and serious injury for bottlenose dolphins is insignificant and approaching zero mortality and serious injury rate.

HAWAII PELAGIC STOCK

POPULATION SIZE

Population estimates have been made in Japanese waters (Miyashita 1993), but it is not known whether these animals are part of the same population that occurs around the Hawaiian Islands. A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 3,215 (CV= 0.59) bottlenose dolphins (Barlow 2006), equivalent to a density of 1.31 individuals per 1000 km^2. Applying this density to the area of the Pelagic Stock between the 1000m isobath and the Hawaiian Islands EEZ boundary (see Figures 1-2), the stock-specific abundance for 2002 was estimated as 3,178 (CV=0.59). The recent 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 5,950 (CV = 0.59) bottlenose dolphins within the pelagic stock area (Bradford et al 2013). This is currently the best available abundance estimate for the Hawaii Pelagic stock.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al 1995) of the 2010 line-transect abundance estimate for the Hawaii Pelagic Stock, or 3,755 bottlenose dolphins.

Current Population Trend

The broad and overlapping confidence intervals around the 2002 and 2010 estimates preclude assessment of population trends with the available data.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size within the U.S EEZ of the Hawaiian Islands (3,755) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.5 (for a stock of unknown status with a Hawaiian Islands EEZ fishery mortality and serious injury rate CV of 0; Wade and Angliss 1997), resulting in a PBR of 38 bottlenose dolphin per year.

STATUS OF STOCK

The Hawaii Pelagic Stock of bottlenose dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of bottlenose dolphins in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this stock. It is not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. The estimated rate of fisheries-related mortality or serious injury within the Hawaiian Islands EEZ (0.2 animals per year) is less than the PBR (38). The total fishery mortality and serious injury for Hawaii pelagic bottlenose dolphins is insignificant and approaching zero mortality and serious injury rate.

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PANTROPICAL SPOTTED DOLPHIN (*Stenella attenuata attenuata*): Hawaiian Islands Stock Complex – Oahu, 4-Islands, Hawaii Island, and Hawaii Pelagic Stocks

STOCK DEFINITION AND GEOGRAPHIC RANGE

Pantropical spotted dolphins are primarily found in tropical and subtropical waters worldwide (Perrin et al. 2009). Much of what is known about the species in the North Pacific has been learned from specimens obtained in the large directed fishery in Japan and in the eastern tropical Pacific (ETP) tuna purse-seine fishery (Perrin et al. 2009). Spotted dolphins are common and abundant throughout the Hawaiian archipelago, including nearshore where they are the second most frequently sighted species during nearshore surveys (Baird et al. 2013). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands resulted in 14 sightings in 2002 and 49 sightings in 2010 (Barlow 2006, Bradford et al. 2013; Figure 1). Fourteen strandings of this species have been documented in Hawaii since 1975 (Nitta 1991, Maldini et al. 2005, NMFS PIR Marine Mammal Response Network database), including two since 2007. Morphological differences and distribution patterns indicate that the spotted dolphins around the Hawaiian Islands belong to a stock that is distinct from those in the ETP (Perrin 1975; Dizon et al. 1994; Perrin et al. 1994b). Their possible affinities with other stocks elsewhere in the Pacific have not been investigated.

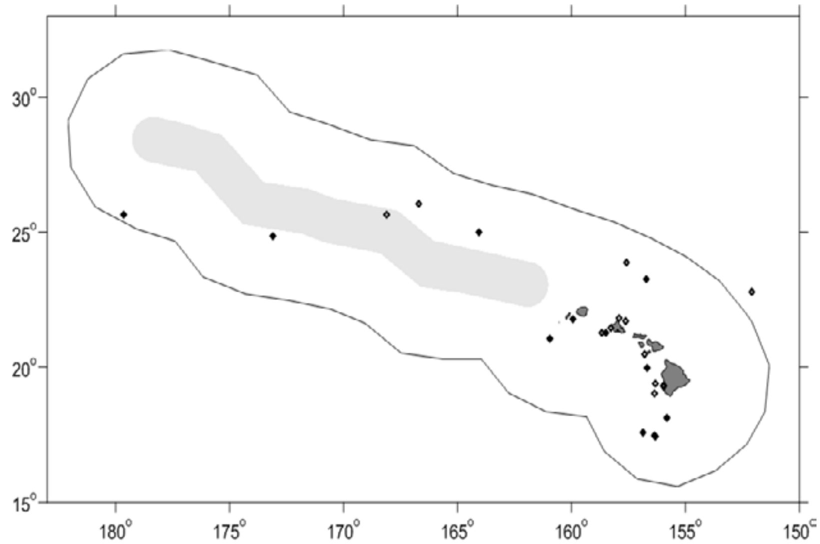

Figure 1. Pantropical spotted dolphin sighting locations during the 2002 (open diamonds) and 2010 (black diamonds) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2013; see Appendix 2 for details on timing and location of survey effort). Outer line represents approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument. Dotted line represents the 1000m isobath. Insular stock boundaries are shown in Figure 2.

Pantropical spotted dolphins have been observed in all months of the year around the main Hawaiian Islands, and in areas ranging from shallow near-shore water to depths of 5,000 m, although they peak in sighting rates in depths from 1,500 to 3,500 m (Baird et al. 2013). Although they represent from 22.9 to 26.5% of the odontocete sightings from Oahu, the 4-islands, and Hawaii Island, they are largely absent from the nearshore waters around Kauai and Niihau,

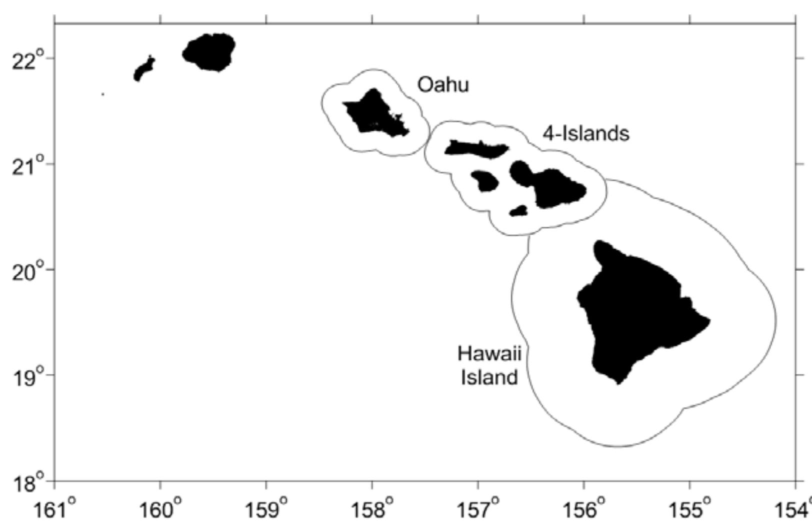

Figure 2. Main Hawaiian Islands insular spotted dolphin stock boundaries (gray lines). Oahu and 4-Islands stocks extend 20km from shore. Hawaii Island stock extends to 65km from shore based on distance of furthest encounter.

representing only 3.9% of sightings in that area (Baird et al. 2013). Genetic analyses of 176 unique samples of pantropical spotted dolphins collected during near-shore surveys off each of the main Hawaiian Islands from 2002 to 2003, and near Hawaii Island from 2005 through 2008 suggest three island-associated stocks are evident (Courbis 2011). The results of the Courbis (2011) study indicate that pantropical spotted dolphins in Hawaii's nearshore waters have low haplotypic diversity with haplotypes unique to each of the island areas. Courbis (2011) conducted extensive tests on the relatedness of individuals among islands using the microsatellite dataset and found significant differences in haplotype frequencies between islands, suggesting genetic differentiation in spotted dolphins among islands. Genetic differentiation is supported by the results of assignments tests, which indicate support for 3 island-associated populations: Hawaii Island, the 4-Islands region, and Oahu. Samples from Kauai and Niihau did not cluster together, but instead were spread among the Hawaii and Oahu clusters. Analysis of migration rate further support the separation of pantropical spotted dolphins into three island-associated stocks, with migration between regions on the order of a few individuals per generation. Based on an overview of all available information on pantropical spotted dolphins in Hawaiian waters, and NMFS guidelines for assessing marine mammal stocks (NMFS 2005), Oleson et al. (2013) proposed designation of three new island associated stocks in Hawaiian waters, as well as recognition of a fourth broadly distributed spotted dolphin stock, given the frequency of sightings in pelagic waters. Fishery interactions with pantropical spotted dolphins and sightings near Palmyra and Johnston Atolls (NMFS PIR unpublished data) demonstrate that this species also occurs in U.S. EEZ waters there, but it is not known whether these animals are part of the Hawaiian population or are a separate stock(s) of pantropical spotted dolphins.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are four Pacific management stocks within the Hawaiian Islands EEZ (Oleson et al. 2013): 1) the Oahu stock, which includes spotted dolphins within 20km of Oahu, 2) the 4-Island stock, which includes spotted dolphins within 20 km of Maui, Molokai, Lanai, and Kahoolawe collectively, 3) the Hawaii Island stock, which includes spotted dolphins found within 65km from Hawaii Island, and 4) the Hawaii pelagic stock, which includes spotted dolphins inhabiting the waters throughout the Hawaiian Islands EEZ, outside of the insular stock areas, but including adjacent high seas waters. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of the Hawaii pelagic stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005). Spotted dolphins involved in eastern tropical Pacific tuna purse-seine fisheries are managed separately under the MMPA.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NMFS 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Entanglement in gillnets and hooking or entanglement in various hook and line fisheries have been reported for small cetaceans in Hawaii

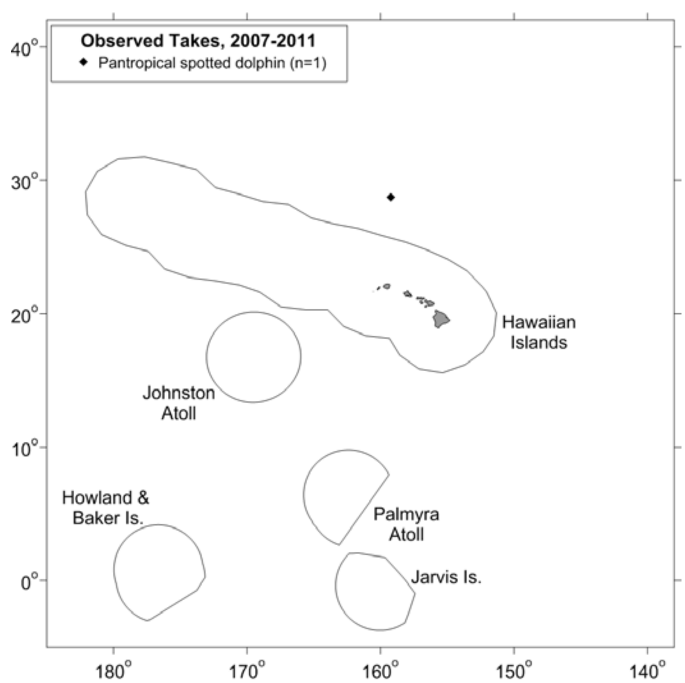

Figure 3. Locations of observed spotted dolphin takes (filled diamonds) in the Hawaii deep-set longline fishery, 2007-2011. Solid lines represent the U.S. EEZ. Set locations in this fishery are summarized in Appendix 1.

(Nitta & Henderson, 1993). No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line or gillnet fisheries because these fisheries are not observed or monitored for protected species bycatch. Commercial and recreational troll fisherman have been observed "fishing" dolphins off the islands of Hawaii, Lanai, and Oahu, including spotted dolphins, in order to catch tuna associated with the animals (Courbis et al. 2009, Rizzuto, 2007, Shallenberger 1981). Anecdotal reports from fisherman indicate that spotted dolphins are sometimes hooked (Rizzuto 1997) and photographs of dolphins suggest animals may be injured by both lines and propeller strikes (Baird unpublished data). In 2010 a spotted dolphin (4-Islands stock) was observed entangled in fishing line off Lanai. There were several wraps of line around the body and peduncle and a constricting wrap around the dorsal fin (Bradford & Lyman 2013). Based on the information provided, this entanglement is considered a serious injury under the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012). The responsible fishery is not known.

Table 1. Summary of available information on incidental mortality and serious injury of pantropical spotted dolphins (Hawaii pelagic stock) in commercial longline fisheries, within and outside of the U.S. EEZs (McCracken 2013). Mean annual takes are based on 2007-2011data unless otherwise indicated. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of Hawaii pelagic pantropical spotted dolphins			
				Outside U.S. EEZs		Hawaiian EEZ	
				Obs. T/MSI	Estimated M&SI (CV)	Obs. T/MSI	Estimated M&SI (CV)
Hawaii-based deep-set longline fishery	2007	Observer data	20%	0	0 (-)	0	0 (-)
	2008		22%	1/1	3 (0.5)	0	0 (-)
	2009		21%	0	0 (-)	0	0 (-)
	2010		21%	0	0 (-)	0	0 (-)
	2011		20%	0	0 (-)	0	0 (-)
Mean Estimated Annual Take (CV)					**0.6 (1.1)**		**0 (-)**
Hawaii-based shallow-set longline fishery	2007	Observer data	100%	0	0	0	0
	2008		100%	0	0	0	0
	2009		100%	0	0	0	0
	2010		100%	0	0	0	0
	2011		100%	0	0	0	0
Mean Annual Takes (100% coverage)					**0**		**0**
Minimum total annual takes within U.S. EEZ							**0 (-)**

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2007 and 2011, no pantropical spotted dolphin were observed hooked or entangled in the SSLL fishery (100% observer coverage), and one pantropical spotted dolphin was observed incidentally killed in high seas waters in the DSLL fishery (20-22% observer coverage) (Bradford & Forney 2013, McCracken 2013) (Figure 3). Average 5-year estimates of annual mortality and serious injury for 2007-2011 are 0.6 (CV=1.1) spotted dolphins outside of U.S. EEZs, and none within the Hawaiian Islands EEZ (Table 1, McCracken 2013). Eight additional unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been spotted dolphins.

OAHU STOCK
POPULATION SIZE

The population size of the Oahu stock of spotted dolphins has not been estimated.

Minimum Population Estimate

There is no information on which to base a minimum population estimate of the Oahu stock of spotted dolphins.

Current Population Trend

No data are available on current population trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Oahu stock is calculated as the minimum population estimate times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a species of unknown status with no estimated fishery mortality or serious injury within the Oahu stock area; Wade and Angliss 1997). Because there is no minimum population estimate available the PBR for the Oahu stock of spotted dolphins is undetermined.

STATUS OF STOCK

The Oahu stock of spotted dolphins is not considered a strategic stock under the MMPA. The status of Oahu spotted dolphins relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance for this stock. Spotted dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. There is no information with which to determine whether the total fishery mortality and serious injury for this stock is insignificant and approaching zero mortality and serious injury rate.

4-ISLANDS STOCK
POPULATION SIZE

The population size of 4-Islands stock of spotted dolphins has not been estimated.

Minimum Population Estimate

There is no information on which to base a minimum population estimate of the 4-Islands stock of spotted dolphins.

Current Population Trend

No data are available on current population trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the 4-Islands stock is calculated as the minimum population estimate times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a species of unknown status with no estimated fishery mortality or serious injury within the 4-Islands stock area; Wade and Angliss 1997). Because there is no minimum population estimate available for this stock the PBR for 4-Islands stock of spotted dolphins is undetermined.

STATUS OF STOCK

The 4-Islands stock of spotted dolphins is not considered a strategic stock under the MMPA. The status of 4-Islands spotted dolphins relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance for this stock. Spotted dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Although one dolphin has been considered seriously injured due to an interaction with fishing gear, insufficient data are available to determine whether the total fishery mortality and serious injury for this stock is insignificant and approaching zero mortality and serious injury rate.

HAWAII ISLAND STOCK
POPULATION SIZE

The population size of the Hawaii Island stock of spotted dolphins has not been estimated. An extensive collection of identification photos from this population are available; however, a photo-identification catalog has not been developed. Such a catalog could serve as the basis for developing mark-recapture estimates, but no such analyses have yet been conducted.

Minimum Population Estimate

There is no information on which to base a minimum population estimate of the Hawaii Island stock of spotted dolphins.

Current Population Trend

No data are available on current population trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii Island stock is calculated as the minimum population estimate times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a species of unknown status with no estimated fishery mortality or serious injury within the Hawaii Island stock area; Wade and Angliss 1997). Because there is no minimum population estimate available for this stock the PBR for Hawaii Island stock of spotted dolphins is undetermined.

STATUS OF STOCK

The Hawaii Island stock of spotted dolphins is not considered a strategic stock under the MMPA. The status of Hawaii Island spotted dolphins relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance for this stock. Spotted dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. There are insufficient data to determine whether the total fishery mortality and serious injury for this stock is insignificant and approaching zero mortality and serious injury rate. One spotted dolphin found stranded on Hawaii Island has tested positive for *Morbillivirus* (Jacob 2012). Although *morbillivus* is known to trigger lethal disease in cetaceans (Van Bressem et al. 2009), its impact on the health of the stranded animal is not known (Jacob 2012). The presence of *morbillivirus* in 10 species of cetacean in Hawaiian waters (Jacob 2012) raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts on Hawaiian cetaceans.

HAWAII PELAGIC STOCK
POPULATION SIZE

Population estimates are available for Japanese waters (Miyashita 1993), but it is not known whether any of these animals are part of the same population that occurs around the Hawaiian Islands. A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 8,978 (CV=0.48) pantropical spotted dolphins (Barlow 2006). The recent 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 15,917 (CV=0.40) spotted dolphins within the pelagic stock area (Bradford et al. 2013). This is currently the best available abundance estimate for pantropical spotted dolphins within the Hawaiian Islands EEZ.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al. 1995) of the 2010 abundance estimate for the pelagic stock area or 11,508 pantropical spotted dolphins.

Current Population Trend

The broad and overlapping confidence intervals around the 2002 and 2010 abundance estimates preclude assessment of trend with the available data.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii pelagic pantropical spotted dolphin stock is calculated as the minimum population estimate within the U.S. EEZ of the Hawaiian Islands (11,508) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no known fishery mortality within the U.S. EEZ of the Hawaiian Islands; Wade and Angliss 1997), resulting in a PBR of 115 pantropical spotted dolphins per year.

STATUS OF STOCK

The Hawaii pelagic stock of spotted dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of Hawaii pelagic pantropical spotted dolphins relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this species. Pantropical spotted dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Given the absence of recent recorded fishery-related mortality or serious injuries within U.S. EEZs, the total fishery mortality and serious injury can be considered to be insignificant and approaching zero.

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SPINNER DOLPHIN (*Stenella longirostris longirostris*): Hawaiian Islands Stock Complex- Hawaii Island, Oahu/4-islands, Kauai/Niihau, Pearl & Hermes Reef, Midway Atoll/Kure, Hawaii Pelagic

STOCK DEFINITION AND GEOGRAPHIC RANGE

Six morphotypes within four subspecies of spinner dolphins have been described worldwide in tropical and warm-temperate waters (Perrin et al. 2009). The Gray's (or pantropical) spinner dolphin (*Stenella longirostris longirostris*) is the most widely distributed subspecies and is found in the Atlantic, Indian, central and western Pacific Oceans (Perrin *et al.* 1991). Within the central and western Pacific, spinner dolphins are island-associated and use shallow protected bays to rest and socialize during the day then move offshore at night to feed (Norris and Dohl 1980; Norris *et al.* 1994). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands, resulted in 8 sightings in 2002 and 2 sightings in 2010,though none of the 2010 sightings occurred during on-effort survey (Barlow 2006, Bradford et al. 2013; Figure 1).

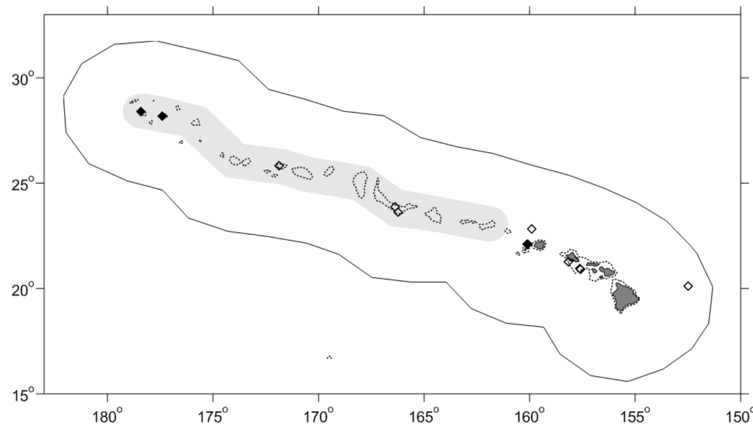

Figure 1. Spinner dolphin sighting locations during the 2002 (open diamonds) and 2010 (black diamonds) shipboard cetacean surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2013; see Appendix 2 for details on timing and location of survey effort). Outer line indicates approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument. Dotted line represents the 1000m isobath. Insular stock boundaries are shown in Figure 2.

Hawaiian spinner dolphins belong to a stock that is separate from animals in the eastern tropical Pacific (Perrin 1975; Dizon et al. 1994). The Hawaiian form is referable to the subspecies *S. longirostris longirostris*, which occurs pantropically (Perrin 1990). Andrews et al. (2010) found that mtDNA control region haplotype and nucleotide diversities of Hawaiian spinner dolphins are low compared with those from other geographic regions and suggested the existence of strong barriers to gene flow, both geographic and ecological. Her analyses also reveal significant genetic distinction, at both mtDNA and microsatellite loci, between spinner dolphins sampled in American Sāmoa and those sampled in the Hawaiian Islands (Johnston *et al.* 2008, Andrews et al. 2010). Andrews et al. (2010) also found significant genetic distinctions between spinner dolphins sampled at different islands within the Hawaiian Archipelago. Most significant was differentiation between animals sampled off the Kona Coast of Hawaii Island and animals sampled at all other Hawaiian Islands. Similarly, in the

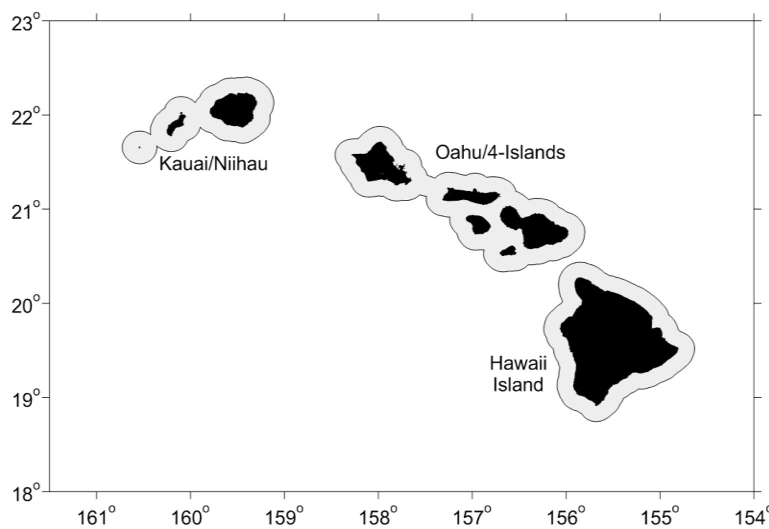

Figure 2. Spinner dolphin stock boundaries in the main Hawaiian Islands (Midway/Kure and Pearl and Hermes stock ranges not pictured). Animals outside of the defined island areas are considered to be part of the Hawaii pelagic stock.

Northwestern Hawaiian Islands, spinner dolphins sampled at Midway and Kure were shown not to be genetically distinct from each other, but are distinct from those sampled at all other islands. Andrews (2009) also found that none of the pairwise comparisons between French Frigate Shoals, Niihau, Kauai, and Oahu were statistically significant and Oahu was not significantly differentiated from Maui/Lanai. Assignment tests, which may provide information about recent gene flow, show that for most islands and atolls within the Hawaiian Archipelago, more samples assigned to the island/atoll at which they were collected than to any other island. These patterns are supported by available photo-ID and animal movement data (Karczmarski et al. 2005). Spinner dolphin genetic data are lacking from some islands and atolls within the Hawaiian Archipelago (e.g., Molokai, Kahoolawe, Nihoa, Mokumanamana (Necker), Gardner Pinnacles, Laysan, and Lisianski). Sighting data confirms the presence of spinner dolphins at some of these locations (e.g., Molokai, Kahoolawe, Mokumanamana, and Gardner Pinnacles; PIFSC unpublished data), however, without genetic or photo-identification data it is difficult to evaluate connectivity between these dolphins and those at other islands.

Hill et al. (2010) proposed designation of island-associated stocks of spinner dolphins at Midway/Kure, Pearl and Hermes Reef, Kauai/Niihau, Oahu/4-Islands, and Hawaii Island based on microsatellite and mtDNA genetic data (Andrews et al. 2010), known movement patterns (Karczmarski 2005), and the geographic distances between the Hawaiian Islands. They suggested an offshore boundary for each island-associated stock at 10 nmi from shore based on anecdotal accounts of spinner dolphin distribution. Analysis of individual spinner dolphin movements suggests that few individuals move long distances (from one main Hawaiian Island to another) and no dolphins have been seen farther than 10 nmi from shore (Hill et al. 2011). Based on the maximum distance from shore observed for island-associated animals, a 10 nmi stock boundary has been assumed for management under the MMPA. Norris et al. (1994) suggested that spinner dolphins may move between leeward and windward shores of the main Hawaiian Islands seasonally.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are six stocks within the U.S. EEZ of the Hawaiian Islands: 1) Hawaii Island, 2) Oahu/4-Islands, 3) Kauai/Niihau, 4) Pearl & Hermes Reef, 5) Kure/Midway, and 6) Hawaii Pelagic, including animals found both within the Hawaiian Islands EEZ (outside of island-associated boundaries) and in adjacent high seas waters. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of the Hawaii pelagic stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005). Spinner dolphins in the eastern tropical Pacific that may interact with tuna purse-seine fisheries are managed separately under the MMPA.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen *et al*. 2008, NMFS 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaii-based fisheries cause marine mammal mortality and serious injury in other U.S. fisheries. Entanglement in gillnets and hooking or entanglement in various hook and line fisheries have been reported for small cetaceans in Hawaii (Nitta & Henderson, 1993). Although gillnet fisheries are not observed or monitored through any State or Federal program, State regulations ban gillnetting around Maui and much of Oahu and require gillnet fishermen to monitor their nets for bycatch every 30 minutes. The bottomfish handline fishery in the Northwestern Hawaiian Islands was observed from 1990 to 1993, resulting in an estimate of 2.67 cetacean interactions per 1,000 landed fish, though none are thought to involve spinner dolphins (Kobayashi and Kawamoto 1995), and again in 2003 to 2005 (18-25% observer coverage) resulting in no incidental takes of cetaceans (NMFS PIR Observer Program). The bottomfish fishery is no longer permitted for the Northwestern Hawaiian Islands. Bottomfish fishermen in the main Hawaiian Islands claim interactions with dolphins that steal bait and catch are increasing. It is not known whether these alleged interactions result in serious injury or mortality of dolphins, nor whether spinner dolphins are involved.

Two spinner dolphins have been reported hooked or entangled by fishing gear in the main Hawaiian Islands between 2007 and 2011 (Bradford & Lyman 2013). One animal was seen in November 2009 off Lahaina, Maui (Oahu/4-Islands stock) with a hook embedded in its right lower jaw and through the tongue, preventing the dolphin from closing its mouth. The animal was seen again two days later, but has not been seen since. One additional spinner dolphin was seen in September 2011 off Kailua-Kona, Hawaii (Hawaii Island stock) with a section of netting entangled around its rostrum and trailing down its side. The animal was swimming behind other dolphins in the group and may not have been able to open its mouth. Based on the description and photographs, both injuries are considered serious under the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012). It is not possible to attribute either interaction to a specific fishery given insufficient details about the gear involved. There are six additional reports between 1991 and 2006 of spinner dolphins found entangled, hooked, or shot (Bradford & Lyman 2013). No estimates of annual human-caused mortality and serious injury are available for nearshore hook and line or gillnet fisheries because these fisheries are not observed or monitored for protected species interactions.

There are two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. However, there are fishery closures within 25-75 miles from shore in the MHI and 50 miles from shore in the NWHI where insular or island-associated stocks occur. Between 2007 and 2011, no spinner dolphins were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (McCracken 2013, Bradford & Forney 2013).

HAWAII ISLAND STOCK

POPULATION SIZE

Over the past few decades abundance estimates have been produced from studies along the Kona coast of Hawaii Island. Norris et al. (1994) photo-identified 192 individuals along the west coast of Hawaii and estimated 960 animals for this area in 1979-1980. For the same study region, Östman (1994) photo-identified 677 individual spinner dolphins from 1989 to 1992 and using the same estimation procedures as Norris et al. (1994), estimated a population size of 2,334 spinner dolphins. New open mark-recapture estimates based on intensive year-round photo-identification surveys in Kauhako Bay, Kealakekua Bay, Honaunau Bay, and Makako Bay along the Kona Coast of Hawaii Island in 2010 and 2011 have resulted in an abundance estimate of 631 (CV=0.09) for the Hawaii Island stock (Tyne et al. 2013). Considerable seasonal variation in spinner dolphin occurrence on the leeward versus south and east sides of the island is thought to occur, with lower abundance off the leeward Kona coast in the winter, potentially due to increased wind and swell in that region (Norris et al. 1994). Because the most recent abundance estimate is based on year-round surveys, at least some of the animals present on the leeway side seasonally have likely been seen. However, because only four Bays were surveyed, it is likely that some portion of the population is not included in this abundance estimate and the new estimate is an underestimate of total population size.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal 20th distribution (Barlow et al. 1995) around the 2011 abundance estimate for Hawaii Island, or 585 spinner dolphins.

Current Population Trend

Quantitative trend analyses have not been conducted with the available data, as estimates from the 1970s and 1980s did not include year-round surveys and used a different survey area than the 2010-2011 surveys.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii Island stock is calculated as the minimum population estimate (585) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no estimated fishery mortality or serious injury within the U.S. EEZ of the Hawaiian Islands; Wade and Angliss 1997) resulting in a PBR of 5.9 spinner dolphins per year.

STATUS OF STOCK

The Hawaii Island stock of spinner dolphins is not considered a strategic stock under the MMPA. The status of Hawaii Island spinner dolphins relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance for this stock. A habitat issue of increasing concern is the potential effect of swim-with-dolphin programs and other tourism activities on spinner dolphins around the main Hawaiian Islands (Danil et al. 2005, Courbis & Timmel 2009). All Hawaiian spinner dolphin stocks are potentially exposed to high levels of Navy sonar and frequent detonations during training exercises. The sensitivity of spinner dolphins to these sound levels is unknown and therefore the impact of these exercises on spinner dolphin stocks is unknown. Spinner dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Insufficient information is available to determine whether the total fishery mortality and serious injury for this Hawaii Island spinner dolphin stock is insignificant and approaching zero mortality and serious injury rate.

OAHU/4-ISLANDS STOCK

POPULATION SIZE

As part of the Marine Mammal Research Program of the Acoustic Thermometry of Ocean Climate (ATOC) study, a total of twelve aerial surveys were conducted within 25 nmi of the main Hawaiian Islands in 1993, 1995 and 1998. An abundance estimate of 3,184 (CV=0.37) spinner dolphins was calculated from the combined survey data (Mobley et al. 2000), now representing the Kauai/Niihau, Oahu/4-Islands, and Hawaii Island stocks. New mark-recapture estimates based on photo-identification studies have resulted in new seasonal abundance estimates for the Oahu/4-Islands stock. Closed capture models provide two separate estimates for the leeward coast of Oahu representing different time periods: 160 (CV = 0.14) for June to July, 2002; and 355 (CV = 0.09) for July to September 2007 (Hill et al. 2011). The 2002 estimate is now more than 8 years old and therefore will no longer be used based on NMFS Guidelines for Assessing Marine Mammal Stocks (NMFS 2005). The 2007 estimate is considered the best-available estimate of the population size of the Oahu/4-Islands stock; however, it is likely an underestimate as it includes only dolphins found off the leeward coast of Oahu, and does not account for individuals that may spend most of their time along other parts of Oahu or somewhere in the 4-Islands area.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al. 1995) from the 2007 abundance estimate for the summertime leeward coast of Oahu and the 4-Islands area, or 329 spinner dolphins. This minimum estimate is likely negatively-biased, as it represents a minimum estimate of the number of dolphins, accounting only for those along the leeward Oahu coast in 2007; no data were included from the rest of the stock range.

Current Population Trend

There are insufficient data to evaluate trends in abundance for this stock.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters. A default level of 4% is assumed for maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Oahu/4-Islands stock is calculated as the minimum population estimate (329) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a species of unknown status with no estimated fishery mortality or serious injury within the U.S. EEZ of the Hawaiian Islands; Wade and Angliss 1997) resulting in a PBR of 3.3 spinner dolphins per year.

STATUS OF STOCK

The Oahu/4-Islands stock of spinner dolphins is not considered a strategic stock under the MMPA. The status of Oahu/4-Islands spinner dolphins relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance for this stock. A habitat issue of increasing concern is the potential effect of swim-with-dolphin programs and other tourism activities on spinner dolphins around the main Hawaiian Islands (Danil et al. 2005, Courbis and Timmel 2009). All Hawaiian spinner dolphin stocks are potentially exposed to high levels of Navy sonar and frequent detonations during training exercises. The sensitivity of spinner dolphins to these sound levels is unknown and therefore the impact of these exercises on spinner dolphin stocks is unknown. Spinner dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Insufficient data exist to determine whether the total fishery mortality and serious injury for this Oahu/4-Islands spinner dolphin stock is insignificant and approaching zero mortality and serious injury rate. One spinner dolphin found stranded on Oahu has tested positive for *Morbillivirus* (Jacob 2012). Although *morbillivus* is known to trigger lethal disease in cetaceans (Van Bressem et al. 2009), its impact on the health of the stranded animal is not known (Jacob 2012). The presence of *morbillivirus* in 10 species of cetacean in Hawaiian waters

(Jacob 2012), raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts on Hawaiian cetaceans.

KAUAI/NIIHAU STOCK

POPULATION SIZE

As part of the Marine Mammal Research Program of the Acoustic Thermometry of Ocean Climate (ATOC) study, a total of twelve aerial surveys were conducted within 25 nmi of the main Hawaiian Islands in 1993, 1995 and 1998. An abundance estimate of 3,184 (CV=0.37) spinner dolphins was calculated from the combined survey data (Mobley et al. 2000), now representing the Kauai/Niihau, Oahu/4-Islands, and Hawaii Island stocks. Those data are well over 8 years old and abundance estimates from these data are out of date. New mark-recapture estimates based on photo-identification studies have resulted in a new seasonal abundance estimate for the Kauai/Niihau stock. Closed capture models provide an estimate of 601 (CV = 0.20) spinner dolphins for the leeward coast of Kauai for the period October to November 2005. This estimate is considered the best-available estimate of the population size of the Kauai/Niihau stock; however, it is likely an underestimate as it includes only dolphins found off the leeward coast of Kauai, and does not account for individuals that may spend most of their time along other parts of Kauai, Niihau, or Kaula Rock.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al. 1995) from the leeward Kauai abundance estimate, or 509 spinner dolphins. This minimum estimate is likely negatively-biased, as it represents a minimum estimate of the number of dolphins, accounting only for those along the leeward Kauai coast in 2005; no data were included from the rest of the stock range near Niihau or Kaula Rock.

Current Population Trend

There is only one abundance estimate available for the stock area of Kauai/Niihau from 2005 and thus, no trend analysis is possible.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters. A default level of 4% is assumed for maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Kauai/Niihau stock is calculated as the minimum population estimate (509) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no estimated fishery mortality or serious injury within the U.S. EEZ of the Hawaiian Islands; Wade and Angliss 1997 resulting in a PBR of 5.1 spinner dolphins per year.

STATUS OF STOCK

The Kauai/Niihau stock of spinner dolphins is not considered a strategic stock under the MMPA. The status of Kauai/Niihau spinner dolphins relative to OSP is unknown, and there are insufficient data to evaluate abundance trends. A habitat issue of increasing concern is the potential effect of swim-with-dolphin programs and other tourism activities on spinner dolphins around the main Hawaiian Islands (Danil et al. 2005, Courbis & Timmel 2009). All Hawaiian spinner dolphin stocks are potentially exposed to high levels of Navy sonar and frequent detonations during training exercises. The sensitivity of spinner dolphins to these sound levels is unknown and therefore the impact of these exercises on spinner dolphin stocks is unknown. Spinner dolphins are not listed as “threatened” or “endangered” under the Endangered Species Act (1973), nor designated as “depleted” under the MMPA. Insufficient data are available to determine whether the total fishery mortality and serious injury for this Kauai/Niihau spinner dolphin stock is insignificant and approaching zero mortality and serious injury rate.

PEARL & HERMES REEF STOCK

POPULATION SIZE

There is no information on the abundance of the Pearl & Hermes Reef stock of spinner dolphins. A photo-identification catalog of individual spinner dolphins from this stock is available, though inadequate survey effort and low re-sighting rates prevent robust estimation of abundance.

Minimum Population Estimate

There is no information on which to base a minimum population estimate for the Pearl & Hermes Reef stock of spinner dolphins.

Current Population Trend

Insufficient data exists to assess population trends.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Pearl & Hermes Reef stock is calculated as the minimum population estimate <u>times</u> one half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> a recovery factor of 0.50 (for a species of unknown status with no estimated fishery mortality or serious injury within the U.S. EEZ of the Hawaiian Islands; Wade and Angliss 1997). Because there is no minimum population estimate available for this stock the PBR for Pearl & Hermes Reef stock of spinner dolphins is undetermined.

STATUS OF STOCK

The Pearl & Hermes Reef stock of spinner dolphins is not considered a strategic stock under the MMPA. The status of Pearl & Hermes Reef spinner dolphins relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance for this stock. Spinner dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Because the stock resides entirely within the Paphanaumokuakea Marine National Monument, where fishing is not permitted, it is assumed that the rate of mortality and serious injury within the stock area is zero.

<u>MIDWAY ATOLL/KURE STOCK</u>

POPULATION SIZE

In the Northwestern Hawaiian Islands, a multi-year photo-identification study at Midway Atoll resulted in a population estimate of 260 spinner dolphins based on 139 identified individuals (Karczmarski et al. 1998). This abundance estimate for the Midway Atoll/Kure stock of spinner dolphins is now more than 8 years old and therefore will no longer be used, based on NMFS Guidelines for Assessing Marine Mammal Stocks (NMFS 2005). A 2010 shipboard line-transect survey within the Hawaiian EEZ resulted in a single off-effort sighting of spinner dolphins at Kure Atoll. This sighting cannot be used within a line-transect framework; however, photographs of individuals may be used in the future to estimate the abundance of spinner dolphin at Midway Atoll/Kure using mark-recapture methods.

Minimum Population Estimate

The minimum population estimate for the Midway Atoll/Kure stock is now more than 8 years old and therefore will no longer be used (NMFS 2005). There is no current minimum population estimate available for this stock.

Current Population Trend

Insufficient data exists to assess population trends.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Midway Atoll/Kure stock is calculated as the minimum population estimate <u>times</u> one half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> a recovery factor of 0.50 (for a species of unknown status with no estimated fishery mortality or serious injury within the U.S. EEZ of the Hawaiian Islands; Wade and Angliss 1997). The PBR for the Midway Atoll/Kure stock of spinner dolphins is undetermined because no minimum population estimate is available for this stock.

STATUS OF STOCK

The Midway Atoll/Kure stock of spinner dolphins is not considered strategic under the MMPA. The status of Midway Atoll/Kure spinner dolphins relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Spinner dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Because the stock resides entirely within the Paphanaumokuakea Marine National Monument, where fishing is not permitted, it is assumed that the rate of mortality and serious injury within the stock area is zero

HAWAII PELAGIC STOCK

POPULATION SIZE

A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 3,351 (CV=0.74) spinner dolphins (Barlow 2006); however, this estimate assumed a single Hawaiian Islands stock. This estimate for the Hawaiian EEZ is more than 8 years old and therefore will no longer be used based on NMFS Guidelines for Assessing Marine Mammal Stocks (NMFS 2005). A 2010 shipboard line-transect survey within the Hawaiian EEZ did not result in any sightings of pelagic spinner dolphins.

Minimum Population Estimate

No minimum population estimate is available for this stock, as there were no sightings of pelagic spinner dolphins during a 2010 shipboard line-transect survey of the Hawaiian EEZ.

Current Population Trend

Insufficient data exists to assess population trends.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii pelagic stock is calculated as the minimum population estimate times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a species of unknown status with no estimated fishery mortality or serious injury within the U.S. EEZ of the Hawaiian Islands; Wade and Angliss 1997). Because there is no minimum population estimate for Hawaii pelagic spinner dolphins, the potential biological removal (PBR) is undetermined.

STATUS OF STOCK

The Hawaii pelagic stock of spinner dolphins is not considered a strategic stock under the MMPA. The status of Hawaii pelagic spinner dolphins relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance for this stock. Spinner dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor as "depleted" under the MMPA. While the estimated rate of fishery mortality and serious injury for this stock is zero in observed U.S. fisheries, this rate cannot be evaluated in the context of the Zero Mortality Rate Goal (ZMRG) (NMFS 2004) because ZMRG is calculated in the context of PBR (<10% of PBR), which is undetermined for this stock. This stock likely extends outside of U.S. EEZ waters, where international high seas fisheries may interact with and take animals from this stock.

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Revised 01/15/2011

SPINNER DOLPHIN (*Stenella longirostris longirostris*): American Samoa Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Gray's spinner dolphins (*Stenella longirostris longirostris*) are the most widely distributed subspecies of spinner dolphins and are found in tropical and subtropical waters of the Atlantic, Indian, central and western Pacific Oceans (Perrin et al. 1991, Norris et al. 1994, Oremus *et al.* 2007, Johnston et al. 2008). Spinner dolphins are considered common in American Samoa (Reeves et al. 1999). During small-boat surveys from 2003 to 2006 in the waters surrounding the island of Tutuila, the spinner dolphin was the most frequently encountered species (i.e., 34 of 52 sightings) and was found in waters with a mean depth of 44m (Johnston et al. 2008). Photo-identification data collected during the surveys indicate the presence of a resident population of spinner dolphins in the waters surrounding Tutuila (Johnston et al. 2008). Approximately 1/3 of the individuals within the photo-id catalog were sighted in multiple years (Johnston et al. 2008). In addition, some of these individuals demonstrated strong site fidelity and were encountered within only a few kilometers from one year to the next (Johnston et al. 2008). During a shipboard survey in 2006 spinner dolphins were also encountered just south of the island of Ta‘u, American Samoa (Johnston et al. 2008).

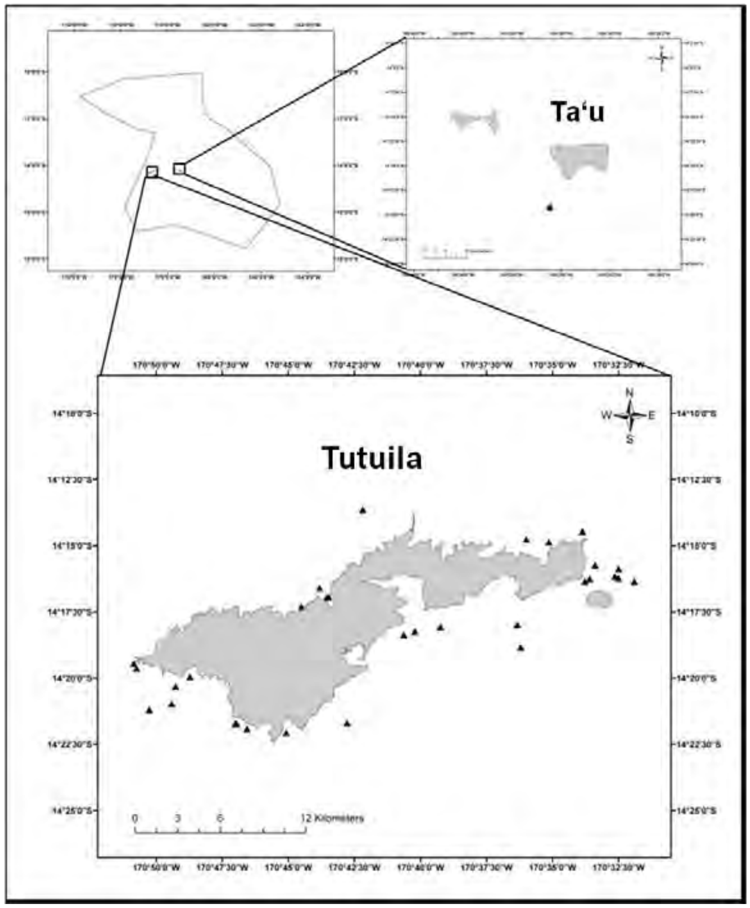

Figure 1. Spinner dolphin sightings from visual sighting surveys, 2003-2006 (Johnston et al 2008).

Genetic analyses of biopsy samples collected during the 2003-2006 small boat surveys around Tutuila indicate that spinner dolphins in American Samoa are distinct from those of the Hawaiian Archipelago. Pairwise F-statistical analyses revealed significant ($p<0.001$) genetic distinction, at both mtDNA and microsatellite loci, between spinner dolphins sampled in American Samoa and those sampled in the Hawaiian Islands (Johnston et al. 2008, Andrews 2009). For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are eight Pacific management stocks, six of these extend from the Hawaiian archipelago to 10 nmi offshore: 1) Kure/Midway, 2) Pearl and Hermes Reef, 3) French Frigate Shoals, 4) Kauai/Niihau, 5) Oahu/4-Islands, and 6) Hawaii Island, The Hawaii Pelagic Stock, which includes animals within the U.S. EEZ of the Hawaiian Islands, but more than 10 nmi from the shore where insular populations exist, and 8) the American Samoa Stock, which include animals inhabiting the EEZ waters around American Samoa (this report). Spinner dolphins involved in eastern tropical Pacific tuna purse-seine fisheries are managed separately under the MMPA.

POPULATION SIZE

No abundance estimates are currently available for spinner dolphins in U.S. EEZ waters of American Samoa; however, density estimates for spinner dolphins in other tropical Pacific regions can provide a range of likely abundance estimates in this unsurveyed region. Published estimates of spinner dolphins (animals per km^2) in the Pacific are: 0.0014 (CV=0.74) for the U.S. EEZ of the Hawaiian Islands (Barlow 2006); 0.0443 (CV=0.37) for nearshore waters surrounding the main Hawaiian Islands (Mobley et al. 2000), 0.0532 (CV=0.19) and 0.0473

(CV=0.15) for the eastern tropical Pacific Ocean (Wade and Gerrodette 1993; Ferguson and Barlow 2003), and 0.1280 (CV=0.27) for eastern tropical Pacific waters west of 120°W and north or south of 10°, a region with similar oceanographic conditions to those around American Samoa. Applying the lowest and highest of these density estimates to U.S. EEZ waters surrounding American Samoa (area size = 404,578 km^2) yields a range of plausible abundance estimates of 553 – 51,773 spinner dolphins.

Minimum Population Estimate
No minimum population estimate is currently available for waters surrounding American Samoa, but the spinner dolphin density estimates from other tropical Pacific regions (Barlow 2003, Mobley et al. 2000, Wade and Gerrodette 1993, Ferguson and Barlow 2003, see above) can provide a range of likely values. The lognormal 20th percentiles of plausible abundance estimates for the American Samoa EEZ, based on the densities observed elsewhere, range from 317 – 41,483 spinner dolphins.

Current Population Trend
No data are available on current population trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES
No data are available on current and maximum net productivity rate in American Samoan waters.

POTENTIAL BIOLOGICAL REMOVAL
No PBR can presently be calculated for spinner dolphins within the American Samoa EEZ, but based on the range of plausible minimum abundance estimates (317 – 41,483), a recovery factor of 0.50 (for a species of unknown status with no fishery mortality and serious injury within the American Samoa EEZ; Wade and Angliss 1997), and the default growth rate (½ of 4%), the PBR would likely fall between 3.2 and 415 spinner dolphins per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY
Fishery Information
Information on fishery-related mortality of cetaceans in American Samoan waters is limited, but the gear types used in American Samoa's fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Gillnets appear to capture marine mammals wherever they are used, and float lines from lobster traps and longlines can be expected to occasionally entangle whales (Perrin et al. 1994). The primary fishery in American Samoa is the commercial pelagic longline fishery that targets tunas, which was introduced in 1995 (Levine and Allen 2009). In 2008, there were 28 federally permitted vessels within the longline fishery in American Samoa (Levine and Allen 2009). The fishery has been monitored since March 2006 under a mandatory observer program, which records all interactions with protected species (Pacific Islands Regional Office 2009). No interactions with spinner dolphins have been recorded. Prior to 1995, bottomfishing and trolling were the primary fisheries in American Samoa but became less prominent after longlining was introduced (Levine and Allen 2009). Nearshore subsistence fisheries include spear fishing, rod and reel, collecting, gill netting, and throw netting (Craig 1993, Levine and Allen 2009). Information on fishery-related mortality of cetaceans in the nearshore fisheries is unknown, but the gear types used in American Samoan fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Gillnets appear to capture marine mammals wherever they are used. Although boat-based nearshore fisheries have been randomly monitored since 1991, by the American Samoa Department of Marine and Wildlife Sources (DMWR), no estimates of annual human-caused mortality and serious injury of cetaceans are available.

STATUS OF STOCK
The status of spinner dolphins in American Samoan waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. No habitat issues are known for spinner dolphins in American Samoa. Spinner dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor as "depleted" under the MMPA. The American Samoan stock of spinner dolphins is not considered a strategic stock under the 1994 amendments to the MMPA because the estimated rate of mortality and serious injury within the American Samoa EEZ is zero. Insufficient information is available to determine whether the total fishery mortality and serious injury for spinner dolphins is insignificant and approaching zero mortality and serious injury rate.

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STRIPED DOLPHIN (*Stenella coeruleoalba*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Striped dolphins are found in tropical to warm-temperate waters throughout the world (Perrin et al. 2009). Sightings have historically been infrequent in nearshore waters (Shallenberger 1981, Mobley et al. 2000, Baird et al. 2013). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands, resulted in 15 sightings of striped dolphins in 2002 and 29 in 2010 (Figure 1; Barlow 2006, Bradford et al. 2013).

Striped dolphins have been intensively exploited in the western North Pacific, where three migratory stocks are provisionally recognized (Kishiro and Kasuya 1993). In the eastern tropical Pacific all striped dolphins are provisionally considered to belong to a single stock (Dizon et al. 1994). For the Marine Mammal Protection Act (MMPA) stock assessment reports, striped dolphins within the Pacific U.S. EEZ are divided into two discrete areas: 1) waters off California, Oregon and Washington, and 2) waters around Hawaii (this report), including animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of the Hawaii stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005). Striped dolphins involved in eastern tropical Pacific tuna purse-seine fisheries are managed separately under the MMPA.

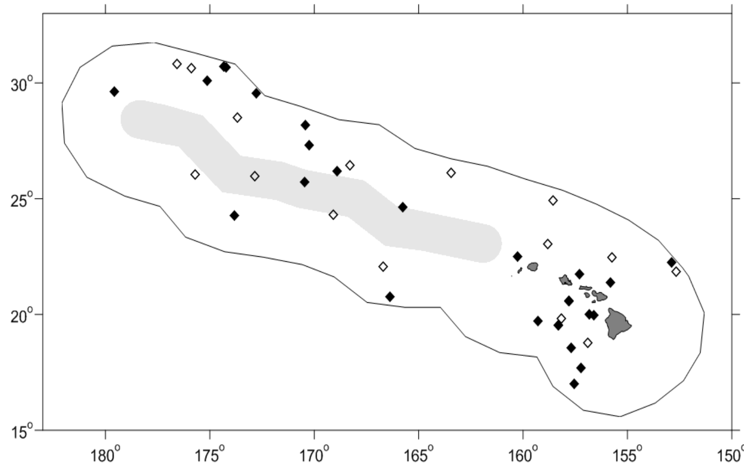

Figure 1. Striped dolphin sighting locations during the 2002 (open diamonds) and 2010 (black diamonds) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2013; see Appendix 2 for details on timing and location of survey effort). Outer line represents approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument.

POPULATION SIZE

Population estimates are available for Japanese waters (Miyashita 1993) and the eastern tropical Pacific (Wade and Gerrodette 1993), but it is not known whether any of these animals are part of the same population that occurs around the Hawaiian Islands. A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 13,143 (CV=0.46) striped dolphins (Barlow 2006). The recent 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 20,650 (CV=0.36) striped dolphins (Bradford et al. 2013). This is currently the best available abundance estimate for this stock.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al. 1995) of the 2010 abundance estimate, or 15,391 striped dolphins.

Current Population Trend

The broad and overlapping confidence intervals around the 2002 and 2010 estimates preclude assessment of trends with the available data.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii stock of striped dolphins is calculated as the minimum population size within the U.S. EEZ of the Hawaiian Islands (15,391) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.5 (for a stock of unknown status with no known fishery mortality and serious injury within the Hawaiian Islands EEZ ; Wade and Angliss 1997), resulting in a PBR of 154 striped dolphins per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NMFS 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Entanglement in gillnets and hooking or entanglement in various hook and line fisheries have been reported for small cetaceans in Hawaii (Nitta & Henderson, 1993). One striped dolphin stranded entangled in fishing gear in 2005, but the responsible fishery cannot be determined, as the entangled gear was not described (NMFS PIR MMRN). No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line or gillnet fisheries because these fisheries are not observed or monitored for protected species bycatch.

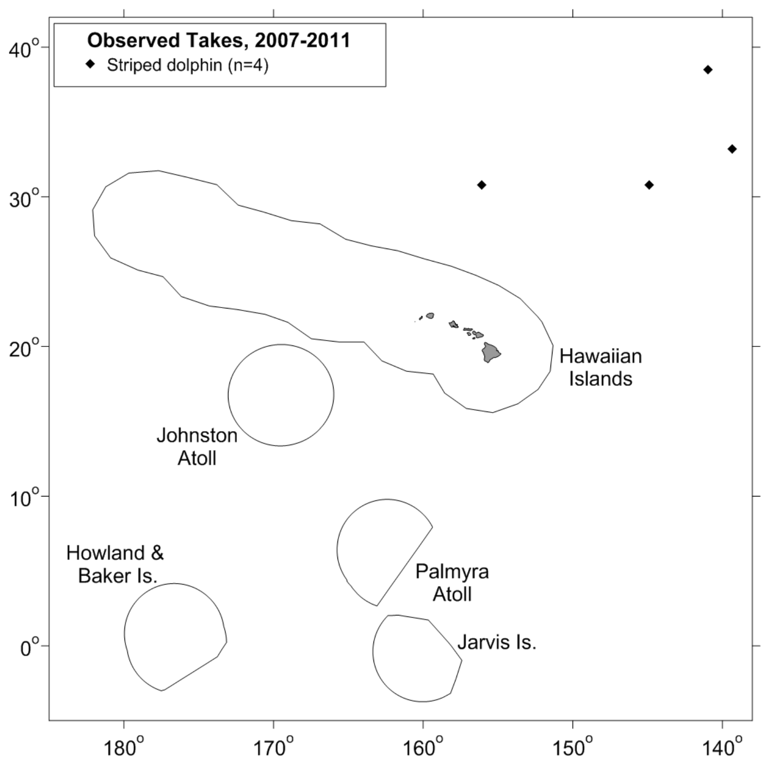

Figure 2. Locations of striped dolphin takes (filled diamonds) in Hawaii-based longline fisheries, 2007-2011 Solid lines represent the U.S. EEZs. Fishery descriptions are provided in Appendix 1.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2007 and 2011, one striped dolphin was killed and two seriously injured on the high seas in the SSLL fishery (100% observer coverage), and one striped dolphin was killed on the high seas in the DSLL fishery (20-22% observer coverage) (Figure 2, Bradford & Forney 2013, McCracken 2013). Average 5-yr estimates of annual mortality and serious injury for 2007-2011 are 1.4 (CV = 0.9) dolphins outside of U.S. EEZs, and zero within the Hawaiian Islands EEZ (Table 1). Eight unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been striped dolphins.

STATUS OF STOCK

The Hawaii stock of striped dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of striped dolphins in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Striped dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Given the absence of recent recorded fishery-related mortality or serious injuries in U.S. EEZ waters, total fishery mortality and serious injury for striped dolphins can be considered insignificant and approaching zero. One striped dolphin stranded in the main Hawaiian Islands tested positive for *Brucella* (Chernov, 2010) and another for *Morbillivirus* (Jacob 2012). *Brucella* is a bacterial infection that may limit recruitment by compromising male and female reproductive systems if it is common in the population, and can also cause neurological disorders that may result in death (Van Bressem et al. 2009). Although *morbillivus* is known to trigger lethal disease in cetaceans (Van Bressem et al. 2009), its impact on the health of the stranded animal is not known as it was found in only a few tested tissues (Jacob 2012). The presence of *Morbillivirus* in 10 species (Jacob 2012) and *Brucella* in 3 species (Cherbov 2010, West unpublished data) raises concerns about the history and prevalence of these diseases in Hawaii and the potential population impacts on Hawaiian cetaceans. It is not known if *Brucella or Morbillivirus* are common in the Hawaii stock.

Table 1. Summary of available information on incidental mortality and serious injury of striped dolphin (Hawaii stock) in commercial longline fisheries, within and outside of U.S. EEZs (McCracken & Forney 2010). Mean annual takes are based on 2007-2011 data unless otherwise indicated. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of striped dolphins			
				Outside U.S. EEZs		Hawaiian EEZ	
				Obs. T/MSI	Estimated M&SI (CV)	Obs. T/MSI	Estimated M&SI (CV)
Hawaii-based deep-set longline fishery	2007	Observer data	20%	0	0 (-)	0	0 (-)
	2008		22%	0	0 (-)	0	0 (-)
	2009		21%	0	0 (-)	0	0 (-)
	2010		21%	0	0 (-)	0	0 (-)
	2011		20%	1/1	4 (1.5)	0	0 (-)
Mean Estimated Annual Take (CV)					**0.8 (0.9)**		**0 (-)**
Hawaii-based shallow-set longline fishery	2007	Observer data	100%	0	0	0	0
	2008		100%	1/1	1	0	0
	2009		100%	0	0	0	0
	2010		100%	2/2	2	0	0
	2011		100%	0	0	0	0
Mean Annual Takes (100% coverage)					**0.6**		**0**
Minimum total annual takes within U.S. EEZ							**0 (-)**

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Revised 7/15/2014

FRASER'S DOLPHIN (*Lagenodelphis hosei*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Fraser's dolphins are distributed worldwide in tropical waters (Dolar 2009 in Perrin et al. 2009). They have only recently been documented within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands, during a 2002 cetacean survey (Barlow 2006), and were seen 4 times during a 2010 survey (Bradford et al. 2013, Figure 1). There have been only 2 sightings of Fraser's dolphins during 13 years of nearshore surveys in the leeward main Hawaii Islands (Baird et al 2013).

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there is a single Pacific management stock including animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

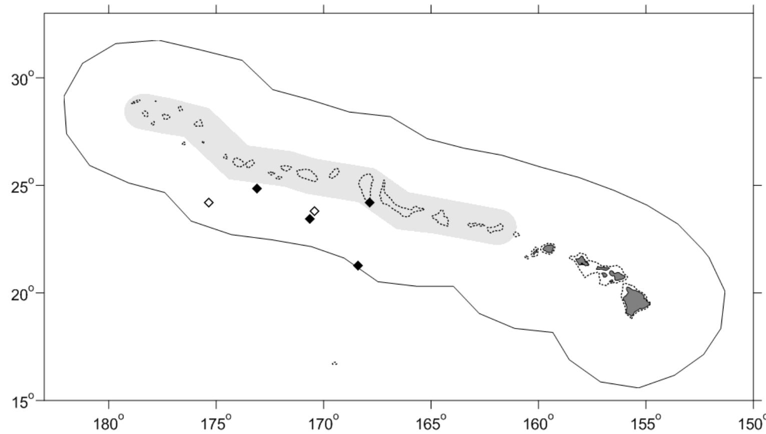

Figure 1. Fraser's dolphin sighting locations during the 2002 (open diamonds) and 2010 (black diamonds) shipboard cetacean surveys of U.S. waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al 2013; see Appendix 2 for details on timing and location of survey effort). Outer line indicates approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument. Dotted line represents the 1000m isobath.

POPULATION SIZE

Population estimates for Fraser's dolphins have been made in the eastern tropical Pacific (Wade and Gerrodette 1993), but it is not known whether these animals are part of the same population that occurs around the Hawaiian Islands and in the central North Pacific. A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 10,226 (CV=1.16) Fraser's dolphins (Barlow 2006). The recent 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 16,992 (CV = 0.66) Fraser's dolphins (Bradford et al 2013). This is currently the best available abundance estimate for this stock.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al 1995) of the 2010 abundance estimate or 10,241 Fraser's dolphins.

Current Population Trend

No data are available on current population trend. The broad and overlapping confidence intervals around the 2002 and 2010 estimates preclude assessment of trend with the available data.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for the Hawaii stock of Fraser's dolphin.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii stock of Fraser's dolphin is calculated as the minimum population size within the U.S. EEZ of the Hawaiian Islands (10,241) <u>times</u> one half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> a recovery factor of 0.50 (for a stock of unknown status with no known fishery mortality or serious injury within the Hawaiian Islands EEZ; Wade and Angliss 1997), resulting in a PBR of 102 Fraser's dolphins per year.

HUMAN CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. No interactions between nearshore fisheries and Fraser's dolphins have been reported in Hawaiian waters.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2007 and 2011, no Fraser's dolphins were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (McCracken 2013, Bradford & Forney 2013). However, eight unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been Fraser's dolphins.

STATUS OF STOCK

The Hawaii stock of Fraser's dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of Fraser's dolphins in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this stock. Fraser's dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Given the absence of recent recorded fishery-related mortality or serious injuries the total fishery mortality and serious injury can be considered to be insignificant and approaching zero.

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MELON-HEADED WHALE (*Peponocephala electra*): Hawaiian Islands Stock Complex: Hawaiian Islands & Kohala Resident Stocks

STOCK DEFINITION AND GEOGRAPHIC RANGE

Melon-headed whales are found in tropical and warm-temperate waters throughout the world. The distribution of reported sightings suggests that the oceanic habitat of this species is primarily equatorial waters (Perryman et al. 1994). Small numbers have been taken in the tuna purse-seine fishery in the eastern tropical Pacific, and they are occasionally killed in direct fisheries in Japan and elsewhere in the western Pacific. Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands during 2002 and 2010 resulted in only one sighting each year (Figure 1; Barlow 2006, Bradford et al. 2013). Little is known about this species elsewhere in its range, and most knowledge about its biology comes from mass strandings (Perryman et al. 1994).

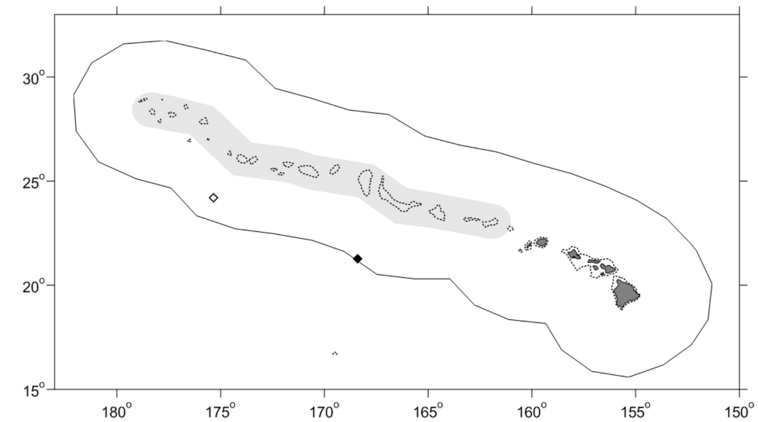

Figure 1. Melon-headed whale sighting locations during the 2002 (open diamond) and 2010 (black diamond) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al 2013; see Appendix 2 for details on timing and location of survey effort). Outer line represents approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument. Dotted line represents the 1000m isobath.

Photo-identification and telemetry studies suggest there are two demographically-independent populations of melon-headed whales in Hawaiian waters, the Hawaiian Islands stock and the Kohala resident stock. Resighting data and social network analyses of photographed individuals indicate very low rates of interchange between these populations (0.0009/yr) (Aschettino et al. 2012). This finding is supported by preliminary genetic analyses that suggest restricted gene flow between the Kohala residents and other melon-headed whales sampled in Hawaiian waters (Oleson et al. 2013). Some individuals in each population have been seen repeatedly for more than a decade, implying high site-fidelity for both populations. Individuals in the larger Hawaiian Islands stock have been resighted throughout the main Hawaiian Islands. Satellite telemetry data revealed distant offshore movements, nearly to the edge of the U.S. EEZ around the Hawaiian Islands (Figure 2), with apparent foraging near cold and warm-core eddies (Woodworth et al. 2012). Individuals in the smaller Kohala resident stock have a range restricted to shallower waters of the Kohala shelf and west side of Hawaii Island (Aschettino et al. 2012, Schorr et al. unpublished data). Satellite telemetry data indicate they occur in waters less than 2500m depth around the northwest and west shores of Hawaii Island, west of 156^0 45' W and north of 19^0 15'N (Oleson et al. 2013). The northern boundary between the two stocks provisionally runs through the Alenuihaha Channel between Hawaii Island and Maui, bisecting the distance between the 1000m depth contours (Oleson et al. 2013).

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are two Pacific management stocks within the Hawaiian Islands EEZ (Oleson et al. 2013): 1) the Kohala resident stock, which includes melon-headed whales off the Kohala Peninsula and west coast of Hawaii Island and in less than 2500m of water, and 2) the Hawaiian Islands stock, which includes melon-headed whales inhabiting waters throughout the U.S. EEZ of the Hawaiian Islands, including the area of the Kohala resident stock, and adjacent high seas waters. At this time, assignment of individual melon-headed whales within the overlap area to either stock requires photographic-identification of the animal. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of the Hawaiian Islands stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

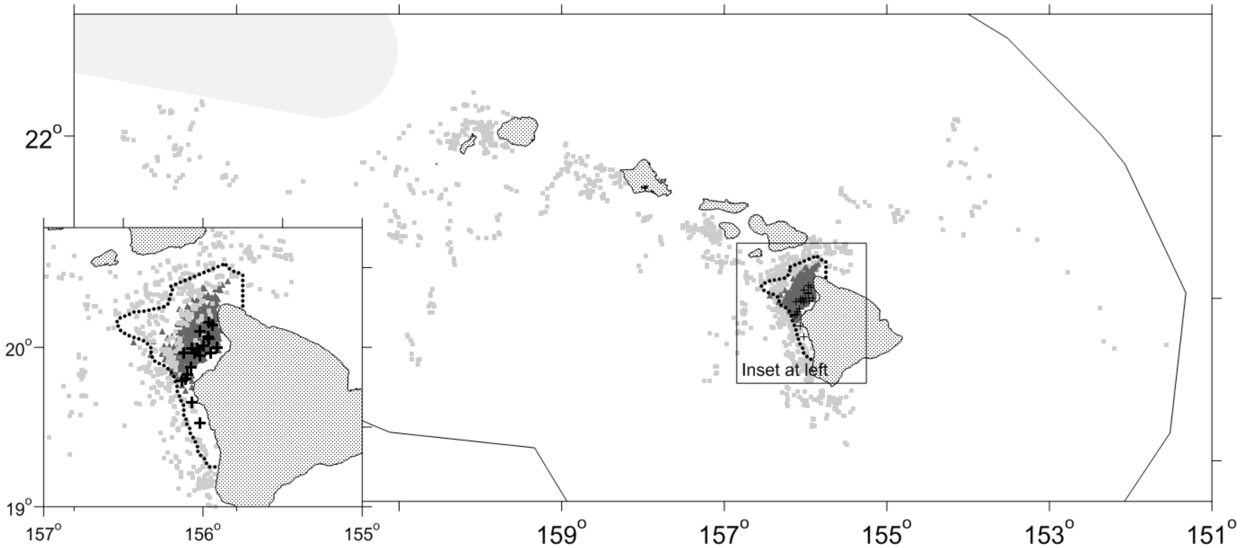

Figure 2. Sighting locations of melon-headed whales identified as being part of the Kohala resident stock (crosses) and telemetry records of Kohala resident (dark gray triangles) and Hawaiian Islands (light gray squares) melon-headed whale stocks (Schorr et al., unpublished data). The dotted line around waters adjacent to the northwest and west shores of Hawaii Island represents the provisional stock boundary for the Kohala resident stock (Oleson et al. 2013). The Kohala resident stock and the Hawaiian Islands stocks overlap throughout the range of the Kohala resident stock**.** Outer line represents U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

Information on fishery-related mortality and serious injury of cetaceans in U.S. EEZ of the Hawaiian Islands waters is limited, but the gear types used in Hawaii fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Entanglement in gillnets and hooking or entanglement in various hook and line fisheries have been reported for small cetaceans in Hawaii (Nitta & Henderson, 1993). No interactions between nearshore fisheries and melon-headed whales have been reported in Hawaiian waters. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line or gillnet fisheries because these fisheries are not observed or monitored for protected species bycatch. Long-term photo-identification studies have noted individuals from both the Kohala Resident and Hawaiian Islands stocks with bullet holes in their dorsal fin or with linear scars on their fins or bodies (Aschettino 2010) which may be consistent fisheries interactions.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2007 and 2011, no melon-headed whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (Bradford & Forney 2013, McCracken 2013). However, eight unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been melon-headed whales.

Other Mortality

In recent years, there has been increasing concern that loud underwater sounds, such as active sonar and seismic operations, may be harmful to beaked whales (Cox et al. 2006) and other cetaceans, including melon-headed whales (Southall et al. 2006) and pygmy killer whales (*Feresa attenuata*) (Wang and Yang 2006). The use of active sonar from military vessels has been implicated in mass strandings of beaked whales and recent mass-stranding reports suggest some delphinids may be impacted as well. A 2004 mass-stranding of 150-200 melon-headed whales in Hanalei Bay, Kauai occurred during a multi-national sonar training event around Hawaii (Southall et al. 2006). Although data limitations regarding the position of the whales prior to their arrival in the Bay, the magnitude of sonar exposure, behavioral responses of melon-headed whales to acoustic stimuli, and other possible relevant factors preclude a conclusive finding regarding the role of Navy sonar in triggering this event, sonar transmissions were considered a plausible cause of the mass stranding based on the spatiotemporal link between the sonar exercises and the stranding, the direction of movement of the transmitting vessels near Hanalei Bay, and propagation modeling suggesting the sonar transmissions would have been audible at the mouth of Hanalei Bay (Southall et al. 2006; Brownell et al. 2009). In 2008 approximately 100 melon-headed whales stranded within a lagoon off Madagascar during high-frequency multi-beam sonar use by oil and gas companies surveying offshore. Although the multi-beam sonar cannot be conclusively deemed the cause of the stranding event, the very close temporal and spatial association and directed movement of the sonar use with the stranding event, the unusual nature of the stranding event, and that all other potential causal factors were considered unlikely to have contributed, an Independent Scientific Review panel found that multi-beam sonar transmissions were a "plausible, if not likely" contributing factor (Southall et al. 2013) in this mass stranding event. This examination together with that of Brownell et al. (2009) suggests melon-headed whale may be particularly sensitive to impacts from anthropogenic sounds. No estimates of potential mortality or serious injury are available for U.S. waters.

KOHALA RESIDENT STOCK

POPULATION SIZE

Using the photo-ID catalog of individuals encountered between 2002 and 2009, Achettino (2010) used a POPAN open-population model to produce a mark-recapture abundance estimate of 447 (CV=0.12) individuals. A portion of the data used in that analysis is more than 8 years old; however, full sighting histories were required to produce a valid model for mark-recapture analyses, such that an estimate restricted to only the later years of the period is not available. Although this estimate includes individuals that have died since 2002, it should be considered an overestimate; however, it is currently the best available abundance estimate for the resident stock.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al 1995) around the 2002-2009 mark-recapture abundance estimate (Aschettino 2010), or 404 melon-headed whales in the Kohala resident stock.

Current Population Trend

Photographic mark-recapture data will be evaluated in the future to assess whether sufficient data exists to assess trends.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population estimate (404) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a species of unknown status with no known fishery mortality; Wade and Angliss 1997), resulting in a PBR of 4.0 Kohala resident melon-headed whales per year.

STATUS OF STOCK

The Kohala resident stock of melon-headed whales is not considered strategic under the MMPA. The status of this stock relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Melon-headed whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. There have been no reports of recent mortality or serious injuries; however, there is no systematic monitoring of takes in near-shore fisheries that may take this species. Given noted bullet holes and potential line injuries on individuals from this stock, insufficient information is available to determine whether the total fishery mortality and serious injury for Kohala Resident melon-headed whales is insignificant and approaching zero mortality and serious injury rate. The restricted range and small population size of Hawaii Island resident melon-headed whales suggests this population may be at risk due to its proximity to U.S. Navy training, including sonar transmissions, in the Alenuihaha Channel between Hawaii Island and Maui (Anonymous 2006). Although a 2004 mass-stranding in Hanalei Bay, Kauai could not be conclusively linked to Naval training events in the region (Southall et al. 2006), the spatiotemporal link between sonar exercises and the stranding does raise concern on the potential impact on the Kohala Resident population due to of sonar training nearby.

HAWAIIAN ISLANDS STOCK

POPULATION SIZE

An abundance estimate of melon-headed whales is available for the eastern tropical Pacific (Wade and Gerrodette 1993), but it is not known whether any of these animals are part of the same population that occurs around the Hawaiian Islands. A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 2,950 (CV=1.17) melon-headed whales (Barlow 2006). The recent 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 2,860 (CV=1.04) melon-headed whales (Bradford et al. 2013). Using the photo-ID catalog of individuals encountered between 2002 and 2009 near the main Hawaiian Islands, Achettino (2010) used a POPAN open-population model to produce a mark-recapture abundance estimate of 5,794 (CV=0.20) individuals. A portion of the data used in that analysis is more than 8 years old; however, full sighting histories were required to produce a valid model for mark-recapture analyses, such that an estimate restricted to only the later years of the period is not available. Although this estimate includes individuals that have died since 2002, the mark-recapture estimate is the best available abundance estimate for the Hawaiian Islands stock given the significantly larger dataset used to produce the estimate versus a single line-transect encounter.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al 1995) of the 2002-2009 mark-recapture abundance estimate (Aschettino 2010) or 4,904 melon-headed whales in the Hawaii pelagic stock. This log-normal 20^{th} percentile minimum population size is greater than the number of photo-identified individuals within the population (820) (Aschettino et al 2012) and greater than the log-normal 20^{th} percentile line-transect estimate (1,326) (Bradford et al. 2013).

Current Population Trend

No trend analyses have been conducted on Hawaiian Islands melon-headed whales from line-transect surveys because only two estimates exist. Photographic mark-recapture data will be evaluated in the future to assess whether sufficient data exists to assess trends.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population estimate for the U.S. EEZ of the Hawaiian Islands (4,904) <u>times</u> one half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> a recovery factor of 0.50 (for a species of unknown status with no known fishery mortality; Wade and Angliss 1997), resulting in a PBR of 49 melon-headed whales per year.

STATUS OF STOCK

The Hawaiian Islands stock of melon-headed whales is not considered strategic under the 1994 amendments to the MMPA. The status of this stock relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Melon-headed whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. There have been no reports of recent mortality or serious injuries; however, there is no systematic monitoring of takes in near-shore fisheries that may take this species. Given noted bullet holes and potential line injuries on individuals from this stock, insufficient information is available to determine whether the total fishery mortality and serious injury for Hawaiian Islands melon-headed whales is insignificant and approaching zero mortality and serious injury rate. A 2004 mass-stranding of melon-headed whales in Hanalei Bay, Kauai occurred during a multi-national sonar training event around Hawaii (Southall et al. 2006). Although the event could not be conclusively linked to Naval training events in the region (Southall et al. 2006), the spatiotemporal link between sonar exercises and the stranding does raise concern on the potential impact on the Hawaiian Islands population due to its frequent use of nearshore areas within the main Hawaiian Islands.

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Revised 7/15/2014

PYGMY KILLER WHALE (*Feresa attenuata*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

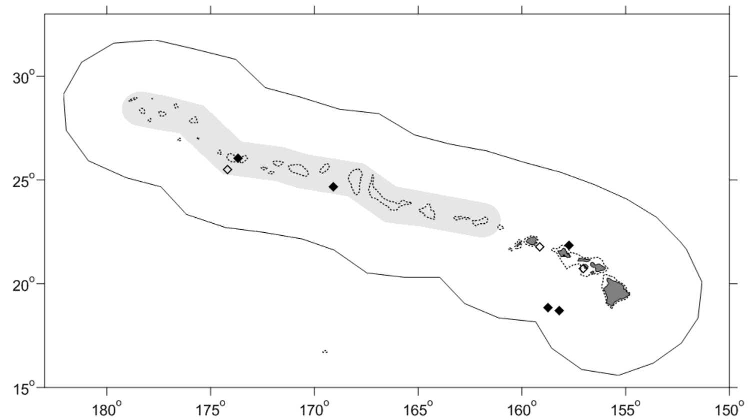

Figure 1. Pygmy killer whale sighting locations during the 2002 (open diamonds) and 2010 (black diamonds) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2013; see Appendix 2 for details on timing and location of survey effort). Outer line represents approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument. Dotted line represents the 1000m isobath.

Pygmy killer whales are found in tropical and subtropical waters throughout the world (Ross and Leatherwood 1994). They are poorly known in most parts of their range. Small numbers have been taken directly and incidentally in both the western and eastern Pacific. Most knowledge of this species is from stranded or live-captured specimens. Pryor et al. (1965) stated that pygmy killer whales have been observed several times off the lee shore of Oahu, and that "they seem to be regular residents of the Hawaiian area." More recently, pygmy killer whales have also been seen off the islands of Niihau and Lanai (McSweeney et al. 2009). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands, resulted in three sightings of pygmy killer whales in 2002 and five in 2010 (Figure 1; Barlow 2006, Bradford et al. 2013).

Several recent studies suggest that while pygmy killer whales are relatively rare in Hawaiian waters, a small resident population occurs in the main Hawaiian Islands (MHI). A 22-year study off the Hawaii Island indicates that pygmy killer whales occur there year-round and in stable social groups. Over 80% of pygmy killer whales seen off Hawaii Island have been resighted and 92% have been linked into a single social network (McSweeney *et al*. 2009). Movements have also been documented between Hawaii Island and Oahu and between Oahu and Lanai (Baird et al 2011a). Satellite telemetry data from four tagged pygmy killer whales suggest this resident group remains within 20km of shore (Baird et al. 2011a,b). Encounter rates for pygmy killer whales during near shore surveys are rare, representing less only 1.7% of all cetacean encounters to since 2000 (Baird et al. 2013). Division of this population into a separate island-associated stock may be warranted in the future.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there is a single Pacific management stock including animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

A population estimate is available from the eastern tropical Pacific (Wade and Gerrodette 1993), but it is not known whether any of these animals are part of the same population that occurs around the Hawaiian Islands. A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 956 (CV=0.83) pygmy killer whales (Barlow 2006). The recent 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 3,433 (CV=0.52) pygmy killer whales (Bradford et al. 2013).This is currently the best available abundance estimate for this stock.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al. 1995) of the 2010 abundance estimate or 2,274 pygmy killer whales within the Hawaiian EEZ.

Current Population Trend

The broad and overlapping confidence intervals around the 2002 and 2010 estimates preclude assessment of pygmy killer whales trends with the available data.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for pygmy killer whales stock is calculated as the minimum population estimate for the U.S. EEZ of the Hawaiian Islands (2,274) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no known fishery mortality or serious injury within the Hawaiian Islands EEZ; Wade and Angliss 1997), resulting in a PBR of 23 pygmy killer whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaii fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Entanglement in gillnets and hooking or entanglement in various hook and line fisheries have been reported for small cetaceans in Hawaii (Nitta & Henderson, 1993). A stranded pygmy killer whale from Oahu showed signs of hooking injury (Schofield 2007) and mouthline injuries have also been noted in some individuals (Baird unpublished data), though it is not known if these interactions result in serious injury or mortality. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line or gillnet fisheries because these fisheries are not observed or monitored for protected species bycatch.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2007 and 2011, no pygmy killer whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (Bradford & Forney 2013, McCracken 2013). However, eight unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been pygmy killer whales.

Other Mortality

In recent years, there has been increasing concern that loud underwater sounds, such as active sonar and seismic operations, may be harmful to beaked whales (Cox et al. 2006) and other cetaceans, including melon-headed whales (Southall et al. 2006, 2013, Brownell et al. 2009) and pygmy killer whales (Wang and Yang 2006). The use of active sonar from military vessels has been implicated in mass strandings of beaked whales, and recent mass-stranding reports suggest some delphinids may be impacted as well. Two mass-strandings of pygmy killer whales occurred in the coastal areas of southwest Taiwan in February 2005, possibly associated with offshore naval training exercises (Wang and Yang 2006). A necropsy of one of the pygmy killer whales revealed hemorrhaging in the cranial tissues of the animal. Additional research on the behavioral response of delphinids in the presence of sonar transmissions is needed in order to understand the level of impact. No estimates of potential mortality or serious injury are available for U.S. waters.

STATUS OF STOCK

The Hawaii stock of pygmy killer whales is not considered strategic under the 1994 amendments to the MMPA. The status of pygmy killer whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Pygmy killer whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Given the absence of recent recorded fishery-related mortality or serious injuries, the total fishery mortality and serious injury can be considered to be insignificant and approaching zero.

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FALSE KILLER WHALE (*Pseudorca crassidens*): Hawaiian Islands Stock Complex – Main Hawaiian Islands Insular, Northwestern Hawaiian Islands, and Hawaii Pelagic Stocks

STOCK DEFINITION AND GEOGRAPHIC RANGE

False killer whales are found worldwide in tropical and warm-temperate waters (Stacey *et al.* 1994). In the North Pacific, this species is well known from southern Japan, Hawaii, and the eastern tropical Pacific. False killer whales were encountered during two shipboard line-transect surveys of the U.S. Exclusive Economic Zone (EEZ) around the Hawaiian Islands in 2002 and 2010 (Figure 1; Barlow 2006, Bradford *et al.* 2014) and focused studies near the main and Northwestern Hawaiian Islands indicate that false killer whales occur in near shore waters throughout the Hawaiian archipelago (Baird et al 2008, 2013). This species also occurs in U.S. EEZ waters around Palmyra and Johnston Atolls (e.g., Barlow *et al.* 2008, Bradford & Forney 2013) and American Samoa (Johnston *et al.* 2008, Oleson 2009).

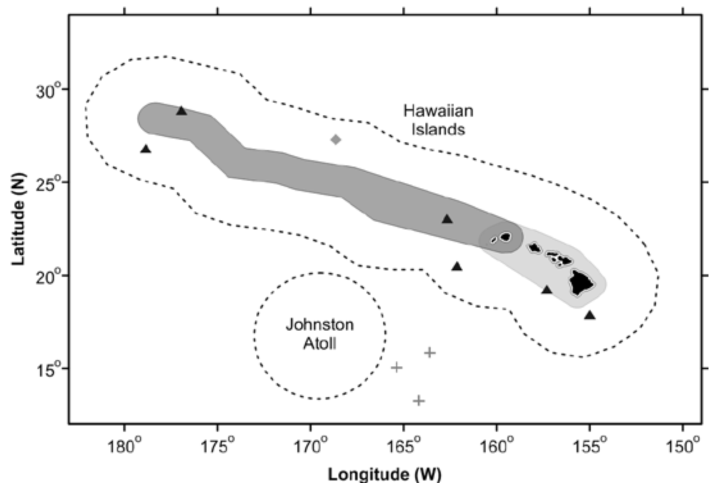

Figure 1. False killer whale on-effort sighting locations during standardized shipboard surveys of the Hawaiian Islands U.S. EEZ (2002, gray diamond, Barlow 2006; 2010, black triangles, Bradford *et al.* 2014, pelagic waters of the central Pacific south of the Hawaiian Islands (2005, gray crosses, Barlow and Rankin 2007) and the Johnston Atoll EEZ. Outer dashed lines represent approximate boundary of U.S. EEZs; light shaded gray area is the main Hawaiian Islands insular false killer whale stock area, including overlap zone between MHI insular and pelagic false killer whale stocks; dark shaded gray area is the Northwestern Hawaiian Islands stock area, which overlaps the pelagic false killer whale stock area and part of the MHI insular false killer whale stock area. Detail of stock boundaries shown in Figure 2.

Genetic, photo-identification, and telemetry studies indicate there are three demographically-independent populations of false killer whales in Hawaiian waters. Genetic analyses indicate restricted gene flow between false killer whales sampled near the main Hawaiian Islands (MHI), the Northwestern Hawaiian Islands (NWHI), and in pelagic waters of the Eastern (ENP) and Central North Pacific (CNP) (Chivers *et al.* 2010; Martien *et al.* 2011, 2014). Martien *et al.* (2014) analyzed mitochondrial DNA (mtDNA) control region sequences and genotypes from 16 nuclear DNA (nuDNA) microsatellite loci from 206 individuals from the MHI, NWHI, and offshore waters of the CNP and ENP and showed highly significant differentiation between populations confirming limited gene flow in both sexes. Their analysis using mtDNA reveals strong phylogeographic patterns consistent with local evolution of haplotypes unique to false killer whales occurring nearshore within the Hawaiian Archipelago and their assessment of nuDNA suggests that NWHI false killer whales are at least as differentiated from MHI animals as they are from offshore animals. Photographic–identification and social network analyses of individuals seen near the MHI indicate a tight social network with no connections to false killer whales seen near the NWHI or in offshore waters, and assessment of satellite telemetry collected from 27 tagged MHI false killer whales shows movements restricted to the MHI (Baird *et al.* 2010, 2012). Further evaluation of photographic and genetic data from individuals seen near the MHI suggests the occurrence of three separate social clusters (Baird *et al.* 2012, Martien *et al.* 2011), where mating occurs primarily, though not exclusively within clusters (Martien *et al.* 2011). Additional details on data and analyses supporting the separation of false killer whales in Hawaiian waters into three separate stocks are summarized within Oleson *et al.* (2010, 2012).

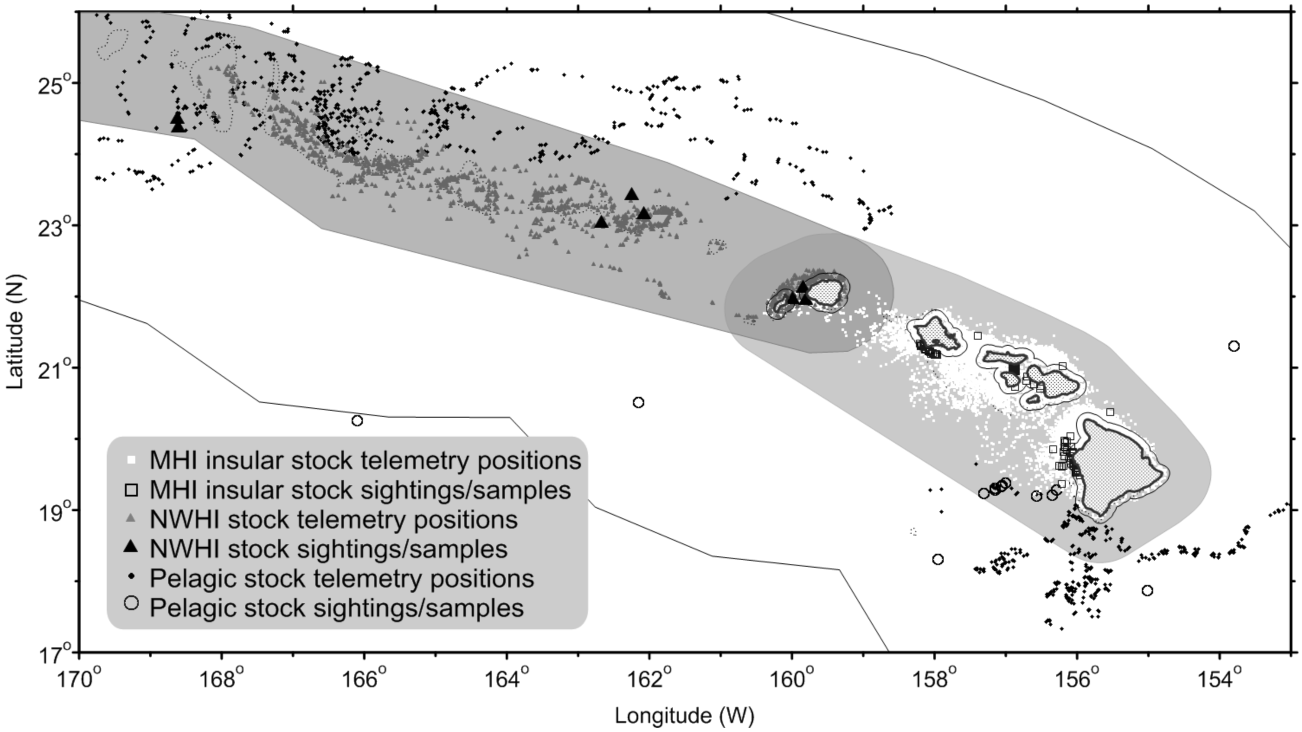

Figure 2. Sighting, biopsy sample, and telemetry record locations of false killer whale identified as being part of the MHI insular (square symbols), NWHI (triangle symbols), or pelagic (circle symbols) stocks. The MHI stock area is shown in light gray; the NWHI stock area is shown in dark gray; the pelagic stock area includes the entire EEZ excluding the region delineated by the black line around each of the MHI (reproduced from Bradford et al. 2015). The MHI insular, pelagic, and NWHI stocks overlap around Kauai and Niihau.

Fishery observers have collected tissue samples for genetic analysis from cetaceans incidentally caught in the Hawaii-based longline fishery since 2003. Between 2003 and 2010, eight false killer whale samples, four collected outside the Hawaiian EEZ and four collected within the EEZ but more than 100 nautical miles (185km) from the main Hawaiian Islands were determined to have Pacific pelagic haplotypes (Chivers *et al.* 2010). At the broadest scale, significant differences in both mtDNA and nuDNA are evident between pelagic false killer whales in the ENP and CNP strata (Chivers *et al.* 2010), although the sample distribution to the east and west of Hawaii is insufficient to determine whether the sampled strata represent one or more stocks, and where pelagic stock boundaries would be drawn.

The stock range and boundaries of the three Hawaiian stocks of false killer whales were recently reevaluated, given significant new information on the occurrence and movements of each stock and are reviewed in detail in Bradford *et al.* (2015) and shown in Figure 2. The stocks have partially overlapping ranges. MHI insular false killer whales have been satellite tracked as far as 115 km from the main Hawaiian Islands, while pelagic stock animals have been tracked to within 11 km of the main Hawaiian Islands and throughout the NWHI. NWHI false killer whales have been seen as far as 93 km from the NWHI and near-shore around Kauai and Oahu (Baird *et al.* 2012, Bradford *et al.* 2015). Stock boundary descriptions are complex, but can be summarized as follows. The MHI insular stock boundary is derived from a Minimum Convex Polygon (MCP) of a 72-km radius extending around the main Hawaiian Islands, with the offshore extent of the radii connected on the leeward sides of Hawaii Island and Niihau to encompass the offshore movements of MHI individuals within that region. The NWHI stock boundary is defined by a 93-km radius around the NWHI, or the boundary of the Papahānaumokuākea Marine National Monument, with this radial boundary extended to the southeast to encompass Kauai and Niihau. The NWHI boundary is latitudinally expanded at the eastern end of the NWHI to encompass animal movements observed outside of the 93-km radius (see Figure 2). The pelagic stock has no outer boundary. Throughout the MHI the pelagic stock inner boundary is placed at 11 km from shore. There is no inner boundary within the NWHI. The construction of these stock boundaries results in a number of stock overlap zones. The waters outside of 11km from shore from Oahu to Hawaii Island out to the MHI insular stock boundary are an overlap zone between the MHI insular and pelagic stocks. The entirety of the NWHI stock range, with the exception of the area within 11km around

Kauai and Niihau is an overlap zone between NWHI and pelagic false killer whales. All three stocks overlap between 11 km from shore around Kauai and Niihau out to the MHI insular stock boundary between Kauai and Nihoa and to the NWHI stock boundary between Kauai and Oahu (see Figure 2).

The pelagic stock includes animals found within the Hawaiian Islands EEZ and in adjacent international waters; however, because data on false killer whale abundance, distribution, and human-caused impacts are largely lacking for international waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005). The Palmyra Atoll stock of false killer whales is still considered to be a separate stock because comparisons amongst false killer whales sampled at Palmyra Atoll and those sampled from the MHI insular stock and the pelagic ENP reveal restricted gene flow, although the sample size remains too low for robust comparisons (Chivers *et al.* 2010). NMFS will obtain and analyze additional samples for genetic studies of Hawaii pelagic and Palmyra stock structure, and will evaluate new information on stock ranges as it becomes available.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are currently five Pacific Islands Region management stocks : 1) the Main Hawaiian Islands insular stock, which includes animals inhabiting waters within a modified 72km radius around the main Hawaiian Islands, 2) the Northwestern Hawaiian Islands stock, which includes animals inhabiting waters within the 93-km radius of the Papahānaumokuākea Marine National Monument and around Kauai, with a slight latitudinal expansion of this area at the eastern end of the range, 3) the Hawaii pelagic stock, which includes false killer whales inhabiting waters greater than 11 km from the main Hawaiian Islands, including adjacent high seas waters, 4) the Palmyra Atoll stock, which includes animals found within the U.S. EEZ of Palmyra Atoll, and 5) the American Samoa stock, which includes animals found within the U.S. EEZ of American Samoa. Estimates of abundance, potential biological removal, and status determinations for the first three stocks are presented below; the Palmyra Atoll and American Samoa stocks are covered in separate reports.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Interactions with false killer whales, including depredation of catch of a variety of pelagic fishes, have been identified in logbooks and NMFS observer records from Hawaii pelagic longline fishing trips (Nitta and Henderson 1993, Oleson *et al.* 2010, PIRO 2015). False killer whales have been observed feeding on mahi mahi, *Coryphaena hippurus*, and yellowfin tuna, *Thunnus albacares* (Baird 2009), and they have been reported to take large fish from the trolling lines of commercial and recreational fishermen (Shallenberger 1981). There are anecdotal reports of marine mammal interactions in the commercial Hawaii shortline fishery which sets gear at Cross Seamount and possibly around the main Hawaiian Islands. The commercial shortline fishery is licensed to sell their catch through the State of Hawaii Commercial Marine License program, and until recently, no reporting systems existed to document marine mammal interactions. Baird and Gorgone (2005) documented high rates of dorsal fin disfigurements consistent with injuries from unidentified fishing line for false killer whales belonging to the MHI insular stock. A recent report included evaluation of additional individuals with dorsal fin injuries and suggested that the rate of interaction between false killer whales and various forms of hook and line gear may vary by population and social cluster, with the MHI insular stock showing the highest rate of dorsal fin disfigurements (Baird *et al.* 2014). The commercial or recreational fishery or fisheries responsible for these injuries is unknown. Examination of a stranded MHI insular false killer whale in October 2013 revealed that this individual had five fishing hooks and fishing line in its stomach (NMFS PIR Marine Mammal Response Network). Although the fishing gear is not believed to have caused the death of the whale, the finding confirms that MHI insular false killer whales are consuming previously hooked fish or are interacting with hook and line fisheries in the MHI. Many of the hooks within the whale's stomach were not consistent with those currently allowed for use within the commercial longline fisheries and could have come from a variety of near-shore fisheries. No estimates of human-caused mortality or serious injury are currently available for near-shore hook and line or other fisheries because these fisheries are not observed or monitored for protected species bycatch.

Because of high rates of false killer whale mortality and serious injury in Hawaii-based longline fisheries, a Take Reduction Team was established in January 2010 (75 FR 2853, 19 January, 2010). The Team was charged with developing recommendations to reduce incidental mortality and serious injury of the Hawaii pelagic, MHI insular and Palmyra stocks of false killer whales in Hawaii-based longline fisheries. The Team submitted a draft Take Reduction Plan (TRP) to NMFS (http://www.nmfs.noaa.gov/pr/pdfs/interactions/fkwtrp_draft.pdf), and NMFS published a final TRP based on the Team's recommendations (77 FR 71260, 29 November, 2012). Take reduction measures include gear requirements, time-area closures, and measures to improve captain and crew response to hooked and entangled false killer whales. The seasonal contraction of the Longline Exclusion Zone (LLEZ) around the MHI was also eliminated. The TRP became effective December 31, 2012, with gear requirements effective February 27, 2013. These measures were not in effect during 2008-2012, the majority of the period for which bycatch was estimated in this report. Adjustments to bycatch estimation methods are implemented for 2013 to account for changes in fishing gear and captain training intended to reduce the false killer whale serious injury rate (see below, McCracken 2015).

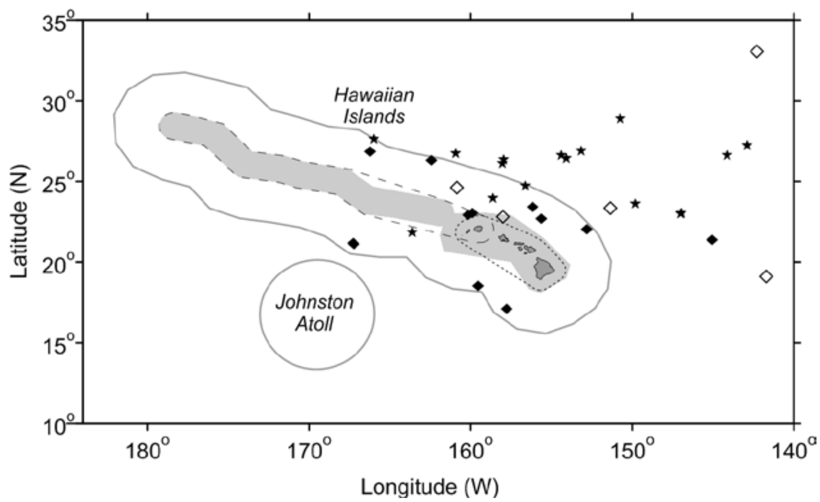

Figure 3. Locations of observed false killer whale takes (black symbols) and possible takes (blackfish) of this species (open symbols) in the Hawaii-based longline fisheries, 2009-2013. Takes occurring prior to the implementation of Take-Reduction Plan (2010-2012) regulations are shown as diamonds, and those since the TRP regulations (2013-2014) are shown as stars. Some take locations overlap. Solid gray lines represent the U.S. EEZ; the dotted line is the MHI insular stock area; the dashed line is the NWHI stock area; both MHI and NWHI stocks overlap with the pelagic stock. The gray shaded area represents the longline exclusion zone, implemented year-round since December 31, 2012, and Papahānaumokuākea Marine National Monument. Both areas are currently closed to longline fishing.

There are two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas, but are prohibited from operating within the Papahānaumokuākea Marine National Monument and within the LLEZ around the main Hawaiian Islands. Stock Assessment Reports generally describe fishery interaction details for the most recent five years, and as such, only years 2010 through 2014 are described here. Years 2008 and 2009 are also included in Table 1 to allow for computation of a 5-yr annual bycatch estimate for the period prior to the implementation of the TRP. Between 2010 and 2014, three false killer whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) within the U.S. EEZ of the Hawaiian Islands, and 25 false killer whales were observed taken in the DSLL fishery (20-22% observer coverage) within Hawaiian waters or adjacent high-seas waters (excluding Palmyra Atoll EEZ waters) (Bradford & Forney 2016). The severity of injuries resulting from interactions with longline gear is determined based on an evaluation of the observer's description of each interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012). Of the three animals taken in the SSLL fishery, two were considered not seriously injured and one could not be determined based on the information provided by the observer. In the DSLL fishery, 12 false killer whales were taken within the Hawaiian EEZ. Two of those takes occurred in 2012 within the pelagic-NWHI overlap zone north of Kauai before this area was closed to longline fishing. Both animals were considered to be seriously injured. Of the remaining 10 interactions within the Hawaiian EEZ, all were within the range of the pelagic stock, with six considered seriously injured, one not considered seriously injured, and three could not be determined based on the information provided by the observer. Outside of the Hawaii EEZ, ten were considered seriously injured, and three were considered not seriously injured. Five additional unidentified "blackfish" (unidentified cetaceans known to be either false killer whales or short-finned pilot whales) were also taken, one within the SSLL fishery and four in the DSLL fishery. The single SSLL interaction occurred outside the Hawaiian EEZ and the animal was considered seriously injured. Of the four DSLL interactions, two occurred inside the Hawaii EEZ, with both considered seriously injured, and two occurred outside the Hawaii EEZ, with one considered seriously injured and one considered not seriously injured.

Table 1. Summary of available information on incidental mortality and serious injury (MSI) of false killer whales and unidentified blackfish (false killer whale or short-finned pilot whale) in commercial longline fisheries, by stock and EEZ area, as applicable (McCracken 2016). 5-yr mean annual takes are presented for 2008-2012, prior to the implementation of the TRP, for 2013-2014 due to changes in fishing gear under the TRP intended to reduce serious injury rate, and for 2010-2014, ignoring any change in mortality rate. Information on all observed takes (T) and combined mortality & serious injury is included. Unidentified blackfish are pro-rated as either false killer whales or short-finned pilot whales according to their distance from shore (McCracken 2010). CVs are estimated based on the combined variances of annual false killer whale and blackfish take estimates and the relative density estimates for each stock within the overlap zones. Values of '0' presented with no further precision are based on observation at 100% coverage and are not estimates.

				Observed takes		**Estimated M&SI (CV)**			
				FKW T/MSI UB T/MSI		**Pelagic Stock**			
Fishery Name	**Year**	**Data Type**	**Percent Observer Coverage**	**Outside U.S EEZ**	**Within Hawaii EEZ**	**Outside U.S EEZ**	**Within Hawaii EEZ**	**MHI insular Stock**	**NWHI Stock**
Hawaii-based deep-set longline fishery	2008	Observer data	22%	0 0	3/3 3/3	0 (-)	16.2 (0.4)	0.3 (0.4)	0.5 (1.1)
	2009		21%	7/7 0	3/3 0	38.5 (0.2)	11.8 (0.9)	0.2 (0.8)	0.4 (1.3)
	2010		21%	1/1 0	3/2 1/1	5.6 (1.5)	13.2 (0.4)	0.4 (0.5)	0.2 (1.0)
	2011		20%	0 1/0	3/3[†] 1/1	2.2 (3.6)	12.2 (0.4)	0.1 (0.6)	0.3 (1.2)
	2012		20%	0 1/1	3/3*[†] 0	3.6 (2.3)	13.0 (0.4)	0.1 (3.9)	1.6 (1.3)
	2013		20%	3/1 0	1/1 0	6.6 (0.9)	4.1 (1.4)	0.0 (1.9)	0.0 (-)
	2014		21%	9/8 0	2/1[†] 0	35.8 (0.5)	8.4 (0.7)	0.0 (0.8)	0.0 (1.5)
Pre-TRP Mean Estimated Annual Take (CV) 2008-2012						**10.0 (0.4)**	**13.3 (0.2)**	**0.2 (0.4)**	**0.6 (0.8)**
Estimated Annual Take (CV) under TRP 2013-2014						**21.2 (0.5)**	**6.2 (0.7)**	**0.0 (0.7)**	**0.0 (1.3)**
Mean Estimated Annual Take (CV) 2010-2014						**10.7 (0.4)**	**10.2 (0.2)**	**0.1 (0.6)**	**0.4 (1.0)**
Hawaii-based shallow-set longline fishery	2008	Observer data	100%	0 1/1	1/0 0	0.6	0.0	0	0.0
	2009		100%	0 0	1/1 0	0	1.0	0	0.0
	2010		100%	0 0	0 0	0	0	0	0
	2011		100%	0 1/1	1/0 0	0.7	0.0	0	0
	2012		100%	0 0	1/1[†] 0	0	0.3	0	0.0
	2013		100%	0 0	0 0	0	0	0	0
	2014		100%	0 0	1/0 0	0	0	0	0
Mean Annual Takes (100% coverage) 2008-2012						**0.3**	**0.3**	**0**	**0.0**
Mean Annual Take (CV) under TRP 2013-2014						**0**	**0**	**0**	**0**

Mean Annual Takes (100% coverage) 2010-2014	**0.1**	**0.1**	**0**	**0.0**
Pre-TRP Minimum total annual takes within U.S. EEZ (2008-2012)		**13.6 (0.2)**	**0.2 (0.4)**	**0.6 (0.8)**
Minimum total take under TRP within U.S. EEZ 2013-2014		**6.2 (0.7)**	**0.0 (0.7)**	**0.0 (1.3)**
Minimum total annual takes within U.S EEZ (2010-2014)		**10.3 (0.2)**	**0.1 (0.6)**	**0.4 (1.0)**

* Two observed takes occurred within the NWHI-pelagic overlap zone and are therefore allocated for proration between NWHI and pelagic stocks. Remaining estimated takes are prorated among stocks as described for each overlap zone.
† Injury status could not be determined based on information collected by the observer. Injury status is prorated (see text).

The injury status of estimated takes is prorated to serious versus non-serious using the historic rate of serious injury within the observed takes. For the period 2008 to 2012, the rate of serious injury for false killer whales was 93% (McCracken 2014). Because the implementation of weak hooks under the TRP was intended to reduce the serious injury rate, these historic averages were not used for 2013-2014. The allocation of estimated serious versus non-serious injuries in 2013-2014 takes was based on the proportion of serious versus non-serious injuries of observed takes in those years (McCracken 2016). The proration of serious injury status will be updated as additional data become available to better estimate serious versus non-serious injury proportion under TRP measures.

Takes of false killer whales of unknown stock within the stock overlap zones must be prorated to MHI insular, pelagic, or NWHI stocks. No genetic samples are available to establish stock identity for the two takes inside the NWHI-pelagic overlap zone north of Kauai, but both stocks are considered at risk of interacting with longline gear. The pelagic stock is known to interact with longline fisheries in waters offshore of the overlap zone, based on two genetic samples obtained by fishery observers (Chivers *et al.* 2010). MHI insular and NWHI false killer whales have been documented via telemetry to move far enough offshore to reach longline fishing areas (Bradford *et al.* 2015), and animals from the MHI insular stock have a high rate of dorsal fin disfigurements consistent with injuries from unidentified fishing line (Baird and Gorgone 2005, Baird *et al.* 2014). Annual bycatch estimates are prorated to stock using the following process. Takes of unidentified blackfish are prorated to false killer whale and short-finned pilot whale based on distance from shore (McCracken 2010). The distance-from-shore model was chosen following consultation with the Pacific Scientific Review Group, based on the model's logic and performance relative to a number of other models with similar output (McCracken 2010). Following proration of unidentified blackfish takes to species, Hawaii EEZ and high-seas estimates of false killer whale take are calculated by summing the annual false killer whale take and the annual blackfish take prorated as false killer whale within each region (McCracken 2016). For the deep-set fishery within the Hawaii EEZ, annual takes are apportioned to each stock overlap zone and the pelagic-only stock area based on relative annual fishing effort in each zone. The total annual EEZ bycatch estimate is multiplied by the proportion of total fishing effort (by set) within each zone to estimate the bycatch within that zone. Because the shallow-set longline fishery is fully observed, takes are assigned to the zone in which they were observed and there is no further apportionment based on fishing effort. For each longline fishery, the zonal bycatch estimates are then multiplied by the relative density of each stock in the respective zone to prorate bycatch to stock. For the deep-set fishery, if bycatch was observed within a specific overlap zone, the observed takes were assigned to that zone and the remaining estimated bycatch was assigned among zones and stocks according to the described process. Following proration by fishing effort and stock density within each zone, stock-specific bycatch estimates are summed across zones to yield the total stock-specific annual bycatch by fishery. Uncertainty in stock-specific bycatch estimates combines variances of total annual false killer whale bycatch and the fractional variance of false killer whale density according to which stock is being estimated. Enumeration of fishing effort within stock overlap zones is assumed to be known without error.

Based on this approach, estimates of annual mortality and serious injury of false killer whales, by stock and EEZ area, are shown in Table 1. Three mortality and serious injury estimates are provided (Table 1): a 5-yr average for the period prior to TRP-implementation (2008-2012), a 2-yr average for the period following TRP implementation (2013-2014), and a 5-yr average for the most recent 5 years assuming no significant change in mortality rate within the fishery (2010-2014). The bycatch rate (per 1000 sets) and of the proportion of non-serious injuries prior to and following TRP implementation were examined as part of the FKW TRT monitoring strategy.

Proration of false killer whale takes within the overlap zones and of unidentified blackfish takes introduces unquantified uncertainty into the bycatch estimates, but until methods of determining stock identity for animals observed taken within the overlap zone are available, and all animals taken can be identified to species (e.g., photos, tissue samples), these proration approaches are needed ensure that potential impacts to all stocks are assessed in the overlap zones.

MAIN HAWAIIAN ISLANDS INSULAR STOCK

POPULATION SIZE

A Status Review for the MHI insular stock in 2010 (Oleson *et al.* 2010) used recent, unpublished estimates of abundance for two time periods, 2000-2004 and 2006-2009 in a Population Viability Analysis (PVA). These estimates were based on open population models, for the two time periods. The abundance estimate for the 2000-2004 period is 162 (CV=0.23) animals. Two separate estimates for 2006-2009 were presented in the Status Review; 151 (CV=0.20) and 170 (CV=0.21), depending on whether animals photographed near Kauai are included in the estimate. The animals seen near Kauai included in the higher estimate have now been associated with the NWHI stock (Baird *et al.* 2013), such that the best estimate of population size for the MHI insular stock is the smaller estimate of 151 animals. Half the data used in the derivation of this population estimate are more than 8 years old and are now considered outdated under NMFS Guidelines for Assessing Marine Mammal Stocks (NMFS 2005).

Minimum Population Estimate

The minimum population estimate for the MHI insular stock of false killer whales is the number of distinctive individuals identified during 2011 to 2014 photo-identification studies, or 92 false killer whales (Baird *et al.* 2015). A portion of the data used in 2006-2009 mark-recapture estimates (Oleson *et al.* 2010) of abundance are considered outdated, and therefore are not suitable for deriving a minimum abundance estimate.

Current Population Trend

Reeves *et al.* (2009) suggested that the MHI insular stock of false killer whales may have declined during the last two decades, based on sightings data collected near Hawaii using various methods between 1989 and 2007. Baird (2009) reviewed trends in sighting rates of false killer whales from aerial surveys conducted using consistent methodology around the main Hawaiian Islands between 1994 and 2003 (Mobley *et al.* 2000). Sighting rates during these surveys showed a statistically significant decline that could not be attributed to any weather or methodological changes. The Status Review of MHI insular false killer whales (Oleson *et al.* 2010) presented a quantitative analysis of extinction risk using a Population Viability Analysis (PVA). The modeling exercise was conducted to evaluate the probability of actual or near extinction, defined as a population reduced to fewer than 20 animals, given measured, estimated, or inferred information on population size and trends, and varying impacts of catastrophes, environmental stochasticity and Allee effects. All plausible models indicated the probability of decline to fewer than 20 animals within 75 years was greater than 20%. Though causation was not evaluated, all plausible models indicated the population has declined since 1989, at an average rate of -9% per year (95% probability intervals -5% to -12.5%), though some two-stage models suggested a lower rate of decline over the past decade (Oleson *et al.* 2010).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the MHI insular false killer whale stock is calculated as the minimum population estimate (92) <u>times</u> one half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> a recovery factor of 0.1 (for a stock listed as Endangered under the ESA and with minimum population size less than 1500 individuals; Taylor *et al.* 2000) resulting in a PBR of 0.18 false killer whales per year, or approximately one animal every 5.5 years.

STATUS OF STOCK

The status of MHI insular stock false killer whales relative to OSP is unknown, although this stock appears to have declined during the past two decades (Oleson *et al.* 2010, Reeves *et al.* 2009; Baird 2009). MHI insular false killer whales are listed as “endangered” under the Endangered Species Act (1973) (77 FR 70915, 28 November, 2012). The Status Review report produced by the Biological Review Team (BRT) (Oleson *et al.* 2010) found that Hawaiian insular false killer whales are a Distinct Population Segment (DPS) of the global false killer whale taxon. Of the 29 identified threats to the population, the BRT considered the effects of small population size, including inbreeding depression and Allee effects, exposure to environmental contaminants (Ylitalo *et al.* 2009), competition for food with commercial fisheries (Boggs & Ito, 1993, Reeves *et al.* 2009), and hooking, entanglement, or intentional harm by fishermen to be the most substantial threats to the population. The BRT concluded that Main Hawaiian Islands insular false killer whales were at high risk of extinction. Following additional information on the occurrence of another island-associated stock in the NWHI, the BRT reevaluated the DPS decision and concluded that the population still met the standard to be listed as a DPS (Oleson *et al.* 2012). Because MHI insular false killer whales are formally listed as "endangered" under the ESA, they are automatically considered as a "depleted" and "strategic" stock under the MMPA. For the 5-yr period prior to the implementation of the TRP, the average estimated mortality and serious injury to MHI insular stock false killer whales (0.21 animals per year) exceeded the PBR (0.18 animals per year). For years 2013-2014, the estimate of mortality and serious injury (0) is below the PBR (0.18), and ignoring any change in mortality rates is assumed under the TRP, the mortality and serious injury to MHI insular false killer whales for the most recent 5-yr period, 2010-2014 (0.1) is less than PBR (0.18). The total fishery mortality and serious injury for the MHI insular stock of false killer whales cannot be considered to be insignificant and approaching zero, as it is greater than 10% of PBR. Following implementation of the TRP a significant portion of the recognized stock range is inside of the expanded year-round LLEZ around the MHI, providing significant protection for this stock from longline fishing. Prior to that time, a seasonal contraction to the LLEZ potentially exposed a significant portion of the offshore range of the stock to longline fishing. Additional monitoring of bycatch rates for this stock will be required before assessing whether the expansion of the LLEZ and other take-reduction measures have reduced fishery takes below PBR. Effects of other threats have yet to be assessed, e.g., nearshore hook and line fishing and environmental contamination. There is significant geographic overlap between various nearshore fisheries and evidence of interactions with hook-and-line gear (e.g. Baird *et al.* 2015), such that these fisheries may pose a threat to the stock. Recent research has indicated that concentrations of polychlorinated biphenyls (PCBs) exceeded proposed threshold levels for health effects in 84% of sampled MHI insular false killer whales (Foltz *et al.* 2014).

HAWAII PELAGIC STOCK

POPULATION SIZE

Analyses of a 2002 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 484 (CV = 0.93) false killer whales within the Hawaiian Islands EEZ outside of about 75 nmi of the main Hawaiian Islands (Barlow & Rankin 2007). A new abundance survey was completed in 2010 within the Hawaiian Islands EEZ and resulted in five on-effort detections of false killer whales attributed to the Hawaii pelagic stock. Analysis of the 2010 HICEAS shipboard line-transect data resulted in an abundance estimate of 1,540 (CV=0.66) false killer whales outside of 11 km of the main Hawaiian Islands (Bradford *et al.* 2014, 2015). Bradford *et al.* (2014) reported that most (64%) false killer whale groups seen during the 2010 HICEAS survey were seen moving toward the vessel when detected by the visual observers. Together with an increase in sightings close to the trackline, these behavioral data suggest vessel attraction is likely occurring and may be significant. Although Bradford *et al.* (2014, 2015) employed a half-normal model to minimize the effect of vessel attraction, the abundance estimate may still be positively biased as a result of vessel attraction because groups originally outside of the survey strip, and therefore unavailable for observation by the visual survey team, may have moved within the survey strip and been sighted. There is some suggestion of such attractive movement within the acoustic data and visual data (Bradford *et al.* 2014), though the extent of any bias created by this movement is unknown. A 2005 survey (Barlow and Rankin 2007) resulted in a separate abundance estimate of 906 (CV=0.68) false killer whales in international waters south of the Hawaiian Islands EEZ and within the EEZ of Johnston Atoll, but it is unknown how many of these animals might belong to the Hawaii pelagic stock.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2010 abundance estimate for the Hawaiian Islands EEZ outside of 11 km from the main Hawaiian Islands (Bradford *et al.* 2014, 2015) or 928 false killer whales. The minimum abundance estimate has not been corrected for vessel attraction and may be positively-biased.

Current Population Trend

No data are available on current population trend. It is incorrect to conclude that the increase in the abundance estimate from 2002 to 2010 represents an increase in population size, given changes to the survey design in 2010 and the analytical framework specifically intended to better enumerate and account for overall group size (Bradford *et al.* 2014), the low precision of each estimate, and a lack of understanding of the oceanographic processes that may drive the distribution of this stock over time. Further, estimation of the detection function for the 2002 and 2010 estimates relied on shared data, such that the resulting abundance estimates are not statistically independent and cannot be compared in standard statistical tests. Only a portion of the overall range of this population has been surveyed, precluding evaluation of abundance of the entire stock.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii pelagic stock of false killer whales is calculated as the minimum population estimate for the U.S. EEZ of the Hawaiian Islands (928) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with a Hawaiian Islands EEZ mortality and serious injury rate CV <= 0.30; Wade and Angliss 1997), resulting in a PBR of 9.3 false killer whales per year.

STATUS OF STOCK

The status of the Hawaii pelagic stock of false killer whales relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Concentrations of polychlorinated biphenyls (PCBs) exceeded proposed threshold levels for health effects in 84% of sampled MHI insular false killer whales (Foltz *et al.* 2014), and elevated concentrations are also expected in pelagic false killer whales given the amplification of these contaminants through the food chain and likely similarity in false killer whale diet across the region. This stock is not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Following the NMFS Guidelines for Assessing Marine Mammal Stocks (NMFS 2005), the status of this transboundary stock of false killer whales is assessed based on the estimated abundance and estimates of mortality and serious injury within the U.S. EEZ of the Hawaiian Islands because estimates of human-caused mortality and serious injury from all U.S. and non-U.S. sources in high seas waters are not available, and because the geographic range of this stock beyond the Hawaiian Islands EEZ is poorly known. For the 5-yr period prior to the implementation of the TRP, the average rate of mortality and serious injury to pelagic stock false killer whales within the Hawaiian Islands EEZ (13.6 animals per year) exceeded the PBR (9.3 animals per year). In most cases, the NMFS Guidelines for Assessing Marine Mammal Stocks (NMFS 2005) suggest pooling estimates of mortality and serious injury across 5 years to reduce the effects of sampling variation. If there have been significant changes in fishery operation that are expected to affect take rates, such as the 2013 implementation of the TRP, the guidelines recommend using only the years since regulations were implemented. Using only bycatch information from 2013-2014, the estimated mortality and serious injury of false killer whales within the HI EEZ (6.2) is below the PBR (9.3). Of note, in 2014 the total number of false killer whales taken in the deep-set fishery (55) is the highest recorded since 2003 and the total estimated mortality and serious injury of false killer whales (44) is the second highest since 2003. The proportion of non-serious injuries is lower in 2013-2014 than the aggregate of all prior years; however, similar 2-year average non-serious injury rates have been observed previously. Further, recent studies (Carretta and Moore 2014) have argued that estimates from a single year of data can be biased when take events are rare, as are takes of false killer whales in the Hawaii-based longline fisheries, and that several years of data may need to be pooled to reduce error. For these reasons, the strategic status for this stock has been evaluated relative to the most recent 5 years of estimated mortality and serious injury. The total 5-year mortality and serious injury for 2010-2014 (10.3) exceeds PBR (9.3), and this stock is considered a "strategic stock" under the MMPA. Additional monitoring of bycatch rates for this stock will be required before assessing whether TRP measures have reduced fishery takes below PBR. The total fishery mortality and serious injury for the Hawaii pelagic stock of false killer whales cannot be considered to be insignificant and approaching zero.

NORTHWESTERN HAWAIIAN ISLANDS STOCK

POPULATION SIZE

A 2010 line transect survey that included the waters surrounding the Northwestern Hawaiian Islands produced an estimate of 617 (CV = 1.11) false killer whales attributed to the Northwestern Hawaiian Islands stock (Bradford *et al.* 2014, 2015). This is the best available abundance estimate for false killer whales within the Northwestern Hawaiian Islands. Bradford *et al.* (2014) reported that most (64%) false killer whale groups seen during the 2010 HICEAS survey were seen moving toward the vessel when detected by the visual observers. Together with an increase in sightings close to the trackline, these behavioral data suggest vessel attraction is likely occurring and may be significant. Bradford *et al.* (2014, 2015) employed a half-normal model to minimize the effect of vessel attraction, because groups originally outside of the survey strip, and therefore unavailable for observation by the visual survey team, may have moved within the survey strip and been sighted. There is some suggestion of such attractive movement within the acoustic and visual data (Bradford *et al.* 2014) though the extent of any bias created by this movement is unknown.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2010 abundance estimate for the Northwestern Hawaiian Islands stock (Bradford *et al.* 2015) or 290 false killer whales. This estimate has not been corrected for vessel attraction and may be positively-biased.

Current Population Trend

No data are available on current population trend because there is only one estimate of abundance from 2010.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in the waters surrounding the Northwestern Hawaiian Islands.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Northwestern Hawaiian Islands false killer whale stock is calculated as the minimum population estimate (290) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.40 (for a stock of unknown status, with a Hawaiian Islands EEZ mortality and serious injury rate CV > 0.8; Wade and Angliss 1997), resulting in a PBR of 2.3 false killer whales per year.

STATUS OF STOCK

The status of false killer whales in Northwestern Hawaiian Islands waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Concentrations of polychlorinated biphenyls (PCBs) exceeded proposed threshold levels for health effects in 84% of sampled MHI insular false killer whales (Foltz et al 2014), and elevated concentrations are also expected in NWHI false killer whales given the amplification of these contaminants through the food chain and likely similarity in false killer whale diet across the region. Biomass of some false killer whale prey species may have declined around the Northwestern Hawaiian Islands (Oleson *et al.* 2010, Boggs & Ito 1993, Reeves *et al.* 2009), though waters within the Papahānaumokuākea Marine National Monument have been closed to commercial longlining since 1991 and to other fishing since 2006. This stock is not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor as "depleted" under the MMPA. The rate of mortality and serious injury to NWHI false killer whales, (0.6 for 2008-2012, 0 for 2013-2014, 0.4 for 2010-2014) is less than the PBR (2.3 animals per year), but is not approaching zero mortality and serious injury rate because it exceeds 10% of PBR (NMFS 2004). A significant portion of the recognized stock range is within the Marine National Monument and the expanded LLEZ, such that this stock is likely not exposed to high levels of fishing effort because commercial and recreational fishing is prohibited within Monument waters and longlines are excluded from the majority of the stock range. Additional monitoring of bycatch rates for this stock will be required before assessing whether TRP measures have reduced fishery takes to below 10% of PBR.

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FALSE KILLER WHALE (*Pseudorca crassidens*): Palmyra Atoll Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

False killer whales are found worldwide mainly in tropical and warm-temperate waters (Stacey et al. 1994). In the North Pacific, this species is known from southern Japan, Hawaii, and the eastern tropical Pacific. Four on-effort sightings of false killer whales were recorded during a 2005 shipboard survey of the U.S. Exclusive Economic Zone (EEZ) of Palmyra Atoll (Figure 1; Barlow & Rankin 2007). This species also occurs in U.S. EEZ waters around Hawaii (Barlow 2006, Bradford et al. 2012), Johnston Atoll (NMFS/PIR/PSD unpublished data), and American Samoa (Johnston et al. 2008, Oleson 2009).

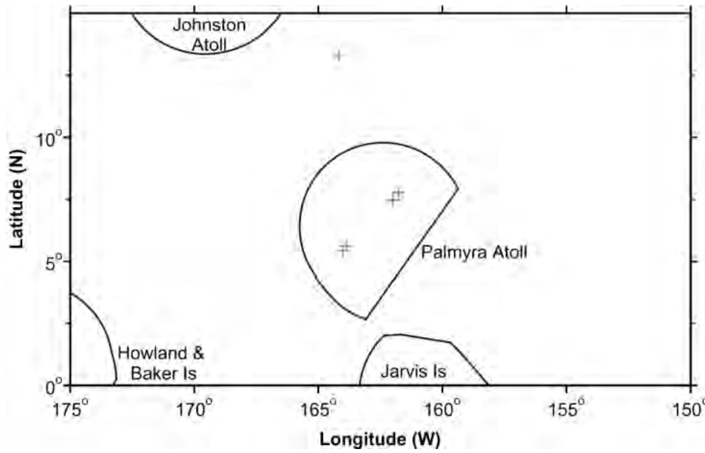

Figure 1. False killer whale on-effort sighting locations during a 2005 standardized shipboard survey of the Palmyra U.S. EEZ and pelagic waters of the central Pacific south of the Hawaiian Islands (gray crosses, Barlow and Rankin 2007). Solid lines represent approximate boundary of U.S. EEZs.

Genetic analyses indicate restricted gene flow between false killer whales sampled near the main Hawaiian Islands (MHI), the Northwestern Hawaiian Islands (NWHI), and in pelagic waters of the Eastern (ENP) and Central North Pacific (CNP) (Chivers et al. 2007, 2010, Martien et al. 2011). The Palmyra Atoll stock of false killer whales remains a separate stock, because comparisons amongst false killer whales sampled at Palmyra Atoll and those sampled from the insular stock of Hawaii and the pelagic ENP revealed restricted gene flow, although the sample size remains low for robust comparisons (Chivers et al. 2007, 2010). NMFS will obtain and analyze additional tissue samples from Palmyra and the broader tropical Pacific for genetic studies of stock structure, and will evaluate new information on stock ranges as it becomes available.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are currently five Pacific Islands Region management stocks (Chivers et al. 2008, Martien et al. 2011): 1) the Hawaii insular stock, which includes animals inhabiting waters within 140 km (approx. 75 nmi) of the main Hawaiian Islands, 2) the Northwestern Hawaiian Islands stock, which includes false killer whales inhabiting waters within 93 km (50 nmi) of the NWHI and Kauai, 3) the Hawaii pelagic stock, which includes false killer whales inhabiting waters greater than 40 km (22 nmi) from the main Hawaiian Islands, 4) the Palmyra Atoll stock, which includes false killer whales found within the U.S. EEZ of Palmyra Atoll, and 5) the American Samoa stock, which includes false killer whales found within the U.S. EEZ of American Samoa. Estimates of abundance, potential biological removal, and status determinations for the Palmyra Atoll stock are presented below; the Hawaii Stock Complex and American Samoa Stocks are presented in separate reports.

POPULATION SIZE

A 2005 line transect survey in the U.S. EEZ waters of Palmyra Atoll produced an estimate of 1,329 (CV = 0.65) false killer whales (Barlow & Rankin 2007). This is the best available abundance estimate for false killer whales within the Palmyra Atoll EEZ.

Minimum Population Estimate

The log-normal 20th percentile of the 2005 abundance estimate for the Palmyra Atoll EEZ (Barlow & Rankin 2007) is 806 false killer whales.

Current Population Trend

No data are available on current population trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Palmyra Atoll waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Palmyra Atoll false killer whale stock is calculated as the minimum population size (806) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.40 (for a stock of unknown status with a mortality and serious injury rate CV >0.80; Wade and Angliss 1997), resulting in a PBR of 6.4 false killer whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Interactions with false killer whales, including depredation of catch, have been identified in logbooks and NMFS observer records from Hawaii pelagic longlines (Nitta and Henderson 1993, NMFS/PIR unpublished data). False killer whales have also been observed feeding on mahi mahi, *Coryphaena hippurus*, and yellowfin tuna, *Thunnus albacares*, and they have been reported to take large fish from the trolling lines of both commercial and recreational fishermen (Shallenberger 1981).

The Hawaii-based deep-set longline (DSLL) fishery targets primarily tunas and operate within U.S. waters and on the high seas near Palmyra Atoll. Between 2006 and 2010, one false killer whale was observed taken in the DSLL fishery within the Palmyra EEZ (≥20% observer coverage) (Forney 2011). Based on an evaluation of the observer's description of each interaction and following the most recently developed criteria for assessing serious injury in marine mammals (Andersen et al. 2008), the single false killer whale taken in the Palmyra EEZ was considered seriously injured (Forney 2011). The total estimated annual and 5-yr average mortality and serious injury of cetaceans in the DSLL fishery operating around Palmyra (with approximately 20% coverage) are reported by McCracken (2011) (Table 1). Although M&SI estimates are shown as whole numbers of animals, the 5-yr average M&SI is calculated based on the unrounded annual estimates.

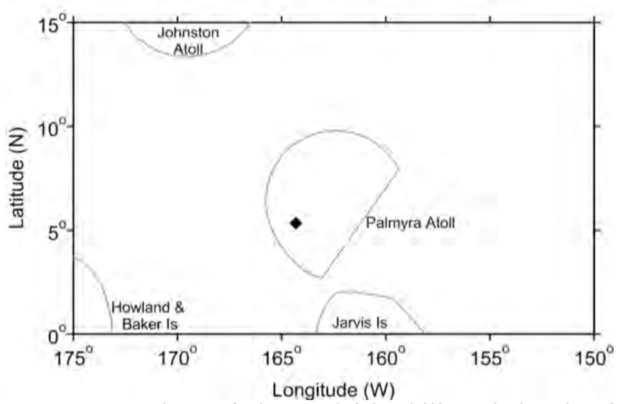

Figure 2. Locations of observed false killer whale takes in the Hawaii-based deep-set longline fishery, 2006-2010. Solid gray lines represent the U.S. EEZ. Fishery descriptions are provided in Appendix 1.

Because of high rates of false killer whale mortality and serious injury in Hawaii-based longline fisheries, a Take-Reduction Team (TRT) was established in January 2010 (75 FR 2853, 19 January 2010). The scope of the TRT was to reduce mortality and serious injury in the Hawaii pelagic, main Hawaiian Islands insular, and Palmyra stocks of false killer whales and across the DSLL and SSLL fisheries. The Team submitted a Draft Take-Reduction Plan to NMFS for consideration (Available at: http://www.nmfs.noaa.gov/pr/pdfs/interactions/fkwtrp_draft.pdf), and NMFS has recently published regulations based on this TRP (77 FR 71260, 29 November, 2012). The Team chose to exclude the Palmyra Atoll stock in the final implementation of the Plan due to low levels of M&SI of this stock for the past 5 years.

Table 1. Summary of available information on incidental mortality and serious injury of false killer whales (Palmyra Atoll stock) in the Hawaii-based longline fishery (McCracken 2011). Mean annual takes are based on 2006-2010 estimates unless otherwise indicated. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed total interactions (T) and mortality events and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of false killer whales in the Palmyra Atoll EEZ	
				Observed T/MSI	Estimated Mean Annual Takes (CV)
Hawaii-based deep-set longline fishery	2006	observer data	22%	0/0	0 (-)
	2007		20%	1/1	2 (0.7)
	2008		22%	0/0	0 (-)
	2009		20%	0/0	0 (-)
	2010		21%	0/0	0 (-)
Minimum total annual takes within U.S. EEZ					**0.3 (1.7)**

STATUS OF STOCK

The status of false killer whales in Palmyra Atoll EEZ waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this stock. They are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor as "depleted" under the MMPA. The rate of mortality and serious injury to false killer whales within the Palmyra Atoll EEZ in the Hawaii-based longline fishery (0.3 animals per year) does not exceed the PBR (6.4) for this stock and thus, this stock is not considered "strategic" under the MMPA. The total fishery mortality and serious injury for Palmyra Atoll false killer whales is less than 10% of the PBR and, therefore, can be considered to be insignificant and approaching zero. Additional injury and mortality of false killer whales is known to occur in U.S and international longline fishing operations in international waters, and the potential effect on the Palmyra stock is unknown.

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Revised 01/15/2011

FALSE KILLER WHALE *(Pseudorca crassidens)*: American Samoa Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

False killer whales are found worldwide mainly in tropical and warm-temperate waters (Stacey et al. 1994). The species is well-documented throughout the tropical and sub-tropical south Pacific, from Papua New Guinea and Australia to the line islands (Reeves et al. 1999). The species has been taken in the drive hunt in the Solomon Islands (Reeves et al 1999).). During small-boat surveys from 2003 to 2006 in the waters surrounding the island of Tutuila, American Samoa, false killer whales were observed during summer surveys on five occasions (Johnston et al 2008). During a shipboard survey in 2006 false killer whales were also encountered just north of the island of Ta‘u, in the Manu’a Group within American Samoa (Johnston et al. 2008). Two false killer whales were entangled near 40-Fathom Bank south of the islands by the American Samoa-based longline fishery in 2008 (Oleson 2009), indicating some false killer whales maintain a more pelagic distribution. Five genetic samples collected near Tutuila are available for comparison to other false killer whale populations throughout the Pacific (Johnston et al 2008). For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are four Pacific management stocks: 1) The Hawaii Insular Stock, which includes animals found within the 25-75 nmi longline exclusion boundary surrounding the main Hawaiian Islands, 2) The Hawaii Pelagic Stock, which includes animals found within the U.S. EEZ of the Hawaiian Islands but outside the 25-75 nmi longline exclusion zone, 3) The Palmyra Stock, which includes animals found within the U.S. EEZ of the Palmyra Atoll, and 4) The American Samoa Stock, which includes animals found within the U.S. EEZ American Samoa (this report).

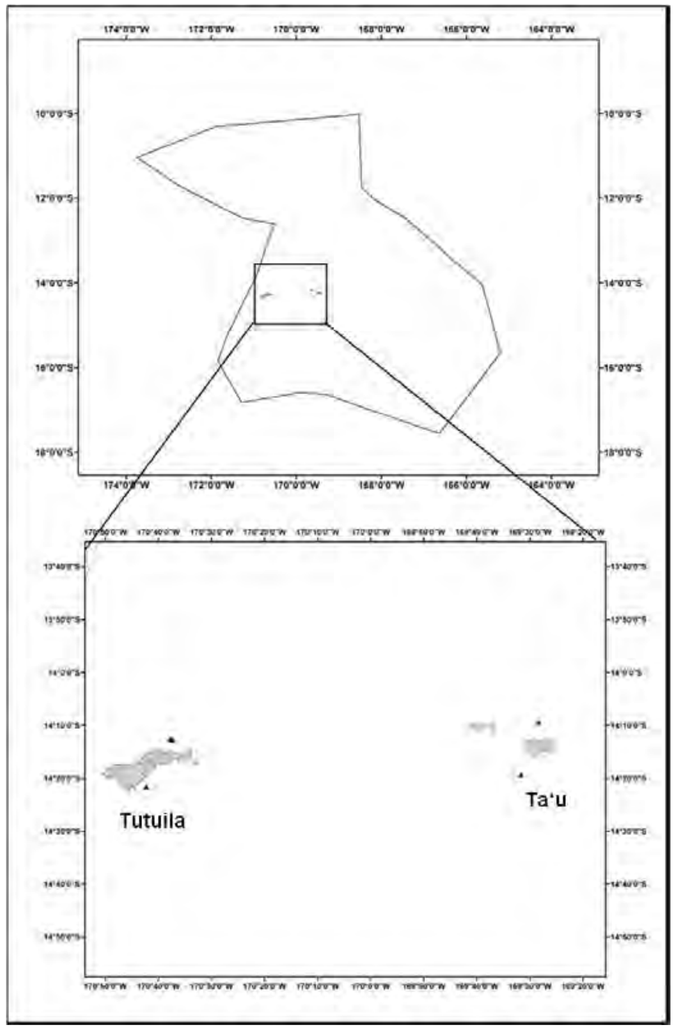

Figure 1. False killer whale sightings during visual surveys from 2003-2006 (Johnston et al 2008).

POPULATION SIZE

No abundance estimates are currently available for false killer whales in U.S. EEZ waters of American Samoa; however, density estimates for false killer whales in other tropical Pacific regions can provide a range of likely abundance estimates in this unsurveyed region. Published estimates of false killer whales (animals per km^2) in the Pacific are: 0.0002 (CV= 0.93) for the U.S. EEZ of the Hawaiian Islands (Barlow and Rankin 2007); 0.0038 (CV=0.65) for the U.S. EEZ around Palmyra, (Barlow and Rankin 2007), 0.0021 (CV=0.64) and 0.0016 (CV=0.31) for the eastern tropical Pacific Ocean (Wade and Gerrodette 1993; Ferguson and Barlow 2003). Applying the lowest and highest of these density estimates to U.S. EEZ waters surrounding American Samoa (area size = 404,578 km^2) yields a range of plausible abundance estimates of 87 – 1,538 false killer whales.

Minimum Population Estimate

No minimum population estimate is currently available for waters surrounding American Samoa, but the false killer whale density estimates from other tropical Pacific regions (Barlow and Rankin 2007, Wade and Gerrodette 1993, Ferguson and Barlow 2003, see above) can provide a range of likely values. The lognormal 20th percentiles of plausible abundance estimates for the American Samoa EEZ, based on the densities observed elsewhere, range from 45 – 936 false killer whales.

Current Population Trend

No data are available on current population trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

No PBR can presently be calculated for false killer whales within the American Samoa EEZ, but based on the range of plausible minimum abundance estimates (45 - 936), a recovery factor of 0.40 (for a species of unknown status with a fishery mortality and serious injury rate CV > 0.80 within the American Samoa EEZ; Wade and Angliss 1997), and the default growth rate (½ of 4%), the PBR would likely fall between 0.4 and 7.5 false killer whales per year.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information on fishery-related mortality of cetaceans in American Samoan waters is limited, but the gear types used in American Samoas fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Gillnets appear to capture marine mammals wherever they are used, and float lines from lobster traps and longlines can be expected to occasionally entangle cetaceans (Perrin et al. 1994). The primary fishery in American Samoa is the commercial pelagic longline fishery that targets tunas, which was introduced in 1995 (Levine and Allen 2009). In 2008, there were 28 federally permitted vessels within the longline fishery in American Samoa. The fishery has been monitored since March 2006 under a mandatory observer program, which records all interactions with protected species (Pacific Islands Regional Office 2009). Two false killer whales were killed or seriously injured by the fishery in 2008 (Oleson 2009). The average annual serious injury and mortality in commercial fisheries for false killer whales in American Samoa waters is 7.8 (CV=1.7) animals per year (Table 1).

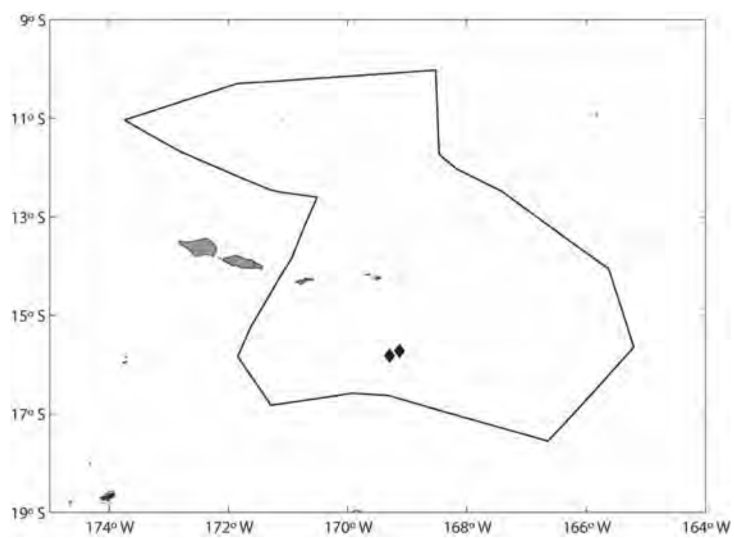

Figure 2. Locations of observed false killer whale takes (filled diamonds) in the American Samoa longline fishery, 2006-2008. Solid line represents the U.S. EEZ. Set locations in this fishery are summarized in Appendix 1.

Prior to 1995, bottomfishing and trolling were the primary fisheries in American Samoa but became less prominent after longlining was introduced (Levine and Allen 2009). Nearshore subsistence fisheries include spear fishing, rod and reel, collecting, gill netting, and throw netting (Craig 1993, Levine and Allen 2009). Information on fishery-related mortality of cetaceans in the nearshore fisheries is unknown, but the gear types used in American Samoan fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Gillnets appear to capture marine mammals wherever they are used. Although boat-based nearshore fisheries have been randomly monitored since 1991, by the American Samoa Department of Marine and Wildlife Sources (DMWR), no estimates of annual human-caused mortality and serious injury of cetaceans are available.

STATUS OF STOCK

The status of false killer whales in American Samoan waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this stock. False killer whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor as "depleted" under the MMPA. The status of the American Samoa stock of false killer whales under the 1994 amendments to the MMPA cannot be determined at this time because no abundance estimates are available and PBR cannot be calculated. However, the estimated rate of fisheries related mortality and serious injury within the American Samoa EEZ (7.8 animals per year) exceeds the range of likely PBRs (0.4 – 7.5) for this region, suggesting that this stock would probably be strategic if abundance estimates were available. Additional research on the abundance of false killer whales in American Samoa is required to resolve this stock's status. Insufficient information is available to determine whether the total fishery mortality and serious injury for false killer whales is insignificant and approaching zero, but this appears unlikely given the estimated takes and likely PBR range.

Table 1. Summary of available information on incidental mortality and serious injury of false killer whales (American Samoa stock) in commercial fisheries operating within the U.S. EEZs (Oleson 2009). Longline fishery take estimates represent only those trips with at least 10 sets/trip (Oleson 2009). Mean annual takes are based on 2006-2008 data unless otherwise indicated.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed and estimated mortality and serious injury of false killer whales in the American Samoa EEZ		
				American Samoa EEZ		
				Obs.	Estimated (CV)	Mean Annual Takes (CV)
American Samoa-based longline fishery	2006 2007 2008	observer data	9.0% 7.7% 8.5%	0 0 2	0 (-) 0 (-) 23.5 (1.9)	7.8 (1.7)
Minimum total annual takes within U.S. EEZ waters						7.8 (1.7)

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Revised 6/4/2014

KILLER WHALE (*Orcinus orca*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Killer whales have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Although reported from tropical and offshore waters (Heyning and Dahlheim 1988), killer whales prefer the colder waters of both hemispheres, with greatest abundances found within 800 km of major continents (Mitchell 1975). They are considered rare in Hawaiian waters. No killer whales were seen during 1993-98 aerial surveys within about 25 nmi of the main Hawaiian Islands, but one sighting was reported during subsequent surveys (Mobley et al. 2000, 2001). Baird et al. (2006) reported 21 sighting records in Hawaiian waters between 1994 and 2004. Summer/fall shipboard surveys of U.S. Exclusive Economic Zone (EEZ) Hawaiian waters resulted in two sightings in 2002 and one in 2010 (Figure 1; Barlow 2006; Bradford et al. 2013). Three strandings have been reported since 1950 (Richards 1952, NMFS PIR Marine Mammal Reponses Network database), including one since 2007. Eighteen additional sightings were reported around the main Hawaiian Islands, French Frigate Shoals, and offshore of the Hawaiian islands (Baird *et al.* 2006). Except in the northeastern Pacific where "resident", "transient", and “offshore” stocks have been described for coastal waters of Alaska, British Columbia, and Washington to California (Bigg 1982; Leatherwood et al. 1990, Bigg et al. 1990, Ford et al. 1994), little is known about stock structure of killer whales in the North Pacific. A global-scale analysis of killer whale phylogeographic structure clustered one animal sampled near Hawaii with eastern and western North Pacific transients. The other Hawaii sample within that analysis did not cluster with any known ecotype, but had divergence time between that of transient and offshore forms (Morin et al 2010).

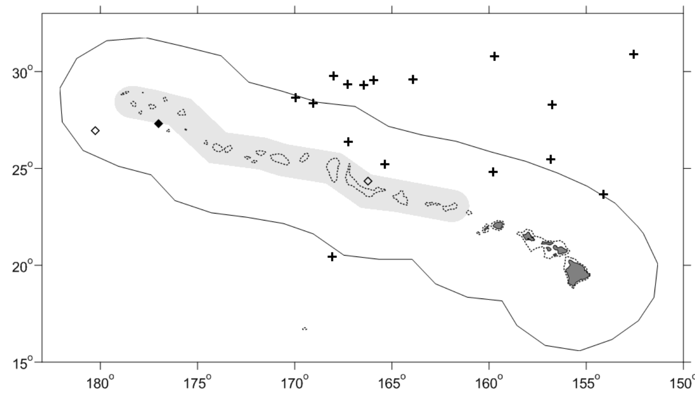

Figure 1. Locations of killer whale sightings from longline observer records (crosses; NMFS/PIR, unpublished data) and sighting locations during the 2002 (open diamonds) and 2010 (black diamonds) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2013; see Appendix 2 for details on timing and location of survey effort). Outer line represents approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument. Dotted line represents the 1,000m isobath.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, eight killer whale stocks are recognized within the Pacific U.S. EEZ: 1) the Eastern North Pacific Alaska Resident stock - occurring from southeastern Alaska to the Aleutian Islands and Bering Sea, 2) the Eastern North Pacific Northern Resident stock - occurring from British Columbia through part of southeastern Alaska, 3) the Eastern North Pacific Southern Resident stock – occurring mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from British Columbia through California, 4) the Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock - occurring mainly from Prince William Sound through the Aleutian Islands and Bering Sea, 5) the AT1 Transient stock - occurring in Alaska from Prince William Sound through the Kenai Fjords, 6) the West Coast Transient stock - occurring from California through southeastern Alaska, 7) the Eastern North Pacific Offshore stock - occurring from California through Alaska, and 8) the Hawaiian stock (this report). The Hawaii stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005). Stock assessment reports for the Southern Resident, Eastern North Pacific Offshore, and Hawaiian stocks can be found in the Pacific Region stock assessment reports; all other killer whale stock assessments are included in the Alaska Region stock assessments.

POPULATION SIZE

A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 349 (CV=0.98) killer whales (Barlow 2006). The recent 2010 shipboard line-transect survey of the

Hawaiian Islands EEZ resulted in an abundance estimate of 101 (CV = 1.0) killer whales (Bradford et al 2013). This is currently the best available abundance estimate for this stock.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al 1995) of the 2010 abundance estimate or 50 killer whales within the Hawaiian Islands EEZ.

Current Population Trend

No data are available on current population trend. The broad and overlapping confidence intervals around the 2002 and 2010 estimates preclude assessment of trend with the available data.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current and maximum net productivity rate in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size within the U.S. EEZ of the Hawaiian Islands (50) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no known fishery mortality or serious injury within the Hawaiian Islands EEZ; Wade and Angliss 1997), resulting in a PBR of 1.0 killer whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. No interactions between nearshore fisheries and killer whales have been reported in Hawaiian waters. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line or gillnet fisheries because these fisheries are not observed or monitored for protected species bycatch. Killer whale interactions with Hawaii fisheries appear to be rare. In 1990, a solitary killer whale was reported to have removed the catch from a longline in Hawaii (Dollar 1991). There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2007 and 2011, no killer whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (McCracken 2013, Bradford & Forney 2013).

STATUS OF STOCK

The Hawaii stock of killer whales is not considered strategic under the 1994 amendments to the MMPA. The status of killer whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this stock. Killer whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Given the absence of recent recorded fishery-related mortality or serious injuries the total fishery mortality and serious injury can be considered to be insignificant and approaching zero.

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SHORT-FINNED PILOT WHALE (*Globicephala macrorhynchus*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Short-finned pilot whales are found in all oceans, primarily in tropical and warm-temperate waters. They are commonly observed around the main Hawaiian Islands and are also present around the Northwestern Hawaiian Islands (Shallenberger 1981, Baird et al. 2013, Bradford et al. 2013). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands resulted in 25 sightings in 2002 and 36 in 2010, including more encounters near shore within the Northwestern Hawaiian Islands (Figure 1; Barlow 2006, Bradford et al. 2013). Twenty-three strandings of short-finned pilot whales have been documented from the Hawaiian Islands since 1957, including five mass strandings in May and October of 1958 and 1959 (Tomich 1986; Nitta 1991; Maldini et al. 2005, NMFS-PIR Marine Mammal Response Network database). There have been four strandings since 2007. Two forms of short-finned pilot whales have been identified in Japanese waters based on pigmentation patterns and differences in the shape of the heads of adult males (Kasuya et al. 1988). The pilot whales in Hawaiian waters are similar morphologically to the Japanese "southern form." Phylogeographic analysis of short-finned pilot whale samples off Hawaii versus those in the eastern tropical Pacific and western Pacific suggest long-term isolation of those animals found in Hawaiian waters (Chivers et al. 2003).

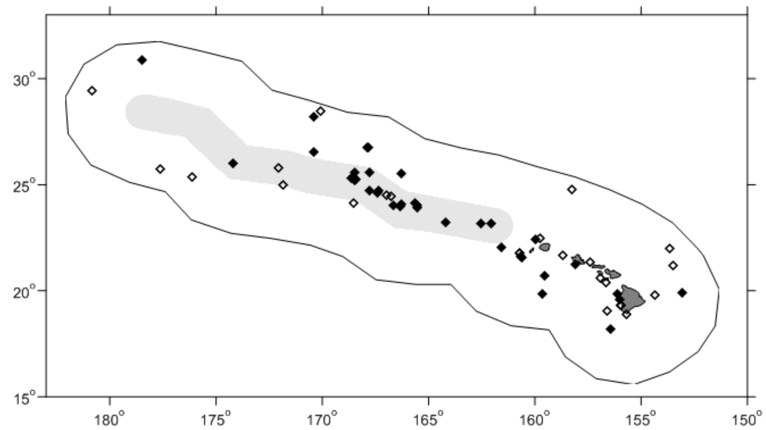

Figure 1. Short-finned pilot whale sighting locations during the 2002 (open diamonds) and 2010 (black diamonds) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2013); see Appendix 2 for details on timing and location of survey effort). Outer solid line represents approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument.

Photo-identification and telemetry studies suggest there may be inshore and pelagic populations of short-finned pilot whales in Hawaiian waters. Resighting and social network analyses of individuals photographed off Hawaii Island suggest the occurrence of one large and several smaller social clusters that use those waters, with some individuals within the smaller social clusters commonly resighted off Hawaii Island (Mahaffy 2012). Further, two groups of 14 individuals have been seen at Hawaii and elsewhere in the main Hawaiian Islands, one off Oahu and the other off Kauai. Satellite telemetry data from over 60 individuals tagged throughout the main Hawaiian Islands also support the occurrence of at least two populations (Oleson et al. 2013). Genetic analyses are underway to evaluate differentiation between island-associated versus pelagic short-finned pilot whales. Oleson et al. (2013) suggested formal stock division would be more robust following conclusion of genetics analyses and updating of the social network with more recent sightings data.

Fishery interactions with short-finned pilot whales demonstrate that this species also occurs in U.S. EEZ waters of Palmyra Atoll and Johnston Atoll, but it is not known whether these animals are part of the Hawaii stock or whether they represent separate stocks of short-finned pilot whales. For the Marine Mammal Protection Act (MMPA) stock assessment reports, short-finned pilot whales within the Pacific U.S. EEZ are divided into two discrete areas: 1) Hawaiian waters (this report), and 2) waters off California, Oregon and Washington. The Hawaii stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters. The status of the Hawaii stock is evaluated based on abundance, distribution, and human-caused impacts within the Hawaiian Islands EEZ, as such datasets are largely lacking for high seas waters (NMFS 2005).

POPULATION SIZE

A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 8,846 (CV=0.49) short-finned pilot whales (Barlow 2006). The recent 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 12,422 (CV = 0.43) short-finned pilot whales (Bradford et al. 2013). This is currently the best available abundance estimate for short-finned pilot whales within the Hawaiian Islands EEZ.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al. 1995) of the 2010 abundance estimate for the Hawaiian Islands EEZ or 8,782 short-finned pilot whales.

Current Population Trend

The broad and overlapping confidence intervals around the 2002 and 2010 estimates preclude assessment of trend with the available data.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii short-finned pilot whale stock is calculated as the minimum population estimate (8,782) <u>times</u> one half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> a recovery factor of 0.40 (for a stock of unknown status with a Hawaiian Islands EEZ fishery mortality and serious injury rate CV> 0.80; Wade and Angliss 1997), resulting in a PBR of 70 short-finned pilot whales.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen *et al*. 2008, NMFS 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Entanglement in gillnets and hooking or entanglement in various hook and line fisheries have been reported for small cetaceans in Hawaii (Nitta & Henderson, 1993). No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line or gillnet fisheries because these

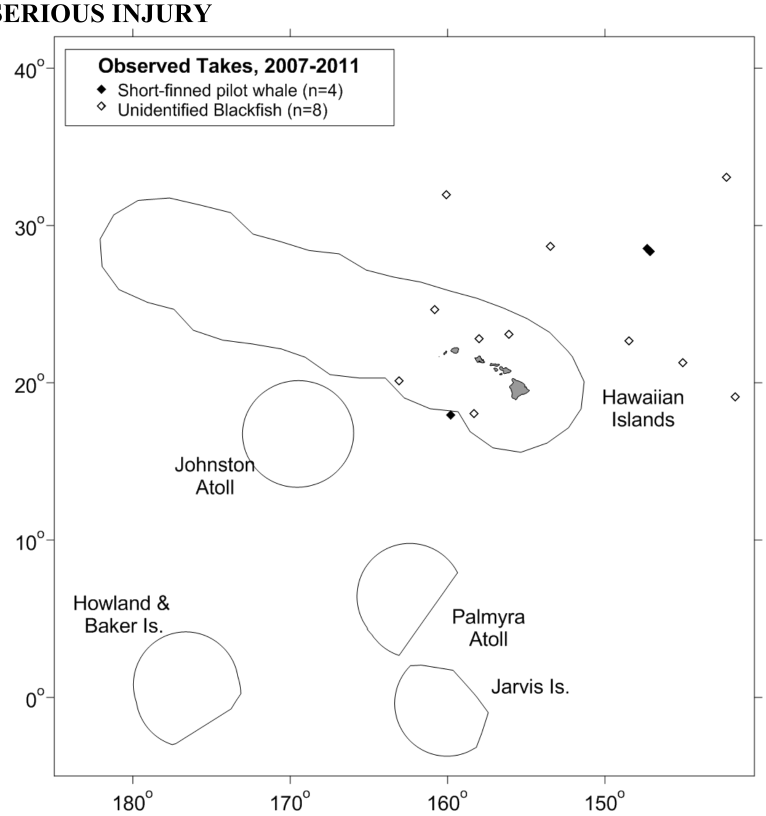

Figure 2. Locations of short-finned pilot whale takes (filled diamonds) and possible takes of this species (open diamonds) in Hawaii-based longline fisheries, 2007-2011. Some take locations overlap. Solid lines represent the U. S. EEZ. Fishery descriptions are provided in Appendix 1.

fisheries are not observed or monitored for protected species bycatch.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas, but are prohibited from operating within the Papahanaumokuakea Marine National Monument, a region that extends 50 nmi from shore around the Northwestern Hawaiian Islands, and within the Longline Exclusion Area, a region extending 25-75 nmi from shore around the main Hawaiian Islands. Between 2007 and 2011, no short-finned pilot whales were observed hooked or entangled in the SSLL fishery (100% observer coverage), and four short-finned pilot whales were observed taken in the DSLL fishery (20-22% observer coverage) (Bradford & Forney 2013, McCracken 2013), all in high-seas waters. Based on an evaluation of the observer's description of the interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012), two short-finned pilot whales were considered not seriously injured, and the other two were considered seriously injured (Bradford & Forney 2013). Seven additional unidentified "blackfish" (unidentified cetaceans known to be either false killer whales or short-finned pilot whales) that may have been pilot whales were also seriously injured during 2007-2011 (Bradford & Forney 2013). Additionally, one

Table 1. Summary of available information on incidental mortality and serious injury of short-finned pilot whales (Hawaii stock) and including those presumed to be short-finned pilot whales based on assignment of unidentified blackfish to this species in commercial longline fisheries, within and outside of the U.S. EEZs (McCracken 2013). Mean annual takes are based on 2007-2011 data unless otherwise indicated. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome. Unidentified blackfish are pro-rated as either false killer whales or short-finned pilot whales according to their distance from shore (McCracken 2010). CVs are estimated based on the combination of annual short-finned pilot whale and blackfish variances and do not yet incorporate additional uncertainty introduced by prorating the unidentified blackfish.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of short-finned pilot whales (GM)			
				Outside U.S. EEZs		Hawaiian EEZ	
				Obs. GM T/MSI Obs. UB T/MSI	Estimated M&SI (CV)	Obs. GM T/MSI Obs. UB T/MSI	Estimated M&SI (CV)
Hawaii-based deep-set longline fishery	2007	Observer data	20%	1/1 0	2 (2.4)	0 0	0 (-)
	2008		22%	3/1 0	2 (1.6)	0 3/3	0 (0.5)
	2009		21%	0 0	0 (-)	0 0	0 (-)
	2010		21%	0 0	0 (-)	0 1/1	0 (1.2)
	2011		20%	0 1/0	0 (1.1)	0 1/1	0 (0.9)
Mean Estimated Annual Take (CV)					**1.0 (2.1)**		**0.1 (7.2)**
Hawaii-based shallow-set longline fishery	2007	Observer data	100%	0 0	0	0 0	0
	2008		100%	0 1/1	0	0 0	0
	2009		100%	0 0	0	0 0	0
	2010		100%	0 0	0	0 0	0
	2011		100%	0 1/1	0	0 0	0
Mean Annual Takes (100% coverage)					**0.1**		**0**
Minimum total annual takes within U.S. EEZ							**0.1 (7.2)**

unidentified blackfish was taken on the high seas in the deep set longline fishery in 2011, but was not seriously injured (Table 1). Five of the seven serious injuries were taken in the DSLL fishery within U.S. EEZ waters and the remaining two serious injuries were taken the SSLL fishery on the high seas (Table 1 and Figure 3).Unidentified blackfish are prorated to each stock based on distance from shore (McCracken 2010). The distance-from-shore model was chosen following consultation with the Pacific Scientific Review Group, based on the model's performance and simplicity relative to a number of other more complicated models with similar output (McCracken 2010). Proration of unidentified blackfish takes introduces unquantified uncertainty into the bycatch estimates, but until all animals taken can be identified to species (e.g., photos, tissue samples), this approach ensures that potential impacts to all stocks are assessed. Average 5-yr estimates of annual mortality and serious injury for 2007-2011 are 0.7 (CV = 2.1) short-finned pilot whales outside of U.S. EEZs and 0.1 (CV = 7.2) within the Hawaiian Islands EEZ. Although M&SI estimates are shown as whole numbers of animals, the 5-yr average M&SI is calculated based on the unrounded annual estimates. Eight unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been short-finned pilot whales.

STATUS OF STOCK

The Hawaii stock of short-finned pilot whales is not considered strategic under the 1994 amendments to the MMPA. The status of short-finned pilot whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this stock. Short-finned pilot whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. The estimated rate of mortality and serious injury within the Hawaiian Islands EEZ (0.1 animals per year) is less than the PBR (70). Based on the available data, which indicate total fishery-related takes are less than 10% of PBR, the total fishery mortality and serious injury for short-finned pilot whales can be considered to be insignificant and approaching zero.

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BLAINVILLE'S BEAKED WHALE (*Mesoplodon densirostris*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Blainville's beaked whale has a cosmopolitan distribution in tropical and temperate waters, apparently the most extensive known distribution of any *Mesoplodon* species (Mead 1989). Forty-five sightings over 13 years were reported from the main islands by Baird et al (2013), who indicated that Blainville's beaked whale represent a small proportion (2-3%) of all odontocete sightings in the main Hawaiian Islands. Shallenberger (1981) suggested that Blainville's beaked whales were present off the Waianae Coast of Oahu for prolonged periods annually. Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands, resulted in three sightings in 2002 and one in 2010; however, several sightings of unidentified *Mesoplodon* whales may have also been Blainville's beaked whale (Figure 1; Barlow 2006, Bradford et. al. 2013).

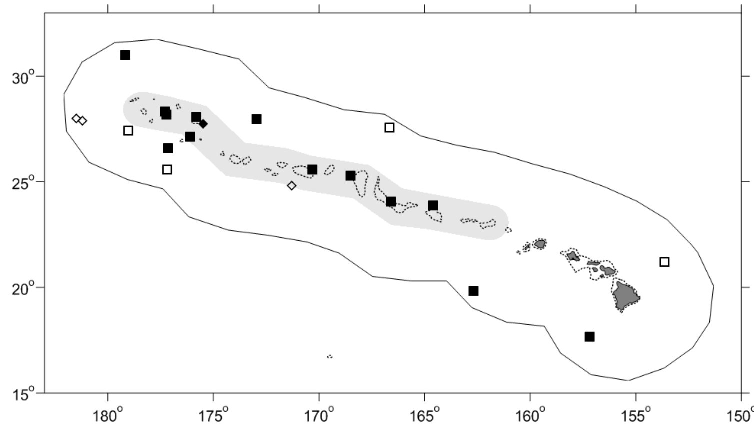

Figure 1. Sighting locations of *Mesoplodon densirostris* (diamonds) and unidentified *Mesoplodon* beaked whales (squares) during the 2002 (open symbols) and 2010 (black symbols) shipboard cetacean surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006; see Appendix 2 for details on timing and location of survey effort). Outer line indicates approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument. Dotted line represents the 1,000m isobath.

Recent analysis of Blainville's beaked whale resightings and movements near the main Hawaiian Islands (MHI) suggest the existence of insular and offshore (pelagic) populations of this species in Hawaiian waters (McSweeney et al. 2007, Schorr et al., 2009, Baird et al. 2013). Photo-identification of individual Blainville's beaked whales from Hawaii Island since 1986 reveal repeated use of this area by individuals for over 17 years (Baird et al. 2011) and 75% of individuals seen off Hawaii Island link by association into a single social network (Baird et al. 2013). Those individuals seen farthest from shore and in deep water (>2100m) have not been resighted, suggesting they may be part of an offshore, pelagic population (Baird et al. 2011). Eleven Blainville's beaked whales linked to the social network have been satellite tagged off Hawaii Island. All 11 individuals had movements restricted to the MHI, extending to nearshore waters of Oahu, with average distance from shore of 21.6 km (Baird et al. 2013). One individual tagged 32km from Hawaii Island did not link to the social network and had movements extending far from shore, moving over 900km from the tagging location in 20 days, approaching the edge of the Hawaiian EEZ west of Nihoa (Baird et al. 2011). Division of this population into a separate island-associated stock may be warranted in the future.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, three *Mesoplodon* stocks are defined within the Pacific U.S. EEZ: 1) *M. densirostris* in Hawaiian waters (this report), 2) *M. stejnegeri* in Alaskan waters, and 3) all *Mesoplodon* species off California, Oregon and Washington. The Hawaii stock of Blainville's beaked whales includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 2,872 (CV=1.17) Blainville's beaked whales (Barlow 2006). The recent 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 2,338 (CV = 1.13) Blainville's beaked whales (Bradford et al. 2013) in the Hawaii stock. This is currently the best available abundance estimate for this stock.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al. 1995) of the 2010 abundance estimate or 1,088 Blainville's beaked whales within the Hawaiian Islands EEZ.

Current Population Trend

The broad and overlapping confidence intervals around the 2002 and 2010 estimates preclude assessment of population trend for the Hawaii stock with the available data.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population estimate for the U.S. EEZ of the Hawaiian Islands (1,088) <u>times</u> one half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> a recovery factor of 0.50 (for a species of unknown status with no recent fishery mortality or serious injury within the Hawaiian Islands EEZ; Wade and Angliss 1997), resulting in a PBR of 11 Hawaii Blainville's beaked whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaii fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. No interactions between nearshore fisheries and Blainville's beaked whales have been reported in Hawaiian waters. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2007 and 2011, no Blainville's beaked whale was observed killed or seriously injured in the SSLL fishery (100% observer coverage) or the DSLL

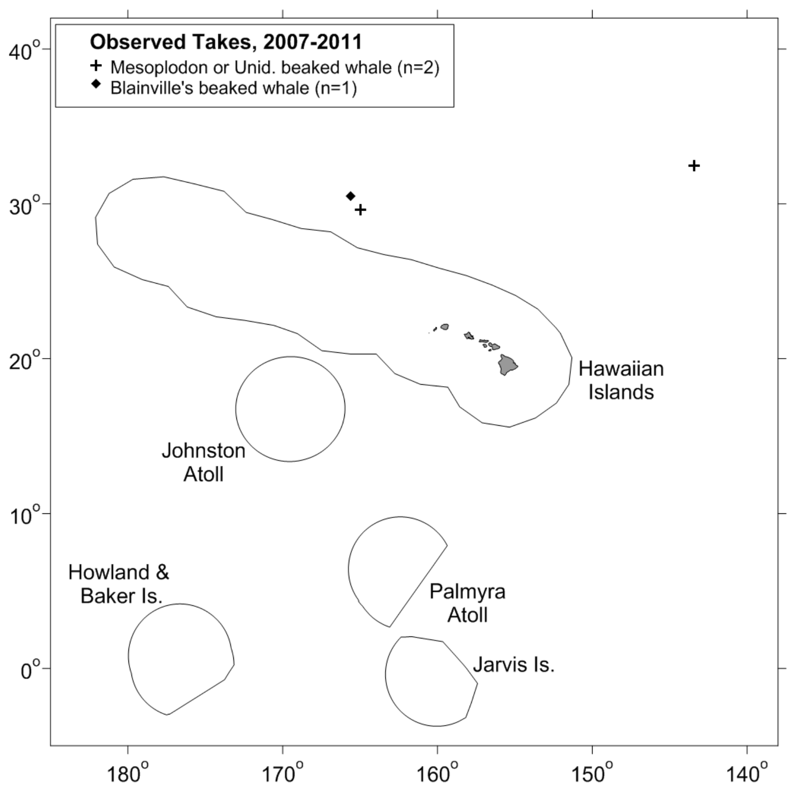

Figure 2. Location of the Blainville's beaked whale take (filled diamond) and the possible takes of this species (cross) in Hawaii-based longline fisheries, 2007-2011. Solid lines represent the U.S. EEZ. Fishery descriptions are provided in Appendix 1.

fishery (20-22% observer coverage) (Bradford & Forney 2013 , McCracken 2013) within the Hawaiian EEZ. One Blainville's beaked whale was observed taken, but not seriously injured, on the high seas in the SSLL fishery (Bradford & Forney 2013). One unidentified *Mesoplodon* whale and one unidentified beaked whale were taken in the SSLL fishery and both were considered to be seriously injured based on an evaluation of the observer's description of the interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012). Average 5-yr estimates of annual mortality and serious injury for 2007-2011 are zero Blainville's beaked whales within or outside of the U.S. EEZs, and 0.4 (CV = 0) *Mesoplodon* or unidentified beaked whales outside the U.S. EEZs (Table 1). Eight unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been Blainville's beaked whales.

Table 1. Summary of available information on incidental mortality and serious injury of Blainville's beaked whales (Hawaii stock) in commercial longline fisheries, within and outside of the Hawaiian Islands EEZ (McCracken 2013). Mean annual takes are based on 2007-2011 data unless otherwise indicated. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of Blainville's beaked whales (MD), unidentified Mesoplont whales (UM) and unidentified beaked whales (ZU)			
				Outside U.S. EEZs		Hawaiian EEZ	
				Obs. MD T/MSI Obs. UM+ZU T/MSI	Estimated MD M&SI (CV) Estimated UM+ZU MSI (CV)	Obs. MD T/MSI Obs. UM+ZU T/MSI	Estimated MD M&SI (CV) Estimated UM+ZU MSI (CV)
Hawaii-based deep-set longline fishery	2007	Observer data	20%	0	0 (-)	0	0 (-)
	2008		22%	0	0 (-)	0	0 (-)
	2009		21%	0	0 (-)	0	0 (-)
	2010		21%	0	0 (-)	0	0 (-)
	2011		20%	0	0 (-)	0	0 (-)
Mean Estimated Annual MD Take (CV)					**0 (-)**		**0 (-)**
Mean Estimated Annual UM+ZU Take (CV)					**0 (-)**		**0 (-)**
Hawaii-based shallow-set longline fishery	2007	Observer data	100%	0	0	0	0
	2008		100%	0	0	0	0
	2009		100%	0	0	0	0
	2010		100%	0	0	0	0
	2011		100%	1/0 2/2	0 0.4	0	0
Mean Annual MD Takes (100% coverage)					**0**		**0**
Mean Annual UM + ZU Takes (100% coverage)					**0.4**		**0**
Minimum total annual MD takes within U.S. EEZ							**0 (-)**

Other Mortality

Anthropogenic sound sources, such as military sonar and seismic testing have been implicated in the mass strandings of beaked whales, including atypical events involving multiple beaked whale species (Simmonds and Lopez-Jurado 1991, Frantiz 1998, Anon. 2001, Jepson et al. 2003, Cox et al. 2006). While D'Amico et al. (2009) note that most mass strandings of beaked whales are unassociated with documented sonar activities, lethal or sub-lethal effects of such activities would rarely be documented, due to the remote nature of such activities and the low probability that an injured or dead beaked whale would strand. Filadelpho et al. (2009) reported statistically significant correlations between military sonar use and mass strandings of beaked whales in the Mediterranean and Caribbean Seas, but not in Japanese and Southern California waters, and hypothesized that regions with steep bathymetry adjacent to coastlines are more conducive to stranding events in the presence of sonar use. In Hawaiian waters, Faerber & Baird (2010) suggest that the probability of stranding is lower than in some other regions due to nearshore currents carrying animals away from beaches, and that stranded animals are less likely to be detected due to low human population density near many of Hawaii's beaches. Actual and simulated sonar are known to interrupt the foraging dives and echolocation activities of tagged beaked whales (Tyack et al. 2011, DeRuiter et al. 2013). Cuvier's beaked whales tagged and tracked during simulated mid-frequency sonar exposure showed avoidance reactions, including prolonged diving, cessation of echolocation click production associated with foraging, and directional travel away from the simulated sonar source (DeRuiter et al. 2013). Blainville's beaked whale presence was monitored on hydrophone arrays before, during, and after sonar activities on a Caribbean military range, with evidence of avoidance behavior: whales were detected throughout the range prior to sonar exposure, not detected in the center of the range coincident with highest sonar use, and gradually returned to the range center after the cessation of sonar activity (Tyack et al. 2011). Fernández et al. (2013) report that there have been no mass strandings of beaked whales in the Canary Islands following a 2004 ban on sonar activities in that region. The absence of beaked whale bycatch in California drift gillnets following the introduction of acoustic pingers into the fishery implies additional sensitivity of beaked whales to anthropogenic sound (Carretta et al. 2008, Carretta and Barlow 2011). The impact of sonar exercises on resident versus offshore beaked whales may be significantly different with offshore animals less frequently exposed, and possibly subject to more extreme reactions (Baird *et al.* 2009). No estimates of potential mortality or serious injury are available for U.S. waters.

STATUS OF STOCK

The Hawaii stock of Blainville's beaked whales is not considered strategic under the 1994 amendments to the MMPA The status of Blainville's beaked whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Blainville's beaked whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Given the absence of recorded recent fishery-related mortality or serious injuries within U.S. EEZs, the total fishery mortality and serious injury can be considered to be insignificant and approaching zero. The impacts of anthropogenic sound on beaked whales remain a concern (Barlow and Gisiner 2006, Cox et al. 2006, Hildebrand et al. 2005, Weilgart 2007). One Blainville's beaked whale found stranded on the main Hawaiian Islands has tested positive for *Morbillivirus* (Jacob 2012). Although *morbillivus* is known to trigger lethal disease in cetaceans (Van Bressem et al. 2009), its impact on the health of the stranded animal is not known as it was found in only a few tested tissues (Jacob 2012). The presence of *morbillivirus* in 10 species of cetacean in Hawaiian waters, including all 3 known species of beaked whales (Jacob 2012), raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts on Hawaiian cetaceans.

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CUVIER'S BEAKED WHALE (*Ziphius cavirostris*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Cuvier's beaked whales occur in all oceans and major seas (Heyning 1989). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands, resulted in four sightings in 2002 and 22 in 2010, including markedly higher sighting rates during nearshore surveys in the Northwestern Hawaiian Islands. (Figure 1; Barlow 2006, Bradford et al. 2013).

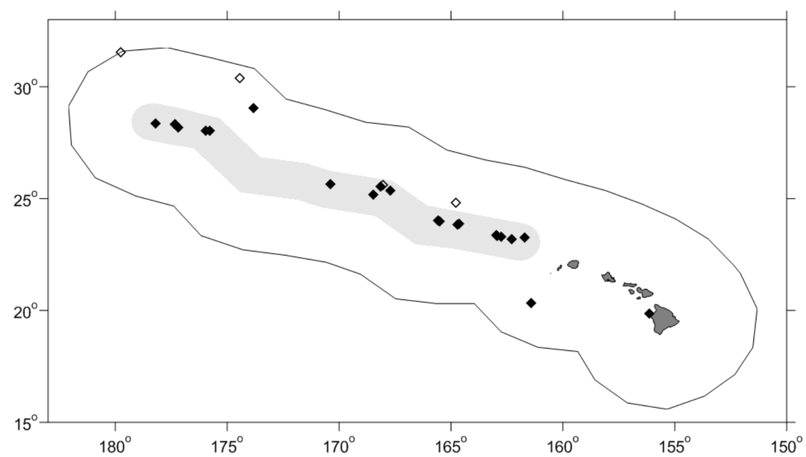

Figure 1. Cuvier's beaked whale sighting locations during the 2002 (open diamonds) and 2010 (black diamonds) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006; see Appendix 2 for details on timing and location of survey effort). Outer line represents approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument.

Resighting and movement data of individual Cuvier's beaked whales suggest the existence of insular and offshore populations of this species in Hawaiian waters. A 21-yr study off Hawaii Island suggests long-term site fidelity and year-round occurrence (McSweeney *et al* 2007). Eight Cuvier's beaked whales have been tagged off Hawaii Island since 2006, with all remaining close to the island of Hawaii for the duration of tag data received (Baird et al 2013). Approximately 95% of all locations were within 45 km of shore and the farthest offshore an individual was documented was 67 km (Baird et al. 2013). The satellite data suggest that a resident population may occur near Hawaii Island, distinct from offshore, pelagic Cuvier's beaked whales. This conclusion is further supported by the long-term site fidelity evident from photo-identification data (McSweeney et al. 2007). Division of this population into a separate island-associated stock may be warranted in the future.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, Cuvier's beaked whales within the Pacific U.S. EEZ are divided into three discrete, non-contiguous areas: 1) Hawaiian waters (this report), 2) Alaskan waters, and 3) waters off California, Oregon and Washington. The Hawaii stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Wade and Gerrodette (1993) estimated population size for Cuvier's beaked whales in the eastern tropical Pacific, but it is not known whether any of these animals are part of the same population that occurs around the Hawaiian Islands. A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 15,242 (CV=1.43) Cuvier's beaked whales (Barlow 2006). The recent 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 1,941 (CV = 0.70) Cuvier's beaked whales (Bradford et al 2013), including a correction factor for missed diving animals. This is currently the best available abundance estimate for the Hawaii stock.

Minimum Population Estimate

Minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al. 1995) of the 2010 abundance estimate, or 1,142 Cuvier's beaked whales.

Current Population Trend

The significant decrease in abundance estimates between the 2002 and 2010 surveys is attributed to the use of higher sea states (beaufort 0–5) in estimating the trackline detection probability for the 2010 survey, compared to the 2002 survey, which utilized only beaufort sea state data 0 through 2 (Bradford et al. 2013). This change in analysis methodology resulted in far less extrapolation over the survey area, resulting in a more representative estimate of abundance. The 2002 survey data have not been reanalyzed using this method. This change precludes evaluation of population trends at this time.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the pelagic stock of Cuvier's beaked whales is calculated as the minimum population estimate for the U.S. EEZ of the Hawaiian Islands (1,142) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a species of unknown status with no known fishery mortality within the Hawaiian Islands EEZ; Wade and Angliss 1997), resulting in a PBR of 11.4 Cuvier's beaked whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. In 1998, a Cuvier's beaked whale stranded possibly entangled, with scars and cuts from fishing gear along its body (Bradford & Lyman 2013). The gear was not described. No other interactions between nearshore fisheries and Cuvier's beaked whales have been reported in Hawaiian waters. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2007 and 2011, no Cuvier's beaked whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (Bradford and Forney 2013, McCracken 2013).

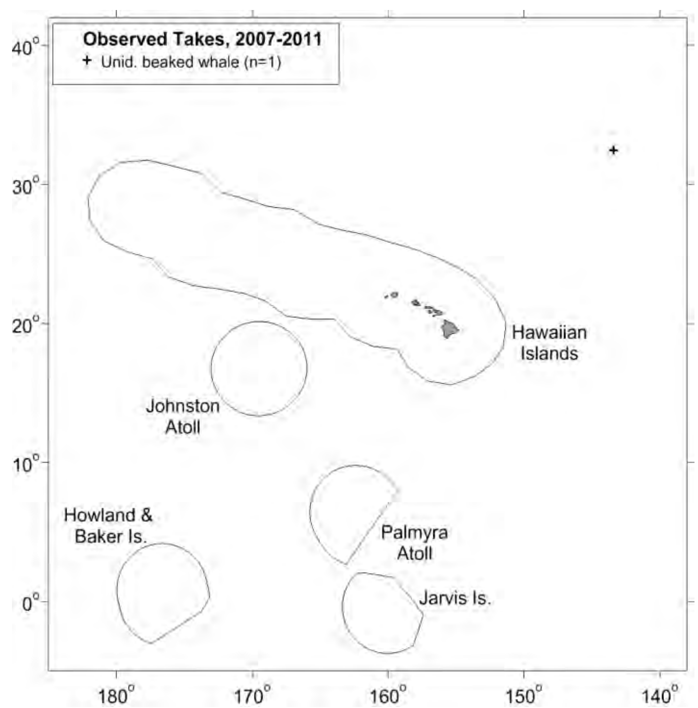

Figure 2. Location of the possible take of Cuvier's beaked whale (cross) in Hawaii-based longline fisheries, 2007-2011. Solid lines represent the U.S. EEZ. Fishery descriptions are provided in Appendix 1.

One unidentified beaked whale was taken in the SSLL fishery and considered seriously injured based on an evaluation of the observer's description of the interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012). Average 5-yr estimates of annual mortality and serious injury for 2007-2011 are zero Cuvier's beaked whales within or outside of the U.S. EEZs, and 0.2 unidentified beaked whales outside the U.S. EEZs (Table 1). Eight unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which could have been Cuvier's beaked whales.

Table 1. Summary of available information on incidental mortality and serious injury of Cuvier's beaked whales (Hawaii pelagic stock) and unidentified beaked whales (ZU) in commercial longline fisheries, within and outside of the Hawaiian Islands EEZ (McCracken 2013). Mean annual takes are based on 2007-2011 data unless otherwise indicated. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.

				Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) unidentified beaked whales			
				Outside U.S. EEZs		Hawaiian EEZ	
Fishery Name	**Year**	**Data Type**	**Percent Observer Coverage**	**Obs. T/MSI**	**Estimated ZU MSI (CV)**	**Obs. T/MSI**	**Estimated ZU MSI (CV)**
Hawaii-based deep-set longline fishery	2007	Observer data	20%	0	0 (-)	0	0 (-)
	2008		22%	0	0 (-)	0	0 (-)
	2009		21%	0	0 (-)	0	0 (-)
	2010		21%	0	0 (-)	0	0 (-)
	2011		20%	0	0 (-)	0	0 (-)
Mean Estimated Annual Unidentified Beaked Whale Take (CV)					**0 (-)**		**0 (-)**
Hawaii-based shallow-set longline fishery	2007	Observer data	100%	0	0	0	0
	2008		100%	0	0	0	0
	2009		100%	0	0	0	0
	2010		100%	0	0	0	0
	2011		100%	1/1	0.2	0	0
Mean Annual Unidentified Beaked Whale Takes (100% coverage)					**0.2**		**0**
Minimum total annual ZI takes within U.S. EEZ							**0 (-)**

Other Mortality

Anthropogenic sound sources, such as military sonar and seismic testing have been implicated in the mass strandings of beaked whales, including atypical events involving multiple beaked whale species (Simmonds and Lopez-Jurado 1991, Frantiz 1998, Anon. 2001, Jepson et al. 2003, Cox et al. 2006). While D'Amico et al. (2009) note that most mass strandings of beaked whales are unassociated with documented sonar activities, lethal or sub-lethal effects of such activities would rarely be documented, due to the remote nature of such activities and the low probability that an injured or dead beaked whale would strand. Filadelpho et al. (2009) reported statistically significant correlations between military sonar use and mass strandings of beaked whales in the Mediterranean and Caribbean Seas, but not in Japanese and Southern California waters, and hypothesized that regions with steep bathymetry adjacent to coastlines are more conducive to stranding events in the presence of sonar use. In Hawaiian waters, Faerber & Baird (2010) suggest that the probability of stranding is lower than in some other regions due to nearshore currents carrying animals away from beaches, and that stranded animals are less likely to be detected due to low human population density near many of Hawaii's beaches. Actual and simulated sonar are known to interrupt the foraging dives and echolocation activities of tagged beaked whales (Tyack et al. 2011, DeRuiter et al. 2013). Cuvier's beaked whales tagged and tracked during simulated mid-frequency sonar exposure showed avoidance reactions, including prolonged diving, cessation of echolocation click production associated with foraging, and directional travel away from the simulated sonar source (DeRuiter et al. 2013). Blainville's beaked whale presence was monitored on hydrophone arrays before, during, and after sonar activities on a Caribbean military range, with evidence of avoidance behavior: whales were detected throughout the range prior to sonar exposure, not detected in the center of the range coincident with highest sonar use, and gradually returned to the range center after the cessation of sonar activity (Tyack et al. 2011). Fernández et al. (2013) report that there have been no mass strandings of beaked whales in the Canary Islands following a 2004 ban on sonar activities in that region. The absence of beaked whale bycatch in California drift gillnets following the introduction of acoustic pingers into the fishery implies additional sensitivity of beaked whales to anthropogenic sound (Carretta et al. 2008, Carretta and Barlow 2011). The impact of sonar exercises on resident versus offshore beaked whales may be significantly different with offshore animals less frequently exposed, and possibly subject to more extreme reactions (Baird *et al.* 2009). No estimates of potential mortality or serious injury are available for U.S. waters.

STATUS OF STOCK

The Hawaii stock of Cuvier's beaked whales is not considered strategic under the 1994 amendments to the MMPA. The status of Cuvier's beaked whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Cuvier's beaked whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. There have been no reported fishery related mortality or injuries within the Hawaiian Islands EEZ, such that the total mortality and serious injury can be considered to be insignificant and approaching zero. The impacts of anthropogenic sound on beaked whales remain a concern (Barlow and Gisiner 2006, Cox et al. 2006, Hildebrand et al. 2005, Weilgart 2007). One Cuvier's beaked whale found stranded on the main Hawaiian Islands tested positive for *Morbillivirus* (Jacob 2012). Although *morbillivus* is known to trigger lethal disease in cetaceans (Van Bressem et al. 2009), its impact on the health of the stranded animal is not known as it was found in only a few tested tissues (Jacob 2012). The presence of *morbillivirus* in 10 species of cetacean in Hawaiian waters, including all 3 known species of beaked whales (Jacob 2012), raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts on Hawaiian cetaceans.

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Revised 6/4/2014

LONGMAN'S BEAKED WHALE (*Indopacetus pacificus*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Longman's beaked whale is considered one of the least known cetacean species (Jefferson et al. 1993; Rice 1998; Dalebout et al. 2003). Until recently, it was known only from two skulls found in Australia and Somalia (Longman 1926; Azzaroli 1968). Recent genetic studies (Dalebout et al. 2003) have revealed that sightings of 'tropical bottlenose whales' (*Hyperoodon* sp.; Pitman et al. 1999) in the Indo-Pacific region were in fact Longman's beaked whales, providing the first description of the external appearance of this species. Although originally described as *Mesoplodon pacificus* (Longman 1926), it has been proposed that this species is sufficiently unique to be placed within its own genus, *Indopacetus* (Moore 1968; Dalebout et al. 2003). The distribution of Longman's beaked whale, as determined from stranded specimens and sighting records of 'tropical bottlenose whales', includes tropical waters from the eastern Pacific westward through the Indian Ocean to the eastern coast of Africa. A single stranding of Longman's beaked whale has been reported in Hawaii, in 2010 near Hana, Maui (West et al. 2012), and there was a single sighting off Kona over 13 years of nearshore surveys off the leeward waters of the main Hawaiian Islands (Baird et al. 2013). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands, resulted in one sighting in 2002 and three in 2010 (Barlow 2006, Bradford et al. 2013; Figure 1).

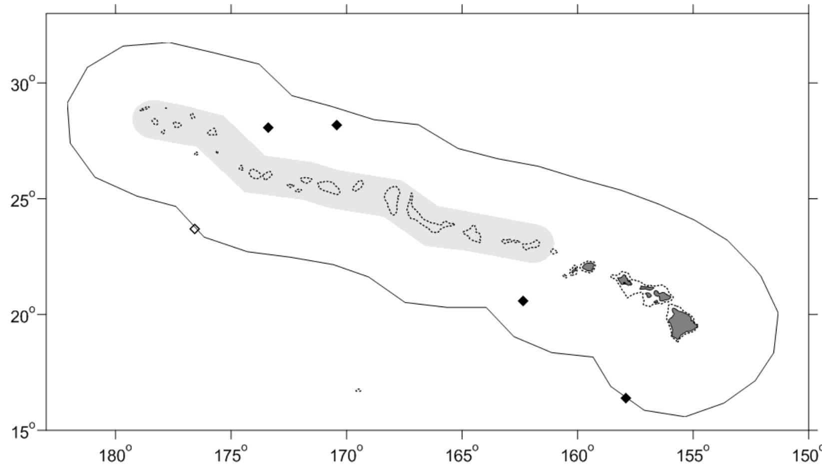

Figure 1. Sighting locations of Longman's beaked whale during the 2002 (open diamond) and 2010 (black diamonds) shipboard cetacean surveys of U.S. waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2013; see Appendix 2 for details on timing and location of survey effort). Outer line indicates approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument. Dotted line represents the 1000m isobath.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there is one Pacific stock of Longman's beaked whales, found within waters of the Hawaiian Islands EEZ. This stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 1,007 (CV=1.25) Longman's beaked whales (Barlow 2006). The recent 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 4,571 (CV = 0.65) Longman's beaked whales (Bradford et al 2013). This is currently the best available abundance estimate for this stock.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al 1995) around the 2010 abundance estimate, or 2,773 Longman's beaked whales within the Hawaiian Islands EEZ.

Current Population Trend

The increase in the abundance estimate for the 2010 survey versus the 2002 survey is attributed primarily to use of beaufort sea states 0-5 in 2010 versus 0-2 in the 2002 when estimating the trackline detection probability, resulting in significantly less extrapolation to unsurveyed areas in 2010 (Bradford et al. 2013). This change in analysis methodology precludes evaluation of population trend at this time.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for Longman's beaked whales.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size within the U.S. EEZ of the Hawaiian Islands (2,773) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no known fishery mortality or serious injury within the Hawaiian Islands EEZ; Wade and Angliss 1997), resulting in a PBR of 28 Longman's beaked whales per year.

HUMAN CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. No interactions between nearshore fisheries and Longman's beaked whales have been reported in Hawaiian waters. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch. There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2007 and 2011, no Longman's beaked whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (McCracken 2013, Bradford & Forney 2013). However, eight unidentified cetaceans, which may have included Longman's beaked whales, were taken in the DSLL fishery, and two unidentified cetaceans, one unidentified Mesoplodon, and one unidentified beaked whale, which may have included Longman's beaked whales, were taken in the SSLL fishery.

Other Mortality

Anthropogenic sound sources, such as military sonar and seismic testing have been implicated in the mass strandings of beaked whales, including atypical events involving multiple beaked whale species (Simmonds and Lopez-Jurado 1991, Frantiz 1998, Anon. 2001, Jepson et al. 2003, Cox et al. 2006). While D'Amico et al. (2009) note that most mass strandings of beaked whales are unassociated with documented sonar activities, lethal or sub-lethal effects of such activities would rarely be documented, due to the remote nature of such activities and the low probability that an injured or dead beaked whale would strand. Filadelpho et al. (2009) reported statistically significant correlations between military sonar use and mass strandings of beaked whales in the Mediterranean and Caribbean Seas, but not in Japanese and Southern California waters, and hypothesized that regions with steep bathymetry adjacent to coastlines are more conducive to stranding events in the presence of sonar use. In Hawaiian waters, Faerber & Baird (2010) suggest that the probability of stranding is lower than in some other regions due to nearshore currents carrying animals away from beaches, and that stranded animals are less likely to be detected due to low human population density near many of Hawaii's beaches. Actual and simulated sonar are known to interrupt the foraging dives and echolocation activities of tagged beaked whales (Tyack et al. 2011, DeRuiter et al. 2013). Cuvier's beaked whales tagged and tracked during simulated mid-frequency sonar exposure showed avoidance reactions, including prolonged diving, cessation of echolocation click production associated with foraging, and directional travel away from the simulated sonar source (DeRuiter et al. 2013). Blainville's beaked whale presence was monitored on hydrophone arrays before, during, and after sonar activities on a Caribbean military range, with evidence of avoidance behavior: whales were detected throughout the range prior to sonar exposure, not detected in the center of the range coincident with highest sonar use, and gradually returned to the range center after the cessation of sonar activity (Tyack et al. 2011). Fernández et al. (2013) report that there have been no mass strandings of beaked whales in the Canary Islands following a 2004 ban on sonar activities in that region. The absence of beaked whale bycatch in California drift gillnets following the introduction of acoustic pingers into the fishery implies additional sensitivity of beaked whales to anthropogenic sound (Carretta et al. 2008, Carretta and Barlow 2011). No estimates of potential mortality or serious injury are available for U.S. waters.

STATUS OF STOCK

The Hawaii stock of Longman's beaked whales is not considered strategic under the 1994 amendments to the MMPA. The status of Longman's beaked whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Longmans' beaked whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Given the absence of recent recorded fishery-related mortality or serious injuries, the total fishery mortality and serious injury can be considered to be insignificant and approaching zero. The impacts of anthropogenic sound on beaked whales remain a concern (Barlow and Gisiner 2006, Cox et al. 2006, Hildebrand et al. 2005, Weilgart 2007). The first confirmed case of *morbillivirus* in a Hawaiian cetacean was found in a subadult Longman's beaked whale stranded on Maui in 2010 (West et al. 2012). The presence of *morbillivirus* in 10 species of cetacean in Hawaiian waters, including all 3 known species of beaked whales (Jacob 2012), raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts on Hawaii cetaceans.

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PYGMY SPERM WHALE (*Kogia breviceps*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Pygmy sperm whales are found throughout the world in tropical and warm-temperate waters (Caldwell and Caldwell 1989). Pygmy sperm whales have been observed in nearshore waters off Oahu, Maui, Niihau, and Hawaii Island (Shallenberger 1981, Mobley et al. 2000, Baird 2005, Baird et al. 2013). Two sightings were made during a 2002 shipboard survey of waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands (Figure 1; Barlow 2006). A freshly dead pygmy sperm whale was picked up approximately 100 nmi north of French Frigate Shoals on a similar 2010 survey (NMFS, unpublished data). Nothing is known about stock structure for this species.

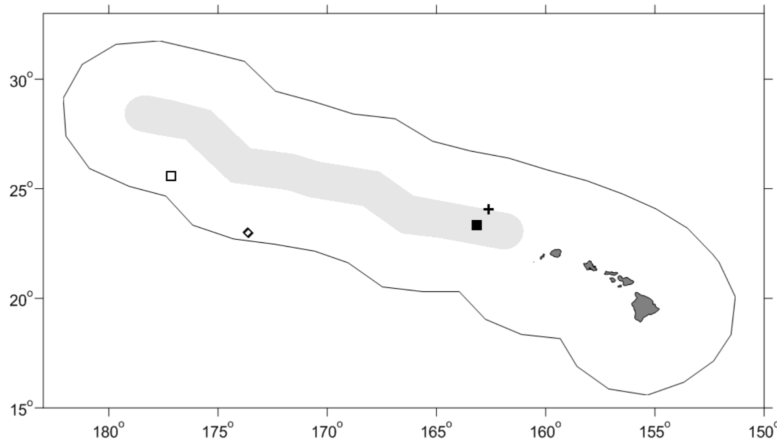

Figure 1. Pygmy sperm whale (open diamond) and unidentified *Kogia* (open square) sighting locations during the 2002 shipboard survey and unidentified *Kogia* (filled square) during the 2010 shipboard cetacean surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2013; see Appendix 2 for details on timing and location of survey effort). A freshly dead pygmy sperm whale was also retrieved during the 2010 survey (cross). Outer line indicates approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, pygmy sperm whales within the Pacific U.S. EEZ are divided into two discreate areas: 1) Hawaiian waters (this report), and 2) waters off California, Oregon and Washington. The Hawaii stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 7,138 (CV=1.12) pygmy sperm whales (Barlow 2006), including a correction factor for missed diving animals. This estimate for the Hawaiian EEZ is more than 8 years old and therefore will no longer be used based on NMFS Guidelines for Assessing Marine Mammal Stocks (NMFS 2005). A 2010 shipboard line-transect survey within the Hawaiian EEZ did not result in any sightings of pygmy sperm whales (Bradford et al. 2013).

Minimum Population Estimate

No minimum estimate of abundance is available for pygmy sperm whales, as there were no on-effort sightings during a 2010 shipboard line-transect survey of the Hawaiian EEZ.

Current Population Trend

No data are available on current population abundance or trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size within the U.S EEZ of the Hawaiian Islands <u>times</u> one half the default maximum net growth rate for cetaceans (½ of

4%) times a recovery factor of 0.50 (for a stock of unknown status with no known fishery mortality or serious injury within the Hawaiian Islands EEZ; Wade and Angliss 1997). Because there is no minimum population size estimate for pygmy sperm whales in Hawaii, the PBR is undetermined.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. One pygmy sperm whale was found entangled in fishing gear off Oahu in 1994 (Bradford & Lyman 2013), but the gear was not described and the fishery not identified. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2007 and 2011, one pygmy or dwarf sperm whale was observed hooked in the SSLL fishery (100% observer coverage) (Figure 2, Bradford & Forney 2013, McCracken 2013). Based on an evaluation of the observer's description of the interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012), this animal was considered not seriously injured (Bradford & Forney 2013). No pygmy sperm whales were observed hooked or entangled in the DSLL fishery (20-22% observer coverage). Eight unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been pygmy sperm whales.

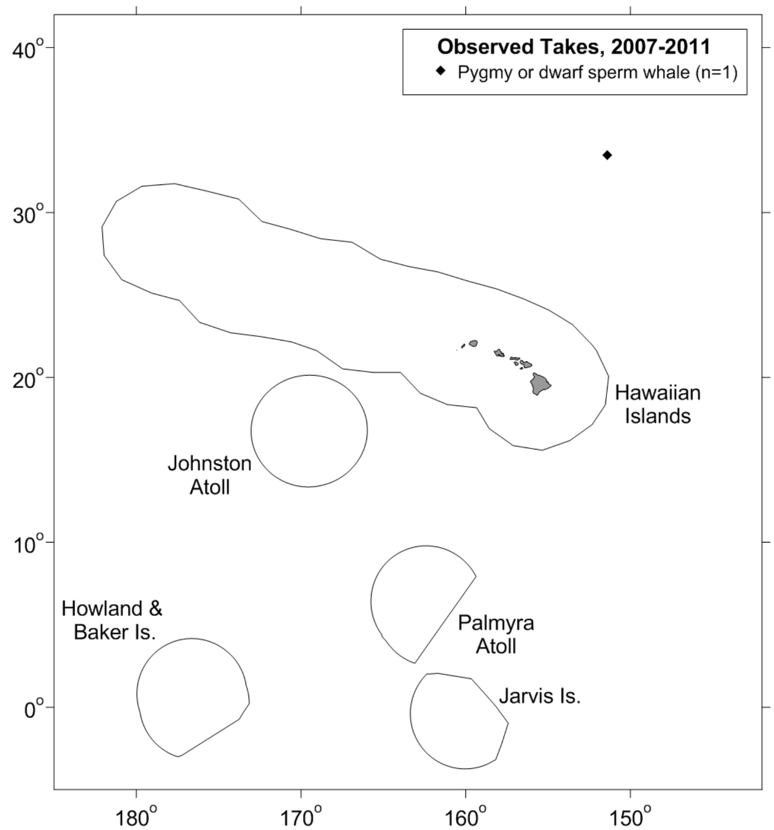

Figure 2. Location of pygmy or dwarf sperm whale takes (filled diamond) in Hawaii-based longline fisheries, 2007-2011. Solid lines represent the U.S. EEZs. Fishery descriptions are provided in Appendix 1.

STATUS OF STOCK

The Hawaii stock of pygmy sperm whales is not considered strategic under the 1994 amendments to the MMPA. The status of pygmy sperm whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Pygmy sperm whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Given the absence of recent recorded fishery-related mortality or serious injuries within the Hawaiian Islands EEZ, the total fishery mortality and serious injury can be considered to be insignificant and approaching zero. The increasing level of anthropogenic noise in the world's oceans has been suggested to be a habitat concern for whales (Richardson et al. 1995), particularly for deep-diving whales like pygmy sperm whales that feed in the oceans' "sound channel". One pygmy sperm whale found stranded in the main Hawaiian Islands tested positive for *Morbillivirus* (Jacob 2012). Although *morbillivus* is known to trigger lethal disease in cetaceans (Van Bressem et al. 2009), its impact on the health of the stranded animal is unknown (Jacob 2012). The presence of *morbillivirus* in 10 species of cetacean in Hawaiian waters (Jacob 2012) raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts on Hawaiian cetaceans.

Table 1. Summary of available information on incidental mortality and serious injury of pygmy sperm whales (Hawaiian stock) in commercial longline fisheries within and outside of the Hawaiian Islands EEZ (McCracken 2013). Mean annual takes are based on 2007-2011 data unless otherwise indicated. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of pygmy sperm whales			
				Outside U.S. EEZs		Inside Hawaiian EEZ	
				Obs. T/MSI	Estimated M&SI (CV)	Obs. T/MSI	Estimated M&SI (CV)
Hawaii-based deep-set longline fishery	2007	Observer data	20%	0	0 (-)	0	0 (-)
	2008		22%	0	0 (-)	0	0 (-)
	2009		21%	0	0 (-)	0	0 (-)
	2010		21%	0	0 (-)	0	0 (-)
	2011		20%	0	0 (-)	0	0 (-)
Mean Estimated Annual Take (CV)					**0 (-)**		**0 (-)**
Hawaii-based shallow-set longline fishery	2007	Observer data	100%	0	0	0	0
	2008		100%	1*/0	0	0	0
	2009		100%	0	0	0	0
	2010		100%	0	0	0	0
	2011		100%	0	0	0	0
Mean Annual Takes (100% coverage)					**0**		**0**
Minimum total annual takes within U.S. EEZ							**0 (-)**

*One animal was identified as either a pygmy sperm whale or a dwarf sperm whale.

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Revised 6/4/2014

DWARF SPERM WHALE (*Kogia sima*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

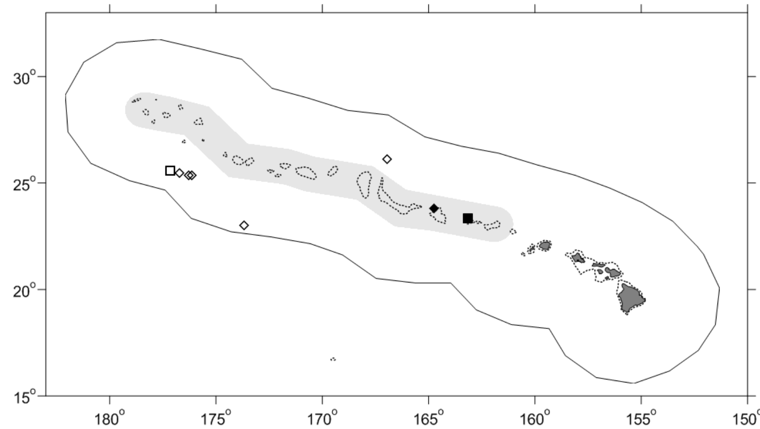

Figure 1. Dwarf sperm whale (diamonds) and unidentified *Kogia* (squares) sighting locations during the 2002 (open symbols) and 2010 (black symbols) shipboard cetacean surveys of U.S. waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2013; see Appendix 2 for details on timing and location of survey effort). Outer line indicates approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument. Dotted line represents the 1000m isobath.

Dwarf sperm whales are found throughout the world in tropical to warm-temperate waters (Nagorsen 1985). At least eight strandings of dwarf sperm whales have been documented in Hawaii since 1985 (Tomich 1986; Nitta 1991; Maldini et al. 2005, NMFS PIR Marine Mammal Response Network database), including two since 2007. From 2002 and 2012, dwarf sperm whales have been seen near Niihau, Kauai, Oahu, Lanai, and Hawaii during small boat surveys (Baird et al 2005, Baird et al 2013). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands resulted in five sightings of dwarf sperm whales during 2002 and one during 2010 (Figure 1; Barlow 2006, Bradford et al. 2013).

Small boat surveys within the main Hawaiian Islands (MHI) since 2002 have documented dwarf sperm whales on 73 occasions, most commonly in water depths between 500m and 1,000m (Baird et al. 2013). Long-term site-fidelity is evident off Hawaii Island, with one third of the distinctive individuals seen there encountered in more than one year. Resighting data from 25 individuals documented at Hawaii Island suggest an island-resident population with restricted range, with all encounters in less than 1,600m water depth and less than 20 km from shore (Baird et al 2013). Division of this population into a separate island-associated stock may be warranted in the future. For the Marine Mammal Protection Act (MMPA) stock assessment reports, dwarf sperm whales within the Pacific U.S. EEZ are divided into two discrete, non-contiguous areas: 1) Hawaiian waters (this report), and 2) waters off California, Oregon and Washington. The Hawaii stock includes animals found within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Wade and Gerrodette (1993) provided an estimate for the eastern tropical Pacific, but it is not known whether these animals are part of the same population that occurs in the central North Pacific. This species' small size, tendency to avoid vessels, and deep-diving habits, combined with the high proportion of *Kogia* sightings that are not identified to species, may result in negatively biased estimates of relative abundance in this region. A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 17,519 (CV=0.74) dwarf sperm whales (Barlow 2006), including a correction factor for missed diving animals. There were no on-effort sightings of dwarf sperm whales during the 2010 shipboard survey of the Hawaiian EEZ (Bradford et al 2013), such that there is no current abundance estimate for this stock.

Minimum Population Estimate

The log-normal 20th percentile of the 2002 abundance estimate (Barlow 2006) is 10,043 dwarf sperm whales within the Hawaiian Islands EEZ; however, the minimum abundance estimate for the entire Hawaiian EEZ is ≥ 8 years old and will no longer be used (NMFS 2005). No minimum estimate of abundance is available for this stock, as there were no sightings of dwarf sperm whales during a 2010 shipboard line-transect survey of the Hawaiian EEZ.

Current Population Trend

No data are available on current population abundance or trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size within the U.S. EEZ of the Hawaiian Islands times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no known fishery mortality or serious injury within the Hawaiian Islands EEZ; Wade and Angliss 1997). Because there is no minimum population size estimate for Hawaii pelagic dwarf sperm whales, the PBR is undetermined.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. No interactions between nearshore fisheries and dwarf sperm whales have been reported in Hawaiian waters. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2007 and 2011, one pygmy or dwarf sperm whale was observed hooked in the SSLL fishery (100% observer coverage) (Figure 2, McCracken 2013, Bradford & Forney 2013). Based on an evaluation of the observer's description of the interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012), this

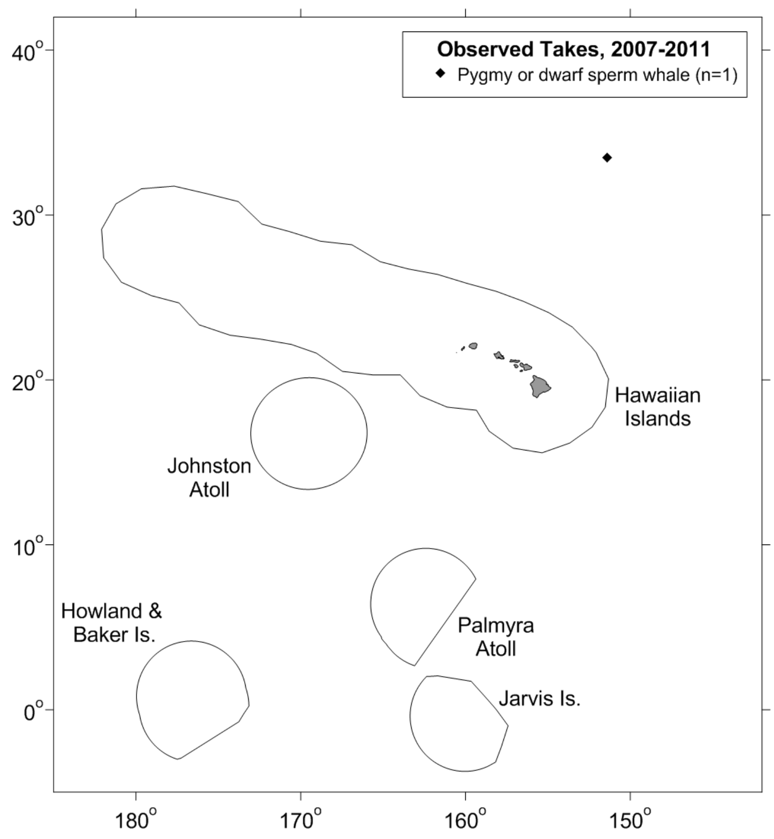

Figure 2. Location of pygmy or dwarf sperm whale take (filled diamond) in Hawaii-based longline fisheries, 2007-2011. Solid lines represent the U.S. EEZs. Fishery descriptions are provided in Appendix 1.

animal was considered not seriously injured (Bradford & Forney 2013). No dwarf sperm whales were observed hooked or entangled in the DSLL fishery (20-22% observer coverage). Eight unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been dwarf sperm whales.

Table 1. Summary of available information on incidental mortality and serious injury of dwarf sperm whales (Hawaii stock) in commercial longline fisheries, within and outside of the Hawaiian Islands EEZ (McCracken 2013). Mean annual takes are based on 2007-2011 data unless otherwise indicated. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of dwarf sperm whales			
				Outside U.S. EEZs		Inside Hawaiian EEZ	
				Obs. T/MSI	Estimated M&SI (CV)	Obs. T/MSI	Estimated M&SI (CV)
Hawaii-based deep-set longline fishery	2007	Observer data	20%	0	0 (-)	0	0 (-)
	2008		22%	0	0 (-)	0	0 (-)
	2009		21%	0	0 (-)	0	0 (-)
	2010		21%	0	0 (-)	0	0 (-)
	2011		20%	0	0 (-)	0	0 (-)
Mean Estimated Annual Take (CV)					**0 (-)**		**0 (-)**
Hawaii-based shallow-set longline fishery	2007	Observer data	100%	0	0	0	0
	2008		100%	1*/0	0	0	0
	2009		100%	0	0	0	0
	2010		100%	0	0	0	0
	2011		100%	0	0	0	0
Mean Annual Takes (100% coverage)					**0**		**0**
Minimum total annual takes within U.S. EEZ							**0 (-)**

*One animal was identified as either a pygmy sperm whale or a dwarf sperm whale.

STATUS OF STOCK

The Hawaii stock of dwarf sperm whales is not considered strategic under the 1994 amendments to the MMPA. The status of dwarf sperm whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Dwarf sperm whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. There have been no reported fishery related mortality or injuries within the Hawaiian Islands EEZ, such that the total mortality and serious injury can be considered to be insignificant and approaching zero. The increasing levels of anthropogenic noise in the world's oceans has been suggested to be a habitat concern for whales (Richardson et al. 1995), particularly for deep-diving whales like dwarf sperm whales that feed in the oceans' "sound channel".

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Revised 6/4/2014

SPERM WHALE (*Physeter macrocephalus*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

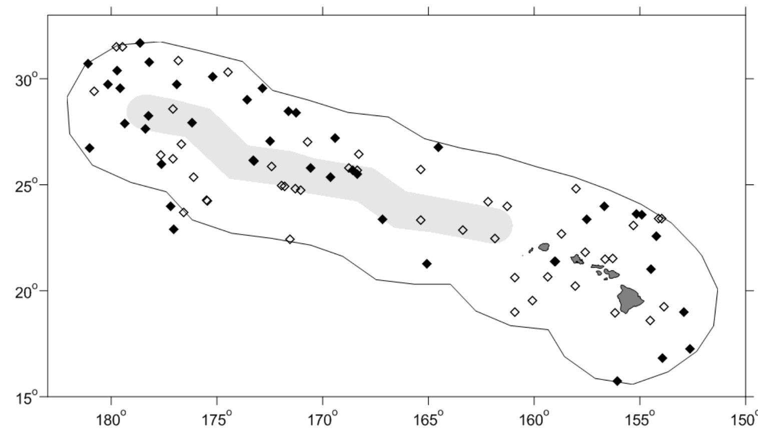

Figure 1. Sperm whale sighting locations during the 2002 (open diamonds) and 2010 (black diamonds) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2013; see Appendix 2 for details on timing and location of survey effort). Outer line represents approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument.

Sperm whales are widely distributed across the entire North Pacific and into the southern Bering Sea in summer but the majority are thought to be south of 40^{o}N in winter (Rice 1974, 1989; Gosho et al. 1984; Miyashita et al. 1995). For management, the International Whaling Commission (IWC) had divided the North Pacific into two management regions (Donovan 1991) defined by a zig-zag line which starts at 150^{o}W at the equator to 160^{o}W between 40-50^{o}N, and ending at 180^{o}W north of 50^{o}N; however, the IWC has not reviewed this stock boundary in many years (Donovan 1991). Summer/fall surveys in the eastern tropical Pacific (Wade and Gerrodette 1993) show that although sperm whales are widely distributed in the tropics, their relative abundance tapers off markedly westward towards the middle of the tropical Pacific (near the IWC stock boundary at 150^{o}W) and tapers off northward towards the tip of Baja California. The Hawaiian Islands marked the center of a major nineteenth century whaling ground for sperm whales (Gilmore 1959; Townsend 1935). Since 1936, at least 28 strandings have been reported from the Hawaiian Islands (Woodward 1972; Nitta 1991; Maldini et al. 2005, NMFS PIR Marine Mammal Response Network databse), including 7 since 2007. Sperm whales have also been sighted throughout the Hawaiian EEZ, including nearshore waters of the main and Northwestern Hawaiian Islands (Rice 1960; Barlow 2006; Lee 1993; Mobley et al. 2000; Shallenberger 1981). In addition, sperm whale sounds have been recorded throughout the year off Oahu (Thompson and Friedl 1982). Summer/fall shipboard surveys of waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands resulted in 43 sperm whale sightings in 2002 and 46 in 2010 throughout the study area (Figure 1; Barlow 2006, Bradford et al. 2013).

The stock identity of sperm whales in the North Pacific has been inferred from historical catch records (Bannister and Mitchell 1980) and from trends in CPUE and tag-recapture data (Ohsumi and Masaki 1977). A 1997 survey designed specifically to investigate stock structure and abundance of sperm whales in the northeastern temperate Pacific revealed no apparent hiatus in distribution between the U.S. EEZ off California and areas farther west, out to Hawaii (Barlow and Taylor 2005). Recent genetic analyses revealed significant differences in mitochondrial and nuclear DNA and in single-nucleotide polymorphisms between sperm whales sampled off the coast of California, Oregon and Washington and those sampled near Hawaii and in the eastern tropical Pacific (ETP) (Mesnick et al. 2011). These results suggest demographic independence between matrilineal groups found California, Oregon, and Washington, and those found elsewhere in the central and eastern tropical Pacific. Further, assignment tests identified male sperm whales sampled in the sub-Arctic with each of the three regions, suggesting mixing of males from potentially several populations during the summer (Mesnick et al. 2011).

For the Marine Mammal Protection Act (MMPA) stock assessment reports, sperm whales within the Pacific U.S. EEZ are divided into three discrete, non-contiguous stocks: 1) waters around Hawaii (this report), 2) California, Oregon and Washington waters, and 3) Alaskan waters. The Hawaii stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of the Hawaii stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

A large 1982 abundance estimate for the entire eastern North Pacific (Gosho et al. 1984) was based on a CPUE method which is no longer accepted as valid by the International Whaling Commission. A spring 1997 combined visual and acoustic line-transect survey conducted in the eastern temperate North Pacific resulted in estimates of 26,300 (CV=0.81) sperm whales based on visual sightings, and 32,100 (CV=0.36) based on acoustic detections and visual group size estimates (Barlow and Taylor 2005). Sperm whales appear to be a good candidate for acoustic surveys due to the increased range of detection; however, visual estimates of group size are still required (Barlow and Taylor 2005). In the eastern tropical Pacific, the abundance of sperm whales has been estimated as 22,700 (95% C.I.=14,800-34,600; Wade and Gerrodette 1993). However, it is not known whether any or all of these animals routinely enter the U.S. EEZ of the Hawaiian Islands. A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 6,919 (CV=0.81) sperm whales (Barlow 2006). The recent 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 3,354 (CV = 0.34) sperm whales (Bradford et al. 2013), including a correction factor for missed diving animals. This is currently the best available abundance estimate for this stock.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al. 1995) around the 2010 abundance estimate or 2,539 sperm whales within the Hawaiian Islands EEZ.

Current Population Trend

The broad and overlapping confidence intervals around the 2002 and 2010 estimates preclude assessment of trend with the available data.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data on current or maximum net productivity rate are available.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii stock of sperm whales is calculated as the minimum population size (2,539) within the U.S. EEZ of the Hawaiian Islands times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.2 (for an endangered species with N_{min} > 1,500 and CV_{Nmin} > 0.50, with low vulnerability to extinction; (Taylor et al. 2003), resulting in a PBR of 10.2 sperm whales per year.

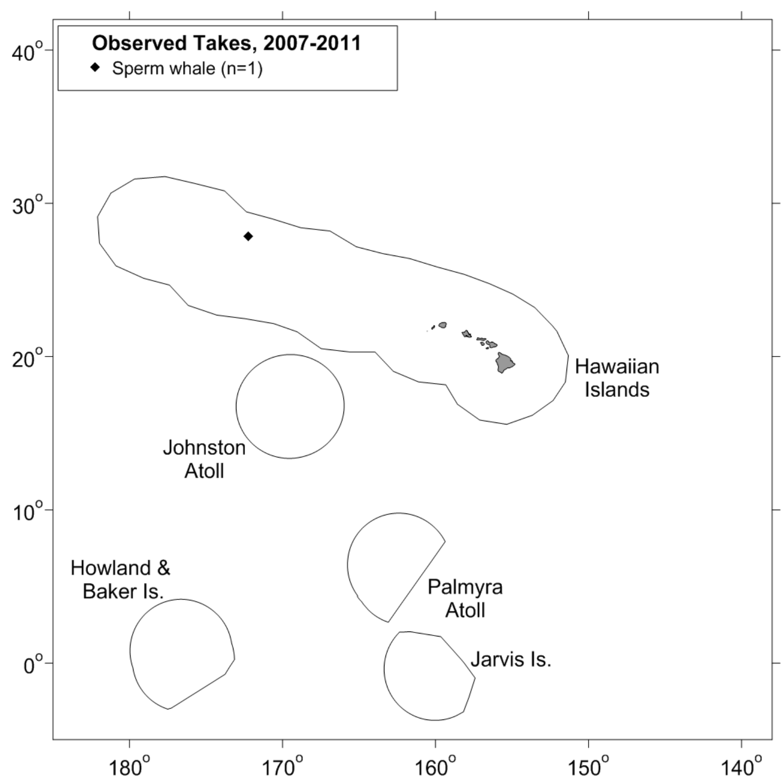

Figure 2. Locations of observed sperm whale take (filled diamonds) in the Hawaii-based longline fishery, 2007-2011. Solid lines represent the U. S. EEZ. Fishery descriptions are provided in Appendix 1.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen *et al*. 2008, NMFS 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. One stranded sperm whale was found with fishing line and netting its stomach, though it is unclear whether the gear caused its death, nor what fisheries the gear came from (NMFS PIR MMRN). No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas Between 2007 and 2011, no sperm whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) and one was observed either hooked or entangled in the DSLL fishery (20-22% observer coverage) (Bradford & Forney 2013). The observer could not determine whether the whale was hooked or entangled; however, the mainline came under tension when the animal surfaced. The whale was cut free with the hook, 0.5m wire leader, 45g weight, 12m of branchline, and 25-30 ft of mainline possibly attached. This interaction was prorated as 75% probability of serious injury because the whale was hooked or entangled but the exact nature of the injury could not be determined (Bradford & Forney 2013). This determination is based on an evaluation of the observer's description of the interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012). The prorating of serious injury is based on the proportion of known outcomes for whales with similar fisheries interactions in other regions. Average 5-yr estimates of annual mortality and serious injury for sperm whales during 2007-2011 are zero sperm whales outside of U.S. EEZs, and 0.7 (CV = 0.6) within the Hawaiian Islands EEZ (Table 1, McCracken 2013).

Table 1. Summary of available information on incidental mortality and serious injury of sperm whales in commercial longline fisheries, within and outside of the U.S. EEZs (McCracken 2013). Mean annual takes are based on 2007-2011 data. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of sperm whales			
				Outside U.S. EEZs		Hawaiian EEZ	
				Obs. T/MSI	Estimated M&SI (CV)	Obs. T/MSI	Estimated M&SI (CV)
Hawaii-based deep-set longline fishery	2007	Observer data	20%	0	0 (-)	0	0 (-)
	2008		22%	0	0 (-)	0	0 (-)
	2009		21%	0	0 (-)	0	0 (-)
	2010		21%	0	0 (-)	0	0 (-)
	2011		20%	0	0 (-)	1/1*	3 (0.2)
Mean Estimated Annual Take (CV)					**0 (-)**		**0.7 (0.5)**
Hawaii-based shallow-set longline fishery	2007	Observer data	100%	0	0	0	0
	2008		100%	0	0	0	0
	2009		100%	0	0	0	0
	2010		100%	0	0	0	0
	2011		100%	0	0	0	0
Mean Annual Takes (100% coverage)							**0**
Minimum total annual takes within U.S. EEZ							**0.7 (0.5)**

*This injury was prorated 75% probability of being a serious injury based on known outcomes from other whales with this injury type (NOAA 2012).

Historical Mortality

Between 1800 and 1909, about 60,842 sperm whales were estimated taken in the North Pacific (Best 1976). The reported take of North Pacific sperm whales by commercial whalers between 1947 and 1987 totaled 258,000 (C.

Allison, pers. comm.). Factory ships operated as far south as 20°N (Ohsumi 1980). Ohsumi (1980) lists an additional 28,198 sperm whales taken mainly in coastal whaling operations from 1910 to 1946. Based on the massive under-reporting of Soviet catches, Brownell et al. (1998) estimated that about 89,000 whales were additionally taken by the Soviet pelagic whaling fleet between 1949 and 1979. Japanese coastal operations apparently also under-reported catches by an unknown amount (Kasuya 1998). Thus a total of at least 436,000 sperm whales were taken between 1800 and the end of commercial whaling for this species in 1987. Of this grand total, an estimated 33,842 were taken by Soviet and Japanese pelagic whaling operations in the eastern North Pacific from the longitude of Hawaii to the U.S. West coast, between 1961 and 1976 (Allen 1980, IWC statistical Areas II and III), and 965 were reported taken in land-based U.S. West coast whaling operations between 1947 and 1971 (Ohsumi 1980). In addition, 13 sperm whales were taken by shore whaling stations in California between 1919 and 1926 (Clapham et al. 1997). There has been a prohibition on taking sperm whales in the North Pacific since 1988, but large-scale pelagic whaling stopped earlier, in 1980. Some of the whales taken during the whaling era were certainly from a population or populations that occur within Hawaiian waters.

STATUS OF STOCK

The only estimate of the status of North Pacific sperm whales in relation to carrying capacity (Gosho et al. 1984) is based on a CPUE method which is no longer accepted as valid. The status of sperm whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Sperm whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently the Hawaiian stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. The estimated rate of fisheries related mortality or serious injury within the Hawaiian Islands EEZ (0.7 animals per year) is less than the PBR (10.2). Insufficient information is available to determine whether the total fishery mortality and serious injury for sperm whales is insignificant and approaching zero mortality and serious injury rate. The increasing level of anthropogenic noise in the world's oceans has been suggested to be a habitat concern for whales (Richardson et al. 1995), particularly for deep-diving whales like sperm whales that feed in the oceans' "sound channel". One sperm whale stranded in the main Hawaiian Islands tested positive for both *Brucella* and *Morbillivirus* (Jacob 2012, West, unpublished data). *Brucella* is a bacterial infection that may limit recruitment by compromising male and female reproductive systems if it is common in the population, and it can also cause neurological disorders that may result in death (Van Bressem et al. 2009). *Morbillivus* is known to trigger lethal disease in cetaceans (Van Bressem et al. 2009); however, investigation of the pathology of the stranded sperm whale suggests that *Brucella* was more likely the cause of death in this sperm whale (West, unpublished data). The presence of *Morbillivirus* in 10 species (Jacob 2012) and *Brucella* in 3 species (Cherbov 2010, West unpublished data) raises concerns about the history and prevalence of these diseases in Hawaii and the potential population impacts on Hawaiian cetaceans. It is not known if *Brucella or Morbillivirus* are common in the Hawaii stock.

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BLUE WHALE (*Balaenoptera musculus musculus*): Central North Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The International Whaling Commission (IWC) has formally considered only one management stock for blue whales in the North Pacific (Donovan 1991), but up to five populations have been proposed (Reeves et al. 1998). Rice (1974) hypothesized that blue whales from Baja California migrated far offshore to feed in the eastern Aleutians or Gulf of Alaska and returned to feed in California waters; though more recently concluded that the California population is separate from the Gulf of Alaska population (Rice 1992). Length frequency analyses (Gilpatrick et al. 1996) and photo-identification studies (Calambokidis et al. 1995) through the 1990s supported separate populations for blue whales feeding off California and those feeding in Alaskan waters. Whaling catch data indicated that whales feeding along the Aleutian Islands were probably part of a central Pacific stock (Reeves et al. 1998), which was thought to migrate to offshore waters north of Hawaii in winter (Berzin and Rovnin 1966). Blue whale feeding aggregations have not been found in Alaska despite several surveys (Leatherwood et al. 1982; Stewart et al. 1987; Forney and Brownell 1996). More recently, analyses of acoustic data obtained throughout the North Pacific (Stafford et al. 2001; Stafford 2003) have revealed two distinct blue whale call types, suggesting two North Pacific stocks: eastern and central (formerly western). The regional occurrence patterns suggest that blue whales from the eastern North Pacific stock winter off Mexico, Central America, and as far south as 8° S (Stafford et al. 1999), and feed during summer off the U. S. West Coast and to a lesser extent in the Gulf of Alaska. This stock has previously been observed to feed in waters off California (and occasionally as far north as British Columbia; Calambokidis et al. 1998) in summer/fall (from June to November) migrating south to productive areas off Mexico (Calambokidis et al. 1990) and as far south as the Costa Rica Dome (10° N) in winter/spring (Mate et al. 1999, Stafford et al. 1999). Blue whales belonging to the central Pacific stock appear to feed in summer southwest of Kamchatka, south of the Aleutians, and in the Gulf of Alaska (Stafford 2003; Watkins et al. 2000), and in winter migrate to lower latitudes in the western and central Pacific, including Hawaii (Stafford et al. 2001).

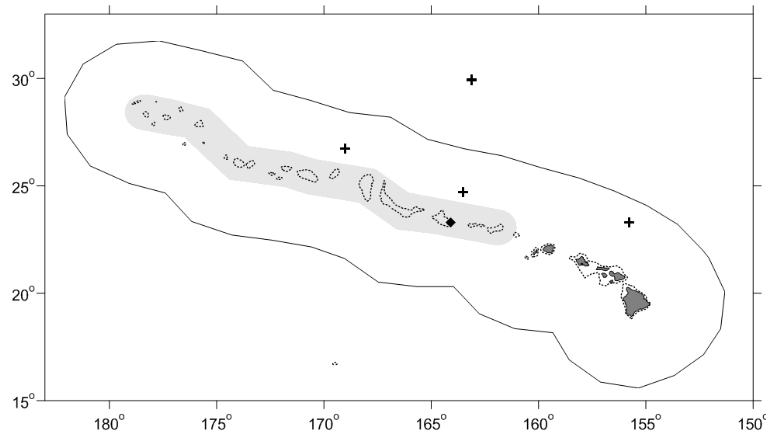

Figure 1. Locations of blue whale sightings made by observers aboard Hawaii-based longline fishing vessels between July 1994 and December 2009 (crosses, NMFS/PIR unpublished data), and location of a single blue whale sighting during a 2010 (black diamond) shipboard cetacean survey of U.S. EEZ waters surrounding the Hawaiian Islands (Bradford et al. 2013; see Appendix 2 for details on timing and location of survey effort). Outer line indicates approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument. Dotted line represents the 1000m isobath.

The first published sighting record of blue whales near Hawaii is that of Berzin and Rovnin (1966), though recently, two blue whales were seen with fin whales and an unidentified rorqual in November 2010 during a survey of Hawaiian U.S. EEZ waters (Bradford et al. 2013). Four sightings have been made by observers on Hawaii-based longline vessels (Figure 1; NMFS/PIR, unpublished data). Additional evidence that blue whales occur in this area comes from acoustic recordings made off Oahu and Midway Islands (Northrop et al. 1971; Thompson and Friedl 1982), which likely included at least some whales within the EEZ. The recordings made off Hawaii showed bimodal peaks throughout the year (Stafford et al. 2001), with central Pacific call types heard during winter and eastern Pacific calls heard during summer. For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are two blue whale stocks within the Pacific U.S. EEZ: 1) the central North Pacific stock (this report), which includes whales found around the Hawaiian Islands during winter and 2) the eastern North Pacific stock, which feeds primarily off California.

POPULATION SIZE

From ship line-transect surveys, Wade and Gerrodette (1993) estimated 1,400 blue whales for the eastern tropical Pacific. No blue whale sightings were made during summer/fall 2002 shipboard surveys of the entire Hawaiian Islands EEZ (Barlow 2006). A 2010 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in a summer/fall abundance estimate of 81 (CV = 1.14) blue whales (Bradford et al. 2013). This is currently the best available abundance estimate for this stock within the Hawaii EEZ, but the majority of blue whales would be expected to be at higher latitudes feeding grounds at this time of year.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al. 1995) of the 2010 abundance estimate, or 38 blue whales within the Hawaiian Islands EEZ.

Current Population Trend

The first sightings of blue whales during systematic surveys occurred in 2010, and there is currently insufficient data to assess population trends.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Central North Pacific stock of blue whales is calculated as the minimum population size within the U.S. EEZ of the Hawaiian Islands (38) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.1 (the default value for an endangered species with N_{min} <1500; Taylor et al. 2003), resulting in a PBR of 0.1 Central Pacific blue whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen *et al*. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2007 and 2011, no blue whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (McCracken 2013, Bradford & Forney 2013).

Historical Mortality

At least 9,500 blue whales were taken by commercial whalers throughout the North Pacific between 1910 and 1965 (Ohsumi and Wada 1972). Some proportion of this total may have been from a population or populations that migrate seasonally into the Hawaiian EEZ. The species has been protected in the North Pacific by the IWC since 1966.

STATUS OF STOCK

The status of blue whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Blue whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently the central Pacific stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. Because there have been no reported fishery related mortality or serious injuries of blue whales within the Hawaiian Islands EEZ, the total fishery-related mortality and serious injury of this stock can be considered to be insignificant and approaching zero. Increasing levels of anthropogenic noise in the world's oceans has been suggested to be a habitat concern for blue whales (Reeves et al. 1998). Tagged blue whales exposed to simulated mid-frequency sonar and pseudo-random noise demonstrated a variety of behavioral responses, including no change in behavior, termination of deep dives, directed travel away from sound sources, and cessation of feeding (Goldbogen et al. 2013). Behavioral responses were highly dependent upon the type of sound source and the behavioral state of the animal at the time of exposure. Deep-feeding and non-feeding whales reacted more strongly to experimental sound sources than surface-feeding whales that typically showed no change in behavior. The authors stated that behavioral responses to such sounds are influenced by a complex interaction of behavioral state, environmental context, and prior exposure of individuals to such sound sources. One concern expressed by the authors is if blue whales did not habituate to such sounds near feeding areas that "repeated exposures could negatively impact individual feeding performance, body condition and ultimately fitness and potentially population health." Currently, no evidence indicates that such reduced population health exists, but such evidence would be difficult to differentiate from natural sources of reduced fitness or mortality in the population.

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FIN WHALE (*Balaenoptera physalus physalus*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

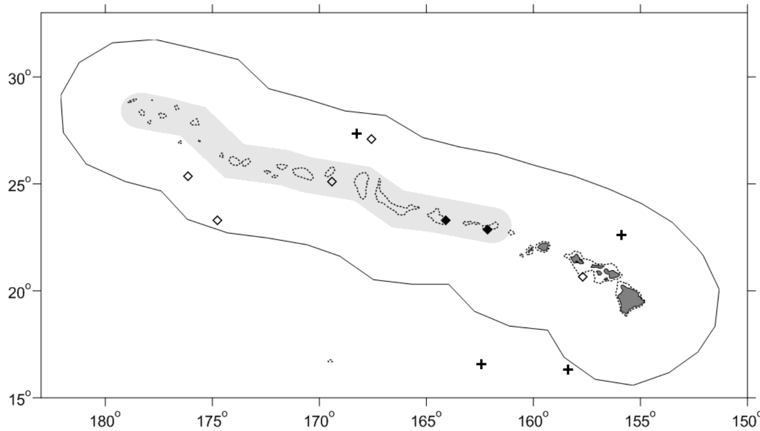

Figure 1. Locations of fin whale sightings from longline observer records (crosses; NMFS/PIR, unpublished data) and sighting locations during the 2002 (open diamonds) and 2010 (black diamonds) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2003, Bradford et al 2013; see Appendix 2 for details on timing and location of survey effort). Outer line represents approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument. Dotted line represents the 1000m isobath.

Fin whales are found throughout all oceans from tropical to polar latitudes. They have been considered rare in Hawaiian waters and are absent to rare in eastern tropical Pacific waters (Hamilton et al. 2009). Balcomb (1987) observed 8-12 fin whales in a multispecies feeding assemblage on 20 May 1966 approx. 250 mi. south of Honolulu. Additional sightings were reported north of Oahu in May 1976, in the Kauai Channel in February 1979 (Shallenberger 1981), north of Kauai in February 1994 (Mobley et al. 1996), and off Lanai in 2012 (Baird unpublished data). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands resulted in five sightings in 2002 and two sightings in 2010 (Barlow 2003, Bradford et al 2013; Figure 1). A single stranding was reported on Maui in 1954 (Shallenberger 1981). Thompson and Friedl (1982; and see Northrop et al. 1968) suggested that fin whales migrate into Hawaiian waters mainly in fall and winter, based on acoustic recordings off Oahu and Midway Islands. Although the exact positions of the whales producing the sounds could not be determined, at least some of them were almost certainly within the U.S. EEZ. More recently, McDonald and Fox (1999) reported an average of 0.027 calling fin whales per 1000^2 km (grouped by 8-hr periods) based on passive acoustic recordings within about 16 km of the north shore of Oahu.

The International Whaling Commission (IWC) recognized two stocks of fin whales in the North Pacific: the East China Sea and the rest of the North Pacific (Donovan 1991). Mizroch et al. (1984) cite evidence for additional fin whale subpopulations in the North Pacific. There is still insufficient information to accurately determine population structure, but from a conservation perspective it may be risky to assume panmixia in the entire North Pacific. In the North Atlantic, fin whales were locally depleted in some feeding areas by commercial whaling (Mizroch et al. 1984), in part because subpopulations were not recognized. The Marine Mammal Protection Act (MMPA) stock assessment reports recognize three stocks of fin whales in the North Pacific: 1) the Hawaii stock (this report), 2) the California/Oregon/Washington stock, and 3) the Alaska stock. The Hawaiian stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Using passive acoustic detections from a hydrophone north of Oahu, MacDonald and Fox (1999) estimated an average density of 0.027 calling fin whales per 1000 km^2 within about 16 km from shore. However, the relationship between the number of whales present and the number of calls detected is not known, and therefore this acoustic method does not provide an estimate of absolute abundance for fin whales. A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 174 (CV=0.72) fin whales (Barlow 2003). The recent 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 58 (CV = 1.12) fin whales (Bradford et al 2013). This is currently the best available abundance estimate for this stock within the Hawaii EEZ, but the majority of fin whales would be expected to be at higher latitudes feeding grounds at this time of year

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al 1995) around the 2010 abundance estimate or 27 fin whales within the Hawaiian Islands EEZ.

Current Population Trend

No data are available on current population trend. The broad and overlapping confidence intervals around the 2002 and 2010 estimates preclude assessment of trend with the available data.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii stock of fin whales is calculated as the minimum population size within the U.S EEZ of the Hawaiian Islands (27) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.1 (the default value for an endangered species with Nmin <1500; Taylor et al 2003), resulting in a PBR of 0.1 fin whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2007 and 2011, no fin whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (McCracken 2013, Bradford & Forney 2013.

Historical Mortality

Large numbers of fin whales were taken by commercial whalers throughout the North Pacific from the early 20th century until the 1970s (Tønnessen and Johnsen 1982). Approximately 46,000 fin whales were taken from the North Pacific by commercial whalers between 1947 and 1987 (C. Allison, IWC, pers. comm.). Some of the whales taken may have been from a population or populations that migrate seasonally into the Hawaiian EEZ. The species has been protected in the North Pacific by the IWC since 1976.

STATUS OF STOCK

The status of fin whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Fin whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently the Hawaiian stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. Because there have been no reported fishery related mortality or serious injuries within the Hawaiian Islands EEZ, the total fishery-related mortality and serious injury of this stock can be considered to be insignificant and approaching zero. Increasing levels of anthropogenic sound in the world's oceans has been suggested to be a habitat concern for whales, particularly for baleen whales that may communicate using low-frequency sound (Croll et al. 2002). Behavioral changes associated with exposure to simulated mid-frequency sonar, including no change in behavior, cessation of feeding, increased swimming speeds, and movement away from simulated sound sources has been documented in tagged blue whales (Goldbogen et al. 2013), but it is unknown if fin whales respond in the same manner to such sounds.

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Revised 7/15/2014

BRYDE'S WHALE (*Balaenoptera edeni*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Bryde's whales occur in tropical and warm temperate waters throughout the world. Leatherwood et al. (1982) described the species as relatively abundant in summer and fall on the Mellish and Miluoki banks northeast of Hawaii and around Midway Islands. Ohsumi and Masaki (1975) reported the tagging of "many" Bryde's whales between the Bonin and Hawaiian Islands in the winters of 1971 and 1972 (Ohsumi 1977). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands resulted in 13 Bryde’s whale sightings throughout the study area in 2002 and 30 in 2010 (Figure 1; Barlow 2006; Bradford et al 2013). There is currently no biological basis for defining separate stocks of Bryde's whales in the central North Pacific. Bryde's whales were seen occasionally off southern California (Morejohn and Rice 1973) in the 1960s, but their seasonal occurrence has increased since at least 2000 based on detection of their distinctive calls (Kerosky et al. 2012).

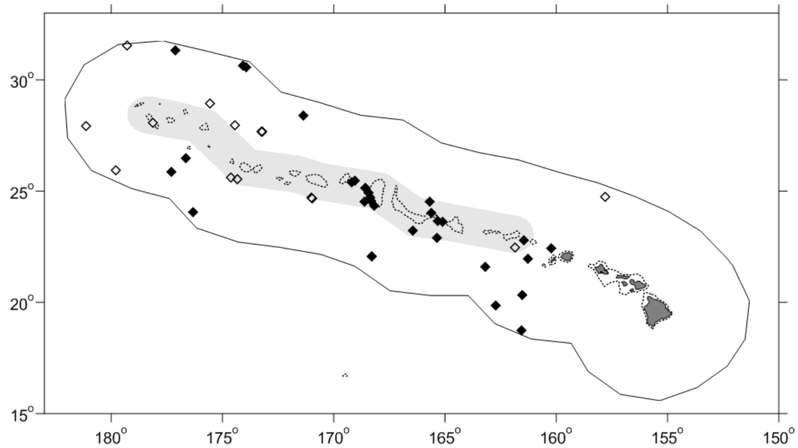

Figure 1. Bryde’s whale sighting locations during the 2002 (open diamonds) and 2010 (black diamonds) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al 2013; see Appendix 2 for details on timing and location of survey effort). Outer line represents approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument. Dotted line represents the 1000m isobath.

For the MMPA stock assessment reports, Bryde's whales within the Pacific U.S. EEZ are divided into two areas: 1) Hawaiian waters (this report), and 2) the eastern Pacific (east of 150°W and including the Gulf of California and waters off California). The Hawaiian stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Tillman (1978) concluded from Japanese and Soviet CPUE data that the stock size in the North Pacific pelagic whaling grounds, mostly to the west of the Hawaiian Islands, declined from approximately 22,500 in 1971 to 17,800 in 1977. An estimate of 13,000 (CV=0.20) Bryde's whales was made from vessel surveys in the eastern tropical Pacific between 1986 and 1990 (Wade and Gerrodette 1993). The area to which this estimate applies is mainly southeast of the Hawaiian Islands, and it is not known whether these animals are part of the same population that occurs around the Hawaiian Islands. A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 469 (CV=0.45) Bryde’s whales (Barlow 2006). A more recent estimate from a similar 2010 EEZ-wide survey resulted in an abundance estimate of 798 (CV = 0.28) Bryde’s whales (Bradford et al. 2013). This is currently the best available abundance estimate for this stock.

Minimum Population Estimate

Minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al. 1995) of the 2010 abundance estimate, or 633 Bryde’s whales.

Current Population Trend

No data are available on current population trends. The broad and overlapping confidence intervals around the 2002 and 2010 estimates preclude assessment of trends with the available data.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii stock of Bryde's whales is calculated as the minimum population size within the U.S EEZ of the Hawaiian Islands (633) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no known fishery mortality or serious injury within the Hawaiian Islands EEZ; Wade and Angliss 1997), resulting in a PBR of 6.3 Bryde's whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2007 and 2011, no Bryde's whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (McCracken 2013, Bradford & Forney 2013). One Bryde's whale was observed entangled in shallow-set longline gear off the Hawaiian Islands in 2005 (Forney 2010).

Historical Mortality

Small numbers of Bryde's whales were taken near the Northwestern Hawaiian Islands by Japanese and Soviet whaling fleets in the early 1970s (Ohsumi 1977). Pelagic whaling for Bryde's whales in the North Pacific ended after the 1979 season (IWC 1981), and coastal whaling for this species ended in the western Pacific in 1987 (IWC 1989).

STATUS OF STOCK

The Hawaii stock of Bryde's whales is not considered strategic under the 1994 amendments to the MMPA. The status of Bryde's whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Bryde's whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Given the absence of recent recorded fishery-related mortality or serious injuries within the Hawaiian Islands EEZ, the total fishery mortality and serious injury can be considered to be insignificant and approaching zero. The increasing level of anthropogenic noise in the world's oceans has been suggested to be a habitat concern for whales (Richardson et al. 1995, Weilgart 2007).

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SEI WHALE (*Balaenoptera borealis borealis*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

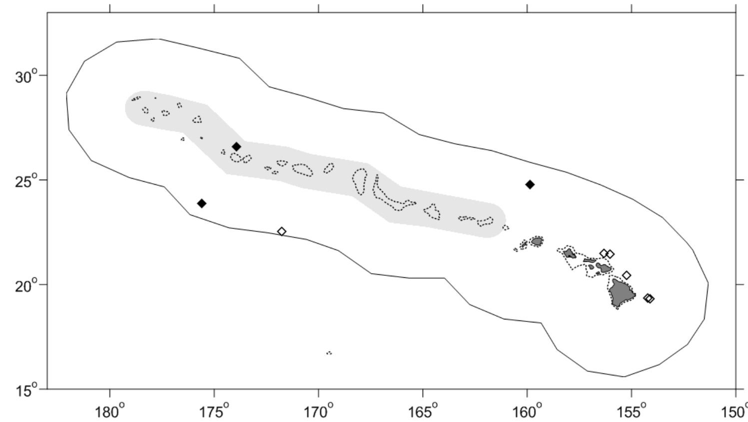

Figure 1. Sei whale sighting locations during the 2002 (open diamonds) and 2010 (black diamonds) shipboard cetacean surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2003, Bradford et al. 2013; see Appendix 2 for details on timing and location of survey effort). Outer line indicates approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument. Dotted line represents the 1000m isobath.

The International Whaling Commission (IWC) recognizes one stock of sei whales in the North Pacific (Donovan 1991), but some evidence exists for multiple populations (Masaki 1977; Mizroch et al. 1984; Horwood 1987). Sei whales are distributed far out to sea in temperate regions of the world and do not appear to be associated with coastal features. Whaling effort for this species was distributed continuously across the North Pacific between 45-55°N (Masaki 1977). Two sei whales that were tagged off California were later killed in whaling operations off Washington and British Columbia (Rice 1974) and the movement of tagged animals has been noted in many other regions of the North Pacific. There is still insufficient information to accurately determine population structure, but from a conservation perspective it may be risky to assume panmixia in the entire North Pacific. Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands resulted in four sightings in 2002 and three in 2010 (Figure 1; Barlow 2003; Bradford et al. 2013). There have been no reported strandings of sei whales in the Hawaiian Islands.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, sei whales within the Pacific U.S. EEZ are divided into three discrete areas: 1) waters around Hawaii (this report), 2) California, Oregon and Washington waters, and 3) Alaskan waters. The Hawaiian stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Ohsumi and Wada (1974) estimate the pre-whaling abundance of sei whales to be 58,000-62,000 in the North Pacific. Later, Tillman (1977) used a variety of methods to estimate sei whale abundance in the North Pacific and revised the pre-whaling estimate to 42,000. His estimates for the year 1974, following 27 years of whaling, ranged from 7,260 to 12,620. All methods depend on using the history of catches and trends in CPUE or sighting rates; there have been no direct estimates of sei whale abundance in the entire North Pacific based on sighting surveys. A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in a summer/fall abundance estimate of 77 (CV=1.06) sei whales (Barlow 2003). More recently, the 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in a summer/fall abundance estimate of 178 (CV = 0.9) sei whales (Bradford et al. 2013). This is currently the best available abundance estimate for this stock, but the majority of sei whales would be expected to be in higher-latitude feeding grounds at this time of year.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al 1995) of the 2010 abundance estimate or 93 sei whales within the Hawaiian Islands EEZ.

Current Population Trend

No data are available on current population trend. Although the population in the North Pacific is expected to have grown since being given protected status in 1976, the possible effects of continued unauthorized takes (Yablokov 1994) make this uncertain. The broad and overlapping confidence intervals around the 2002 and 2010 estimates preclude assessment of trend with the available data.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for sei whales.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size within the U.S. EEZ of the Hawaiian Islands (93) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.1 (the default value for an endangered species with N_{min} <1500; Taylor et al. 2003), resulting in a PBR of 0.2 sei whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. In March 2011 a subadult sei whale was found near Lahaina, Maui entangled with one or two wraps of heavy-gauge polypropylene line around the tailstock and trailing about 30 feet of line including a large bundle (Bradford & Lyman 2013). Closer examination also revealed line scars on the body near the dorsal fin. Although disentanglement was attempted, the gear could not be removed. Although the source of the line entangling the whale could not be determined, this injury is considered serious based on extent of trailing gear and condition of the whale (Bradford & Lyman 2013, NMFS 2012). This serious injury record results in an average annual serious injury and mortality rate of 0.2 sei whales for the period 2007 to 2011.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2007 and 2011, no sei whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (McCracken 2013, Bradford & Forney 2013).

Historical Whaling

The reported take of North Pacific sei whales by commercial whalers totaled 61,500 between 1947 and 1987 (C. Allison, IWC, pers. comm.). There has been an IWC prohibition on taking sei whales since 1976, and commercial whaling in the U.S. has been prohibited since 1972.

STATUS OF STOCK

Previously, sei whales were estimated to have been reduced to 20% (8,600 out of 42,000) of their pre-whaling abundance in the North Pacific (Tillman 1977). Sei whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently the Hawaiian stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. The observed rate of fisheries-related mortality or serious injury within the Hawaiian Islands EEZ (0.2 animals per year) is equal to the PBR (0.2), though the responsible fishery is unknown. The increasing level of anthropogenic noise in the world's oceans has been suggested to be a habitat concern for whales (Richardson et al. 1995). Behavioral changes associated with exposure to simulated mid-frequency sonar, including no change in behavior, cessation of feeding, increased swimming speeds, and movement away from simulated sound sources has been documented in tagged blue whales (Goldbogen et al. 2013), but it is unknown if sei whales respond in the same manner to such sounds.

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MINKE WHALE (*Balaenoptera acutorostrata scammoni*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The International Whaling Commission (IWC) recognizes 3 stocks of minke whales in the North Pacific: one in the Sea of Japan/East China Sea, one in the rest of the western Pacific west of 180^{o}N, and one in the "remainder" of the Pacific (Donovan 1991). The "remainder" stock only reflects the lack of exploitation in the eastern Pacific and does not imply that only one population exists in that area (Donovan 1991). In the "remainder" area, minke whales are relatively common in the Bering and Chukchi seas and in the Gulf of Alaska, but are not considered abundant in any other part of the eastern Pacific (Leatherwood et al. 1982; Brueggeman et al. 1990). In the Pacific, minke whales are usually seen over continental shelves (Brueggeman et al. 1990). In the extreme north, minke whales are believed to be migratory, but in inland waters of Washington and in central California they appear to establish home ranges (Dorsey et al. 1990).

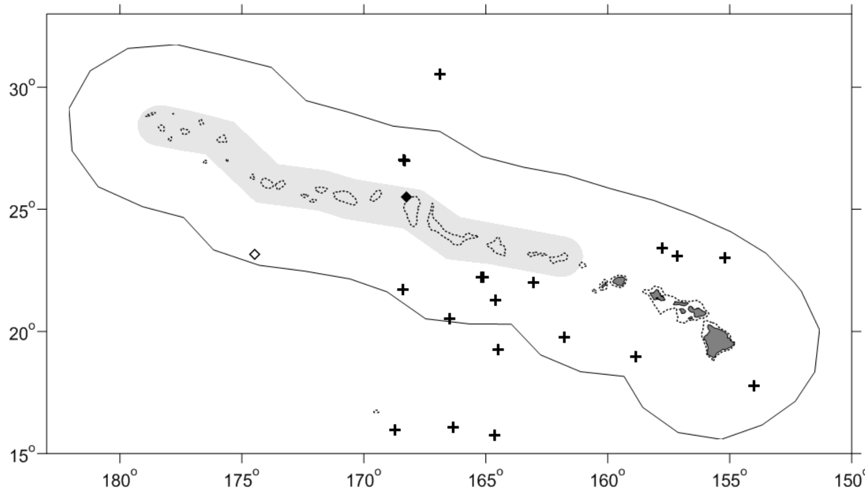

Figure 1. Locations of minke whale sightings from longline observer records (crosses; NMFS/PIR, unpublished data), and sightings made during the 2002 (open diamond) and 2010 (black diamond) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2013; see Appendix 2 for details on timing and location of survey effort). Outer line indicates approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument. Dotted line represents the 1000m isobath.

Minke whales occur seasonally around the Hawaiian Islands (Barlow 2003, Rankin and Barlow, 2005), and their migration routes or destinations are unknown. Minke whale “boing” sounds have been detected near the Hawaiian Islands for decades, with detections by the U.S. Navy during February and March (Thompson and Friedl 1982) and at the ALOHA Cabled Observatory 100km north of Oahu from October to May (Oswald et al. 2011). Minke whales were observed within 22km of Kauai in February 2005 (Rankin et al. 2007) and by observers in the Hawaii-based longline fishery since 1994 (Figure 1; NMFS/PIR unpublished data). Two confirmed sightings of minke whale were made, one in November 2002 and the other during October 2010 during surveys of waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands (Barlow 2003; Bradford et al. 2013). There are no known stranding records of this species from the main islands (Nitta 1991; Maldini et al. 2005).

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are three stocks of minke whale within the Pacific U.S. EEZ: 1) a Hawaiian stock (this report), 2) a California/Oregon/ Washington stock, and 3) an Alaskan stock. The Hawaiian stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Using passive acoustic detections from an array of seafloor hydrophones north of Kauai, Martin et al. (2012) estimate a preliminary average density of 2.15 ”boing” calling minke whales per 1000 km^2 during the period February through April and within an area of 8,767 km^2 centered on the seafloor array positioned roughly 50km from shore. However, the relationship between the number of whales present and the number of calls detected is not known, and therefore this acoustic method does not provide an estimate of absolute abundance for minke whales.

Summer/fall 2002 and 2010 shipboard line-transect surveys of the entire Hawaiian Islands EEZ each resulted in one 'off effort' sighting of a minke whale (Barlow 2003, Bradford et al. 2013). These sightings were not part of regular survey operations and, therefore, could not be used to calculate estimates of abundance (Barlow 2003; Bradford et al. 2013). The majority of this survey took place during summer and early fall, when the Hawaiian stock of minke whale would be expected to be farther north. There currently is no abundance estimate for this stock of minke whales, which appears to occur seasonally (about October - April) around the Hawaiian Islands.

Minimum Population Estimate

There is no minimum population estimate for the Hawaiian stock of minke whales.

Current Population Trend

No data are available on population size or current population trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for Hawaiian minke whales.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii stock of minke whales is calculated as the minimum population estimate times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a species of unknown status with no estimated fishery mortality or serious injury within the U.S. EEZ of the Hawaiian Islands; Wade and Angliss 1997). Because there is no minimum population estimate for Hawaii minke whales, the PBR is undetermined.

HUMAN CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fishery Information

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2007 and 2011, no minke whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (McCracken 2013).

STATUS OF STOCK

The Hawaii stock of minke whales is not considered strategic under the 1994 amendments to the MMPA. The status of minke whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Minke whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Because there has been no reported fisheries related mortality or serious injury within the Hawaiian Islands EEZ, the total fishery mortality and serious injury for minke whales can be considered insignificant and approaching zero mortality and serious injury rate. The increasing level of anthropogenic sound in the world's oceans has been suggested to be a habitat concern for whales (Richardson et al. 1995).

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Revised 10/15/2009

HUMPBACK WHALE (*Megaptera novaeangliae*)
IUCN Oceania subpopulation – American Samoa Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The humpback whale has a global distribution. Humpback whales migrate long distances between their feeding grounds at mid- to high latitudes and their calving and mating grounds in tropical waters. The Oceania subpopulation (as defined by the IUCN Red List process, see Childerhouse *et al*. 2008) ranges throughout the South Pacific, except the west coast of South America, and from the equator to the edges of the Antarctic ice. Humpback whales have been recorded across most of the lower latitudes of the South Pacific from approximately 30°S northwards to the equator during the austral autumn and winter. Although there have been no comprehensive surveys of this huge area, humpback whale densities are known to vary extensively from high densities in East Australia to low densities at many island groups. Many regional research projects have documented the presence of these whales around various island groups, but they are also found in open water away from islands (SPWRC 2008). Movements of individual whales between the tropical wintering grounds and the Antarctic summer feeding grounds have been documented by a variety of methods including Discovery tagging, photo-identification, matching genotypes from biopsies or carcasses, and satellite telemetry (Mackintosh 1942; Chittleborough 1965; Dawbin 1966; Mikhalev 2000; Rock *et al*. 2006, Franklin *et al*. 2007, Robbins *et al*. 2008). However, migratory routes and specific destinations remain poorly known. Unlike the other humpback stocks found in U. S. waters, the IUCN Oceania subpopulation is defined by structure on its calving grounds (Garrigue *et al*. 2006b, Olavarria *et al*. 2006, 2007) rather than on its feeding grounds. The Oceania subpopulation consists of breeding stocks E (including E1, E2 and E3) and F recognized by the International Whaling Commission (IWC). It is found in the area defined by the following approximate boundaries: 145°E (eastern Australia) in the west, 120°W (between French Polynesia and South America) in the east, the equator in the north, and 30°S in the south (Childerhouse *et al.* 2008).

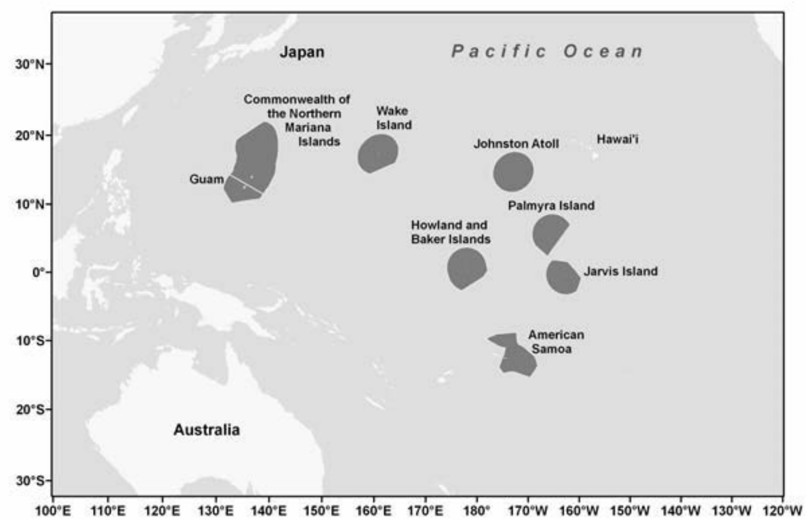

Figure 1. Western Pacific Exclusive Economic Zones for selected U.S. territories, including American Samoa. Information on the American Samoa stock of humpback whales in this report is derived from survey work conducted within the American Samoa EEZ, although animals range well outside this area (see text).

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there is need for only one South Pacific Island region management stock of humpback whales, the American Samoa stock. American Samoa lies at the boundary of breeding stocks E3 and F. Surveys have been undertaken annually at the primary island of Tutuila since 2003. A total of 150 unique individuals were identified by fluke photographs during 58 days at sea, 2003-2008 (D. Mattila and J. Robbins, unpublished data). Individuals have been resighted on multiple days in a single breeding season, but only three inter-annual re-sightings have been made to date (two based on dorsal fin photographs) (D. Mattila and J. Robbins, unpublished data). Breeding behavior and the presence of very young calves has been documented in American Samoa waters. One whale that was sighted initially without a calf was re-sighted later in the season with a calf. Individual exchange has been documented with Western Samoa (SPWRC 2008), as well as Tonga, French Polynesia and the Cook Islands (Garrigue *et al*. 2007). Although the feeding range of American Samoan whales has not yet been defined, there has been one photo-ID match to the Antarctic Peninsula (IWC Antarctic Area I, Robbins *et al*. 2008). Whales at Tonga have exhibited exchange with both Antarctic Area V (Dawbin 1959) and Area I (Brown 1957, Dawbin 1956) and so whales from American Samoa may have a similarly wide feeding range.

On-going photographic studies indicate a higher frequency of certain types of skin lesions on humpback whales at American Samoa as compared to humpback whale populations at Hawaii or the Gulf of Maine (Mattila and Robbins, 2008). However, the cause and implications have yet to be determined. Some similar skin lesions on blue whales in Chilean waters have been observed (Brownell *et al*. 2008).

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Historic whaling

Southern Hemisphere humpback whales were hunted extensively during the last two centuries, and it is thought that populations have been reduced to a small percentage of their former levels (Chapman 1974). After correcting catch records for illegal Soviet whaling, (Clapham & Baker 2002) estimated that over 200,000 Southern Hemisphere humpback whales were killed from 1904 to 1980. Humpback whales were protected from commercial whaling in 1966 by the IWC but they continued to be killed illegally by the Soviet Union until 1972. Illegal Soviet catches of 25,000 humpback whales in two seasons (1959/60 and 1960/61) precipitated a population crash and the closure of land stations in Australia and New Zealand, including Norfolk Island (Mikhalev 2000; Clapham *et al*. 2005).

POPULATION SIZE

There is currently no estimate of abundance for humpback whales in American Samoan waters. The South Pacific Whale Research Consortium produced a number of preliminary mark-recapture estimates of abundance for Oceania and its subregions (SPWRC, 2006). A closed population estimate of 3,827 (CV 0.15) was calculated for eastern Oceania (breeding stocks E3 and F) for 1999-2004 and this may be the most relevant of those currently available, given observed exchange between American Samoa, Tonga, the Cook Islands, and French Polynesia (Garrigue *et al.* 2006a). However, the extent and biological significance of the documented interchange is still poorly understood.

Minimum Population Estimate

The minimum population estimate for this stock is 150 whales, which is the number of individual humpbacks identified in the waters around American Samoa between 2003-2008 by fluke photo identification (J. Robbins, personal communication). This is clearly an underestimation of the true minimum population size as photo ID studies have been conducted over a few weeks per year and there is also evidence of exchange with other areas in Oceania. There are also insufficient data to estimate the proportion of time Oceania humpback whales spend in waters of American Samoa.

Current Population Trend

No data are available on current population trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No estimates of current or maximum net productivity rates are available for this species in Samoan waters. However, the maximum plausible growth rate for Southern Hemisphere humpback whale populations is estimated as 10.6% (Clapham *et al*. 2006).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) for this stock is calculated as the minimum population size (150) times one half the estimated maximum growth rate for humpback whales in the Southern Hemisphere (1/2 of 10.6%) times a recovery factor of 0.1 (for an endangered species with a total population size of less than 1,500), resulting in a PBR of 0.8. This stock of humpback whales is migratory and thus, it is reasonable to expect that animals spend at least half the year outside of the relatively small American Samoa EEZ. Therefore, the PBR allocation for U.S. waters is half of 0.8, or 0.4 whales.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

No human-related mortalities of humpback whales have been recorded in American Samoan waters. Human-related mortality of humpback whales due to entanglements in fishing gear and collisions with ship have been reported elsewhere in the Southern Hemisphere. Entanglement of humpback whales in pot lines has been reported in both New Zealand and Australia but there are no estimated rates available. There is little information from the rest of the South Pacific but a humpback mother (with calf) was reported entangled in a longline in 2007 in the Cook Islands (N. Hauser, reported in SPWRC 2008).

A photographic-based scar study of the humpback whales of American Samoa has been initiated and there is some indication of healed entanglement and ship strike wounds, although perhaps not at the levels found in some Northern Hemisphere populations (D. Mattila and J. Robbins, unpublished data). However, the sample size to date is insufficient for robust comparison and the study is ongoing.

STATUS OF STOCK

The status of humpback whales in American Samoan EEZ waters relative to OSP is unknown and there are insufficient data to estimate trends in abundance. However, humpback whale populations throughout the South Pacific were drastically reduced by historical whaling and IUCN classifies the Oceania subpopulation as "Endangered" (Childerhouse *et al.* 2008). Worldwide humpback whales are listed as "endangered" under the Endangered Species Act (1973) so the Samoan stock is automatically considered a "depleted" and "strategic" stock under the MMPA. There are no habitat concerns for the stock.

Japan has proposed killing 50 humpback whales as part of its program of scientific research under special permit (scientific whaling) called JARPA II in the IWC management areas IV and V in the Antarctic (Gales *et al.* 2005). Areas IV and V have demonstrated links with breeding stock E. Japan postponed their proposed catch in the 2007/08 and 2008/09 seasons but have not removed them from their future whaling program. The JARPA II program has the potential to negatively impact the recovery of humpbacks in Oceania.

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The Marine Mammal Protection Act (MMPA) requires NMFS to publish a list of commercial fisheries (List Of Fisheries or "LOF") and classify each fishery based on whether incidental mortality and serious injury of marine mammals is frequent (Category I), occasional (Category II), or unlikely or unknown (Category III). The LOF is published annually in the Federal Register. The categorization of a fishery in the LOF determines whether participants in that fishery are subject to certain provisions of the MMPA, such as registration, observer coverage, and take reduction plan requirements. The categorization criteria as they appear in the LOF is reprinted below:

The fishery classification criteria consist of a two-tiered, stock-specific approach that first addresses the total impact of all fisheries on each marine mammal stock, and then addresses the impact of individual fisheries on each stock. This approach is based on consideration of the rate, in numbers of animals per year, of incidental mortality and serious injury of marine mammals due to commercial fishing operations relative to the Potential Biological Removal (PBR) level for each marine mammal stock. The MMPA (16 U.S.C. 1362 (20)) defines the PBR level as the maximum number of animals, not including natural mortality, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. This definition can also be found in the implementing regulations for section 118 at 50 CFR 229.2.

Tier 1: If the total annual mortality and serious injury across all fisheries that interact with a stock is less than or equal to 10 percent of the PBR level of the stock, all fisheries interacting with the stock would be placed in Category III. Otherwise, these fisheries are subject to the next tier (Tier 2) of analysis to determine their classification.

Tier 2, Category I: Annual mortality and serious injury of a stock in a given fishery is greater than or equal to 50 percent of the PBR level.

Tier 2, Category II: Annual mortality and serious injury of a stock in a given fishery is greater than 1 percent and less than 50 percent of the PBR level.

Tier 2, Category III: Annual mortality and serious injury of a stock in a given fishery is less than or equal to 1 percent of the PBR level.

While Tier 1 considers the cumulative fishery mortality and serious injury for a particular stock, Tier 2 considers fishery-specific mortality and serious injury for a particular stock. Additional details regarding how the categories were determined are provided in the preamble to the final rule implementing section 118 of the MMPA (60 FR 45086, August 30, 1995). Since fisheries are categorized on a per-stock basis, a fishery may qualify as one Category for one marine mammal stock and another Category for a different marine mammal stock. A fishery is typically categorized on the LOF at its highest level of classification (e.g., a fishery that qualifies for Category III for one marine mammal stock and for Category II for another marine mammal stock will be listed under Category II).

Other Criteria That May Be Considered

In the absence of reliable information indicating the frequency of incidental mortality and serious injury of marine mammals by a commercial fishery, NMFS will determine whether the incidental serious injury or mortality qualifies for Category II by evaluating other factors such as fishing techniques, gear used, methods used to deter marine mammals, target species, seasons and areas fished, qualitative data from logbooks or fisher reports, stranding data, and the species and distribution of marine mammals in the area, or at the discretion of the Assistant Administrator for Fisheries (50 CFR 229.2).

This appendix describes commercial fisheries that occur in California, Oregon, Washington, and Hawaiian waters and that interact or may interact with marine mammals. The first three sections describe sources of marine mammal mortality data for these fisheries. The fourth section describes the commercial fisheries for these states. A list of all known fisheries for these states was published as a proposed rule in the Federal Register, 71 FR 20941, 24 April 2006.

1. Sources of Mortality/Injury Data

There are three major sources of marine mammal mortality/injury data for the active commercial fisheries in California, Oregon, Washington, and Hawaii. These sources are the NMFS Observer Programs, the Marine Mammal

Authorization Program (MMAP) data, and the NMFS Marine Mammal Stranding Network (MMSN) data. Each of these data sources has a unique objective. Data on mammal mortality and injury are reported to the MMAP by fishers in any commercial fisheries. Marine mammal mortality and injury is also monitored by the NMFS Marine Mammal Stranding Network (MMSN). Data provided by the MMSN is not duplicated by either the NMFS Observer Program or MMAP reporting. Human-related data from the MMSN include occurrences of mortality due to entrainment in power station intakes, ship strikes, shooting, evidence of net and line fishery entanglement (net remaining on animal, net marks, severed flukes), and ingestion of hooks.

2. Marine Mammal Reporting from Fisheries

In 1994, the MMPA was amended to implement a long-term regime for managing mammal interactions with commercial fisheries (the Marine Mammal Authorization Program, or MMAP). Logbooks are no longer required - instead vessel owners/operators in any commercial fishery (Category I, II, or III) are required to submit one-page pre-printed reports for all interactions (including those that occur while an observer is onboard) resulting in an injury to or death of a marine mammal. The report must include owner/operator's name and address, vessel name and ID, where and when the interaction occurred, the fishery, species involved, and type of injury (if the animal was released alive). These postage-paid report forms are mailed to all Category I and II fishery participants that have registered with NMFS, and must be completed and returned to NMFS within 48 hours of returning to port for trips in which a marine mammal injury or mortality occurred. The number of self-reported marine mammal interactions is considerably lower than the number reported by fishery observers, even though observer reports are typically based on 20% observer effort. For example, from 2000-2004, there were 112 fisher self-reports of marine mammal interactions in the California swordfish/thresher shark drift gillnet fishery. This compares with 141 observed interactions over the same period, based on only 20% observer coverage. This suggests that fisher self-reports are negatively-biased. From 2007-2011 there were 12 fisher self-reports of marine mammal interactions in the Hawaii-based deep-set longline fishery, 11 of which corresponded to observer records. This compares with 50 observed interactions over the same period, based on 20-22% observer coverage. This suggests fisher self-reports are significantly negatively biased.

3. NMFS Marine Mammal Stranding Network data

From 2000-2004, there were 1,022 cetacean and 13,215 pinniped strandings recorded in California, Oregon, and Washington states. Approximately 10% of all cetacean and 6% of all pinniped strandings showed evidence of human-caused mortality during this period. From 2007-2011, there were 144 cetacean strandings recorded in Hawaii, with 42% of all cetacean strandings showing evidence of human-caused mortality during this period. Human-related causes of mortality include: entrainment in power station intakes, shooting, net fishery entanglement, and hook/line, set-net and trap fishery interaction.

4. Fishery Descriptions

Category I, CA/OR thresher shark/swordfish drift gillnet fishery (≥14 inch mesh)

Number of permit holders: The numbers of eligible permit holders in California for, 2008 to 2012 ranged between 78 and 84 (data source: California Deparment of Fish and Wildlife website: www.dfg.ca.gov/licensing). Permits are non-transferable and are linked to individual fishermen, not vessels.

Number of active permit holders: The numbers of vessels active in this fishery declined from 40 in 2008 to 16 vessels in 2012.

Total effort: Both estimated and observed effort for the drift-net fishery during the calendar years 1990 through 2012 are shown in Figure 2.

Geographic range: Effort in this fishery ranges from the U.S./Mexico border north to waters off the state of Oregon. For this fishery there are area-season closures (see below). Figures 1 shows locations of observed sets for the period 1990 to 2012.

Seasons: This fishery is subject to season-area restrictions. From February 1 to May 15 effort must be further than 200 nautical miles (nmi) from shore; from May 16 to August 14, effort must be further than 75 nmi from shore, and from

August 15 to January 31 there is only the 3 nmi off-shore restriction for all gillnets in southern California (see halibut and white seabass fishery below). The majority of the effort occurs from October through December. A season-area closure to protect leatherback sea turtles was implemented in this fishery in August 2001. The closure area prohibits drift gillnet fishing from August 15 through November 15, in the area bounded by straight lines from Point Sur, California (N36° 17') to N 34° 27' W 123° 35', west to W129°, north to N 45°, then east to the Oregon coast. An additional season-area closure south of Point Conception and east of W120 degrees longitude is effective during the months of June, July, and August during El Niño years to protect loggerhead turtles (Federal Register, 68 FR 69962, 16 December 2003).

Gear type and fishing method: Typical gear used for this fishery is a 1000-fathom gillnet with a stretched mesh size typically ranging from 18-22 inches (14 inch minimum). The net is set at dusk and allowed to drift during the night after which, it is retrieved. The fishing vessel is typically attached to one end of the net. Soak duration is typically 12-14 hours depending on the length of the night. Net extender lengths of a minimum 36 ft. became mandatory for the 1997-1998 fishing season. The use of acoustic warning devices (pingers) became mandatory 28 October 1997.

Regulations: The fishery is managed under a Fishery Management Plan (FMP) developed by the Pacific Fishery Management Council and NMFS.

Management type: The drift-net fishery is a limited-entry fishery with seasonal closures and gear restrictions (see above). The state of Oregon restricts landing to swordfish only.

Comments: This fishery has had a NMFS observer program in place since 1990. Due to bycatch of strategic stocks including short-finned pilot whales, beaked whales, sperm whales and humpback whales, a Take Reduction Team was formed in 1996. Since then, the implementation of increased extender lengths and the deployment of pingers have substantially decreased cetacean entanglement. The fraction of active vessels in this fishery that are not observed owing to a lack of berthing space for observers has been increasing. The fishery currently operates under an emergency rule designed to reduce to the bycatch of sperm whales (Federal Register 4 September 2013, Volume 78: pages 54548-54552.

Category I, Hawaii deep-set (tuna target) longline/set line fishery

Note: The Hawaii-based longline fisheries of the Pelagic Fishery Ecosystem Plan (FEP) consist of two separately managed longline fisheries. One is the deep-set (tuna targeted) fishery which is classified as a Category I fishery under the MMPA. This fishery is discussed here. The classification of this fishery was elevated to Category I in 2004 based on revised PBR levels of false killer whales and observed false killer whale mortality in this fishery (Federal Register 69 FR 48407 1, 10 August 2004). The other Hawaii-based longline fishery is the Hawaii shallow-set longline (swordfish targeted) fishery which is classified as a Category II fishery under the MMPA and is discussed in the Category II section of this Appendix.

Number of permit holders: The number of Hawaii longline limited access permit holders is 164. Not all such permits are renewed and used every year. Permit holders may use the permits for either deep-set or shallow-set fishing, but must notify NMFS how they will fish before each trip. Most holders of Hawaii longline limited access permits are based in, or operate out of, Hawaii**.**

Number of active deep-set longline vessels targeting tuna: From 2007 to 2011, the number of active longline vessels based and landing in Hawaii was 129, 127, 127, 122, and 129, respectively (http://www.pifsc.noaa.gov/fmsd/reports.php).

Total effort: The number of trips ranged from a low of approximately 500 (in 1992) to 1,427 in 2007. Figure 4 shows the number of fishing trips by longline vessels based and landing in Hawaii, by year and trip type, 1991-2009. The number of sets for the deep-set tuna fishery in 2007-2011was 17,885, 16,810, 16,070, and 17,155 . The number of hooks set in 2007-2011 was 38.8 million, 40.1 million, 37.7 million, 37.1 million, and 40.7 million.

Geographic range: The Hawaii-based pelagic, deep-set longline fishery operates inside and outside the EEZ, primarily around the main Hawaiian Islands and Northwestern Hawaiian Islands, with some trips to the EEZs around the remote U.S. Pacific islands (however there are restricted areas, please refer to "Regulations"). Vessels vary their fishing grounds depending on their target species. Most of the deep-set fishing occurs south of 25° N.

Seasons: This fishery operates year-round, although vessel activity increases during the fall and is greatest during the winter and spring months.

Gear type: Deep-set longline gear typically consists of a continuous main line set on the surface and supported in the water column horizontally by floats with branch lines connected at intervals to the main line. In addition radio buoys are also used to keep track of the mainline as it drifts at sea. A line shooter is used on deep-sets to deploy the mainline faster than the speed of the vessel, thus allowing the longline gear to sink to its target depth (average target depth is 167 m, target depth for bigeye tuna is approximately 400 m). The main line is typically 30 to 100 km (18 to 60 nm) long. A minimum of 15, but typically 20 to 30, weighted branch lines (gangions) are clipped to the mainline at regular intervals between the floats. Each gangion terminates with a single baited hook. The branch lines are typically 11 to 15 meters (35 to 50 feet) long. Sanma (saury) or sardines are used for bait. Lightsticks are not typically attached to the gangions on this type of longline set. Deep-set longline gear is set in the morning and hauled in the evening and at night.

Regulations: This fishery is managed under the Pelagics FEP and subject to Federal regulation. Measures that are currently applicable to the fishery include, but are not limited to, limited access (requirement for a permit), vessel and gear marking requirements, vessel length restrictions, Federal catch and effort logbooks, large longline restricted areas around the Hawaiian Archipelago, vessel monitoring system (VMS), annual protected species workshops, use of circle hooks with wire diameter not greater than 4.5mm and branch line not less than 2.0mm, and the use of sea turtle, seabird, and marine mammal handling and mitigation gear and techniques. The vessel operator must notify NMFS prior to departure whether the vessel is undertaking a deep-set or shallow-set trip. Once the trip type is set, it cannot be changed during the trip. Vessel operators must take a NMFS contracted observer if requested by NMFS – target observer coverage is 20 percent of trips. If any marine mammal interaction (hooking or entanglement) resulting in injury or mortality occurs, the vessel operator must complete and mail a pre-addressed, postage paid form to NOAA Fisheries within 48 hours of the end of the trip. Additional information on all applicable regulations for the deep-set longline fishery is available at http://www.fpir.noaa.gov/SFD/SFD_regs_2.html. This fishery is subject to the False Killer Whale Take-Reduction Team. NMFS is currently implementing the Take-Reduction Plan and associated regulations.

Management type: Federal limited access program. This fishery is managed under a Fishery Ecosystem Plan (FEP) developed by the Western Pacific Fishery Management Council and NMFS.

Comments: Non-target species are caught incidentally. Interactions with common bottlenose dolphins, false killer whales, humpback whales, short-finned pilot whales, pantropical spotted dolphins, Blainville's beaked whale, sperm whales, striped dolphins and Risso's dolphins have been documented. Due to interactions with protected species, especially turtles, this fishery has been observed since February 24, 1994. Initially, observer coverage was less than 5%, increased to 10% in 2000, and equaled or exceeded 20% since 2001. *Observed* marine mammal injures and deaths form 2007-2011 included 24 false killer whales, 4 short-finned pilot whales, 3 Risso's dolphins, 2 common bottlenose dolphins, 1 sperm whale, 1 pantropical spotted dolphin, one striped dolphin, and 14 unidentified cetaceans. Four of the interactions were deaths, 32 were serious injuries, nine were non-serious injuries, one involved prorating a large whale interaction as 0.75 serious (NMFS, 2012), and four were classified as cannot-be-determined.

Category II , CA halibut/white seabass and other species set gillnet fishery (>3.5 inch mesh).

Halibut are typically targeted using 8.5 inch mesh while the remainder of the fishery targets white seabass and yellowtail using 6.5 inch mesh. In recent years, there has been an increasing number of 6.0-6.5 inch mesh sets fished using drifting methods; this component is now identified as a separate fishery (see "**CA yellowtail, barracuda, white seabass, and tuna drift gillnet fishery (>3.5 and <14 in mesh)**" fishery described below).

Number of permit holders: There is no specific permit category for this fishery. Overall, the current number of legal permit holders for gill and trammel nets, excluding swordfish drift gillnets and herring gillnets were between 141 and 154 annually. Information on permit numbers is available from the California Department of Fish and Game website (http://www.dfg.ca.gov/licensing).

Number of active permit holders: Approximately 50 vessels participate in this fishery (NMFS List of Fisheries, Federal Register 29 August 2013).

Total effort: Total fishing effort for the period 2008 to 2012 has been approximately 2,000 sets annually.

Geographic range: Effort in this fishery previously ranged from the U.S./Mexico border north to Monterey Bay and was localized in more productive areas: San Ysidro, San Diego, Oceanside, Newport, San Pedro, Ventura, Santa Barbara, Morro Bay, and Monterey Bay. Fishery effort is now predominantly in the Ventura Flats area off of Ventura, the San Pedro area between Pt. Vicente and Santa Catalina Island and in the Monterey Bay area. The central California portion of the fishery from Point Arguello to Point Reyes has been closed since September 2002 when a ban on gillnets inshore of 60 fathoms took effect.

Seasons: This fishery operates year round. Effort generally increases during the summer months and declines during the last three months of a year.

Gear type and fishing method: Typical gear used for this fishery is a 200 fathom gillnet with a stretched mesh size of 8.5 inches. The component of this fishery that targets white seabass and yellowtail utilizes 6.5 inch mesh. The net is generally set during the day and allowed to soak for up to 2 days. Soak duration is typically 8-10, 19-24, or 44-49 hours. The depth of water ranges from 15-50 fathoms with most sets in water depths of 15-35 fathoms.

Regulations: This fishery is managed by the California Dept. of Fish and Game in accordance with state and federal laws.

Management type: The halibut and white seabass set-net fishery is a limited-entry fishery with gear restrictions and area closures.

Comments: An observer program for the halibut and white seabass portion of this fishery operated from 1990-94 and was discontinued after area closures were implemented in 1994, which prohibited gillnets within 3 nmi of the mainland and within 1 nmi of the Channel Islands in southern California. NMFS re-established an observer program for this fishery in Monterey Bay in 1999-2000 due to a suspected increase in harbor porpoise mortality in Monterey Bay. In 1999 and 2000, fishery mortality exceeded PBR for the Monterey Bay harbor porpoise stock, which at that time, was designated as strategic [the stock is currently non-strategic]. In the autumn of 2000, the California Department of Fish and Game implemented the first in a series of emergency area closures to set gillnets within 60 fathoms along the central California coast in response to mortality of common murres and threats to sea otters. This effectively reduced fishing effort to negligible levels in 2001 and 2002 in Monterey Bay. A ban on gill and trammel nets inside of 60 fathoms from Point Reyes to Point Arguello became effective in September 2002. Bycatch of marine mammals, including California sea lions and harbor seals, continues in this fishery, based on limited observer data.

Category II, Hawaii shallow-set (swordfish target) longline/set line fishery

Note: The Hawaii-based longline fisheries of the Pelagic Fishery Ecosystem Plan (FEP) consist of two separately managed longline fisheries. One is the deep-set (tuna targeted) fishery which is classified as a Category I fishery under the MMPA. The other is the Hawaii shallow-set longline (swordfish targeted) fishery which is classified as a Category II fishery under the MMPA and is discussed here.

Number of permit holders: The number of Hawaii longline limited access permit holders is 164. Not all such permits are renewed and used every year. Permit holders may use the permits for either deep-set or shallow-set fishing, but must notify NMFS how they will fish before each trip. Most holders of Hawaii longline limited access permits are based in, or operate out of, Hawaii. Longline general permits are not limited by number. These general permits are open access and usable in Guam, CNMI, and the Pacific Remote Island Areas; they are usually not more than a half dozen a year.

Number of active shallow-set longline vessels targeting swordfish: From 2007 to 2011, the number of active shallow-set longline vessels based in and landing in Hawaii was 28, 27, 28, 28, and 20.

Total effort: The number of trips since 1991 has ranged from zero (2002-2003) to approximately 300 in 1993. Figure 4 shows the number of fishing trips by longline vessels based and landing in Hawaii, by year and trip type, 1991-2011. The number of sets for the shallow-set swordfish fishery in 2007-2011 was 1,570, 1,597, 1,762, 1,833, and 1,468. The number of hooks set in 2007-2011 was 1.4 million, and 1.5 million, 1.7 million, 1.8 million, 1.5 million.

Geographic range:
The most productive swordfishing areas for Hawaii-based longline vessels are north of Hawaii outside the U.S. Exclusive Economic Zone (EEZ) on the high seas, and this fishery operates almost entirely north of Hawaii (north of approximately 20° N). In some years, when influenced by seawater temperature, this fishery may operate mostly north of 30° N.

Seasons: Shallow-set effort is highest in either the first or second quarter of the calendar year and drops off substantially in the latter half of the year.

Gear type: Shallow-set longline gear typically consists of a continuous main line set on the surface and supported in the water column horizontally by floats with branch lines connected at intervals to the main line. In addition radio buoys are also used to keep track of the mainline as it drifts at sea. Longline fishing for swordfish is known as shallow-set longline fishing as the bait is set at depths of 30–90 m. The portion of the mainline with branchlines attached is suspended between floats at about 20–75 m of depth, and the branchlines hang off the mainline another 10–15 m. Only 4-6 branchlines are clipped to the mainline between floats, and a typical set for swordfish uses about 1,000-1,200 hooks. Shallow-set longline gear is set at night, with luminescent light sticks attached to the branchlines. Formerly, J-hooks and squid bait were used, but since 2004, circle hooks and mackerel-type bait have been required. These gear restrictions were implemented to reduce sea turtle bycatch.

Regulations: This fishery is managed under the Pelagics FEP and subject to Federal regulation. Measures that are currently applicable to the fishery include, but are not limited to, limited access (requirement for a permit), vessel and gear marking requirements, vessel length restrictions, Federal catch and effort logbooks, 100-percent observer coverage, large longline restricted areas around the Hawaiian Archipelago, vessel monitoring system (VMS), annual protected species workshops, and the use of sea turtle, seabird, and marine mammal handling and mitigation gear and techniques. The vessel operator must notify NMFS prior to departure whether the vessel is undertaking a shallow-set or a deep-set trip. Once the trip type is set, the type cannot be changed during the trip. All shallow-set trips must have a NMFS contracted observer. If any marine mammal interaction (hooking or entanglement) resulting in injury or mortality occurs, the vessel operator must complete and mail a pre-addressed, postage paid form to NOAA Fisheries within 48 hours of the end of the trip. More information on all applicable regulations is available at http://www.fpir.noaa.gov/SFD/SFD_regs_2.html. This fishery is subject to the False Killer Whale Take-Reduction Team. NMFS is currently implementing the Take-Reduction Plan and associated regulations.

Management type: Federal limited access program. This fishery is managed under a Fishery Ecosystem Plan (FEP) by the Western Pacific Fishery Management Council and NMFS.

Comments: Non-target species are caught incidentally. Interactions with common bottlenose dolphins, false killer whales, humpback whales, short-finned pilot whales, striped dolphins, Bryde's whales, Risso's dolphins, sperm whales, spinner dolphins, pygmy sperm or dwarf sperm whales, Blainville's beaked whales, and common dolphins have been documented. The shallow-set fishery was completely closed in 2001 and reopened in 2004. One hundred percent observer coverage is required in this fishery. *Observed* injuries of marine mammals in this fishery in 2007-2011 included 3 false killer whales, 21 Risso's dolphins, 2 humpback whale, 1 pygmy or dwarf sperm whale, 3 striped dolphins, 8 common bottlenose dolphins, 1 short-beaked common dolphin, 1 Blainville's beaked whale, 2 unidentified beaked whales, and 2 unidentified dolphins. Three of the interactions were deaths, 31 were serious injuries, 10 were non-serious injuries, and 2 involved prorating a large whale interaction as 0.75 serious. .

Category II, Hawaii Shortline Fishery

Note: The Hawaii shortline fishery was added to the 2010 List of Fisheries as a Category II fishery under the MMPA based on analogy with the Category I "HI deep-set (tuna-target) longline/set line" and Category II "HI shallow-set (swordfish-target) longline/set line" fisheries (Federal Register 74 FR 58859, 16 November 2009).

Number of permit holders: There are no specific fishing permits issued for this fishery. However, all persons with a State of Hawaii Commercial Marine License (CML) may participate in any fishery, including the "HI shortline" fishery.

Number of active shortline vessels: Of those persons possessing CMLs, shortline participation has varied between 5 and 14 vessels from 2003 - 2011.

Total effort: From 2003-2008, there was an average of 135,757 pounds (lbs) of fish landed each year. In 2008 alone, 104,152 lbs of fish were landed.

Geographic range: The Category II "HI shortline" fishery is a small-scale system operating off the State of HI, and targeting bigeye tuna (*Thunnus obesus*) or the lustrous pomfret (*Eumigistes illustris*). This fishery was developed to target these fish species when they concentrate over the summit of Cross Seamount, -290 km (180 mi) south of the State of HI.

Seasons: This fishery has no seasonal component and may operate year-round.

Gear type: The gear style is designed specifically to target the aggregating fish species over seamount structures. The primary gear type used is a horizontal main line (monofilament) less than 1 nautical mile long, and includes two baskets of approximately 50 hooks each. The gear is set before dawn and has a short soak time, with the gear retrieved about two hours after it is set.

Regulations: All persons with a State of Hawaii Commercial Marine License (CML) may participate in -the "HI shortline" fishery. The mainline length must be less than 1 nautical mile.

Management type: Hawaii State managed fishery.

Comments: Currently, there is no Federal reporting system in place to document potential marine mammal interactions in this fishery. However, there are anecdotal reports of interactions off the north side of Maui, but the species and extent of interactions are unknown.

Category II, American Samoa Longline Fishery

Note: The American Samoa longline fishery was added to the 2006 List of Fisheries as a Category II fishery under the MMPA based on analogy with Category I "HI deep-set (tuna-target) longline/set line" and Category II "HI shallow-set (swordfish-target) longline/set line" fisheries.

Number of permit holders: 46

Number of active longline vessels: From 2007 to 2011, the number of active vessels was 29, 28, 26, 26, and 24.

Total effort: The number of trips for 2007-2011 was 377, 287, 175, 264, and 274. The number of sets for the American Samoa longline fishery in 2007-2011 was 5,910, 4,730, 4,601, 4,496, and 3,776. The number of hooks set in 2007-2011 was 17,524, 14,372, 14,207, 13,067, and 10,767.

Geographic range: Waters surrounding American Samoa year-round.

Seasons: Shallow-set effort is highest in either the first or second quarter of the calendar year and drops off substantially in the latter half of the year.

Gear type: This fishery uses longline gear. Vessels over 50 ft (15.2 m) may set 1,500-2,500 hooks and have a greater fishing range and capacity for storing fish (8-40 metric tons). The fleet reached a peak of 66 vessels in 2001, and set a peak of almost 7,000 sets in 2002. It is more common for fishermen to set their gear in the day and haul in the afternoon, mainly to improve their catch rates.

Regulations: This fishery is a limited entry fishery for pelagic longline vessels in the U.S. EEZ around American Samoa. In 2000, the fishery began to expand rapidly with the influx of large (more than 50 ft (15.2m m) overall length) conventional mono hull vessels, similar to the type used in the Hawaii-based longline fisheries. Regulations implemented in 2002 prohibit any large U.S. vessels (50 ft (15.2 m) and longer) from fishing within 50 nmi around the islands of American Samoa. In 2005, the rapid expansion of longline fishing effort within the U.S. EEZ waters around American Samoa prompted the implementation of a limited entry system. Under the limited access program, NMFS issued a total of 60 initial longline limited entry permits in 2005 to qualified candidates, spread among 4 vessel size classes: 22 permits issued in Class A (less than or equal to 40 ft (12.2 m) length); 5 in Class B (40-50 ft (12.2-15.2m)); 12 in Class C (50.1–70 ft (15.2–21.3 m)); and 21 in Class D (more than 70 ft (21.3 m)). The number of active vessels has shifted to large vessels (Class C and D), with only a couple of small vessels active in the past two years. Permits may be transferred and renewed. Under the limited entry program, vessel operators must submit federal catch and effort logbooks, vessels over 40 ft (12.2 m) must carry observers if requested by NMFS, and vessels over 50 ft (15.2 m) must have an operational vessel monitoring system (VMS). In addition, vessel owners and operators must attend a protected species workshop annually, carry and use dip nets, clippers, and bolt cutters, and follow handling, resuscitation, and release requirements for incidentally hooked or entangled sea turtles.

Management type: Federal limited access program. This fishery is managed under a Fishery Ecosystem Plan (FEP) by the Western Pacific Fishery Management Council and NMFS.

Comments: Non-target species are caught incidentally. Interactions with false killer whales, Risso's dolphins, and Cuvier's beaked whale have been documented. One hundred percent observer coverage is required in this fishery. *Observed* injuries of marine mammals in this fishery in 2007-2011 included 3 false killer whales, 21 Risso's dolphins, 2 humpback whale, 1 pygmy or dwarf sperm whale, 3 striped dolphins, 8 common bottlenose dolphins, 1 short-beaked common dolphin, 1 Blainville's beaked whale, 2 unidentified beaked whales, and 2 unidentified dolphins. Three of the interactions were deaths, 31 were serious injuries, 10 were non-serious injuries, and 2 involved prorating a large whale interaction as 0.75 serious.

Category II, CA yellowtail, barracuda, white seabass, and tuna drift gillnet fishery (>3.5 and <14 in mesh)

Number of permit holders: There are approximately 24 active permit holders in this fishery.

Total effort: From 2008 to 2012, there were between 207 and 271 small-mesh drift gillnet sets fished annually, as determined from California Department of Fish and Game logbook data.

Geographic range: This drift gillnet component of this fishery operates primarily south of Point Conception. Observed sets have been clustered around Santa Cruz Island, the east Santa Barbara Channel, and Cortez and Tanner Banks. Some effort has also been observed around San Clemente Island and San Nicolas Island.

Seasons: This fishery operates year round. Targeted species is typically determined by market demand on a short-term basis.

Gear type and fishing method: Typical gear used for this fishery is a 150 to 200-fathom gillnet, which is allowed to drift. The mesh size depends on the target species but typical values observed are 6.0 and 6.5 inches.

Regulations: This fishery is managed by the California Dept. of Fish and Game in accordance with State and Federal laws.

Management type: This fishery is a limited-entry fishery with gear restrictions and area closures.

Comments: This fishery primarily targets white seabass and yellowtail but also targets barracuda and albacore tuna. From 2002-2004, there have been 63 sets observed from 17 vessel trips. Marine mammal mortality includes two long-beaked common dolphin and 3 California sea lions. Also, 4 California sea lions were entangled and released alive during this period. In 2003, there was one coastal bottlenose dolphin stranded with 3.5-inch gillnet wrapped around its tailstock, the responsible fishery is unknown. Observer coverage in this fishery was 12% in 2002, 10% in 2003, and 17% in 2004.

Category II, California Anchovy, Mackerel, and Sardine Purse Seine Fishery. [1]

Number of permit holders: There are 63 limited-entry permits (Pacific Fishery Management Council. 2005. Status of the Pacific Coast coastal pelagic species fishery and recommended acceptable biological catches. Stock Assessment and Fishery Evaluation Report 2005).

Number of active permit holders: There are 61 vessels actively fishing.

Total effort: The fishery is managed under a capacity goal, with gross tonnage of vessels used as a proxy for fishing capacity. Capacity for the fleet is approximately 5,400 gross tons. Harvest guidelines for sardine and mackerel are also set annually.

Geographic range: These fisheries occur along the coast of California predominantly from San Pedro, including the Channel Islands, north to San Francisco.

Seasons: This fishery operates year round. Targeted species vary seasonally with availability and market demand.

Gear type and fishing method: Purse seine, drum seine and lampara nets utilizing standard seining techniques.

Regulations: This is a limited-entry fishery.

Management type: The fishery is managed under a Coastal Pelagic Species Fisheries Management Plan developed by the Pacific Fishery Management Council and NMFS.

A NMFS pilot observer program began in July 2004 and continued through January 2006. A total of 93 sets have been observed. Observed marine mammal interactions with the fishery have included one California sea lion killed, 54 sea lions released alive, and one sea otter released alive. Under the MMAP self-reporting program, the following mortality was reported: In 2003, four California sea lions drowned after chewing through a bait barge net used by the anchovy lampara net fishery.

Category II, California tuna purse seine fishery.

Note: This fishery was previously included in the CA anchovy, mackerel, and sardine purse seine fishery (see above). Vessels in the anchovy, mackerel, and sardine fishery target tuna when oceanographic conditions result in an influx of tuna into southern California waters. Data for this fishery were obtained from the 'Status of the U.S. West Coast Fisheries for Highly Migratory Species through 2004', available at the Pacific Fishery Management Council website (http://www.pcouncil.org).

Number of permit holders: There are 63 limited-entry permits (Pacific Fishery Management Council. 2005. Status of the Pacific Coast coastal pelagic species fishery and recommended acceptable biological catches. Stock Assessment and Fishery Evaluation Report 2005).

Number of active permit holders: Between one and 23 vessels actively purse seined for tunas during the period 2000-2004.

Total effort: The number of vessels landing bluefin, yellowfin, skipjack, and albacore in 2000-2004 varied between one and 23. Logbooks are not required for this fishery, and the overall number of sets fished is unknown.

[1] Information for this fishery came from the following sources: Pacific Fishery Management Council. 2005. Status of the Pacific Coast coastal pelagic species fishery and recommended acceptable biological catches. Stock assessment and fishery evaluation – 2005; California Coastal Pelagic Species Pilot Observer Program Informational Report 12 October 2005 (NMFS SW Region, unpublished); Lyle Enriquez NMFS Southwest Regional Office (personal communication) and the Marine Mammal Authorization Program, Registration and Reporting System. This fishery was formerly known as the "CA anchovy, mackerel, and tuna purse seine fishery" and was renamed in the NMFS MMPA List of Fisheries for 2007 (Federal Register Volume 72, No. 59, 14466). The "tuna" component of this fishery was designated as a separate fishery in the 2007 List of Fisheries and is named the "CA tuna purse seine fishery" (see fishery description below).

Geographic range: Observed sets in this fishery have occurred in the southern California Bight.

Seasons: Observed sets occurred in August and September. The timing of fishing effort varies with the availability of tuna species in this region.

Gear type and fishing method: Small coastal purse seine vessels with a <640 mt carrying capacity target bluefin, yellowfin, albacore and skipjack tuna during warm-water periods in southern California.

Regulations: This is a limited-entry fishery.

Management type: This fishery is managed under a Highly Migratory Species Management Plan developed by the Pacific Fishery Management Council and NMFS.

Comments: A pilot observer program for this fishery began in July 2004 and ended in January 2006. A total of 9 trips and 15 sets were observed with no marine mammal interactions.

Category II, WA Puget Sound Region salmon drift gillnet fishery.

Number of permit holders: This commercial fishery includes all inland waters south of the US-Canada border and east of the Bonilla/Tatoosh line, at the entrance to the Strait of Juan de Fuca. Treaty Indian salmon gillnet fishing is not included in this commercial fishery. The number of permit holders is reported to be 210 in the NMFS 2013 List of Fisheries (Federal Register 29 August 2013).

Number of active permit holders: The number of "active" permits is assumed to be equal to or less than the number of permits that are eligible to fish.

Total effort: Effort in the Puget Sound salmon drift gillnet fishery is regulated by systematic openings and closures that are specific to area and target salmon species.

Geographic Range: The fishery occurs in the inland marine waters south of the U.S./Canada border and east of the Bonilla/Tatoosh line at the entrance to the Strait of Juan de Fuca. The inland waters are divided into smaller statistical catch areas which are regulated independently.

Seasons: This fishery has multiple seasons throughout the year that vary among local areas dependent on local salmon runs. The seasons are managed to access harvestable surplus of robust stocks of salmon while minimizing impacts on weak stocks.

Gear type and fishing methods: Vessels operating in this fishery use a drift gillnet of single web construction, not exceeding 300 fathoms in length. Minimum mesh size for gillnet gear varies by target species. Fishing directed at sockeye and pink salmon are limited to gillnet gear with a 5-inch minimum mesh and a 6 inch maximum, with an additional "bird mesh" requirement that the first 20 meshes below the corkline be constructed of 5-inch opaque white mesh for visibility; the chinook season has a 7-inch minimum mesh; the coho season has a 5-inch minimum mesh; and the chum season has a 6- to 6.25-inch minimum mesh. The depth of gillnets can vary depending upon the fishery and the area fished. Normally they range from 180 to 220 meshes in depth, with 180 meshes as a common depth. It is the intention of the fisher to keep the net off the bottom. The vessel is attached to one end of the net and drifts with the net. The entire net is periodically retrieved onto the vessel and catch is removed. Drift times vary depending on fishing area, tidal condition and catch.

Regulations: The fishery is a limited-entry fishery with seasonal openings, area closures, and gear restrictions.

Management type: The fishery occurs in State waters and is managed by the Washington Department of Fish and Wildlife consistent with the U.S.-Canada Pacific Salmon Commission management regimes and the ocean salmon management objectives of the Pacific Fishery Management Council. U.S. and Canadian Fraser River sockeye and pink salmon fisheries are managed by the bilateral Fraser Panel in Panel Area waters. This includes the entire U.S. drift gillnet fishery for Fraser sockeye and pink salmon. For U.S. fisheries, Fraser Panel Orders are given effect by federal regulations that consist of In-season Orders issued by the NMFS Regional Administrator of the NMFS Northwest Region. These regulations are filed in the Federal Register post-season.

Comments: Salmon drift gillnet fisheries in Washington inland waters were last observed in 1993 and 1994, with observer coverage levels typically less than 10% (Erstad et al. 1996, Pierce et al. 1994, Pierce et al. 1996, NWIFC 1995). Fishing effort in the inland waters drift gillnet fishery has declined considerably since 1994 because far fewer vessels participate today (NMFS NW Region, unpublished data). Past marine mammal entanglements in this fishery included harbor porpoise, Dall's porpoise, and harbor seals.

Category II, CA squid purse seine fishery.[2]

Number of Permit Holders: A permit has been required to participate in the squid fishery since April 1998. Originally, only two types of permits were issued, either a vessel or light boat permit during the moratorium period from 1998 to 2004. Since the adoption of the Market Squid Fishery Management Plan (MSFMP) in 2005, a total of seven different permit types are now allowed under the restricted access program. Permit types include both transferable and non-transferable vessel, brail and light boat permits whose qualifying criteria are based on historical participation in the fishery during the moratorium period. Market squid vessel and brail permits allow a vessel to use lights to attract and capture squid using either purse seines or brail gear. Light boat owner permits only allow the use of attracting lights to attract and aggregate squid. In addition, three experimental non-transferable permits are allowed for vessel fishing outside of historical fishing areas north of San Francisco. In the 2006/2007 season there were 91 vessel permits, 14 brail permits, 64 light boat permits and 3 experimental permits issued. A permit is not required when fishing for live bait or when landing two short tons or less, which is considered incidental.

Number of Active Permit Holders: The number of active permits varies by year depending on market conditions and availability of squid. During the 2006/2007 season (1 April 2006 – 31 March 2007) there were approximately 84 vessels active during some portion of the year. Twenty-nine vessels harvested 86% of the total landings greater than two tons. The 1999/2000 season had the highest squid landings to date (115,437mt), with 132 vessels making squid landings.

Total Effort: Logbooks have been mandatory for the squid fishery since May 2000. Results for the 2006 calendar year indicate that each hour of fishing required 1.4 hours of search time by light boats. Combined searching and fishing effort resulted in 6.9 metric tons (mt) of catch per hour. In the 2006/2007 season, the fishery made 1,611 landings. This is a 47% decrease from the previous season. In addition, the average landing decreased from 23.9 mt to 21.7 mt.

Geographic Range: Since the 1960's there have been two distinct fisheries in operation north and south of Point Conception. Since the mid-1980's the majority of the squid fishing harvest has occurred in the southern fishery, with efforts focused around the Channel Islands and along the mainland from Port Hueneme to La Jolla. In the 2006/2007 season, the southern fishery landed 98% of the catch with the majority of landings occurring around the northern Channel Islands. In contrast, during the 2005/2006 season, landings in the southern fishery were primarily around Catalina Island. The northern fishery, centered primarily in Monterey Bay, has been in operation since the mid-1860's and has historical significance to California. During the 2002/2003 season, a moderate El Niño condition resulted in nearly 60% of the catch being landed in northern California.

Seasons: The fishery can occur year-round; however, fishing efforts differ north and south of Point Conception. Typically, the northern fishery operates from April through September while the southern fishery is most active from October through March. El Niño conditions generally hamper the fishery in the southern fishery and squid landings are minimal during these events. In contrast, landings in the northern fishery often increase during El Niño events and then are depressed for several years after.

Gear Type: There are several gears employed in this fishery. From 1996 to 2006, the vast majority (95%) of vessels use either purse (69%) or drum (26%) seine nets. Other types of nets used include brail (5%) and lampara nets (<1%). Another

[2]This fishery description was provided by Dianna Porzio and Dale Sweetnam, California Department of Fish and Game. Details of marine mammal interactions with this fishery were obtained from NOAA Fisheries, Southwest Regional Office.

gear type associated with the fishery is attracting lights (30,000 watts maximum) that are used to attract and aggregate spawning squid in shallow waters.

Regulations: Since March 2005, the fishery operates under a restricted access program that requires all vessels to be permitted. A mandatory logbook program for fishing and lighting vessels has been in place since May 2000. A /monitoring program has been in place since 2000 that samples the landings is designed to evaluate the impact of the fishery on the resource. Attracting lights were regulated with each vessel restricted to no more than 30,000 watts of light during fishing activities. These lights must also be shielded and oriented directly downward to reduce light scatter. The lighting restrictions were enacted to avoid risks to nesting brown pelicans and interactions with other seabird species of concern. A seabird closure area restricting the use of attracting lights for commercial purposes in any waters of the Gulf of the Farallones National Marine Sanctuary was enacted. A seasonal catch limitation of 107,047 mt (118,000 short tons) was established to limit further expansion of the fishery. Commercial squid fishing is prohibited between noon on Friday and noon on Sunday of each week to allow an uninterrupted consecutive two-day period of spawning. Additional closure areas to the fishery to protect squid spawning habitat include the Channel Islands Marine Protected Areas (MPAs) and the newly established MPAs along the central California coast as well as areas closed to the use of purse seine gear including the leeward side of Catalina Island, Carmel and Santa Monica Bays.

Management Type: The market squid fishery is under California State management. The fishery was largely unregulated until 1998 when it came under regulatory control of the California Fish and Game Commission and the Department of Fish and Game. The MSFMP was enacted on March 28, 2005. The MSFMP was developed to ensure sustainable long-term conservation and to be responsive to environmental and socioeconomic changes. Market squid is also considered a monitored species under the Pacific Fishery Management Council's (PFMC) Coastal Pelagic Species Fishery Management Plan.

Comments: During the 1980's, California's squid fishery grew rapidly in fleet size and landings when international demand for squid increased due to declining fisheries in other parts of the world. In 1997 industry-sponsored legislation halted the growth of fleet size with a moratorium on new permits. Landing records were set several times during the 1990's, but landings seem to fluctuate with changing environmental and atmospheric conditions of the California Current. Encounters with marine mammals and sea birds are documented in logbooks. Seal bombs are used regularly, but fishermen report that they no longer have an effect. A pilot observer program began in July 2004 and has documented one unidentified common dolphin death in 135 sets through January 2006. In addition, there have been 96 California sea lions and three harbor seals released alive (NMFS, Southwest Region, unpublished data). In addition to the observed death, there were three strandings of Risso's dolphin from 2002-2003 where evidence of gunshot wounds was confirmed, suggesting interaction with this fishery (NMFS Southwest Regional Office, unpublished data). The squid fishery operates primarily at night and targets spawning aggregations of adult squid. In recent years the amount of daylight fishing has increased, especially in Monterey, in part due to better sonar gear, but also to reduce interactions with California sea lions. The PFMC adopted the egg escapement method to monitor the impact of market squid fishery since no reliable biomass estimate has been developed. It is a proxy for Maximum Sustainable Yield (MSY), setting an egg escapement threshold level at which to evaluate the magnitude of fishing mortality on the spawning potential of the squid stock. The egg escapement method was developed on conventional spawning biomass "per-recruit" theory. In general, the MSY Control Rule for market squid is based on evaluating levels of egg escapement associated with the exploited population. The egg escapement threshold, initially set at 30%, represents a biological reference point from which to evaluate fishery related impacts.

Category III, CA Dungeness crab pot

Notes: NMFS is reviewing several pot and trap fisheries along the U.S. west coast, in response to entanglements of humpback whales in pot and trap gear. An update on these fisheries will appear in the MMPA Proposed List of Fisheries for 2009. For all commercial pot and trap fisheries in California, a general trap permit is required, in addition to any specific permits required for an individual fishery. All traps are required to be tended and serviced at least every 96 hours, weather permitting. Descriptions of those pot and/or trap fisheries for which interactions with marine mammals have been documented or suspected are included in this Appendix.

Number of permit holders: The Dungeness crab fishery is a limited access fishery requiring a vessel-based permit that is transferable. This program was initiated in 1994 based on landing histories. The number of vessels participating on an annual basis does vary, but approximately 400 vessels have been landing crab in recent years.

Number of active permit holders: Approximately 400 vessels have been landing crabs in recent years.

Total effort: There is no restriction on the number of traps that may be fished at one time by a single vessel. Some vessels use as many as 1000 or more traps at the peak of the season (December/January).

Geographic range: This fishery operates in central and northern California.

Seasons: The fishery is divided into two management areas. The central region (south of the Mendocino-Sonoma county line) fishery opens November 15 and continues through June 30. The northern region (north of the Mendocino-Sonoma county line) is annually scheduled to open on December 1, but may be delayed by CDF&G based on the condition of market size crabs, and continues until July 15.

Gear type: For each trap fished there is one vertical line in the water, though only in the northern region, is fishing strings illegal. All traps are required to be marked with buoys bearing the commercial fishing license number. The normal operating depth for Dungeness crab is between 35 and 70 m. Traps are typically tended on a daily basis.

Regulations: There is no daily logbook requirement for the commercial Dungeness crab fishery. There is a recreation fishery for Dungeness crab, which allows for 10 crab per day to be harvested except when fishing on a commercial passenger fishing vessel (CPFV) in central California, the limit is 6 crab per person. There is no reliable estimate for the effort or landings in the sport fishery except that CPFVs are required to track catch and effort by species.

Management type: The Dungeness crab pot fishery is managed by the California legislature, CDF&G and also by the tri-state committee for Dungeness, which includes the states of Oregon and Washington.

Comments: Humpback whale entanglements with Dungeness crab gear have not been confirmed, but are suspected as the responsible fishery based on the location and timing of fishing effort and observed humpback entanglements.

Category III, OR Dungeness crab pot

Notes: Dungeness crab is the most significant pot/trap fishery in the state of Oregon. Over the long term, the fishery has averaged around 10 million lb of landings per year; although since 2003, annual landings have been approximately 25 to 30 million lb. This fishery requires an Oregon issued limited-entry permit, which is transferable.

Number of permit holders: There were 433 permit holders in 2006.

Number of active permit holders: A total of 364 vessels landed crabs in 2006.

Total effort: In 2006, the fishery made a transition to a three-tiered pot limitation program which allows a maximum of 200, 300, or 500 pots to be fished at any one time depending on previous landing history. The pot limitation is implemented through a buoy tag requirement. All Dungeness crab pots require buoy tags with the identifying associated permit attached. The expected result of the buoy tags and tier limits is to reduce the number of pots in Oregon waters down from 200,000 to approximately 150,000.

Geographic range: Oregon waters.

Seasons: The Dungeness crab season runs from December 1 to August 14. The highest landings are always recorded in December through February, at the beginning of the season.

Gear type: Pots.

Regulations: All Oregon pot/trap gear must be marked on its terminal ends with pole and flag, light, radar reflector, and buoy with the owner/operator number clearly marked. By law, gear may not be left unattended for more than seven days. All vessel operators and deck hands must have a commercial fishing license or crewmembers license.

Management type: State management, Oregon Department of Fish and Wildlife.

Comments: Humpback whale entanglements with Dungeness crab gear have not been confirmed, but are suspected as the responsible fishery based on the location and timing of fishing effort and observed humpback entanglements.

Category III, CA spot prawn fishery

Number of permit holders: A three-tiered limited access permit system is used in this fishery to accommodate changes in the fishery that occurred when trawling methods were banned and replaced with trap fishing in 2003. Permits are linked to the vessel owner and only Tier 1 permits are transferable. Tier 1 permits allow a maximum of 500 traps in use at a time. Eighteen vessels had Tier 1 permits in 2007. Tier 2 permits allow 150 traps in use at a time. There were three vessels utilizing Tier 2 permits in 2007. Tier 3 permits were issued to allow vessels that previously used trawl gear to switch to trap gear to target spot prawn. There were nine Tier 3 permits issued in 2007. Information on 2007 license statistics was obtained from the CA Department of Fish and Game website, http://www.dfg.ca.gov/licensing/statistics/statistics.html.

Number of active permit holders: A total of 30 vessels participated in this fishery in 2007.

Total effort: Landings have increased every year since 2003. The total number of traps set is unknown, although the theoretical maximum number of traps that may be fished annually is approximately 13,000.

Geographic range: The fishery operates from Monterey south. Over half of the landings are made in Los Angeles and San Diego. Traps are typically set in waters of 182 m (100 fathoms) or more. South of Point Arguello, traps must be fished in waters 91 m (50 fathoms) or deeper.

Seasons: North of Point Arguello, the fishery is open from February 1 to October 30. North of Point Arguello, the open season is August 1 to April 30.

Gear type: Strings of 25 to 50 traps are fished in deep waters (>182 m).

Regulations: For all commercial pot and trap fisheries in California, a general trap permit is required, in addition to any specific permits required for an individual fishery. All traps are required to be tended and serviced at least every 96 hours, weather permitting. There is a daily logbook requirement in this fishery. There is no buoy marking requirement and no recreational fishery for this species.

Management type: This fishery is managed under state authority by the California Department of Fish and Game.

Comments: One humpback whale was seriously injured in 2006 as a result of entanglement in spot prawn trap gear.

Category III, WA/OR/CA sablefish pot

Notes: Sablefish is likely the most commonly targeted groundfish caught in pot gear in off the U.S. west coast.

Number of permit holders: There are 32 limited-entry permits (LEPs) to catch sablefish with pot gear. Open access privileges are also available to fishermen.

Number of active permit holders: Including all vessels which made landings with an LEP or under open access rules, a total of about 150 vessels participated in this fishery in 2007. This total fluctuates on an annual basis.

Total effort: Estimated annual landings indicate usually over 1 million lbs of sablefish are landed per year in this fishery.

Geographic range: The fishery is well distributed from central California north to the U.S./Canadian border. Most of the effort occurs out in deeper waters (200-400 m).

Seasons: Most fishing effort occurs January through September.

Gear type: Traps <6 ft. in any dimension.

Regulations: A general trap permit is all that is required for open access to this fishery by the states along the U.S. west coast. LEPs are divided into a three-tiered system which allocates annual landing limits to individual permits based on the status of the stock. Daily logbook reporting is required.

Management type: Sablefish is managed under the federal Groundfish Fishery Management Plan. This is the only trap fishery regulated by the federal government; all others are managed by the states.

Comments: One humpback whale was seriously injured in 2006 as a result of entanglement in sablefish trap gear.

Category III, CA rock crab

Number of permit holders: There were 134 permits issued in 2007.

Number of active permit holders: Unknown, but it is likely that most issued permits are active.

Total effort: Annual landings averaged approximately 1 million pounds from 2000 to 2005.

Geographic range: The fishery operates throughout California waters. Most landings are made south of Morro Bay, California, with approximately 65% of all landings coming from the Santa Barbara area.

Seasons: There are no seasonal restrictions, though some area closures exist.

Gear type: There is no restriction on the number of traps that may be fished at one time by the vessel but the typical number of traps operated at any given time is less than 200. Traps are usually buoyed singularly or in pairs, but fishing strings (multiple traps attached together between two buoys) is allowed. Buoys are required to be marked with the license number of the operator. The normal working depth of traps in this fishery is 10 to 35 fathoms.

Regulations: There is no daily logbook requirement for the commercial rock crab fishery.

Management type: The fishery is managed by the California Department of Fish and Game.

Comments: The recreational bag limit is 35 crabs per day, but there is no reliable estimate of the effort or landings in the sport fishery.

Category III, CA halibut bottom trawl.

Notes: This is a newly-listed fishery in the 2007 MMPA NMFS List of Fisheries (Federal Register Volume 72, No. 59, 14466). Information on fishing effort was provided by Stephen Wertz, California Department of Fish and Game.

Number of permit holders: There were 60 permits issued in 2006.

Number of active permit holders: There were 31 active permit holders in 2006.

Total effort: Thirty one vessels made 3,711 tows statewide in 2006, totaling 3,897 tow hours, in 332 days of fishing effort.

Geographic range: The fishery operates from Bodega Bay in northern California to San Diego in southern California, from 3 to 200 nautical miles offshore. Trawling is prohibited in state waters (0 to 3 nmi offshore) and within the entire Monterey

Bay, except in the designated "California halibut trawl grounds", between Point Arguello and Point Mugu beyond 1 nautical mile from shore. Trawls used in this region must have a minimum mesh size of 7.5 in and trawling is prohibited here between 15 March and 15 June to protect spawning adults.

Seasons: Fishing is permitted year-round, except in state waters. State waters are closed between 15 March and 15 June.

Gear type: Otter trawls, with a minimum mesh size of 4.5 inches are required in federal waters, while fishing in state waters has a 7.5 inch mesh size requirement.

Regulations: Fishing in state waters is limited to the period 14 March – 16 June in the 'California halibut trawl grounds' in southern California between Point Arguello and Point Mugu. All other fishing must occur in federal waters beyond 3 nautical miles from shore.

Management type: The fishery is managed by the California Department of Fish and Game.

Comments: No marine mammal interactions have been documented for this fishery, but the gear type and fishing methods are similar to the WA/OR/CA groundfish trawl fishery (also category III), which is known to interact with marine mammals.

Category III, CA herring gillnet fishery.[3]

The herring fishery is concentrated in four spawning areas which are managed separately by the California Department of Fish and Game (CDFG); catch quotas are based on population estimates derived from acoustic and spawning-ground surveys. The largest spawning aggregations occur in San Francisco Bay and produces more than 90% of the herring catch. Smaller spawning aggregations are fished in Tomales Bay, Humboldt Bay, and Crescent City Harbor. During the early 1990's, there were 26 round haul permits (either purse seine or lampara nets). Between 1993 and 1998, all purse seine fishers converted their gear to gillnets with stretched mesh size less than 2.5 inches (which are not known to take mammals) as part of CDFG efforts to protect herring resources. The fishery is managed through a limited-entry program. The California Department of Fish and Game website lists a total of 447 herring gillnet permits for 2005 (http://www.dfg.ca.gov/mrd/herring/index.html). Of these, 406 permits exist for San Francisco Bay, 34 in Tomales Bay, 4 in Humboldt Bay, and 3 in Crescent City Harbor. This fishery begins in December (San Francisco Bay) or January (northern California) and ends when the quotas have been reached, but no later than mid-March.

Category III, WA Willapa Bay salmon drift gillnet fishery.

Number of permit holders: The total number of permit holders for this fishery in 1995 and 1996 was 300, but this number has declined in subsequent years. In 1997 there were 264 total permits and 243 in 1998. The NMFS 2001 List of Fisheries lists an estimate of 82 vessels/persons in this fishery.

Number of active permit holders: The number of active permit holders is assumed to be equal to or less than the number of permits eligible to fish in a given year. The number of permits renewed and eligible to fish in 1996 was 300 but declined to 224 in 1997 and 196 permits were renewed for 1998. The 1996-98 counts do not include permits held on waivers for those years, but do include permits that were eligible to fish at some point during the year and subsequently entered into a buyback program. The number of permits issued for this fishery has been reduced through a combination of State and federal permit buyback programs. Vessels permitted to fish in the Willapa Bay are also permitted to fish in the lower Columbia River drift gillnet fishery.

Total effort: Effort in this fishery is regulated through area and species openings. The fishery was observed in 1992 and 1993 when fishery opening were greater than in recent years. In 1992 and 1993 there were 42 and 19 days of open fishing time during the summer "dip-in" fishery. The "dip-in" fishery was closed in 1994 through 1999. Available openings have also declined in the fall chinook/coho fisheries. In 1992/93 respectively there were 44 and 78 days of available fishing time. There were 43, 45, 22 and 16.5 available open fishing days during 1995 through 1998.

[3] Pers. Comm. Becky Ota, State Herring Manager, Senior Biologist.

Geographic range: This fishery includes all inland marine waters of Willapa Bay. The waters of the Bay are further divided into smaller statistical catch areas.

Seasons: Seasonal openings coincide with local salmon run timing and fish abundance.

Gear type: Fishing gear used in this fishery is a drift gillnet of single web construction, not exceeding 250 fathoms in length, with a minimum stretched mesh size ranging upward from 5 inches depending on target salmon species. The gear is commonly set during periods of low and high slack tides. It is the intention of the fisher to keep the net off the bottom. The vessel is attached to one end of the net and drifts with the net. The entire net is periodically retrieved onto the vessel and catch is removed. Drift times vary depending on fishing area, tidal condition, and catch.

Regulations: This fishery is a limited-entry fishery with seasonal openings and gear restrictions.

Management type: The salmon drift gillnet fishery is managed by the Washington Department of Fish and Wildlife.

Comments: Observers were placed onboard vessels in this fishery to monitor marine mammal interactions in the early 1980s and in 1990-93. Five incidentally taken harbor seals were recovered by observers in the fishery from 1991through 1993 (3 in '92 and 2 in '93). Two incidentally taken northern elephant seals were recovered by observers from the fishery in 1991 but no takes of this species were observed. The summer fishery (July- August) in Willapa Bay has been closed since it was last observed in 1993 and available fishing time declined from 1996 through 1998.

Category III, WA Grays Harbor salmon drift gillnet fishery.

Number of permit holders: This commercial drift gillnet fishery does not include Treaty Indian salmon gillnet fishing. The total number of permit holders for this commercial fishery in 1995 and 1996 was 117 but this number has declined in subsequent years. In 1997 there were 101 total permits and 87 in 1998.

Number of active permit holders: The NMFS 2001 List of Fisheries lists a total of 24 vessels/persons operating in this fishery. The number of active permit holders is assumed to be equal to or less than the number of permits eligible to fish in a given year. The number of permits renewed and eligible to fish in 1996 was 117 but declined to 79 in 1997 and 59 permits were renewed for 1998. The 1996-98 counts do not include permits held on waivers for those years but do include permits that were eligible to fish at some point during the year and subsequently entered a buyback program. The number of permits issued for this fishery has been reduced through a combination of State and federal permit buyback programs. Vessels permitted to fish in Grays Harbor are also permitted to fish in the lower Columbia River salmon drift gillnet fishery.

Total effort: Effort in this fishery is regulated through area and species openings. The fishery was observed in 1992 and 1993 when fishery openings were greater than in recent years. In 1992 and 1993 there were 42 and 19 days of open fishing time during the summer "dip-in" fishery. The "dip-in" fishery was closed in 1994 through 1999. Available openings have also declined in the fall chinook/coho fisheries. There were 11, 17.5, 9 and 5 available open fishing days during the 1995 through 1998 fall season.

Geographic range: Effort in this fishery includes all marine waters of Grays Harbor. The waters are further divided into smaller statistical catch areas.

Seasons: This fishery is subject to seasonal openings which coincide with local salmon run timing and fish abundance.

Gear type: Fishing gear used in this fishery is a drift gillnet of single web construction, not exceeding 250 fathoms in length, with a minimum stretched mesh size ranging of 5 inches depending on target salmon species. The gear is commonly set during periods of low and high slack tides and retrieved periodically by the tending vessel. It is the intention of the fisher to keep the net off the bottom. The vessel is attached to one end of the net and drifts with the net. The entire net is periodically retrieved onto the vessel and catch is removed. Drift times vary depending on fishing area, tidal condition, and catch.

Regulations: The fishery is a limited-entry fishery with seasonal openings and gear restrictions.

Management type: The salmon drift gillnet fishery is managed by the Washington Department of Fish and Wildlife.

Comments: Observers were placed onboard vessels in this fishery to monitor marine mammal interactions in the early 1980s and in 1990-93. Incidental take of harbor seals was observed during the fishery in 1992 and 1993. In 1992, one harbor seal was observed entangled dead during the summer fishery and one additional seal was observed entangled during the fall fishery but it escaped uninjured. In 1993, one harbor seal was observed entangled dead and one additional seal was recovered by observers during the summer fishery. The summer fishery (July-August) in Grays Harbor has been closed since it was last observed in 1993. Available fishing time in the fall chinook fisheries declined from 1996 through 1998.

Category III, WA, OR lower Columbia River salmon drift gillnet fishery.

Number of permit holders: The total number of permit holders was 856 (344 from Oregon and 512 from Washington) when the fishery was last observed in 1993. In 1995 through 1998 the number of permits was 747, 693, 675 and 620 respectively. The number of permits issued for this fishery by Washington has been reduced through a combination of State and federal buy-back programs. This reduction is reflected in the overall decline in the total number of permits.

Number of active permit holders: The number of active permits is a subset of the total permits issued for the fishery. For example, in 1995, 110 vessels (of the 747 vessels holding permits) landed fish in the mainstem fishery.

Total effort: Effort in this fishery is regulated through species related seasonal openings and gear restrictions. The fishery was observed in 1991, 1992 and 1993 during several seasons of the year. The winter seasons (openings) for 1991 through 1993 totaled 13, 9.5, and 6 days respectively. The winter season has subsequently been reduced to remnant levels to protect upriver ESA listed salmon stocks. In 1995 there was no winter salmon season, in 1996 the fishery was open for 1 day. In 1997 and 1998 the season was shifted to earlier in the year and gear restrictions were imposed to target primarily sturgeon. The fall fishery in the mainstem was also observed 1992 and 1993 as was the Young's Bay terminal fishery in 1993, however, no marine mammal mortality was observed in these fisheries. The fall mainstem fishery openings varied from 1 day in 1995 to just under 19.5 days in 1997 and 6 days in 1998. The fall Youngs Bay terminal fishery fluctuated between 60 and 70 days for the 1995 through 1998 period which was similar to the fishery during the period observed.

Geographic range: This fishery occurs in the main stem of the Columbia river from the mouth at the Pacific Ocean upstream to river mile 140 near the Bonneville Dam. The lower Columbia is further subdivided into smaller statistical catch areas which can be regulated independently.

Seasons: This fishery is subject to season and statistical area openings which are designed to coincide with run timing of harvestable salmon runs while protecting weak salmon stocks and those listed under the Endangered Species Act. In recent years, early spring (winter) fisheries have been sharply curtailed for the protection of listed salmon species. In 1994, for example, the spring fishery was open for only three days with approximately 1900 fish landed. In 1995 the spring fishery was closed and in 1996 the fishery was open for one day but fishing effort was minimal owing to severe flooding. Only 100 fish were landed during the one day in 1996.

Gear type: Typical gear used in this fishery is a gillnet of single web construction, not exceeding 250 fathoms in length, with a minimum stretched mesh size ranging upwards from 5 inches depending on target salmon species. The gear is commonly set during periods of low and high slack tides. It is the intention of the fisher to keep the net off the bottom. The vessel is attached to one end of the net and drifts with the net. The entire net is periodically retrieved onto the vessel and catch is removed. Drift times vary depending on fishing area, tidal condition, and catch.

Regulations: The fishery is a limited-entry fishery with seasonal openings, area closures, and gear restrictions.

Management type: The lower Columbia River salmon drift gillnet fishery is managed jointly by the Washington Department of Fish and Wildlife and the Oregon Department of Fish and Wildlife.

Comments: Observers were placed onboard vessels in this fishery to monitor marine mammal interactions in the early 1980s and in 1990-93. Incidental takes of harbor seals and California sea lions were documented, but only during the winter seasons (which have been reduced dramatically in recent years to protect ESA-listed salmon). No mortality was observed during the fall fisheries.

Category III, WA, OR salmon net pens.

Number of permit holders: There were 12 commercial salmon net pen ("grow out") facilities licensed in Washington in 1998. There are no commercial salmon net pen or aquaculture facilities currently licensed in Oregon. Non-commercial salmon enhancement pens are not included in the list of commercial fisheries.

Number of active permit holders: Twelve salmon net pen facilities in Washington.

Total effort: The 12 licensed facilities on Washington operate year-round.

Geographic range: In Washington, net pens are found in protected waters in the Straits (Port Angeles), northern Puget Sound (in the San Juan Island area) as well as in Puget Sound south of Admirality Inlet. There are currently no commercial salmon pens in Oregon.

Seasons: Salmon net pens operate year-round.

Gear type: Net pens are large net impoundments suspended below a floating dock-like structure. The floating docks are anchored to the bottom and may also support guard (predator) net systems. Multiple pens are commonly rafted together and the entire facility is positioned in an area with adequate tidal flow to maintain water quality.

Regulations: Specific regulations unknown.

Management type: In Washington, the salmon net pen fishery is managed by the Washington Department of Natural Resources through Aquatic Lands Permits as well as the Washington Department of Fish and Wildlife.

Comments: Salmon net pen operations have not been monitored by NMFS for marine mammal interactions, however, incidental takes of California sea lions and harbor seals have been reported.

Category III, WA, OR, CA groundfish trawl.

Approximate number of vessels/persons: In 1998, approximately 332 vessels used bottom and mid-water trawl gear to harvest Pacific coast groundfish. This is down from 383 vessels in 1995. The NMFS List of Fisheries for 2001 lists 585 vessels as participating in this fishery. Groundfish trawl vessels harvest a variety of species including Pacific hake, flatfish, sablefish, lingcod, and rockfish. This commercial fishery does not include Treaty Indian fishing for groundfish.

All observed incidental marine mammal takes have occurred in the mid-water trawl fishery for Pacific hake. The annual hake allocation is divided between vessels that harvest and process catch at sea and those that harvest and deliver catch to shore-based processing facilities. At least one NMFS-trained observer is placed on board each at-sea processing vessel to provide comprehensive data on total catch, including marine mammal takes. In the California, Oregon, and Washington range of the fishery, the number of vessels fishing ranged between 12 and 16 (all with observers) during 1997-2001. Hake vessels that deliver to shore-based processors are issued Exempted Fishing Permits that requires the entire catch to be delivered unsorted to processing facilities where State technicians have the opportunity to sample. In 1998, 13% of the hake deliveries landed at shore-based processors were monitored. The following is a description of the commercial hake fishery.

Number of permit holders/active permit holders: A license limitation ("limited-entry") program has been in effect in the Pacific coast groundfish fishery since 1994. The number of limited-entry permits is limited to 404. Non-tribal trawl vessels that harvest groundfish are required to possess a limited-entry permit to operate in the fishery. Any vessel with a federal limited-entry trawl permit may fish for hake, but the number of vessels that do is smaller than the number of permits. In 1998, approximately 61 limited-entry vessels, 7 catcher/processors and 50 catcher vessels delivering to shoreside and mothership processors, made commercial landings of hake during the regular season. In addition, 6 unpermitted mothership processors received unsorted hake catch.

Total effort: The hake allocation continues to be fully utilized. From 1997 to 1999 the annual allocation was 232,000 mt/year, this is an increase over the 1996 allocation of 212,000 mt and the 1995 allocation of 178,400 mt. In 1998, motherships vessels received 50,087 mt of hake in 17 days, catcher/processors took 70,365 mt of hake in 54 days and shore-based processors received 87,862 mt of hake over a 196 day period.

Geographic range: The fishery extends from northern California (about 40^{o} 30' N. latitude) to the U.S.-Canada border. Pacific hake migrate from south to north during the fishing season, so effort in the south usually occurs earlier than in the north.

Seasons: From 1997 to 1999, season start dates have remained unchanged. The shore-based season in most of the Eureka area (between 42^{O}- 40^{O}30' N latitude) began on April 1, the fishery south of 40^{O}30' N latitude opened April 15, and the fishery north of 42^{O} N latitude started on June 15. In 1998, the primary season for the shore-based fleet closed on October 13, 1998. The primary seasons for the mothership and catcher/processor sectors began May 15, north of 42^{0} N. lat. In 1998, the mothership fishery closed on May 31, the catcher/processor fishery closed on August 7.

Gear type: The Pacific hake trawl fishery is conducted with mid-water trawl gear with a minimum mesh size of 3 inches throughout the net.

Regulations/Management type: This fishery is managed through Federal regulations by the Pacific Fishery Management Council under the Groundfish Fishery Management Plan.

Comments: Since 1991, incidental takes of Steller sea lions, Pacific white-sided dolphins, Dall's porpoise, California sea lions, harbor seals, northern fur seals, and northern elephant seals have been documented in the hake fishery. From 1997-2001, 4 California sea lions, 2 harbor seals, 2 northern elephant seals, 1 Pacific white-sided dolphin, and 6 Dall’s porpoise were reported taken in California/Oregon/Washington regions by this fishery.

Category III fisheries in Hawaii are managed primarily by the State of Hawaii[4]. Some fisheries have undergone many changes in geographic and temporal extent in recent years and complete analyses of fishing effort for recent years are not yet available. For many, fishing season and specific gear types are not well defined. These fishery descriptions will be updated as new information and analyses become available.

Category III, Hawaii gillnet fishery.[5]

Number of active permit holders: In 2011 there were 36 active commercial fishers. In 1995 there were approximately 115.

Total effort: In 2011 there were 495 trips.. This fishery operates in nearshore and coastal pelagic regions.

Seasons: This fishery operates year-round with the exception of juvenile big-eyed scad less than 8.5 inches which cannot be taken from July through October.

Gear type: Gillnets are of stretched mesh greater than 2 inches and stretched mesh size greater than 2.75 inches for stationary gillnets. The net dimensions may not exceed 7 feet high and 125 feet long.

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[4]Descriptions of Hawaii State managed fisheries provided by Reggie Kokubun and Sarah Courbis , State of Hawaii, Department of Land and Natural Resources, Division of Aquatic Resources and Hawaii Humpback Whale National Marine Sanctuary, Honolulu Hawaii.

Regulations: Stationary nets must be inspected every 2 hours and total soak time cannot exceed four hours in the same location. New restrictions implemented in 2007 include that nets may not: 1) be used more than once in a 24-hour period; 2) exceed a 7 ft stretched height limit; 3) exceed a single-panel; 4) be used at night; 5) be set within 250 ft. of another lay net; 6) be set in more than 80 ft depths; 7) be left unattended for more than ½ hour; 8) break coral during retrieval, 9) be set in freshwater streams or stream mouths, and nets must be 1) registered with the Division of Aquatic Resources; 2) inspected within two hours after being set; 2) tagged with two marker buoys while fished. Gillnets are prohibited around all of Maui and portions of Oahu and Hawaii Island.
Management type: A commercial marine license issued by the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR) is required for all commercial fishing activities in Hawaii State waters. The Federal Fishery Ecosystem Plan for the Hawaii Archipelago contains no management measures applicable to this gear.

Comments: The principle catches include reef fishes and big-eyed scad (akule) and mackerel scad (opelu). Interactions have been documented with bottlenose dolphins and spinner dolphins.

Category III, Hawaii lift (opelu) net fishery

Number of active permit holders: In 2011 there were 22 active commercial fishers.

Total effort: In 2011 there were 843 trips.

Seasons: unknown.

Gear type: Fishing with a net that captures fish by raising the net from beneath a school of fish. Normally fish are encouraged over and into the new with chum.

Regulations: unknown.

Management type: A commercial marine license issued by the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR) is required for all commercial fishing activities in Hawaii State waters. The Federal Fishery Ecosystem Plan for the Hawaii Archipelago contains no management measures applicable to this gear.

Category III, Hawaii inshore purse seine fishery

Number of active permit holders: In 2011 there were less than 3 active commercial fishers.

Total effort: Cannot be reported to protect confidentiality.

Seasons: Year round.

Gear type: Fishing with a net that is used to surround a school of fish and is closed by drawing the bottom of the net together to form a bag.

Regulations: It is unlawful for any person without a valid commercial marine license to take akule with any net that has less than 2-3/4" stretched mesh. It is unlawful to take akule less than 8.5 inches with net from July – October or possess or sell more than 200 lbs of akule less than 8.5 inches per day during July – October. Federal regulations governing this gear can be found in the Code of Federal Regulations, Title 50, Part 665, Subpart C.

Management type: A commercial marine license issued by the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR) is required for all commercial fishing activities in Hawaii State waters. This fishery is also managed under the Federal Hawaiian Archipelago Fishery Ecosystem Plan in waters outside of 3 nmi from shore.

Category III, Hawaii throw net/ cast net fishery

Number of active permit holders: In 2011 there were 29 active commercial fishers.

Total effort: In 2011 there were 445 fishing trips.

Seasons: unknown.

Gear type: Fishing with a round or conical shaped net with a weighted outer perimeter that is thrown over fish.

Regulations: Minimum size 2 inch stretched mesh. Possession of thrownets with mesh size less than 2 inches in or near the water where fish may be taken is unlawful. Nets with smaller mesh may be used to take shrimp (`opae), `opelu, and makiawa.

Management type: A commercial marine license issued by the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR) is required for all commercial fishing activities in Hawaii State waters. The Federal Fishery Ecosystem Plan for the Hawaii Archipelago contains no management measures applicable to this gear.

Comments: Targets inshore and reef fish.

Category III, Hawaii seine net fishery

Number of active permit holders: In 2011 there were 26 active commercial fishers.

Total effort: In 2011 there were 227 fishing trips.

Seasons: unknown.

Gear type: Includes hukilau, beach seine, dragnet, pen, surround, etc. Fishing with a net by moving it through the water to surround fish by corralling and trapping them within the walls of the net.

Regulations:.Outside of 3nmi from shore, the Federal Fishery Ecosystem Plan for the Hawaii Archipelago requires seine nets be attended to at all times. Federal regulations governing this gear can be found in the Code of Federal Regulations, Title 50, Part 665, Subpart C.

Management type: A commercial marine license issued by the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR) is required for all commercial fishing activities in Hawaii State waters. This fishery is also managed under the Federal Hawaiian Archipelago Fishery Ecosystem Plan outside of 3 nmi from shore.

Comments: Typical species: usually inshore and reef fish.

Category III, Hawaii trolling, rod, and reel fishery.

Number of active permit holders: In 2011 there were 2,126 active commercial fishers.

Total effort: In 2011 there were 30,020 fishing trips.

Seasons: Year round.

Gear type: Fishing by towing or dragging line(s) with artificial lure(s), dead or live bait, or green stick and dnaglers using a sail, surf or motor-powered vessel underway. Up to six lines rigged with artificial lures may be trolled when outrigger poles are used to keep gear from tangling. When using live bait, trollers move at slower speeds to permit the bait to swim naturally. Pelagic trollers generally fish at an average distance of 5 to 8 miles from shore, with a maximum distance of about 30 miles from shore. Trollers fish where water masses converge and where submarine cliffs, seamounts, and other underwater features dramatically change the bathymetry. Trolls often fish drifting logs, other flotsam, underneath bird aggregations, and near FADs. Typical target species include mahimahi, ono, billfishes (marlin, sailfishes, etc.), kaku, uluas, kamanu, tunas, etc.

Regulations: The Fishery Ecosystem Plan for Pelagic Fisheries of the Western Pacific contains no management regulation applicable to pelagic trolling in Federal waters around Hawaii.

Management type: A commercial marine license issued by the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR) is required for all commercial fishing activities in Hawaii State waters. This fishery is also managed under the Federal Pacific Pelagics Fishery Ecosystem Plan outside of 3 nmi from shore.

Category III, Hawaii kaka line fishery.

Number of active permit holders: In 2011 there were 17 active commercial fishers.

Total effort: In 2011 there were 46 fishing trips.

Seasons: unknown.

Gear type: Fishing with a gear consisting of a mainline less than one nautical mile in length to which are attached multiple branchlines with baited hooks. Mainline is set horizontally, and fixed on or near the bottom, or in shallow midwater. Typical target species varies spending on set location, e.g., nearshore or pelagics.

Regulations: Managed under State of Hawaii regulations.

Management type: A commercial marine license issued by the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR) is required for all commercial fishing activities in Hawaii State waters. The Fishery Ecosystem Plan for the Hawaii Archipelago contains no management measures applicable to this gear.

Category III, Hawaii vertical longline fishery.

Number of active permit holders: In 2011 there were 9 active commercial fishers.

Total effort: In 2011 there were 92 fishing trips.

Seasons: unknown.

Gear type: Fishing using a vertical mainline, less than one nautical mile in length and suspended from the surface with float, from which leaders with baited hooks are attached and ending with a terminal weight.

Regulations: unknown.

Management type: A commercial marine license issued by the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR) is required for all commercial fishing activities in Hawaii State waters. The Fishery Ecosystem Plan for the Hawaii Archipelago contains no management measures applicable to this gear.

Category III, Hawaii crab trap fishery.

Number of active permit holders: In 2011 there were 9 license holders fishing crab traps.

Total effort: In 2011 there were 168 crab traps trips.

Seasons: unknown.

Gear type: Fishing with any of various fishing devices made into the shape of a box, container, or enclosure, with one or more openings that allow marine life to get inside but keep them from leaving.

Regulations: Minimum mesh size: Netting - stretched mesh 2 inches; Rigid material - 2 inches by 1 inch. Entrance cones for traps have no minimum mesh size. Traps must be portable and not exceed 10 feet in length or 6 feet in height or width.

Management type: A commercial marine license issued by the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR) is required for all commercial fishing activities in Hawaii State waters. The Fishery Ecosystem Plan for the Hawaii Archipelago contains no management measures applicable to this gear.

Comments: From 2007-2011, five humpback whales were reported as entangled in Hawaii trap gear (Lyman 2013, NMFS unpublished data). The gear involved in two entanglements was identified as crab trap gear, one was identified as possibly crab trap gear, and the remaining two could not be identified to a specific trap fishery (NMFS unpublished data). Pre-mitigation injury determinations for the crab trap and possible crab trap entanglements were two serious injuries and one prorated as 0.75 serious injury (Bradford and Lyman 2013, NMFS unpublished data). Humpback serious injury and mortality in the crab trap fishery from 2007-2011 is 2.75, with a 5-year annual average of 0.55 per year.

Category III, Hawaii fish trap fishery.

Number of active permit holders: In 2011 there were 9 active commercial fishers.

Total effort: In 2011, there were 125 fish trap trips.

Seasons: unknown.

Gear type: Fishing with any of various fishing devices made into the shape of a box, container, or enclosure, with one or more openings that allow marine life to get inside but keep them from leaving.

Regulations: Minimum mesh size: Netting - stretched mesh 2 inches; Rigid material - 2 inches by 1 inch. Entrance cones for traps have no minimum mesh size. Traps must be portable and not exceed 10 feet in length or 6 feet in height or width.

Management type: A commercial marine license issued by the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR) is required for all commercial fishing activities in Hawaii State waters. The Fishery Ecosystem Plan for the Hawaii Archipelago contains no management measures applicable to this gear.

Category III, Main Hawaiian Islands lobster trap fishery.

Number of active permit holders: In 2011 there were less than 3 active commercial fishers.

Geographic range: Lobster fishing is prohibited within the NWHI.

Seasons: In the MHI, open season is from September through April.

Gear type: One string consists of approximately 100-fathom-plus plastic lobster traps. About 10 such strings are pulled and set each day. Since 1987 escape vents that allow small lobsters to escape from the trap have been mandatory. In 1996, the fishery became "retain all", i.e. there are no size limits or prohibitions on the retention of berried female lobsters. The entry-way of the lobster trap must be less than 6.5 inches to prevent monk seals from getting their heads stuck in the trap. In the MHI, rigid trap materials must have a dimension greater than 1 inch by 2 inches, with the trap not exceeding 10 feet by six feet.

Regulations: The MHI fishery is managed by the State of Hawaii, Division of Aquatic Resources with season and gear restrictions (see above).

Management type: A commercial marine license issued by the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR) is required for all commercial fishing activities in Hawaii State waters. The Fishery Ecosystem Plan for the Hawaii Archipelago contains no management measures applicable to this gear.

Category III, Hawaii shrimp trap fishery.

Number of active permit holders: In 2011 there were 4 active commercial fishers

Total effort: In 2011 there were 69 shrimp trap trips.

Seasons: unknown.

Gear type: Fishing with any of various fishing devices made into the shape of a box, container, or enclosure, with one or more openings that allow marine life to enter but not exit.

Regulations: State regulations specify a minimum mesh size for traps: netting must be a minimum of 2 inches stretched mesh, and rigid material must be a minimum of 2 inches by 1 inch. Entrance cones for traps have no minimum mesh size. Traps must be portable and not exceed 10 feet in length or 6 feet in height or width.

Management type: A commercial marine license issued by the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR) is required for all commercial fishing activities in Hawaii State waters. The Fishery Ecosystem Plan for the Hawaii Archipelago contains no management measures applicable to this gear. *Heterocarpus* shrimp are a federally managed complex caught by traps and are subject to annually set Annual Catch Limits.

Category III, Hawaii crab net fishery.

Number of active permit holders: In 2011 there were 6 active commercial fishers

Total effort: In 2011 there were 61 crab net trips.

Seasons: unknown.

Gear type: Fishing normally with a small circular lift net that is used to catch crabs. Ring nets set manually from the shoreline, mainly in estuarine areas. The nets are used singly, and are not connected with a ground line. Gear is typically tended.

Regulations: Managed under State of Hawaii regulations.

Management type: A commercial marine license issued by the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR) is required for all commercial fishing activities in Hawaii State waters. The Fishery Ecosystem Plan for the Hawaii Archipelago contains no management measures applicable to this gear.

Category III, Hawaii Kona crab net fishery.

Number of active permit holders: In 2011 there were 48 active commercial fishers

Total effort: In 2011 there were 179 Kona crab trips.

Seasons: Closed during breeding season May-August

Regulations: Only male crabs of at least 4 inches carapace length may be retained.

Management type: A commercial marine license issued by the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR) is required for all commercial fishing activities in Hawaii State waters. The Fishery Ecosystem Plan for the Hawaii Archipelago contains no management measures applicable to this gear.

Category III, aku boat- pole and line fishery.

Number of active permit holders: In 2011 there were 3 active commercial fishers

Total effort: In 2011 there were 86 aku boat trips.

Seasons: unknown.

Gear type: Fishing for aku (skipjack tuna) using live bait (such as nehu or iao) and or artificial lures. Generally live bait and/or water is flung or sprayed out from the stern of the (often drifting) vessel to "chum up the school" and get them feeding. Fishers on the stern of the boat often jig and slap the water with their poles to increase surface feeding behavior. Fish are hooked with pole and line, using a barbless hook (feathered, baited or not).

Regulations: Managed under State of Hawaii regulations. Specific licenses administered by DAR for the taking of baitfish and nehu (Hawaiian anchovy) for baiting purposes may be required. No baitfish may be sold or transferred except for bait purposes and licensees must furnish monthly baitfish catch reports to the DAR.

Management type: A commercial marine license issued by the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR) is required for all commercial fishing activities in Hawaii State waters. This fishery is also managed under the Federal Pacific Pelagics Fishery Ecosystem Plan outside of 3 nmi from shore.

Category III, Hawaii Main Hawaiian Islands deep sea bottomfish handline fishery.

Note: The Hawaii bottomfish complex is a U.S. fishery management unit comprised primarily of several species of snappers and jacks and a grouper inhabiting waters of the Hawaiian Archipelago. The federal fisheries management regime includes three fishing zones: the main Hawaiian Islands (MHI) Zone, and two zones in the Northwestern Hawaiian Islands, the Mau Zone and the Hoomalu Zone. All bottomfish fishing currently takes place in the MHI zone due to the closure of the Northwestern Hawaiian Islands under Presidential Proclamation 8031. The main Hawaiian Islands bottomfish fishery is managed jointly by NMFS and the State of Hawaii.

Number of permit holders: In 2010 there were 569 active commercial fishers.

Total effort: From 2008 to 2010 in the MHI the reported average annual catch was 221,500 lbs., with an additional 44,300 to 553,700 lbs. estimated to have been caught but not reported[6]

Seasons: Fishing occurs year-round, but effort is concentrated in the late fall and winter and peaks during periods of low wind and sea conditions.

[6] Brodziak, J., D. Courtney, L. Wagatsuma, J. O'Malley, H-H. Lee, W. Walsh, A. Andrews, R. Humphreys, and G. DiNardo. 2011. Stock assessment of the main Hawaiian Islands Deep7 bottomfish complex through 2010. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-PIFSC-29, 176 p. + Appendix

Gear type: This fishery is a hook-and-line fishery that takes place in deep water. In the MHI the vessels are smaller than 30 ft and trips last from 1 to 3 days.

Regulations: In the MHI, the sale of snappers (opakapaka, onaga and uku) and jacks less than one pound is prohibited. In June of 1998, Hawaii Division of Aquatic Resources (HDAR) closed 19 areas to bottomfishing, and regulations pertaining to seven species (onaga, opakapaka, ehu, kalekale, gindai, hapuupuu and lehi) were enacted. Total Allowable Catch (TAC) limits have been established for the "Deep-7" bottomfish species; these are the 7 primary species targeted by the commercial fleet. The TAC applies to both commercial and non-commercial sectors of the fishery. To ensure the TAC is not exceeded, NMFS and the State of Hawaii monitor the catch of Deep-7 bottomfish during the annual fishing season. Annual TAC quota for Hawaii Restricted Bottomfish Species specified in Federal Register by August 31st each year.

Management type: The portion of the fishery in Federal waters is managed under the Fishery Ecosystem Plan for the Hawaiian Archipelago, and operates under an annual catch limit. The fishery is co-managed with the State of Hawaii, which has adopted complementary measures in State waters.

Comments: The deep-slope bottomfish fishery in Hawaii concentrates on species of eteline snappers, carangids, and a single species of grouper concentrated at depths of 30-150 fathoms. These fish have been fished on a subsistence basis since ancient times and commercially for at least 90 years. Effort in this fishery increases significantly around the Christmas season because a target species, a true snapper, is typically sought for cultural festivities.[11]

Category III, Hawaii inshore handline fishery.

Number of active permit holders: In 2011 there were 378 active commercial fishers

Total effort: In 2011 there were 4,577 inshore handline trips.

Seasons: unknown.
Gear type: Fishing from a vessel using a vertical mainline with single/multiple lures or baited hooks and weight, lowered near the bottom to include drifting for octopus (tako) while using a handline. Fishing tackle usually consists of lighter gear than deep-sea handline. Line can be retrieved manually or by any other powered method. This fishery occurs in nearshore and coastal pelagic regions.

Regulations: Managed under State of Hawaii regulations.

Management type: A commercial marine license issued by the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR) is required for all commercial fishing activities in Hawaii State waters. The Pacific Pelagics Fishery Ecosystem Plan contains no management measures applicable to this gear.

Comments: The principal catches include reef fishes and big-eyed scad (akule) and mackerel scad (opelu). Bottlenose dolphins and rough-toothed dolphins have been reported as depredating bait or catch from handlines (Shallenberger 1981, Nitta and Henderson 1993). Depredation behavior may increase the risk of marine mammals becoming hooked or entangled.

Category III, Hawaii tuna handline ~~and jig~~ fishery.

Number of active permit holders: In 2011 there were 498 active commercial fishers.

Total effort: In 2011 there were 4,619 trips classified as one of the three tuna handline methods, 74 hybrid, 1,626 ika-shibi, and 2,919 palu-ahi.

Seasons: unknown.

Gear type: Palu-ahi tuna handline fishing usually takes place during the daytime. Sometimes instead of using lead weights, the baited hook and cut pieces of bait ("chum") are laid on a stone and the leader is wrapped around the stone and secured with a slipknot. The line wrapped stone is then lowered to the desired depth, where a tug on the line releases the slipknot, dispersing the chum and releasing the baited hook. The stone falls to the bottom, leaving the line free to be worked by the fisherman. This method also includes the use of "danglers" for reporting purposes. Iki-shibi tuna handline fishing occurs mainly at night also using a vertical mainline with high-test monofilament leader, from which is suspended a single baited hook. A weight may be used between the mainline and leader, with four or more lines usually attached to the vessel by breakaway links. A sea anchor is used to control and slow (at times stop) the drift of the vessel. A small light is usually suspended from the boat to attract muhe'e ("true squid") or opelu, typically used as bait. Line may be hauled manually, mechanically or by any powered method. Hybrid tuna handline fishing is a unique mixture of fishing methods used to catch pelagic species primarily on offshore seamounts and near NOAA weather buoys. It is generally a combination of methods which could include handlining, trolling, baiting techniques and other methods which are used simultaneously.

Regulations: Managed under State of Hawaii regulations.

Management type: A commercial marine license issued by the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR) is required for all commercial fishing activities in Hawaii State waters. The Fishery Ecosystem Plan for the Hawaii Archipelago contains no management measures applicable to this gear.

Comments: This fishery occurs around offshore fish aggregating devices and mid-ocean seamounts and pinnacles. The principal catches are small to medium sized bigeye, yellowfin and albacore tuna. There are several types of handline methods in the Hawaiian fisheries. Baited lines with chum are used in day fishing operations (palu-ahi), another version uses squid as bait during night operations (ika-shibi), and an operation called "danglers" uses multiple lines with artificial lures suspended or dangled over the water. Bottlenose dolphins and rough-toothed dolphins have been reported as depredating bait or catch from handlines (Shallenberger 1981, Nitta and Henderson 1993). Depredation behavior may increase the risk of marine mammals becoming hooked or entangled.

Category III, Hawaii spearfishing fishery.

Number of active permit holders: In 2011 there were 143 active commercial fishers

Total effort: In 2011 there were 2,142 spearfishing trips.

Seasons: unknown.

Gear type: Fishing with a shaft with one or more sharpened points at one end usually associated with diving. Includes bow and torch fishing.

Regulations: Managed under State of Hawaii regulations.

Management type: A commercial marine license issued by the Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (DAR) is required for all commercial fishing activities in Hawaii State waters. The Fishery Ecosystem Plan for the Hawaii Archipelago contains no management measures applicable to this gear.

Comments: Interactions have been documented with Hawaiian monk seals.

References:

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Table 1. Characteristics of Category I and Category II gillnet fisheries in California.

Fishery	Species	Mesh Size	Water Depth	Set Duration	Deployment	Miscellaneous
Category I CA/OR thresher shark and swordfish drift gillnet fishery	swordfish/shark	14 to 22 inches	Ranges from 90 to 4600 meters	Typically 8 to 15 hrs	Drift net only	Nets 500 to 1800 meters in length; other species caught: opah, louver, tuna, thresher, blue shark, mako shark
Category I CA halibut and white seabass set gillnet fishery (>3.5 inch mesh)	Halibut	8.5 inch	< 70 meters	24 hrs	Set net	
	Barracuda	3.5 inch		< 12 hrs	Drift net	April – July
	Leopard Shark	7.0 to 9.0 inch	< 90 meters			Fished similar to halibut.
	Perch/Croaker	3.5 to 4.0 inch	< 40 meters	< 24 hrs	Set net	Few boats target these species
	Rockfish	4.5 to 7.5 inch	> 90 meters	12 to 18 hrs	Set net	Net lengths 450 to 1800 meters. Soupfin shark is major bycatch.
	Soupfin shark/white seabass	6.0 to 8.5 inch	> 50 meters	24 hrs	Set net	Few boats target this species.
	Miscellaneous shark	6.0 to 14 inch	< 70 meters	8 to 24 hrs	Drift, some set net	Species include thresher and swell sharks.
Category II CA Yellowtail, barracuda, white seabass, and tuna drift gillnet fishery	White seabass, yellowtail, barracuda, white seabass, and tuna	Typically 6.5 inch	15 to 90 meters	8 to 24 hrs	Mostly drift net	White seabass predominant target species.

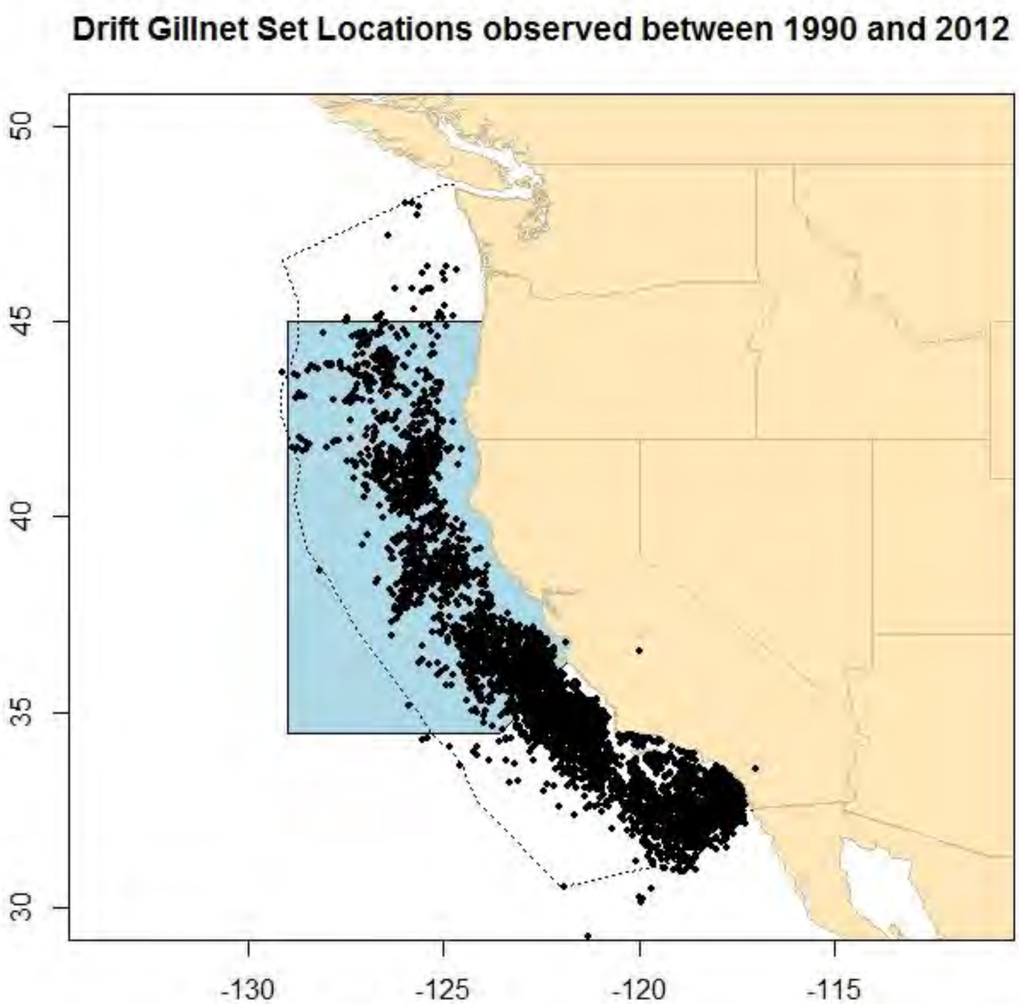

Figure 1. Locations of 8,365 sets observed in the California/Oregon large-mesh drift gillnet fishery for thresher shark and swordfish, 1990- 2012. The area in blue has been closed to gillnetting from 15 August to 15 November each year since 2001 to protect leatherback turtles. The outer dashed line represents the U.S. Exclusive Economic Zone. Observed sets represent approximately 15% of all fishing effort during the period 1990 to 2012, where the total estimate of fishing effort is approximately 53,000 sets.

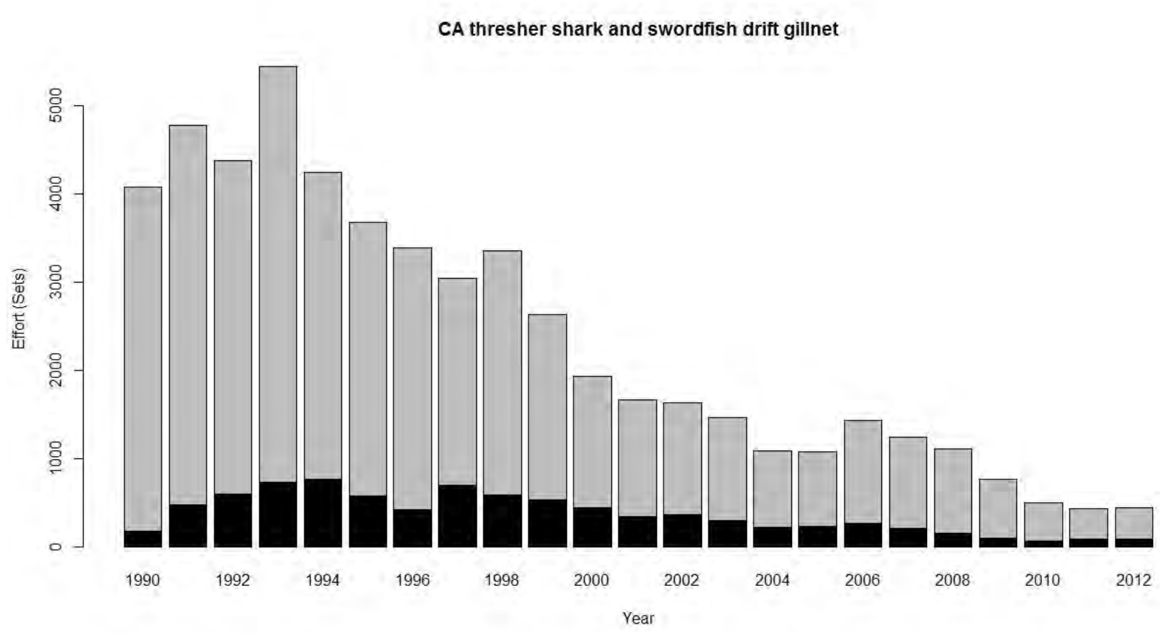

Figure 2. Estimated (gray) and observed (black) days of fishing effort for 1990-2012 in the California/Oregon thresher shark/swordfish drift gillnet fishery (≥ 14 inch mesh). One fishing day is equal to one set in this fishery. The approximate observer coverage during this period has been 15% (Carretta and Barlow 2011).

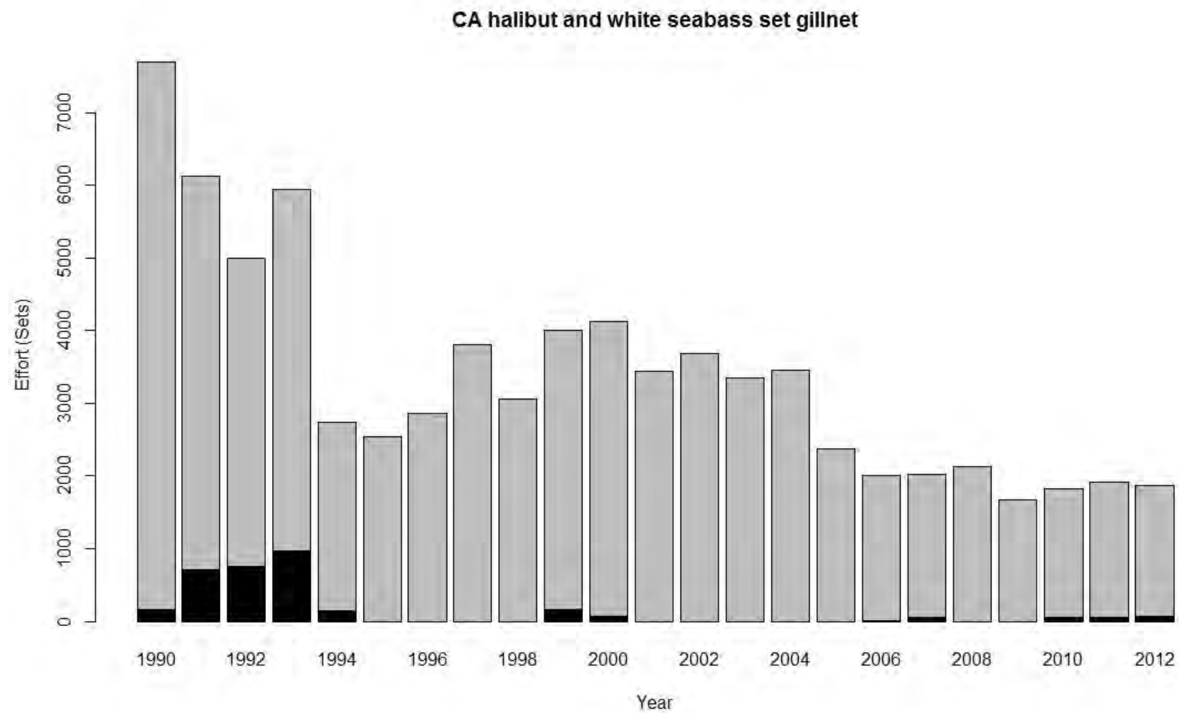

Figure 3. Estimated (gray) and observed (black) days of fishing effort for 1990- 2012 in the California halibut/white seabass set gillnet fishery (> 3.5 inch mesh). The fishery has been observed only sporadically since 1994.

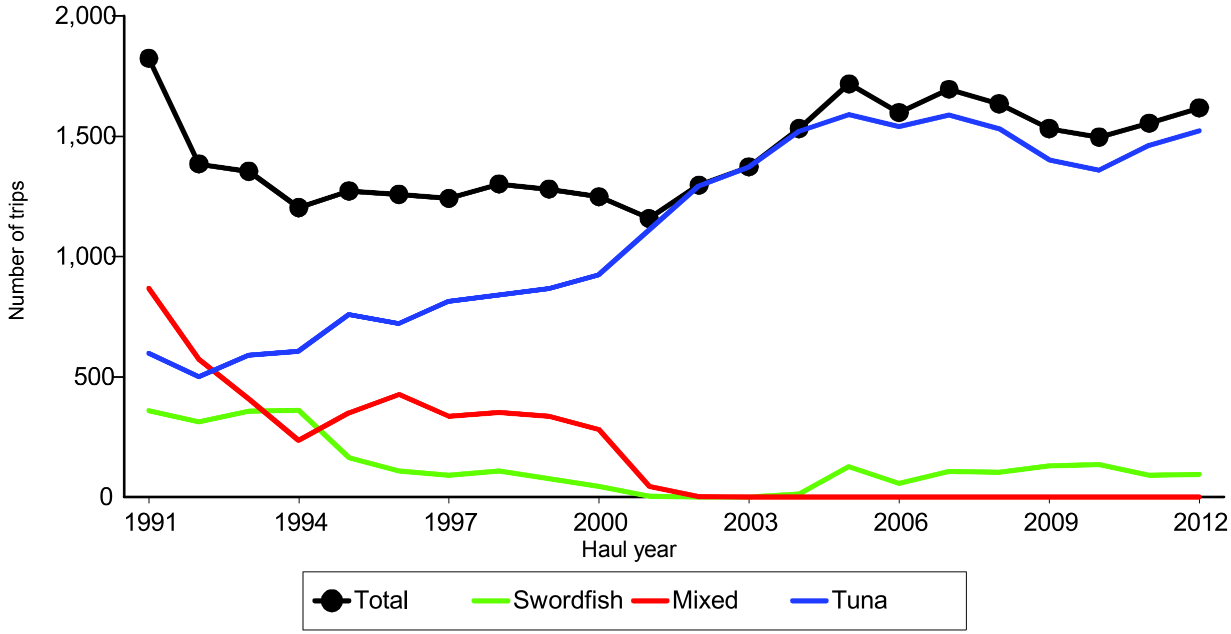

Figure 4. Number of fishing trips by longline vessels based and landing in Hawaii, by year and trip type, 1991-2012. Source: http://www.pifsc.noaa.gov/fmb/reports.php.

Appendix 2. Cetacean Survey Effort

Documentation of cetacean abundance estimates used in the 2008 draft Pacific Marine Mammal Stock Assessments.

Cetacean abundance estimates reported in the Pacific Marine Mammal Stock Assessments originate from several sources: vessel line-transect surveys of U.S. west coast and Pacific Island Exclusive Economic Zone (EEZ) waters (Barlow 2006, Barlow and Rankin 2007, Barlow and Forney 2007, Forney 2007); aerial line-transect surveys of harbor porpoises (Carretta and Forney 2004, Laake et al. 1998); photographic mark-recapture analyses of large whales (Calambokidis et al. 2007); Hawaiian small cetaceans (Baird et al. 2005); and southern resident killer whales (Center For Whale Research, unpublished data). Often, multiple abundance estimates are available for a given cetacean stock and decisions about which estimates to utilize in the stock assessment report must be made, based on what is known about the stock. Considerable interannual variability in abundance estimates can occur because the range of many cetacean stocks extends beyond the U.S. EEZ boundaries where surveys are conducted. For this reason, multi-year averages are utilized in the stock assessments when possible.

Abundance estimates for U.S. west coast coast cetacean stocks are available in two separate publications (Barlow and Forney 2007, Forney 2007). The Barlow and Forney (2007) paper presents a 1991-2005 time series of abundance estimates, based on large-scale vessel line-transect surveys of California, Oregon, and Washington waters out to 300 nmi. The Forney (2007) report presents estimates from a 2005 vessel line transect survey that is included in the Barlow and Forney (2007) paper, however, the Forney (2007) report includes additional analyses from fine-scale strata from coastal waters of the Olympic, Farallones, and Monterey Bay National Marine Sanctuaries. These coastal strata appear to represent seasonally important habitat for some species as Dall's porpoise, northern right whale dolphin, humpback whales, Pacific white-sided dolphin, and blue whales. Inclusion of these coastal strata resulted in improved estimates of abundance for several species and thus, the Forney (2007) report is used for reporting 2005 abundance estimates, while the Barlow and Forney (2007) paper is used for 2001 estimates. For most U.S. west coast cetaceans, average abundances reported in the draft 2008 Pacific Marine Mammal Stock Assessments represent the geometric mean* of 2001 estimates reported by Barlow and Forney (2007) and 2005 estimates reported by Forney (2005). In the case of humpback and blue whales, mark-recapture estimates may sometimes be substituted for line-transect estimates if the precision of the mark-recapture estimate is superior.

* Current stock assessment preparation guidelines currently recommend reporting a weighted arithmetic mean, weighted by the inverse of the variances of the individual abundance estimates. However, the authors of the Pacific stock assessment reports have found that the unweighted geometric mean is a more appropriate measure of mean abundance for cases where estimates are log-normally distributed. The problem with the weighted arithmetic mean is easily understood by example. Consider a case where two equally precise abundance estimates are available; one relatively large, the other small (e.g., N_1 = 20,000, CV_1 = 0.3; N_2 = 5,000, CV_2 = 0.3). Calculating a mean abundance using the inverse variance method arbitrarily underweights the larger estimate (due to its larger variance), resulting in a negatively biased mean estimate (N_{mean} = 5,882). By comparison, the geometric mean of the two estimates is $N_{geomean}$ = 10,000, which is equivalent to calculating the mean of the logarithms of N_1 and N_2.

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Species (Stock Area)	N est	CV N est	N min	R max	Fr	PBR	Total Annual Mortality + Serious Injury	Annual Fishery Mortality + Serious Injury	Strategic Status	Recent Abundance Surveys			SAR Last Revised
California sea lion (U.S.)	296,750	n/a	153,337	0.12	1	9,200	389	331	N	2007	2008	2011	2014
Harbor seal (California)	30,968	n/a	27,348	0.12	1	1,641	43	30	N	2004	2009	2012	2014
Harbor seal (Oregon/Washington Coast)	unk	unk	unk	0.12	1	undet	10.6	7.4	N	1999			2013
Harbor seal (Washington Northern Inland Waters)	unk	unk	unk	0.12	1	undet	9.8	2.8	N	1999			2013
Harbor seal (Southern Puget Sound)	unk	unk	unk	0.12	1	undet	3.4	1	N	1999			2013
Harbor seal (Hood Canal)	unk	unk	unk	0.12	1	undet	0.2	0.2	N	1999			2013
Northern Elephant Seal (California Breeding)	179,000	n/a	81,368	0.12	1	4,882	8.8	4	N	2002	2005	2010	2014
Guadalupe Fur Seal (Mexico to California)	20,000	n/a	15,830	0.137	0.5	542	≥3.2	≥3.2	S	2008	2009	2010	2016
Northern Fur Seal (California)	14,050	n/a	7,524	0.12	1	451	1.8	≥0.8	N	2010	2011	2013	2015
Monk Seal (Hawaii)	1,272	n/a	1,205	0.07	0.1	undet	≥2.8	≥1.2	S	2011	2013	2014	2016
Harbor porpoise (Morro Bay)	2,917	0.41	2,102	0.04	0.5	21	≥0.6	≥0.6	N	2002	2007	2012	2013
Harbor porpoise (Monterey Bay)	3,715	0.51	2,480	0.04	0.5	25	0	0	N	2002	2007	2011	2013
Harbor porpoise (San Francisco - Russian River)	9,886	0.51	6,625	0.04	0.5	66	0	0	N	2002	2007	2011	2013
Harbor porpoise (Northern CA/Southern OR)	35,769	0.52	23,749	0.04	1	475	≥0.6	≥0.6	N	2002	2007	2011	2013
Harbor porpoise (Northern OR/Washington Coast)	21,487	0.44	15,123	0.04	0.5	151	≥3.0	≥3.0	N	2002	2010	2011	2013
Harbor porpoise (Washington Inland Waters)	11,233	0.37	8,308	0.04	0.4	66	≥7.2	≥7.2	N	2013	2014	2015	2016
Dall's porpoise (California/Oregon/Washington)	25,750	0.45	17,954	0.04	0.48	172	0.3	0.3	N	2005	2008	2014	2016
Pacific white-sided dolphin (California/Oregon/Washington)	26,814	0.28	21,195	0.04	0.45	191	7.5	1.1	N	2005	2008	2014	2016
Risso's dolphin (California/Oregon/Washington)	6,336	0.32	4,817	0.04	0.48	46	≥3.7	≥3.7	N	2005	2008	2014	2016
Common Bottlenose dolphin (California Coastal)	453	0.06	346	0.04	0.48	2.7	≥2.0	≥1.6	N	2009	2010	2011	2016
Common Bottlenose dolphin (California/Oregon/Washington Offshore)	1,924	0.54	1,255	0.04	0.45	11	≥1.6	≥1.6	N	2005	2008	2014	2016
Striped dolphin (California/Oregon/Washington)	29,211	0.20	24,782	0.04	0.48	238	≥0.8	≥0.8	N	2005	2008	2014	2016
Common dolphin, short-beaked (California/Oregon/Washington)	969,861	0.17	839,325	0.04	0.5	8,393	≥40	≥40	N	2005	2008	2014	2016
Common dolphin, long-beaked (California)	101,305	0.49	68,432	0.04	0.48	657	≥35.4	≥32.0	N	2005	2008	2014	2016
Northern right whale dolphin (California/Oregon/Washington)	26,556	0.44	18,608	0.04	0.48	179	3.8	3.8	N	2005	2008	2014	2016
Killer whale (Eastern N Pacific Offshore)	240	0.49	162	0.04	0.5	1.6	0	0	N	2005	2008	2014	2016
Killer whale (Eastern N Pacific Southern Resident)	81	n/a	81	0.035	0.1	0.14	0	0	S	2013	2014	2015	2016
Short-finned pilot whale (California/Oregon/Washington)	836	0.79	466	0.04	0.48	4.5	1.2	1.2	N	2005	2008	2014	2016
Baird's beaked whale (California/Oregon/Washington)	847	0.81	466	0.04	0.5	4.7	0	0	N	2001	2005	2008	2013
Mesoplodont beaked whales (California/Oregon/Washington)	694	0.65	389	0.04	0.5	3.9	0	0	S	2001	2005	2008	2013
Cuvier's beaked whale (California/Oregon/Washington)	6,590	0.55	4,481	0.04	0.5	45	0	0	S	2001	2005	2008	2013
Pygmy Sperm whale (California/Oregon/Washington)	4,111	1.12	1,924	0.04	0.5	19	0	0	N	2005	2008	2014	2016

Species (Stock Area)	N est	CV N est	N min	R max	Fr	PBR	Total Annual Mortality + Serious Injury	Annual Fishery Mortality + Serious Injury	Strategic Status	Recent Abundance Surveys			SAR Last Revised
Dwarf sperm whale (California/Oregon/Washington)	unk	unk	unk	0.04	0.5	undet	0	0	N	2005	2008	2014	2016
Sperm whale (California/Oregon/Washington)	2,106	0.58	1,332	0.04	0.1	2.7	1.7	1.7	S	2001	2005	2008	2014
Gray whale (Eastern N Pacific)	20,990	0.05	20,125	0.062	1.0	624	132	4.25	N	2009	2010	2011	2014
Gray whale (Western N Pacific)	140	0.04	135	0.062	0.1	0.06	unk	unk	S			2011	2014
Humpback whale (California/Oregon/Washington)	1,918	0.03	1,876	0.08	0.3	11.0	≥ 6.5	≥ 5.3	S	2005	2008	2014	2016
Blue whale (Eastern N Pacific)	1,647	0.07	1,551	0.04	0.3	2.3	0.9	0	S	2005	2008	2011	2015
Fin whale (California/Oregon/Washington)	9,029	0.12	8,127	0.04	0.5	81	≥ 2.0	≥ 0.2	S	2005	2008	2014	2016
Sei whale (Eastern N Pacific)	519	0.4	374	0.04	0.1	0.75	0	0	S	2005	2008	2014	2016
Minke whale (California/Oregon/Washington)	636	0.72	369	0.04	0.48	3.5	≥ 1.3	≥ 1.3	N	2005	2008	2014	2016
Bryde’s whale (Eastern Tropical Pacific)	unk	unk	unk	0.04	0.5	undet	unk	unk	N	n/a	n/a	n/a	2015
Rough-toothed dolphin (Hawaii)	6,288	0.39	4,581	0.04	0.5	46	unk	unk	N		2002	2010	2013
Rough-toothed dolphin (American Samoa)	unk	unk	unk	0.04	0.5	undet	unk	unk	unk	n/a	n/a	n/a	2010
Risso’s dolphin (Hawaii)	7,256	0.41	5,207	0.04	0.5	42	0.6	0.6	N		2002	2010	2013
Common Bottlenose dolphin (Hawaii Pelagic)	5,950	0.59	3,755	0.04	0.5	38	0.2	0.2	N		2002	2010	2013
Common Bottlenose dolphin (Kaua'i and Ni'ihau)	184	0.11	168	0.04	0.5	1.7	unk	unk	N	2003	2004	2005	2013
Common Bottlenose dolphin (O'ahu)	743	0.54	485	0.04	0.5	4.9	unk	unk	N	2002	2003	2006	2013
Common Bottlenose dolphin (4 Islands Region)	191	0.24	156	0.04	0.5	1.6	unk	unk	N	2002	2003	2006	2013
Common Bottlenose dolphin (Hawaiian Island)	128	0.13	115	0.04	0.5	1.1	unk	unk	N	2002	2003	2006	2013
Pantropical Spotted dolphin (Hawaii Pelagic)	15,917	0.40	11,508	0.04	0.5	115.0	0	0	N		2002	2010	2013
Pantropical Spotted dolphin (O'ahu)	unk	unk	unk	0.04	0.5	undet	unk	unk	N			n/a	2013
Pantropical Spotted dolphin (4 Islands Region)	unk	unk	unk	0.04	0.5	undet	unk	unk	N			n/a	2013
Pantropical Spotted dolphin (Hawaii Island)	unk	unk	unk	0.04	0.5	undet	unk	unk	N			n/a	2013
Spinner dolphin (Hawaii Pelagic)	unk	unk	unk	0.04	0.5	undet	0	0	N		2002	2010	2013
Spinner dolphin (Hawaii Island)	631	0.04	585	0.04	0.5	5.9	unk	unk	N	1994	2003	2011	2013
Spinner dolphin (O'ahu / 4 Islands)	355	0.09	329	0.04	0.5	3.3	unk	unk	N	1993	1998	2007	2013
Spinner dolphin (Kaua'i / Ni'ihau)	601	0	509	0.04	0.5	5.1	unk	unk	N	1995	1998	2005	2013
Spinner dolphin (Kure / Midway)	unk	unk	unk	0.04	0.5	undet	unk	unk	N		1998	2010	2013
Spinner dolphin (Pearl and Hermes Reef)	unk	unk	unk	0.04	0.5	undet	unk	unk	N			n/a	2013
Spinner dolphin (American Samoa)	unk	unk	unk	0.04	0.5	undet	unk	unk	unk			n/a	2010
Striped dolphin (Hawaii Pelagic)	20,650	0.36	15,391	0.04	0.5	154	unk	unk	N		2002	2010	2013
Fraser’s dolphin (Hawaii)	16,992	0.66	10,241	0.04	0.5	102	0	0	N		2002	2010	2010
Melon-headed whale (Hawaiian Islands)	5,794	0.20	4,904	0.04	0.5	49	0	0	N		2002	2010	2013

Species (Stock Area)	N est	CV N est	N min	R max	Fr	PBR	Total Annual Mortality + Serious Injury	Annual Fishery Mortality + Serious Injury	Strategic Status	Recent Abundance Surveys			SAR Last Revised
Melon-headed whale (Kohala Resident)	447	0.12	404	0.04	0.5	4.0	0	0	N			2009	2013
Pygmy killer whale (Hawaii)	3,433	0.52	2,274	0.04	0.5	23.0	0	0	N		2002	2010	2013
False killer whale (NW Hawaiian Islands)	617	1.11	290	0.04	0.4	2.3	0.4	0.4	N			2010	2016
False killer whale (Hawaii Pelagic)	1,540	0.66	928	0.04	0.5	9.3	10.3	10.3	S		2002	2010	2016
False killer whale (Palmyra Atoll)	1,329	0.65	806	0.04	0.4	6.4	0.3	0.3	N			2005	2013
False killer whale (Main Hawaiian Islands Insular)	151	0.20	92	0.04	0.1	0.18	0.1	0.1	S	2012	2013	2014	2016
False killer whale (American Samoa)	unk	unk	unk	0.04	0.5	undet	unk	unk	unk	n/a	n/a	n/a	2010
Killer whale (Hawaii)	101	1.00	50	0.04	0.5	1.0	0	0	N		2002	2010	2013
Pilot whale, short-finned (Hawaii)	12,422	0.43	8,782	0.04	0.4	70	0.1	0.1	N		2002	2010	2013
Blainville’s beaked whale (Hawaii Pelagic)	2,338	1.13	1,088	0.04	0.5	11.0	0	0	N		2002	2010	2013
Longman's Beaked Whale (Hawaii)	4,571	0.65	2,773	0.04	0.5	28.0	0	0	N		2002	2010	2013
Cuvier’s beaked whale (Hawaii Pelagic)	1,941		1,142	0.04	0.5	11.4	0	0	N		2002	2010	2013
Pygmy sperm whale (Hawaii)	unk	unk	unk	0.04	0.5	undet	0	0	N		2002	2010	2013
Dwarf sperm whale (Hawaii)	unk	unk	unk	0.04	0.5	undet	0	0	N		2002	2010	2013
Sperm whale (Hawaii)	3,354	0.34	2,539	0.04	0.1	10.2	0.7	0.7	S		2002	2010	2013
Blue whale (Central N Pacific)	81	1.14	38	0.04	0.1	0.1	0	0	S		2002	2010	2013
Fin whale (Hawaii)	58	1.12	27	0.04	0.1	0.1	0	0	S		2002	2010	2013
Bryde’s whale (Hawaii)	798	0.28	633	0.04	0.5	6.3	0	0	N		2002	2010	2013
Sei whale (Hawaii)	178	0.90	93	0.04	0.1	0.2	0.2	0.2	S		2002	2010	2013
Minke whale (Hawaii)	unk	unk	unk	0.04	0.5	undet	0	0	N		2002	2010	2013
Humpback whale (American Samoa)	unk	unk	150	0.106	0.1	0.4	0	0	S	2006	2007	2008	2009
Sea Otter (Southern)	2,826	n/a	2,723	0.06	0.1	8	≥0.8	≥0.8	S	2006	2007	2008	2008
Sea Otter (Washington)	n/a	n/a	1,125	0.2	0.1	11	≥0.2	≥0.2	N	2006	2007	2008	2008

SOUTHERN SEA OTTER (*Enhydra lutris nereis*)

U.S. Fish and Wildlife Service, Ventura, California

STOCK DEFINITION AND GEOGRAPHIC RANGE

Southern sea otters are listed as threatened under the Endangered Species Act. They occupy nearshore waters along the mainland coastline of California from San Mateo County to Santa Barbara County (Figure 1). A small colony of southern sea otters also exists at San Nicolas Island, Ventura County, as a result of translocation efforts initiated in 1987. Under Public Law 99-625, the San Nicolas Island colony was formerly considered to be an experimental population (52 FR 29754; August 11, 1987), but the experimental population designation was removed upon termination of the translocation program and its respective translocation and management zones (77 FR 75266; December 19, 2012). With the termination of the translocation program, the special status afforded to southern sea otters within the management and translocation zones pursuant to Public Law 99-625 also ended.

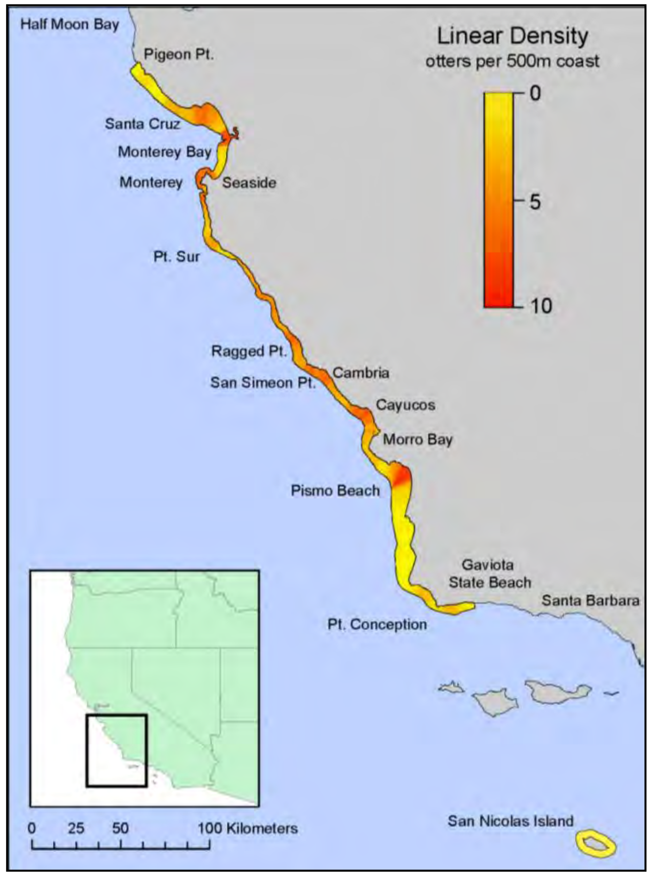

Figure 1. Current range of the southern sea otter (2013 census). Source: U.S. Geological Survey, http://www.werc.usgs.gov/seaottercount

Historically, southern sea otters ranged from Punta Abreojos, Baja California, Mexico to Oregon (Valentine *et al.* 2008), or possibly as far north as Prince William Sound, Alaska (reviewed in Riedman and Estes 1990). During the 1700s and 1800s, the killing of sea otters for their pelts extirpated the subspecies throughout most of its range. A small population of southern sea otters survived near Bixby Creek in Monterey County, California, numbering an estimated 50 animals in 1914 (Bryant 1915). Since receiving protection under the International Fur Seal Treaty in 1911, southern sea otters have gradually expanded northward and southward along the central California coast. The estimated carrying capacity of California is approximately 16,000 animals (Laidre *et al.* 2001).

Sea otter abundance varies considerably across the range, with the highest densities occurring in the center part of the range (Monterey peninsula to Estero Bay), where sea otters have been present for the longest. Sea otter densities tend to be most stable from year-to-year in rocky, kelp-dominated areas that are primarily occupied by females, dependent pups, and territorial males. In contrast, sandy and soft-bottom habitats (in particular those in Monterey Bay, Estero Bay, and Pismo Beach to Pt. Sal) tend to be occupied by non-territorial males and sub-adult animals of both sexes (but rarely by adult females and pups) and are more variable in abundance from year to year.[1] This variation is apparently driven in part by the long-distance movements and seasonal redistribution of males (Tinker *et al.* 2006a). The variability of counts at the south end of the range is also related to seasonal movements: many males migrate to the range peripheries during the winter and early spring, apparently to take advantage of more abundant prey resources, but then return to the range center during the period when most breeding occurs (June to November) in search of estrous females (Jameson 1989, Ralls *et al.* 1996, Tinker *et al.* 2006a). Pupping of southern sea otters takes place year round, but a birth peak extending over several months occurs in the spring, and a secondary birth peak occurs in the fall (Siniff and Ralls 1991, Riedman *et al.* 1994).

All sea otters of the subspecies *Enhydra lutris nereis* are considered to belong to a single stock because of their recent descent from a single remnant population. Southern sea otters are geographically isolated from the other two recognized subspecies of sea otters, *E. l. lutris* and *E. l. kenyoni*, and have been shown to be distinct from these subspecies in studies of cranial morphology (Wilson *et al.* 1991) and variation at the molecular level (Sanchez 1992; Cronin *et al.* 1996; Larson *et al.* 2002).

POPULATION SIZE

Data on population size have been gathered for more than 50 years. In 1982, a standardized survey technique was adopted to ensure that subsequent counts were comparable (Estes and Jameson 1988). This survey method involves shore-based censuses of approximately 60% of the range, with the remainder surveyed from the air. These surveys are conducted once each year (in spring). At San Nicolas Island, counts are conducted from shore (formerly quarterly, but semi-annually as of 2013). The highest of the counts is used as the official count for the year. In 2013, the official population index reported by the U.S. Geological Survey (2,941) included the 3-year running average for the mainland population (2,882) and the previous year's high count at San Nicolas Island (59). The 2011 mainland spring census was not completed due to weather conditions; therefore, the mainland 3-year running average is calculated from only the 2012 and 2013 raw counts (2,719 and 2,865, respectively) (U.S. Geological Survey, http://www.werc.usgs.gov/seaottercount).

Minimum Population Estimate

The minimum population estimate for the southern sea otter stock is taken as the lesser of the latest raw count or the latest 3-year running average for the mainland population, plus the count for San Nicolas Island. In 2013, the mainland count was 2,865. The 3-year running average was slightly higher, 2,882. Therefore, the minimum population estimate is 2,865 plus 59, or 2,924 animals.

Current Population Trend

As recommended in the Final Revised Recovery Plan for the Southern Sea Otter (U.S. Fish and Wildlife Service 2003), 3-year running averages are used to characterize trends in the mainland population to dampen the effects of anomalous counts in any given year. Based on 3-year running averages of the annual spring counts, population performance along the mainland coastline has been mixed over the past several years, increasing between 2006 and 2008,

[1] Personal communication, M. Tim Tinker, 2008. Research Wildlife Biologist, USGS-Western Ecological Research Center, Santa Cruz Field Station, and Department of Ecology & Evolutionary Biology, University of California at Santa Cruz, 100 Shaffer Road, Santa Cruz, CA 95060.

decreasing between 2008 and 2010, and increasing again between 2010 and 2013 (Figure 2). The overall trend for the past 5 years has been essentially flat (0.16 percent), although this average growth rate masks considerable regional variation within the range. Growth of the colony at San Nicolas Island has averaged approximately 7.6 percent per year over the past 5 years (U.S. Geological Survey, http://www.werc.usgs.gov/seaottercount).

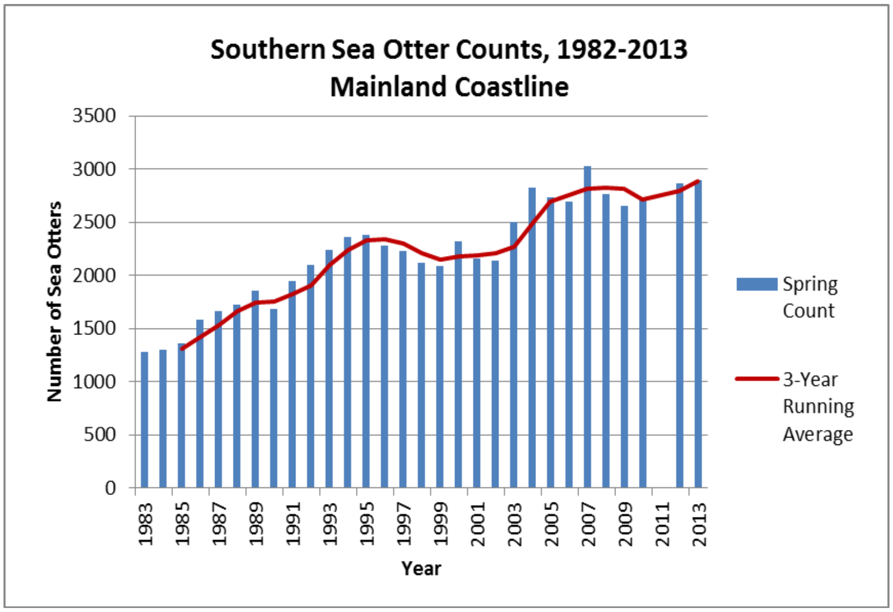

Figure 2. Southern sea otter counts 1983-2013 (mainland population). Data source: U.S. Geological Survey, http://www.werc.usgs.gov/seaottercount.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

We use the 5-year population trend to characterize current net productivity rates. As stated above, the average growth rate for this period is approximately 0.16 percent annually for the mainland population and approximately 7.6 percent annually for the San Nicolas Island population.

The maximum growth rate (R_{max}) for southern sea otters along the mainland coastline since the early 1980s (when reliable trend data first become available) appears to be 6 percent per year, although localized sub-populations have been observed to grow at much higher rates immediately after re-colonization.[2] In contrast, recovering or translocated populations at Attu Island, southeast Alaska, British Columbia, and Washington state all exhibited growth rates of up to 17 or 20 percent annually during the early stages of recovery (Estes 1990, Jameson and Jeffries 1999, Jameson and Jeffries 2005).

Although there has been speculation that the slower rate of population growth observed for the southern sea otter reflects some fundamental difference in survival or reproduction relative to northern sea otter populations, recent data and analyses call this assumption into question. First, a variety of evidence in recent years supports the conclusion that sea otters throughout much of central California are at or very near carrying capacity of the local environment, which explains the lack of growth in these areas (*i.e.*, further growth is limited by available food resources) (Tinker *et al.* 2006b, Tinker *et al.* 2008). Second, radio-tagging studies report age- and sex-specific rates of survival and reproduction that are comparable for southern sea otters and northern sea otters, at least when status with respect to carrying capacity is controlled for (Monson *et al.* 2000, Tinker *et al.* 2006b). Finally, recent modeling analyses

[2] Personal communication, M. Tim Tinker, 2013. Research Wildlife Biologist, USGS-Western Ecological Research Center, Santa Cruz Field Station, and Department of Ecology & Evolutionary Biology, University of California at Santa Cruz, 100 Shaffer Road, Santa Cruz, CA 95060.

indicate that the spatial configuration of available habitat (the long narrow strip of coastal shelf characteristic of California versus the bays, islands, and complex matrices of inland channels characteristic of the habitat in Washington, British Columbia, and Alaska), combined with the high degree of spatial structure in sea otter populations (due to limited mobility of reproductive females), will result in greatly different expected population growth rates over the long term, and may account in large part for the differences in trends between the southern sea otter and northern sea otter populations.[3]

From the early 1900s to the mid-1970s, the southern sea otter population is thought to have increased at about 5 percent annually (Estes 1990), although consistent surveys and trend data from early years are lacking. From 1983 to 1995, annual growth averaged about 6 percent. The population declined during the late 1990s, resumed growth in the early 2000s, and ceased growth again beginning in 2008. Growth rates at San Nicolas Island averaged approximately 9 percent annually from the early 1990s to the mid-2000s and approximately 7.6 percent over the past 5 years.

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of three elements: the minimum population estimate (N_{min}); half the maximum net productivity rate (0.5 R_{max}); and a recovery factor (F_r). This can be written as: PBR = (N_{min}) (½ of R_{max})(F_r).

For the southern sea otter stock, N_{min} = 2,924, R_{max} = 6 percent, and F_r = 0.1. A recovery factor of 0.1 is used for the southern sea otter stock because, although the population appears to be stable, Nmin is below 5,000, and the species is vulnerable to a natural or human-caused catastrophe, such as an oil spill, due to its restricted geographic distribution in nearshore waters (Taylor *et al.* 2002). Therefore, the PBR for the southern sea otter stock is 8.77, which when rounded down to the nearest whole animal is 8. It is important to note that take of southern sea otters incidental to commercial fishing operations cannot be authorized under the MMPA. Thus, the provisions governing the authorization of incidental take in commercial fisheries at MMPA Sections 101(a)(5)(E) and 118, which include requirements to develop take reduction plans with the goal of reducing incidental mortality or serious injury of marine mammals to levels less than the PBR, do not apply with respect to southern sea otters.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Sea otters are susceptible to entanglement and drowning in gill nets. The set gill net fishery in California is estimated to have killed from 48 to 166 (average of 103) southern sea otters per year from 1973 to 1983 (Herrick and Hanan 1988) and 80 sea otters annually from June 1982 to June 1984 (Wendell *et al.* 1986). A 1991 closure restricted gill and trammel nets to waters deeper than 30 fathoms (55 meters) throughout most of the southern sea otter's range (California Senate Bill No. 2563). In 1990, NMFS started an observer program using at-sea observers, which provided data on incidental mortality rates relative to the distribution of fishing effort. The observer program was active through 1994, discontinued from 1995 to 1998, and reinstated in the Monterey Bay area in 1999 and 2000 because of concern over increased harbor

[3] Personal communication, M. Tim Tinker, 2013. Research Wildlife Biologist, USGS-Western Ecological Research Center, Santa Cruz Field Station, and Department of Ecology & Evolutionary Biology, University of California at Santa Cruz, 100 Shaffer Road, Santa Cruz, CA 95060.

porpoise mortality. Based on a detailed analysis of fishing effort, sea otter distributions by depth, and regional entanglement patterns during observed years, NMFS estimated southern sea otter mortality in the halibut set gill net fishery to have been 64 in 1990, zero from 1991 to 1994, 3 to 13 in 1995, 2 to 29 in 1996, 6 to 47 in 1997, 6 to 36 in 1998, 5 in 1999, and zero in 2000 (Cameron and Forney 2000; Carretta 2001; Forney *et al.* 2001). The increase in estimated mortality from 1995 to 1998 was attributed to a shift in set gill net fishing effort into areas where sea otters are found in waters deeper than 30 fathoms (55 meters).

Fishing with gill nets has since been further restricted throughout the range of the southern sea otter. An order prohibiting the use of gill and trammel nets year-round in ocean waters of 60 fathoms or less from Point Reyes, Marin County, to Point Arguello, Santa Barbara County was made permanent in September 2002. In the waters south of Point Arguello, the Marine Resources Protection Act of 1990 (California Constitution Article 10B) defined a Marine Resources Protection zone in which the use of gill and trammel nets is banned. This zone includes waters less than 70 fathoms (128 meters) or within one nautical mile (1.9 kilometers), whichever is less, around the Channel Islands, and waters generally within three nautical miles (5.6 kilometers) offshore of the mainland coast from Point Arguello to the Mexican border. Although sea otters occasionally dive to depths of 328 feet (100 meters), the vast majority (>99 percent) of dives are to depths of 131 feet (40 meters) or less.[4] Because of these restrictions and the current extent of the southern sea otter's range, southern sea otter mortalities resulting from entanglement in gill nets are likely to be at or near zero. Nevertheless, sea otters may occasionally transit areas that are not subject to closures, and levels of observer coverage of gill and trammel net fisheries are insufficient to confirm an annual incidental mortality and serious injury rate of zero in these fisheries (see Table 1) (Barlow 1989, Babcock *et al.* 2003). An estimated 50 vessels participate in the CA halibut/white seabass and other species set gillnet (>3.5" mesh) fishery (78 FR 53336, August 29, 2013). Approximately 30 vessels participate in the CA yellowtail, barracuda, and white seabass drift gillnet fishery (mesh size ≥3.5" and <14") (78 FR 53336, August 29, 2013). Approximately 25 vessels participate in the CA thresher shark/swordfish drift gillnet fishery (≥14" mesh) (78 FR 53336, August 29, 2013).

Three southern sea otter interactions with the California purse seine fishery for Northern anchovy and Pacific sardine have been documented. In 2005, a contract observer in the NOAA Fisheries California Coastal Pelagic Species observer program documented the incidental, non-lethal capture of two sea otters that were temporarily encircled in a purse seine net targeting Northern anchovy but escaped unharmed by jumping over the corkline. In 2006, a contract observer in the same program documented the incidental, non-lethal capture of a sea otter in a purse seine net targeting Pacific sardine. Again, the sea otter escaped the net at end of the haul without assistance.[5] Based on these observations and the levels of observer coverage in each year, 58 and 20 such interactions are estimated to have occurred in the CA sardine purse seine fishery in 2005 and 2006, respectively, but these estimates are accompanied by considerable uncertainty because of the low levels of observer coverage.[6] There are no data available to assess whether sea otter interactions with purse-seine gear are currently resulting in mortality or

[4] Personal communication, M. Tim Tinker, 2008. Research Wildlife Biologist, USGS-Western Ecological Research Center, Santa Cruz Field Station, and Department of Ecology & Evolutionary Biology, University of California at Santa Cruz, 100 Shaffer Road, Santa Cruz, CA 95060.

[5] Personal communication, Lyle Enriquez, 2006. Southwest Regional Office, NOAA, U.S. National Marine Fisheries Service, 501 West Ocean Boulevard, Long Beach, CA 90802.

[6] Personal communication, Jim Carretta, 2008. Southwest Fisheries Science Center, NOAA, U.S. National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037.

serious injury. The 2007 list of fisheries reorganized purse seine fisheries targeting anchovy and sardines into the "CA anchovy, mackerel, sardine purse seine" fishery. An estimated 65 vessels participate in the CA anchovy, mackerel, and sardine purse seine fishery (78 FR 53336, August 29, 2013).

The potential exists for sea otters to drown in traps set for crabs, lobsters, and finfish, but only limited documentation of mortalities is available. Hatfield and Estes (2000) summarize records of 18 sea otter mortalities in trap gear, 14 of which occurred in Alaska. With the exception of one sea otter, which was found in a crab trap, all of the reported Alaska mortalities involved Pacific cod traps and were either recorded by NMFS observers or reported to NMFS observers by fishers. Four sea otters are known to have died in trap gear in California: one in a lobster trap near Santa Cruz Island in 1987; a mother and pup in a trap with a 10-inch diameter opening (presumed to be an experimental trap) in Monterey Bay in 1987; and one in a rock crab trap 0.5 miles off Pt. Santa Cruz, California (Hatfield and Estes 2000). In 1995, the U.S. Geological Survey began opportunistic efforts to observe the finfish trap fishery in California. These efforts were supplemented with observations by the California Department of Fish and Game (CDFG) in 1997 and two hired observers in 1999. No sea otters were found in the 1,624 traps observed (Hatfield and Estes 2000). However, a very high level of observer coverage would be required to see any indication of trap mortality, even if mortality levels were high enough to substantially reduce the rate of population growth (Hatfield *et al.* 2011).

Controlled experiments conducted by the U.S. Geological Survey and the Monterey Bay Aquarium demonstrated that sea otters would enter a baited commercial finfish trap with inner trap funnel openings of 5.5 inches in diameter (Hatfield and Estes 2000). Hatfield *et al.* (2011) confirmed that some sea otters exposed to finfish, lobster, and mock Dungeness crab traps in a captive setting would succeed in entering them. Based on experiments with carcasses and live sea otters, they concluded that finfish traps with 5-inch-diameter circular openings would largely exclude diving sea otters; that circular openings of 5.5 to 6 inches in diameter and rectangular openings 4 inches high (typical of Dungeness crab pots) would allow the passage of sea otters up to about 2 years of age; and that the larger fyke openings of spiny lobster pots and finfish traps with openings larger than 5 inches would admit larger sea otters. Reducing the fyke-opening height of Dungeness crab traps by one inch (to 3 inches) would exclude nearly all diving sea otters while not significantly affecting the number or size of harvested crabs (Hatfield *et al.* 2011). Since January 2002, CDFG has required 5-inch sea-otter-exclusion rings to be placed in live-fish traps used along the central coast from Pt. Montara in San Mateo County to Pt. Arguello in Santa Barbara County. No rings are required for live-fish traps used in the waters south of Point Conception, and no rings are currently required for lobster or crab traps regardless of their location in California waters. Estimates of the number of vessels participating in pot and trap fisheries off California are given in parentheses: CA Dungeness crab pot (534); CA coonstripe shrimp, rock crab, tanner crab pot or trap (305); CA spiny lobster (225); and CA nearshore finfish live trap/hook-and-line (93) (78 FR 53336, August 29, 2013).

Available information on incidental mortality and serious injury of southern sea otters in commercial fisheries is very limited. Due to the lack of observer coverage, a reliable, science-based estimate of the annual rate of mortality and serious injury cannot be determined. Commercial fisheries believed to have the potential to kill or injure southern sea otters are listed in Table 1. Due to the nature of potential interactions (entrapment or entanglement followed by drowning), serious injury is unlikely to be detected prior to the death of the animal.

Table 1. Summary of available information on incidental mortality and serious injury of southern sea otters in commercial fisheries that have the potential to interact with southern sea otters.

Fishery Name	Year(s)	Number of Vessels[1]	Data Type	Percent Observer Coverage[2]	Observed Mortality/ Serious Injury	Estimated Mortality/ Serious Injury	Mean Annual Mortality/ Serious Injury
CA halibut/white seabass and other species set gillnet (>3.5")	2008	50	observer	17.8%	0	n/a	n/a
	2009		n/a	not observed	n/a		
	2010		observer	12.5%	0		
	2011		observer	8%	0		
	2012		observer	5.5%	0		
CA yellowtail, barracuda, and white seabass drift gillnet (≥3.5" and <14")	2008	30	n/a	not observed	n/a	n/a	n/a
	2009		n/a	not observed	n/a		
	2010		n/a	not observed	n/a		
	2011		observer	3.3%	0		
	2012		observer	0.7%	0		
CA thresher shark/swordfish drift gillnet fishery (≥14")	2008	25	observer	13.5%	0	n/a	n/a
	2009			13.3%	0		
	2010			11.9%	0		
	2011			19.5%	0		
	2012			18.6%	0		
CA anchovy, mackerel, and sardine purse seine	2008	65	observer	~5%	0	n/a	n/a
	2009		n/a	not observed	n/a		
	2010		n/a	not observed	n/a		
	2011		n/a	not observed	n/a		
	2012		n/a	not observed	n/a		
CA Dungeness crab pot	2008	534	n/a	not observed	n/a	n/a	n/a
	2009						
	2010						
	2011						
	2012						
CA coonstripe shrimp, rock crab, tanner crab pot or trap[3]	2008	305	n/a	not observed	n/a	n/a	n/a
	2009						
	2010						
	2011						
	2012						
CA spiny lobster[3]	2008	225	n/a	not observed	n/a	n/a	n/a
	2009						
	2010						
	2011						
	2012						
CA nearshore finfish live trap/hook and line[3]	2008	93	n/a	not observed	n/a	n/a	n/a
	2009						
	2010						
	2011						
	2012						
Unknown hook and line	2008	n/a	stranding data	—	0	≥0	≥0
	2009				0		
	2010				0		
	2011				0		
	2012				0		
Unknown net	2008	n/a	stranding data	—	0	≥1	≥0.2
	2009				0		
	2010				0		
	2011				1[4]		
	2012				0		

Note: n/a indicates that data are not available or are insufficient to estimate mortality/serious injury.

[1] Vessel numbers are from the final List of Fisheries for 2013 (78 FR 53336, August 29, 2013).

[2] Personal communication, Jim Carretta, 2010, 2011, 2013. Southwest Fisheries Science Center, NOAA, U.S. National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037.

[3] This fishery is classified as a Category III fishery (78 FR 53336, August 29, 2013). Category III fisheries are not required to accommodate observers aboard vessels due to the remote likelihood of mortality and serious injury of marine mammals.

[4] This sea otter was also shot, apparently after becoming entangled in the net.

Other Mortality

Variation in reproductive success and survival rates of sea otters in central California appears to be influenced primarily by density-dependent resource limitation (Tinker 2013). Physiological condition and nutritional status in turn influence the susceptibility of sea otters to environmental stressors (including pathogens, pollutants, and intoxicants produced during harmful algal blooms), which may result in death by a variety of proximate causes, including infectious disease, intra-specific aggression, intoxication, and other pathological conditions (Tinker 2013).

Common causes of death identified for fresh beach-cast carcasses necropsied from 1998 to 2001 included protozoal encephalitis, acanthocephalan-related disease, shark attack, and cardiac disease (Kreuder *et al.* 2003, Kreuder *et al.* 2005). Encephalitis caused by *Toxoplasma gondii* was associated with shark attack and heart disease (Kreuder *et al.* 2003). Diseases (due to parasites, bacteria, fungi, or unspecified causes) were identified as the primary cause of death in 63.8 percent of the sea otter carcasses examined (Kreuder *et al.* 2003). Unusually high numbers of stranded southern sea otters were recovered in 2003, prompting declaration of an Unusual Mortality Event for the period from 23 May to 1 October 2003. The increase in strandings was not attributable to any one cause, although intoxication by domoic acid produced by blooms of the alga *Pseudonitzchia australis* is believed to have been an important contributor (Jessup *et al.* 2004).

From 2008 through 2012, the number of strandings relative to the spring count averaged 10.4 percent (Figure 3; the entry for 2011 is missing because the spring survey was not completed that year). However, relative strandings have increased sharply over this period, with record highs in 2010 and 2012, 11.2 and 12.8 percent of the spring count, respectively (U.S Geological Survey unpublished data). These spikes in relative strandings appear to be due largely to an upswing in shark bite mortality in the northern and southern portions of the range (north of Seaside and, most markedly, south of Cayucos) (Tinker *et al.* 2013). Increasing shark-bite mortality is also a longer-term trend. The proportion of sea otter deaths caused by shark bites has increased 4-fold over the last 20 years and accounts for 45 percent of the variation in population trends during this period (Tinker *et al.* 2013). The reasons for the increase in shark bite mortality are unknown.

Non-fishery-related anthropogenic mortality of sea otters is a result of indirect and direct causes. The ocean

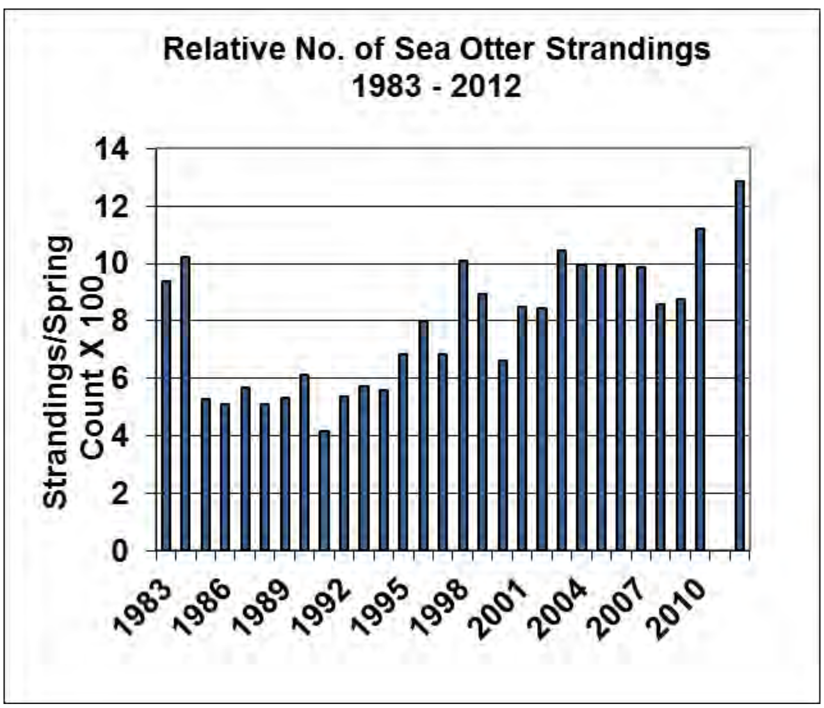

Figure 3. Strandings of southern sea otters relative to the spring count, 1983-2012. The entry for 2011 is missing because the spring survey was not completed that year. Source: U.S. Geological Survey unpublished data.

discharge of freshwater microcystins (persistent biotoxins produced by cyanobacteria of the genus *Microcystis*, which can form toxic blooms under conditions of elevated nutrient concentration, salinity, and temperature), has been linked to the deaths of more than 30 sea otters (through 2012), with the earliest known case occurring in 1999 and the greatest number of cases occurring in 2007 (Miller *et al.* 2010; CDFG unpublished data). Boat strikes typically cause several deaths each year. Shootings are a relatively low but persistent source of anthropogenic mortality. Other rare sources of anthropogenic mortality include debris entanglement and complications associated with research activities. Stranding data indicate that during the period from 2008 through 2012, at least 10 sea otters died of microcystin intoxication, 2 were shot[7], 12 were suspected to have been struck by boats, 1 was entangled in debris, and 3 died as a result of complications related to research activities (U.S. Geological Survey and CDFG unpublished data). Total observed anthropogenic mortality from 2008-2012, excluding any fisheries-related mortality, is 28, yielding an estimated mortality of ≥28 and a mean annual mortality of ≥5.6. Disease is an important proximate cause of death in sea otters, but due to several complicating factors (including the complexity of the pathways by which sea otters are being exposed to land-borne pathogens, the synergistic relationship between sea otter susceptibility to disease and density-dependent resource limitation, and other factors), the anthropogenic contribution to disease-related mortality in sea otters is not well understood. Therefore, animals that died of disease (other than acute liver failure resulting from microcystin poisoning) are not included in the anthropogenic mortalities reported here.

It should be noted that the mean annual mortality/serious injury reported here and in Table 1 are minimum estimates.[8] Documentation of these sources of mortality comes primarily from necropsies of beach-cast carcasses, which constitute a subset (roughly half) of all dead southern sea otters and likely do not represent an unbiased sample with respect to cause of death because carcass deposition and retrieval are dependent on carcass size, location, wind, currents and other factors, including the cause of death itself (Gerber *et al.* 2004, Tinker *et al.* 2006a). Within this subset, the cause of death of many recovered carcasses is unknown, either because the carcass is too decomposed for examination or because cause of death cannot be determined (Gerber *et al.* 2004).[9] Because it is unknown to what extent the levels of human-caused mortality documented in beach-cast carcasses are representative of the relative contributions of known causes or of human-caused mortality as a whole, we are unable to give upper bounds for these estimates.

STATUS OF STOCK

The southern sea otter is designated a fully protected mammal under California State law (California Fish and Game Code §4700) and was listed as a threatened species in 1977 (42 FR 2965) pursuant to the federal Endangered Species Act, as amended (16 U.S.C. 1531 et seq.). As a consequence of its threatened status, the southern sea otter is considered to be a "strategic stock" and "depleted" under the MMPA.

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[7] An additional animal, not included in this total, was also shot, apparently after becoming entangled in a net (fishery unknown).

[8] This statement applies to all causes of death mentioned here except research-related mortalities. Research-related mortalities are unlikely to be undetected because of the intensive monitoring that tagged sea otters receive.

[9] In 2012, the cause of death of approximately 35 percent of recovered carcasses was unknown. Personal communication, Brian Hatfield, 2013. Wildlife Biologist, USGS-Western Ecological Research Center, Hwy. 1, P.O. Box 70. San Simeon, CA 93452.

The status of the southern sea otter in relation to its optimum sustainable population (OSP) level has not been formally determined, but population counts are well below the estimated lower bound of the OSP level for southern sea otters, about 8,400 animals (U.S. Fish and Wildlife Service 2003), which is roughly 50 percent of the estimated carrying capacity of California (Laidre *et al.* 2001). Because of the lack of observer data for several commercial fisheries that may interact with sea otters, it is not possible to make a science-based determination of whether the total mortality and serious injury of sea otters due to interactions with commercial fisheries is insignificant and approaching a zero mortality and serious injury rate.

Habitat Issues

Sea otters are particularly vulnerable to oil contamination (Kooyman and Costa 1979; Siniff *et al.* 1982), and oil spill risk from large vessels that transit the California coast remains a primary threat to the southern sea otter. Studies of contaminants have documented accumulations of dichlorodiphenyltrichloro-ethane (DDT), dichlorodiphenyl-dichloroethylene (DDE) (Bacon 1994; Bacon *et al.* 1999), and polychlorinated biphenyls (PCBs) in stranded sea otters (Nakata *et al.* 1998), as well as the presence of butyltin residues, which are known to be immunosuppressant (Kannan *et al*. 1998). Kannan *et al.* (2006, 2007) found a significant association between infectious diseases and elevated concentrations of perfluorinated contaminants and polychlorinated biphenyls (PCBs) in the livers of sea otters, suggesting that chemical contaminants may influence patterns of sea otter mortality. Harmful algal blooms are increasingly recognized as a source of mortality (*e.g.,* Miller *et al.* 2010). Food limitation and nutritional deficiencies appear to be the primary driver of sea otter mortality (particularly in the central portion of the range from Seaside to Cayucos), either directly or as a consequence of dietary specialization (by increasing the exposure to protozoal pathogens of sea otters that specialize on non-preferred prey types) (Bentall 2005, Tinker *et al.* 2006b, Tinker *et al.* 2008, Johnson *et al.* 2009, Tinker 2013). Changes in the carbonate chemistry of the oceans due to increasing atmospheric CO_2 levels (ocean acidification) may pose a serious threat to marine organisms, particularly calcifying organisms (Kroeker *et al.* 2010, Kurihara *et al.* 2008, Stumpp *et al.* 2011), many of which are important prey for sea otters. However, effects on sea otters will depend on numerous factors (such as potential ecological shifts arising from variable responses among marine organisms) that cannot currently be predicted.

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SEA OTTER (*Enhydra lutris kenyoni*)
WASHINGTON STOCK

U.S. Fish and Wildlife Service
Lacey, Washington

STOCK DEFINITION AND GEOGRAPHIC RANGE

The northern sea otter, *Enhydra lutris kenyoni*, historically ranged throughout the North Pacific, from Asia along the Aleutian Islands, originally as far north as the Pribilof Islands and in the eastern Pacific Ocean from the Alaska Peninsula south along the coast to Oregon (Wilson et al. 1991). In Washington, areas of sea otter concentration were reported from the Columbia River to along the Olympic Peninsula coast (Scheffer 1940). Sea otters were extirpated from most of their range during the 1700s and 1800s as the species was exploited for its fur. Washington's sea otter population was extirpated by the early 1900s. In 1969 and 1970, a total of 59 sea otters were captured at Amchitka Island, Alaska, and released near Point Grenville and LaPush off Washington's Olympic Peninsula coast (Jameson et al. 1982; Jameson et al. 1986). Washington's current sea otter population originated from the Amchitka Island genotype (*Enhydra lutris kenyoni*).

Figure 1. Approximate distribution of Washington sea otter stock.

For management purposes pursuant to the Marine Mammal Protection Act (MMPA), the range of the Washington sea otter stock is within the marine waters of Washington State. However, if the stock expands southward into Oregon or northward into British Columbia, a revised stock assessment would consider this expanded range.

In 2006, the distribution of the majority of the Washington sea otter stock ranged from Pillar Point in the Strait of Juan de Fuca, west to Cape Flattery and as far south as Cape Elizabeth on the outer Olympic Peninsula coast (Figure 1). However, scattered individuals (usually one or two individuals at a time) have been seen outside of this range. For example, sick or injured sea otters have come ashore as far south as Ocean Shores and repeated sightings have been reported in Grays Harbor and as far east as Port Townsend. Sightings around the San Juan Islands, near Deception Pass, off Dumas Bay, off the Nisqually River, and in southern Puget Sound near Squaxin and Hartstene Islands have also been reported. Several of the sea otters in Puget Sound became relatively "tame," and in some cases local residents were feeding these individuals and promoting their "friendly" behavior. The U. S. Fish and Wildlife Service (USFWS) and Washington Department of Fish and Wildlife (WDFW) intervened, to the extent necessary, when these individual sea otters exhibited behaviors that presented a danger to themselves or to human health and safety.

In waters to the north of the Washington stock is the British Columbia sea otter population, which originated from animals also translocated from Amchitka Island and additional individuals from Prince William Sound, Alaska (Watson 2000). British Columbia's sea otter population, which is also increasing, includes at least 3,180 animals distributed mainly along the west coast of Vancouver Island from Barkley Sound to Cape Scott with a separate population along the mainland coast near Goose Island in Queen Charlotte Sound (COSEWIC 2007). Although most of the British Columbia sea otter population remains north of Estevan Point along the west coast of Vancouver Island, groups of 100 to 150 animals have recently been observed south of Estevan Point near Hesquiat Harbor and Flores Island just north of Tofino. Small numbers of animals have also been reported in Barkley Sound and scattered along the coast of the Strait of Juan de Fuca to Victoria. Currently there is no evidence of interchange between the Washington and British Columbia sea otter populations. However, as the Washington and British Columbia populations grow and expand their respective ranges, movement between these populations can be expected.

Sea otters breed and give birth year-round (Riedman and Estes 1990). Pupping period for Washington's sea otter stock is not well defined, with dependent pups observed in all months. However, births in Washington sea otters are believed to occur primarily from March to April, with peak numbers of dependent pups expected to be present from May to September (Ron Jameson, pers. comm.).

POPULATION SIZE

Original Washington Translocation

Fifty-nine sea otters were released off the Washington coast in 1969 and 1970, although almost half of the otters released in 1969 died. Sightings of sea otters were sporadic for several years after the translocations and during surveys through 1976, no more than 10 otters were observed at a time (Jameson et al. 1982). The current Washington sea otter population descended from no more than 43 otters and possibly as few as 10 (Jameson et al. 1982). Reproduction was first documented in 1974 (Jameson et al. 1982) and pups have been observed in all subsequent surveys.

Minimum Population Estimate

The first comprehensive post-release surveys of Washington's sea otter population were conducted by boat in 1977 and again in 1981 (Jameson et al. 1986). Boat, ground, and aerial surveys for sea otters were conducted biennially from 1981 to 1989. Starting in 1989 and continuing to present, Washington's sea otter population estimate has been developed from a combined aerial and ground survey conducted in early July by United States Geological Survey and/or WDFW. Based on the 2007 survey (actual count), the minimum population estimate of the Washington sea otter population is 1,125 individuals (Jameson and Jeffries 2008). No correction factor for missed animals has been applied to count data to determine a total population estimate from survey counts for Washington.

Current Population Trend

Based on count totals from 1977 to 1989, the Washington sea otter population increased at an annual rate of 20 percent (Jameson and Jeffries 1999). As has been done for the southern sea otter (*Enhydra lutris nereis*), three-year running averages are used to characterize population trends to dampen the effects of anomalous counts in any given year (U.S. Fish and Wildlife Service 2003). Jameson and Jeffries (2006) indicate "the finite rate of increase for this population since 1989 is 8 percent." Survey data indicate the Washington stock is nearing equilibrium density north of La Push, where the rate of increase has shown no growth since 2000 (Jameson and Jeffries 2008). South of La Push, the stock has been growing at about 20 percent per year since 1989 (Jameson and Jeffries 2006).

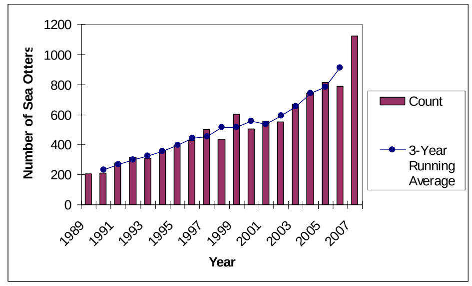

Figure 2. Annual and three-year running average of population estimates (1989-2007).

Laidre et al. (2002) provides a carrying capacity (K) estimate of 1,019 sea otters (95 percent CI 754-1,284) for Washington's sea otter stock to reoccupy rocky habitat from Destruction Island to Neah Bay (e.g., Seal and Sail Rocks). Laidre et al. (2002) also provide a total carrying capacity estimate for Washington of 1,836 sea otters (95 percent CI 1,386-2,286) based on an assumption that sea otters will reoccupy most of their historic habitat along the outer Washington coast (excluding reoccupation of the Columbia River, Willapa Bay, and Grays Harbor estuaries due to significant human alterations and use) and eastward into the Strait of Juan de Fuca as far as Protection Island. The Washington sea otter stock appears to be approaching equilibrium in the rocky habitat along the Olympic Peninsula coast; the reasons why the population has not dispersed into the unoccupied portions of its historic range are unclear.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

The maximum annual growth rate (R_{max}) for sea otter populations for which data are available has been reported as 17 to 20 percent (Estes 1990). From 1977 to 1989, the Washington stock grew at 20 percent (Jameson and Jeffries 1999) and appears to still be growing at this rate south of La Push (Jameson and Jeffries 2008). However, between 1989 and 2007, the growth rate of the entire Washington sea otter stock has slowed to an annual rate of 8 percent (Jameson and Jeffries 2008).

POTENTIAL BIOLOGICAL REMOVAL

The Potential Biological Removal (PBR) is the product of three elements: the minimum population estimate (N_{min}); half the maximum net productivity rate (0.5 R_{max}); and a recovery factor (F_r). For the Washington sea otter stock, N_{min}=1,125; R_{max} uses a maximum sea otter growth rate of 20 percent; and F_r=0.1. A F_r of 0.1 was used for the Washington sea otter stock because even though the population is increasing, the minimum population size is less than 1,500 and the population is restricted in its geographical range making it vulnerable to natural or human-caused catastrophe (Taylor et al. 2002). Therefore, the calculated PBR for the Washington sea otter stock is 11 animals.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Sea otters are susceptible to drowning in gillnets and have been taken in the Makah Northern Washington Marine Set-gillnet Fishery (Gearin et al. 1996). Based on observer data collected from 1988 through 2001, a total of 11 sea otters were taken when fishing effort occurred (Makah Tribe/Makah Tribal Resources and National Marine Fisheries Service (NMFS)/National Marine Mammal Lab (NMML) observer data). Although the fishing effort in this fishery began declining in the mid 1990s, sea otters continue to be taken in this fishery (Table 1). Pre-2000 data indicates sea otter mortalities are likely to occur when there is fishing effort in Areas 4 and 4A (Makah Bay). Only mortalities, not serious injuries, are reflected in Table 1 because the nets set by the Makah fishery do not rise to the surface of the water and any otters that get caught in the nets will likely drown. Due to inconsistent reporting between fishing areas, years, and the associated fishing effort, observer coverage, and otter mortalities (see Table 1), a reliable estimation of the annual sea otter mortality and serious injury in the Makah Northern Washington Marine Set Gillnet Fishery is assumed to be a minimum of 2 when there is fishing effort. In order to provide a more accurate estimate of the annual mortality and serious injury associated with this fishery, the USFWS requested information from the NMFS and the Makah Tribe. The information provided by the NMFS and the Makah Tribe was not sufficient to provide a more accurate estimate.

Table 1. Summary of sea otter incidental mortality in Northern Washington Marine Set-Gillnet Fishery. (Source: NMFS/NMML observer program, BIA, and Makah Tribe)

Fishery Name	Year	Fishing Effort[a] (Yes/No)	Observer Coverage	Observed/Reported mortality (Number of Otters)
Northern WA Marine Set Gillnet Areas 4/4A/4B/5	2003	Yes	None	-
	2004	Yes	1-11 net days observed[b]	2
	2005	Yes	None	-
	2006	Yes	None	-
	2007	Yes	None	-

[a]Overall fishing effort is not available
[b]Observer coverage is presented in format supplied to USFWS

Other fisheries that occur within the range of the sea otter in Washington include treaty and non-treaty gillnet fisheries in the Strait of Juan de Fuca, Puget Sound, and Grays Harbor. Neither the USFWS or the NMFS have received any voluntary or observer reports of sea otters killed or seriously injured in these fisheries. However, the lack of information cannot be interpreted to mean that no sea otters have been killed or seriously injured because there has not been marine mammal observer coverage of these fisheries since 1994, rather, incidental takings of marine mammals in these fisheries are reported to NMFS through self-reporting (Sources: Treaty/Non-treaty sum of landings submitted to the USFWS as part of Biological Opinion reporting requirements, USDC NMFS 2003). The fisheries subject to self-reporting do not include tribal fisheries. An accurate estimate of sea otter mortality and serious injury associated with these fisheries requires instituting an observer program and obtaining fishing effort data. Because this information is not currently available, we cannot provide an accurate estimate of the annual mortality and serious injury associated with these fisheries. Sea otter densities along the Strait of Juan de Fuca in the summer and fall are low, when the fisheries generally operate, so few entanglements would be expected. However, as the Washington sea otter population continues to grow, the possibility of fisheries-related incidental take in these gillnet fisheries will grow.

Other fisheries that also occur within the range of the Washington sea otter stock include: 1) treaty set-gillnet fisheries that occur in the coastal rivers (Quinault, Queets, Hoh, Quillayute, Hoko, and Waatch); 2) treaty and non-treaty groundfish trawl fisheries that occur offshore of the Olympic Peninsula coast; and 3) treaty and non-treaty drift gillnet fisheries that occur in Willapa Bay. These fisheries are unlikely to result in mortality or serious injury because sea otters are unlikely to occur in these areas.

As sea otters expand their range eastward into the Strait of Juan de Fuca or south along the outer Washington coast, they will also encounter important sport and commercial shellfish fisheries (urchins, razor clams, Dungeness crabs, steamer clams, geoducks). "Evidence from California and Alaska suggests that the potential for incidental take of sea otters in crab traps will increase as the population expands its range south of Destruction Island into prime Dungeness crab habitat" (Lance et al. 2004). In addition, the potential exists for increased interactions with invertebrate fisheries, particularly sea urchins and geoducks, as the sea otter population expands eastward into the Strait of Juan de Fuca (Gerber and VanBlaricom 1999).

Other Human-Caused Mortality and Serious Injury

Other sources of human-caused mortality and serious injury affecting the Washington sea otter population are not well documented. Documented sources of human-caused mortality for the southern sea otter include shooting, boat strikes, capture and relocation efforts, oil spills, and possibly elevated levels of polychlorinated biphenyls and other toxic contaminants. In 2003, one Washington sea otter death was presumed to have been caused by a boat strike because of the type of injuries observed during necropsy. However, these injuries could also have been sustained in a variety of other ways.

In the past decade, a number of oil spills have occurred within the range of Washington's sea otter population, with one documented oil related death recorded during one of these spills (Jameson 1996). Additionally, with the increasing volume of shipping traffic into and out of the Strait of Juan de Fuca, the potential for a catastrophic spill exists and most, if not all, of the Washington sea otter population and range is vulnerable to the effects of such a spill. Significant oil-related mortalities and habitat damage would be expected to occur if an oil spill of this nature were to happen and impinge directly on sea otter habitat along Washington's Olympic Peninsula and Strait of Juan de Fuca coastlines.

However, due to the lack of documented mortalities or serious injuries resulting from other human-caused sources and the unpredictability of oil spills, we are unable to provide an estimate of the annual mortality and serious injuries associated with other human-caused mortality and serious injury.

Harvest by Northwest treaty Indian tribes

A number of Native American tribes of the Pacific Northwest have treaty rights to harvest various fish and wildlife resources in Washington State. Currently there is no authorization for harvest of sea otters by Native Americans; however, there is a developing interest in such a program. As affirmed by the Court of Appeals for the Ninth Circuit in Anderson v. Evans (9th Cir. June 7, 2004), any take of sea otters by Native Americans other than Alaskan natives residing in Alaska has to be authorized under the MMPA.

STATUS OF STOCK

The Washington sea otter stock is not listed as "depleted" under the MMPA nor listed as "threatened" or "endangered" under the Endangered Species Act. Sea otters are listed by the State of Washington as "State endangered" under Revised Code of Washington 77.12.020 and Washington Administrative Code (WAC) 232.12.014 due to small population size, restricted distribution, and vulnerability (Lance et al. 2004). The WDFW finalized their sea otter recovery plan in 2004 (Lance et al. 2004).

This stock is not classified as strategic because the population is growing and is not listed as "depleted" under the MMPA or "threatened" or "endangered" under the Endangered Species Act of 1973.

The lower end of the Optimum Sustainable Population (OSP) range is assumed to occur at approximately 60 percent of the maximum population size the environment will support (i.e. carrying capacity) (DeMaster et al. 1996). The total carrying capacity estimate for Washington is 1,836 sea otters (95 CI 1,386 – 2,286) (Laidre et al. 2002). The current population estimate of 1,125 (Jameson and Jeffries 2008) is above the lower end of the OSP (60 percent of 1,836).

The mortality and serious injury for the Makah Northern Washington Marine Set Gillnet Fishery is estimated to be a minimum of two mortalities annually when there is fishing effort. We are unable to provide an estimate of the annual mortality and serious injury associated with other fisheries and other sources of human-caused mortality and serious injury, due to the lack of information. Therefore, we are unable to determine whether the level of human-caused mortalities and serious injuries are insignificant and approaching a zero mortality and serious injury rate.

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GRAY WHALE (*ESCHRICHTIUS ROBUSTUS*) HABITAT UTILIZATION AND PREY SPECIES OFF VANCOUVER ISLAND, B.C.

JAMES D. DARLING
KATHLEEN E. KEOGH
TAMMY E. STEEVES
West Coast Whale Research Foundation,
1200-925 West Georgia St., Vancouver, B.C. Canada V6C 3L2
and
Clayoquot Biosphere Project,
P. O. Box 67, Tofino, B.C. Canada VOR 2ZO
E-mail: darling@island.net

ABSTRACT

Habitat utilization and prey species of Vancouver Island gray whales were investigated by (1) summarizing 26 yr of distribution and feeding data and (2) conducting intensive observations in Clayoquot Sound, Vancouver Island, from 1989 to 1996. Whale distribution and movements were monitored from March to November through systematic boat surveys and whale-watch sighting programs. Prey species were collected by suction hose and plankton net or determined through analysis of fecal samples. Gray whales utilized virtually all of the southern west coast of Vancouver Island over the 26-yr observation period. Distribution, prey species, and feeding behavior showed marked variability during any one season and between years. Some feeding areas were used on an annual basis, others with >10-yr intervals between use. Feeding occurred in shallow sand or mud bays, eel grass beds, kelp beds, in the open water column, and at the surface. Young whales appeared to utilize habitat and prey species differently than adults. Main prey species included herring eggs/larvae (*Clupea harengus pallasi*), crab larvae (*Cancer magister* megalops, *Pachycheles* spp. zoea), mysids (*Holmesimysis sculpta, Neomysis rayii, Acanthomysis* spp.), amphipods (*Ampelisca* spp., *Atylus borealis*), and ghost shrimp (*Callianassa californiensis*). The definition and relative importance of specific feeding grounds and the study of human impacts on this population are complicated by its broad and variable use of habitat and prey species.

Key words: gray whale, *Eschrichtius robustus*, prey, feeding patterns, habitat, Vancouver Island, oil.

The majority of eastern Pacific gray whales (*Eschrichtius robustus*) migrate annually between winter breeding grounds along the Mexican coast and summer feeding grounds in the Bering and Chuckchi Seas (Scammon 1869, Pike

1962, Rice and Wolman 1971, Rugh 1984). Small populations of gray whales inhabit portions of the North American coast from California to Alaska during the summer (Gilmore 1960*a*,*b*, Pike 1962, Pike and MacAskie 1969, Rice and Wolman 1971, Darling 1984, Nerini 1984, Calambokidis *et al.* 1991). A gray whale population occupying a summer range along the west coast of Vancouver Island, British Columbia, has been studied since the early 1970s (*e.g.*, Hatler and Darling 1974; Darling 1978, 1984; Oliver *et al.* 1984; Guerrero 1989; Duffus 1996).

The Vancouver Island gray whale population consists of 35–50 whales which occupy the region for 8–9 mo between northern and southern migrations, the period from approximately March to December. During the summer they range and feed over a distance at least the length of the central Vancouver Island coastline. Between the 1970s and the present, a number of individually identified whales returned to this location each year, suggesting that the area may be a "home summer range" of a specific group of animals. Adults were typically identified over multiple years, and small, very young whales were usually present for 1–2 seasons only (Darling 1984).

Several authors have described gray whale feeding behavior off Vancouver Island. They documented benthic feeding on amphipods, ghost shrimp, and possibly polychaete worms (Hatler and Darling 1974, Darling 1978, Oliver *et al.* 1984, Plewes *et al.* 1984, Kvitek and Oliver 1986) and planktonic feeding on mysids (Murison *et al.* 1984, Guerrero 1989). Collectively, these observations indicate gray whales exploit several types of prey off Vancouver Island.

In December 1988 the Nestucca oil spill resulted in substantial amounts of oil being deposited in gray whale feeding grounds off Vancouver Island (Canadian Coast Guard 1989).[1] In the follow-up assessment, JDD was asked by the Department of Fisheries and Oceans to investigate the impact of the spill on the gray whales feeding in the area. Limited knowledge about the patterns of utilization of feeding grounds and specific prey species obscured our understanding of the impacts of the spill. Such information is key to our ability to determine the impacts of human activity or natural phenomena on the whales. The purpose of this study was to document patterns of habitat and prey utilization by gray whales in the Clayoquot Sound region of Vancouver Island.

METHODS

Study Area

Vancouver Island (Fig. 1) is a 480-km long island approximately half-way between gray whale breeding areas in Mexico and northern feeding grounds.

[1] The spill of 875,000 liters of Number 6 Fuel Oil occurred off Oregon on 28 December 1988, and currents brought oil to Vancouver Island within a few days. Substantial amounts of oil washed onto beaches in gray whale feeding grounds. The majority of gray whales were on their winter migration south of Vancouver Island at the time of the spill.

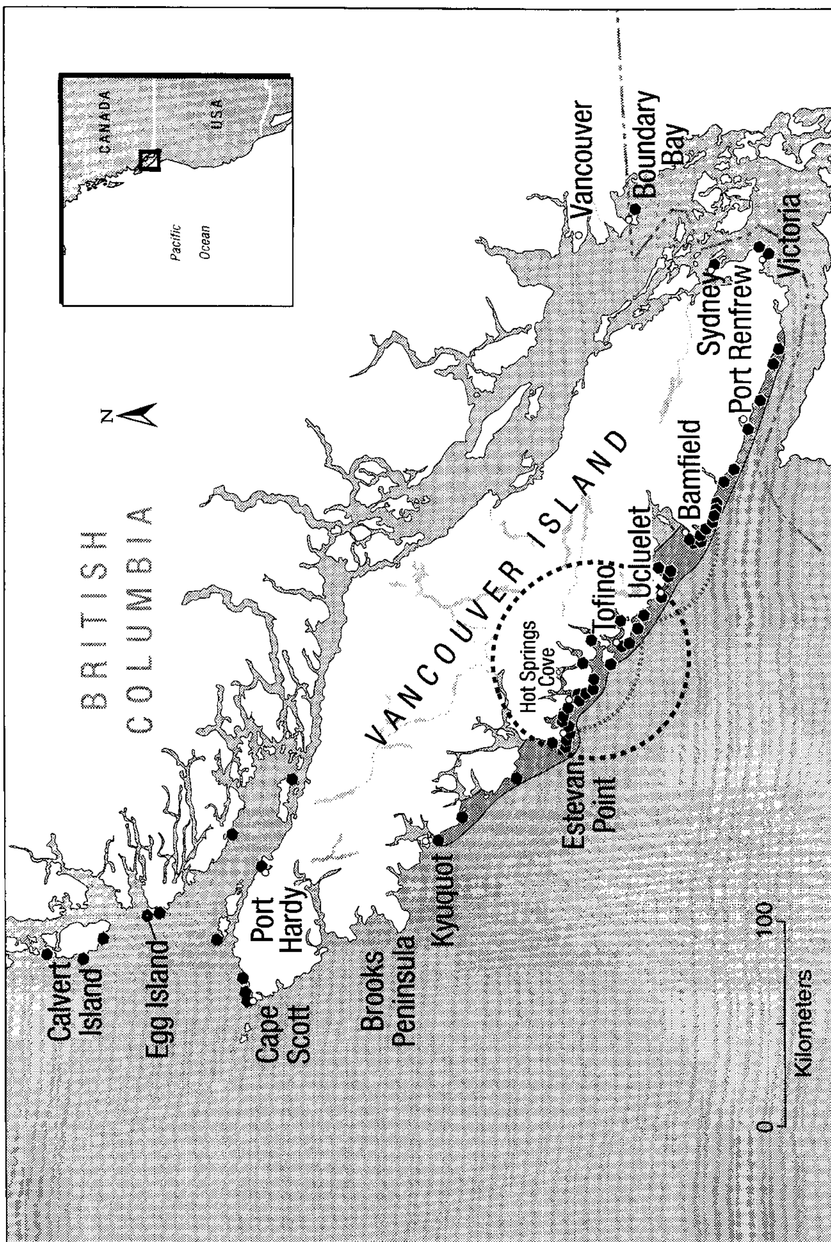


Figure 1. Vancouver Island, study area, and locations of feeding whales, 1971–1996. Primary study area indicated by circle. Dotted lines joining locations indicate actual movements of individuals within one summer and show study area smaller than summer range (Darling 1984).

Between 1971 and 1996, gray whale observations were conducted on the coasts of Vancouver Island between Victoria and Cape Scott and in waters northward on the British Columbia mainland coast. Most of the observations occurred along the 225-km central–southwest coast of Vancouver Island, with the primary study area in the Clayoquot Sound region, extending approximately 80 km from Wickaninnish Bay in the southeast to Estevan Point in the northwest (Fig. 1). Our primary study area is only a portion of the overall summer range of the Vancouver Island population (Darling 1984). This coastline is characterized by open, shallow, sandy bays with surf-swept beaches separated by rocky headlands, coastal islands creating protected inside waterways, and extensive fjords reaching up to 30 km inland.

Vancouver Island and Adjacent B.C Coast Sightings

Sightings were collected along the Vancouver Island and mainland British Columbia coast by JDD and other knowledgeable observers over the 26-yr period, 1971–1996 (Fig. 1). These were recorded in a series of field notebooks, and some have been previously published (Hatler and Darling 1974, Darling 1984).

Clayoquot Sound Observations

The majority of observations that focused on habitat use and prey species were made during an eight-year period from 1989 to 1996. Some of the observations presented originated from earlier work in the region by JDD. Habitat use information was gathered using both research surveys and whale-watch sighting programs. The research effort included systematic small-craft surveys of the study area at least weekly from May through October each year, 1992–1996. Additional surveys were conducted in March–April and November each year as weather allowed. Presence and absence of whales on known feeding grounds were documented. All whales were individually identified by photographs of natural markings on their sides (Darling 1984) and locations, behavior, and associates noted. Photoidentified whales were compared to those in an identification catalog developed over the last 20 yr for sighting histories. Changes in location and habitat use by whales were monitored through these surveys and from the daily whale-watch effort in the region.

Whale watching is a significant industry in the study area and provided an opportunity for an intensive documentation of whale distribution between early March and late October each year. Whale-watch boats searched for whales on a minimum of 175 d between these dates each year, leading to a total of over 1,400 d of observation, 1989–1996. Six–12 boats and one to three planes were involved on any one day, operating from dawn to dusk. A specific marine radio channel allowed all interested to be party to all sightings. Beginning in 1989, whale-watch boats were asked by JDD to record whale sightings. Forms with maps of the region were provided, and boat operators were asked to record trip time, locations, and whale activity (feeding, resting, traveling, rubbing). The majority of the boat operators had at least five years' experience with the whales and were proficient at determining behavior mode. Daily contact between whale-watch operators and researchers conveyed current whale activity, and boat operators contacted a researcher if unusual events occurred. The whale-watch activity amounted to an enormous sighting effort that was difficult to quantify due to variable participation and experience of specific operators. However, we cannot overemphasize the ongoing intensity of this effort, and we are convinced most whale activity in daylight hours in the region was recorded through this program.

The study effort for the years 1992–1996 was nested, with prey collections occurring within regular distribution and abundance surveys occurring within the ongoing whale-watching effort. Combined, these provided an accurate overview of activity in the area.

Prey Collection and Identification

In each feeding location the prey species was determined by collections, or, if needed, fecal analysis. Benthic samples were collected with a suction hose and fine-mesh net. A diver held the collection hose (PVC pipe) on the bottom in the close vicinity of feeding whales and, through use of a scuba tank to create a vacuum, suctioned the sediment/organism mixture into a fine-mesh net. Later, the predominant organisms were sorted and identified. When whales were feeding on deeper plankton or hyperbenthic organisms, collections were made using a plankton net with a cannonball weight attached to drop it to the bottom. It was towed within meters of feeding whales. Patches of prey were usually dense, and the net would often be filled beyond the collection cylinder within a few minutes of tow. When whales were feeding on the surface, the plankton net was used without the weight. If these techniques failed to catch organisms in quantities clearly indicating the prey species, the feces of the whales were collected and examined for body parts identifiable to species.

Once prey organisms were collected from a particular feeding event, the whales were monitored by researchers and whale-watch operators. Any change in behavior or feeding location warranted another collection of prey. Periodic collections were made whether whales had changed behavior or locations or not. This routine was followed throughout the May-November period, 1992–1996. In known benthic-feeding areas in which samples had been repeatedly taken over years (this study and others: *e.g.*, Kvitek and Oliver 1986), collections were made only to confirm prey species. It was presumed that when bottom feeding in these locations the whales were consuming benthic species known to inhabit the region.

Prey organisms were preserved in 5% formalin in seawater and identified by local identification keys such as Kozloff (1983) or by amphipod specialist E. Bousfield at the Royal British Columbia Provincial Museum.

RESULTS

HABITAT UTILIZATION

Vancouver Island and Adjacent B.C. Coast

Observations included both planktonic and benthic feeding activity (Fig. 1). Sightings ranged from Georgia Strait and Victoria on the southern tip of the island to Cape Scott in the north. Whales were also sighted feeding in the Inside Passage, between Vancouver Island and the mainland and along the B.C. mainland coast northwest of Vancouver Island. Research effort was considerably less over the northern half of the Vancouver Island west coast and the mainland coast; the fewer sightings in these regions compared to the southern Vancouver Island west coast, therefore, may reflect effort rather than habitat use. Gray whales occupied a variety of habitats when sighted, ranging from protected, shallow, mud-bottomed bays to exposed surf-swept bays and beaches, to stretches of sandstone shelf, or rugged rocky shoreline with extensive fringing kelp beds. Gray whales were not present in all locations each year, and some locations were more regularly occupied than others. However, the long-term records clearly indicate that virtually all of the central-southern outer Vancouver Island coastline was utilized by gray whales over the 26 yr.

Clayoquot Sound Region

Habitat types included feeding sites, divided into herring, benthic, and plankton feeding locations, and "rubbing" sites (Fig. 2). The whales made use of all of these locations and habitats over time, although not all locations were used each year. Some feeding areas were used regularly, and these are indicated as primary grounds; others were utilized irregularly, and these are shown as secondary feeding grounds (Fig. 2). Primary grounds were those where we observed feeding for at least some portion of the season in most years; secondary grounds included those in which several years separated periods of utilization. The status of sites could change from primary to secondary use over the long term.

Feeding Habitat

Herring sites—These sites could occur wherever herring spawned. Characteristics of herring spawning sites included eel grass or algae beds in semi-protected or protected waters. There was substantial annual variability in the timing, location, and size of the "spawn" and in gray whale use of herring spawn habitat. The most consistent location in the study area was Hesquiat Harbour, at the west end of Clayoquot Sound, a 6 × 10-km shallow bay fringed with eel grass and algae beds and protected from northwesterly seas and weather. Spawning sites within the bay varied somewhat year to year. Other herring spawning habitat utilized by gray whales included sites on the west and east shores of Flores Island and north and east shores of Vargas Island

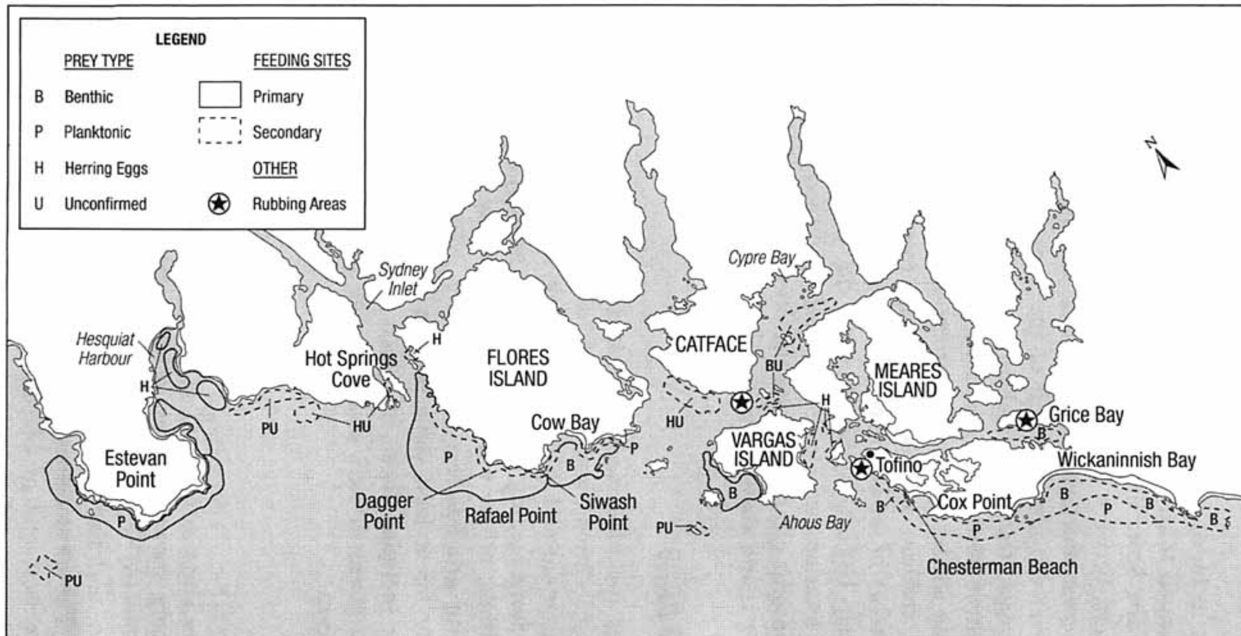


Figure 2. Gray whale habitat use and prey types in Clayoquot Sound, 1971–1996. Primary sites were those used regularly; secondary sites were those used irregularly. Wickaninnish Bay was primary site until early 1980s and now considered secondary site. "U" behind prey type indicates suspected but unconfirmed. Note rubbing areas off Tofino, Catface, and Grice Bay.

and adjacent shorelines (Fig. 2). Gray whale utilization of herring spawn areas occurred also at other locations along the Vancouver Island and Queen Charlotte Island coastlines (JDD, unpublished data).

Benthic feeding sites—Benthic feeding sites were the most definable and predictable of all feeding habitats. The primary sites included Cow Bay on the outside coast of Flores Island and Ahous Bay on the outside of Vargas Island (Fig. 2). Until the late 1970s, Wickanninish Bay and Chesterman Beach, approximately 20 km and 9 km, respectively, to the south of Ahous Bay (Fig. 2) would also have been considered primary benthic feeding sites. However, this has changed in recent years (discussed below). These are all relatively large, shallow, sand-bottom bays with feeding activity ranging from the intertidal zone to approximately 30 m of depth. Many smaller sandy bays in the region were used on occasion. An example of a secondary site was Cypre Bay, a protected passage between Meares Island and the Catface Range (Fig. 2). Several years passed without any extended gray whale use, but in some years this region was occupied by 6–8 whales for weeks at a time. Another important secondary site was Grice Bay, a protected mud-bottom bay so shallow that the majority of it is dry at low tide. It is reached through a 10-km long, narrow, inland passage from the entrance to the open sea at Tofino.

Plankton feeding sites—The plankton feeding sites most consistent over the period of this study were the section of coastline from Wickaninnish Bay to Chestermans Beach near Tofino, the entire outer Flores Island coast from its southern point around to the Sydney Inlet entrance, and the outer coast of Estevan Point (Fig. 2). Different sites within these larger regions were occupied for utilization of different prey species. The boundaries of these sites were quite flexible, with the prey and whales shifting with tide and current. Depending on prey species, the whales were found within and along kelp beds and in the surf zones of rocks (mysids) or slightly farther offshore in open water (crab larvae). Plankton feeding often occurred at locations distinct from benthic feeding sites, but overlap did occur.

Young Whale Habitat

Young whales generally tended to be separated from adult animals and were sometimes found together in small groups. This separation was subtle at times, with the younger animal(s) just several hundred meters away from adult assemblages, often inshore or in a kelp bed; or it was quite marked, when young animals occupied physically separate habitat with nearest adults 10+ km distant. The latter case is exemplified with the utilization of Grice Bay habitat. All sightings in this location over a period of 26 yr were of young whales. Between one and five whales spent months and in some cases a year or more in the bay, feeding benthically.

Sand Bar (Rubbing) Activity

Gray whales used specific habitat in Clayoquot Sound presumably for rubbing purposes. The whales regularly moved to sand bars and gravel spits in

Table 1. Prey species collected in Clayoquot Sound, 1989–1996.

Crab larva	*Cancer magister* (megalops)
	Pachycheles spp. (zoea)
Amphipods	
benthic	*Ampelisca* spp.
swimming	*Atylus borealis*
Mysids	*Holmesimysis sculpta*
	Neomysis rayii
	Acanthomysis spp.
Shrimp	*Callianassa californiensis*
Herring eggs/larvae	*Clupea harengus* pallasi

the region where they rubbed their bodies and "stood" on their tails with heads lunging above the water. This behavior occurred regularly at a sand bar in Templar Channel off Tonquin Beach at the south entrance to Tofino harbor and on a sand bar off Catface Mountain in Calmus Passage (Fig. 2). Whales moved into the area from feeding grounds, or from the migratory route, rubbed for a few minutes to several hours, then moved away again (Darling 1978). Some local observers have suggested that feeding occurs at these sites; however, we have no evidence either way. Whales periodically inhabiting Grice Bay were observed similarly rubbing on the gravel spit off Indian Island. It is possible this activity also occurred regularly on the bottom.

Prey Species

Benthic species (Table 1) included amphipods (*Ampelisca* spp.) and ghost shrimp (*Callianassa californiensis*); planktonic or mobile species included mysids (*Holemsimysis sculpta, Neomysis rayii, Acanthomysis* spp.), crab larvae (*Cancer magister* megalops, *Pachycheles* spp. zoea), and mobile amphipods (*Atylus borealis*). Herring eggs and larvae (*Clupea harengus pallasi*) were also prey for gray whales off Vancouver island.

Appendix 1 gives the prey collection record from 1984 to 1996, including date, locations (Fig. 2), method of collection, and prey species. A total of 43 collections were made. The numbers of collections by species generally reflect only our need to confirm prey during ongoing monitoring and not the relative utilization of the different species.

The leveling off of the graph of "new" species (Fig. 3) indicates that the later collections produced species already documented as prey items. The last 16 collections in 1995 and 1996 and 27 of the last 28 collections since 1994 produced no previously unknown prey species. This suggests that the nine species identified to date made up the predominant prey species of gray whales in the study area during the period of observation. However, we do not wish to imply that this is a complete list. For example, highly suggestive but unconfirmed observations of gray whales feeding on juvenile rockfish and needlefish or sandlance have been made in the region.

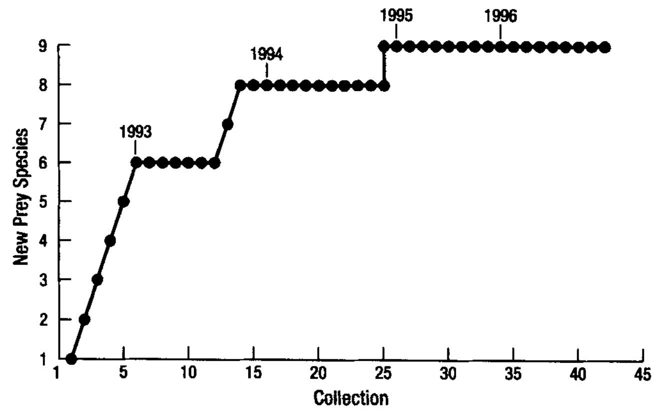


Figure 3. Discovery of prey species, 1984–1996. Leveling off indicates no new species found.

We observed several different feeding techniques and behavior patterns depending on type of prey, including feeding on the bottom, in the water column, and at the surface. Bottom-feeding activity, characterized by whales diving for several minutes and surfacing in approximately the same location streaming sediments from the baleen, and mysid feeding characterized by short dives and more random movements in kelp beds and within the surf zone of rock and islets, have been described by several authors (*e.g.*, Rice and Wolman 1971, Nerini 1984, Murison *et al.* 1984, Guerrero 1989). Feeding on crab larvae included skim feeding, with the whales moving along the surface, the upper jaw above the water, repeatedly "biting" down on the plankton streams along tide lines. When the crab larvae were deeper, the surface activity was similar to benthic feeding, except that the whales generally moved over a greater distance during dives. Feeding on herring eggs often occurred in water several meters deep, the whales on their sides with a flipper and half fluke above the surface. We presume that the whales used suction to engulf the egg masses but this has not been confirmed. A whale that died in the area in April 1997 was found to have its stomach filled with herring eggs (JDD, field notes).

FEEDING PATTERNS IN CLAYOQUOT SOUND

Early Season Herring Spawn Events

Each spring gray whales left the northward migration to feed on herring eggs recently deposited on eel grass and algae beds (Fig. 2). The location, time, and intensity of this activity varied substantially from year to year depending on the timing and abundance of herring. Hesquiat Harbour was the only site in Clayoquot Sound where this feeding occurred on an annual basis throughout the period of study. At Hesquiat the spawn and feeding activity occurred between mid-February and early April and usually lasted two to three weeks, with several separate spawns in some years extending this time considerably. During this period dozens to hundreds of whales utilized the site. It appeared the whales fed until the eggs hatched, which occurs approximately 10 d after spawning (Hart 1973), although we suspect they may also feed on the larvae in some circumstances. There can be an enormous volume of eggs, with egg drifts on beaches a meter or more high. Several other locations in the study area had smaller herring-related feeding events during one or two of the years between 1989 and 1996 (Fig. 2). When this occurred, whales moved into the area for a week or two, then departed. It is likely that herring provided the first food of the season to a portion of the migrating herd. Herring spawn times occurred progressively later along the coastal migratory route of the whales, just ahead of the migration itself. Herring-egg-feeding locations were not included in the annual feeding maps discussed below, as there is no confirmation at this stage that summer resident whales were involved in these events—although there is also no reason to believe they are not.

Summer Feeding Patterns

From observations conducted between 1989 and 1996, we have chosen four years to illustrate feeding patterns in detail: 1992, 1993, 1994, and 1995 (Fig. 4A–D). Observations from other years are referred to in relation to these examples. The terms early-season, mid-season, and late-season are used to generally designate the periods May–June, July–August, and September–November, respectively; and the terms "short-lived" and "extended", "minor," and "major" are arbitrary and used to describe the relative duration and number of whales participating in feeding events. A short-lived event was less than seven days; a major event involved more than ten whales.

1992 (Fig. 4A)—During the early- and mid-season there were several short-lived plankton-feeding events, including: (1) off Cox Point for one week in May (*A. borealis*), (2) north of Rafael Point in late June (*Pachycheles* spp.), and (3) off Estevan Point in mid-July (*Pachycheles* spp.). Beyond these events and through much of the summer, there were few whale sightings in Clayoquot Sound. There were occasional sightings of whales passing through or staying just a few days. On 18 August whales moved into Cow Bay and Ahous Bay and began feeding on benthic amphipods (*Ampelisca* spp.). This activity continued through the rest of the season. Numbers ranged from two to seven whales in Cow Bay through October and one to four in Ahous Bay through November. Noteworthy for this year is that sightings occurred over the period, 8–11 September, in the Cypre Bay region, a secondary ground with the last extended period of use in July–September 1982.

1993 (Fig. 4B)—An extended plankton-feeding event (*A. borealis*) occurred during the period from early May to early June along the coastline from Wickaninnish Bay to Chesterman Beach near Tofino, with up to seven to eight whales involved. During this time, and throughout most of the summer, whales were present in Ahous Bay and Cow Bay feeding on benthic prey (*Ampelisca* spp.). From June to October, one to six whales were periodically present in Ahous Bay. From May to November, one to eleven whales were present in Cow Bay. In the latter an obvious increase in numbers occurred in mid-August, leading to a constant seven to eight whales present through September. Whales also fed on mysids: (*N. rayii*) off Estevan Point in July and (*H. sculpta*) off Rafael Point for a period in July and August.

1994 (Fig. 4C)—This was primarily a plankton-feeding year. Whales were present for a week in early May in Wickanninish Bay (food unknown). From mid-May through late June up to 14 whales were involved in a major mysid-feeding event (*H. sculpta*) in the south Cow Bay area. By July most had moved to Rafael Point, where as many as eight whales fed on crab larva (*Pachycheles* spp.) through the end of August, although the number of whales present declined after 20 August. Whales were present off the Rafael Point–Siwash Point region feeding on plankton through September and October, but the prey species was not confirmed until 2 November: mysids (*N. rayii* and *Acanthomysis* spp.). The whales apparently shifted from crab larvae to mysid prey sometime during this period. Benthic feeding was not observed in the region until 2 November in Ahous Bay.

1995 (Fig. 4D)—Sporadic bottom feeding occurred in Ahous Bay from May to July, with one or two whales present for one or two days at a time. Similarly, sporadic bottom feeding occurred in Cow Bay in June, July, and early August, with one to four whales moving in and out of the area. In Ahous Bay, one to two whales were present continually by mid-September, five to six by early October, and seven to eight by late October. In Cow Bay from mid-August through September whale numbers were steady at three to four, and none were present in October. Through periods of July and August, two to five whales were present in the Rafael Point–Sydney Inlet area feeding on crab larvae (*Pachycheles* spp.), and in September a major feeding event occurred off Estevan Point with 10–15 whales also feeding on crab larvae. The Grice Bay secondary ground was utilized throughout the season, as described below.

Grice Bay utilization—During 1995, one to five young whales occupied the Grice Bay secondary ground from March through August feeding on ghost shrimp (*C. californiensis*). One of the same individuals was also present in the same area in June, July, and September 1996, also feeding on ghost shrimp. This feeding ground had been last utilized extensively in 1984–1985 by one or two young whales, and prior to that, in 1971, by one whale (Fig. 5; Hatler and Darling 1974). During the three documented periods of extended sightings since 1971, at least eight individual whales utilized this habitat for periods up to one year or more. The individual whale present in 1985 was one of the two animals present in 1984 and stayed the winter (JDD, unpublished data). No adults were sighted in the vicinity.

Between-Year Comparisons

It is clear that the differences between years are more striking than any repetitive patterns of occupancy or prey type (Fig. 6). For example, benthic feeding occurred throughout the season in 1993, was virtually non-existent in

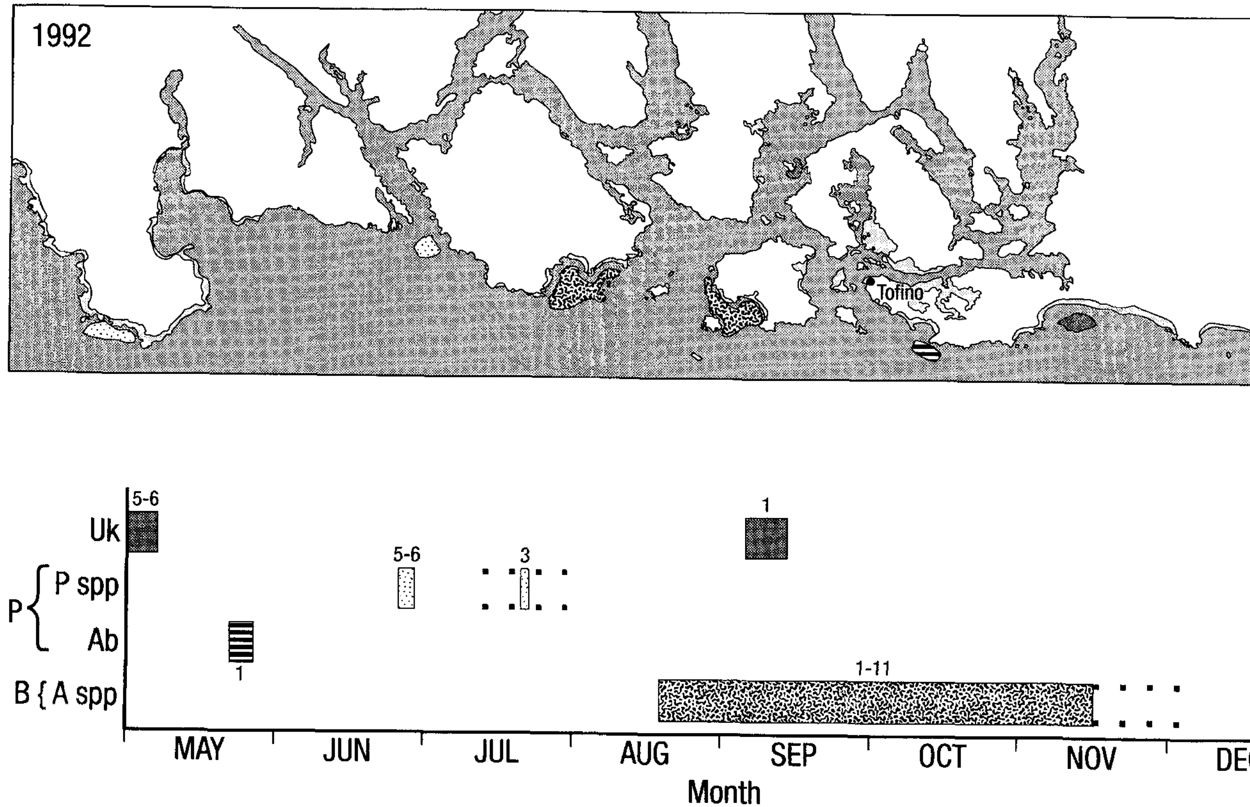


Figure 4. Patterns of habitat and prey utilization: (A) 1992, (B) 1993, (C) 1994, (D) 1995. P = plankton; B = benthic; Uk = unknown; Uk P = unknown plankton; Uk B = unknown benthic; A spp = *Ampelisca* spp; Ab = *Atylus boralis*; Hs = *Holmesimysis sculpta*; Nr = *Neomysis rayii*; P spp= *Pachycheles* spp; Cc = *Callianassa californiensis*. Numerals indicate approximate number of whales involved in feeding event (determined by individual identification). Patterned circles inside "unknown" designation indicates likely prey (*e.g.*, 1993, 1994). Prey collections made within shaded areas.

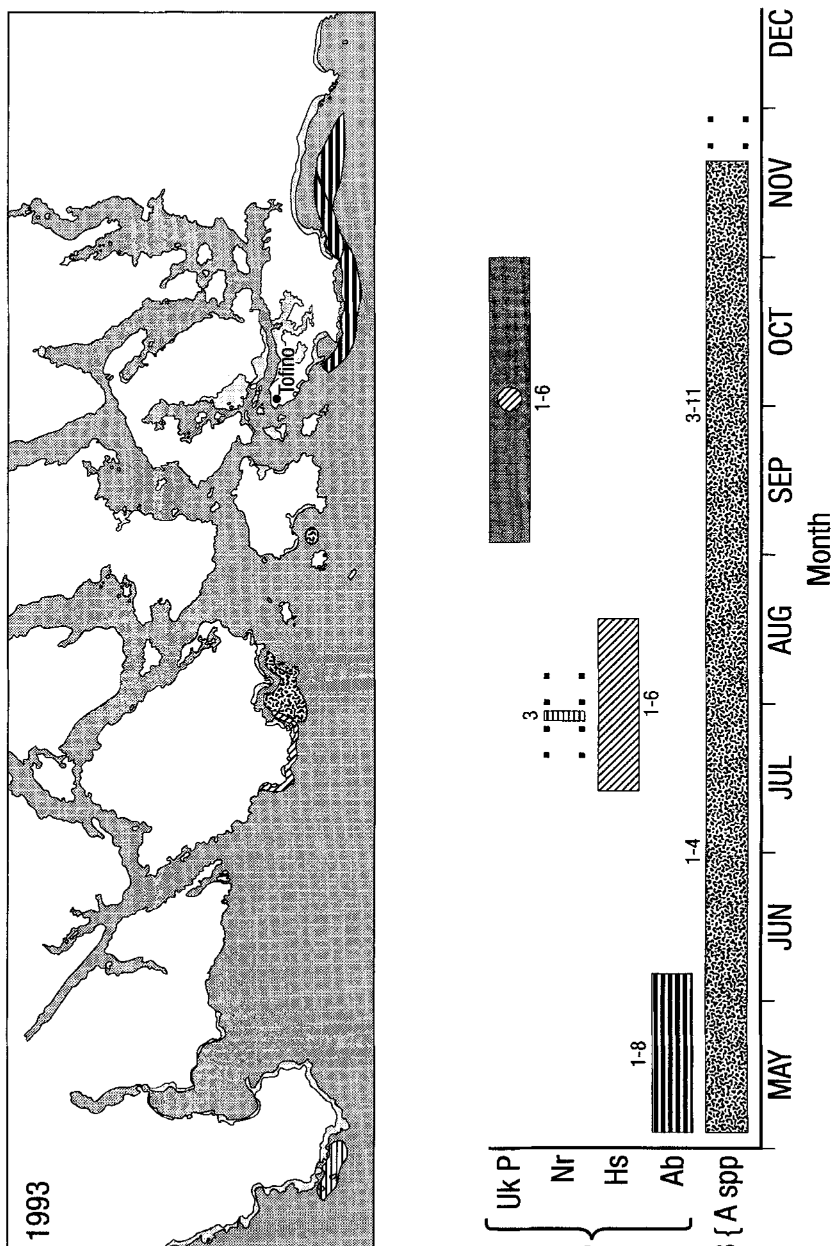


Figure 4. Continued.

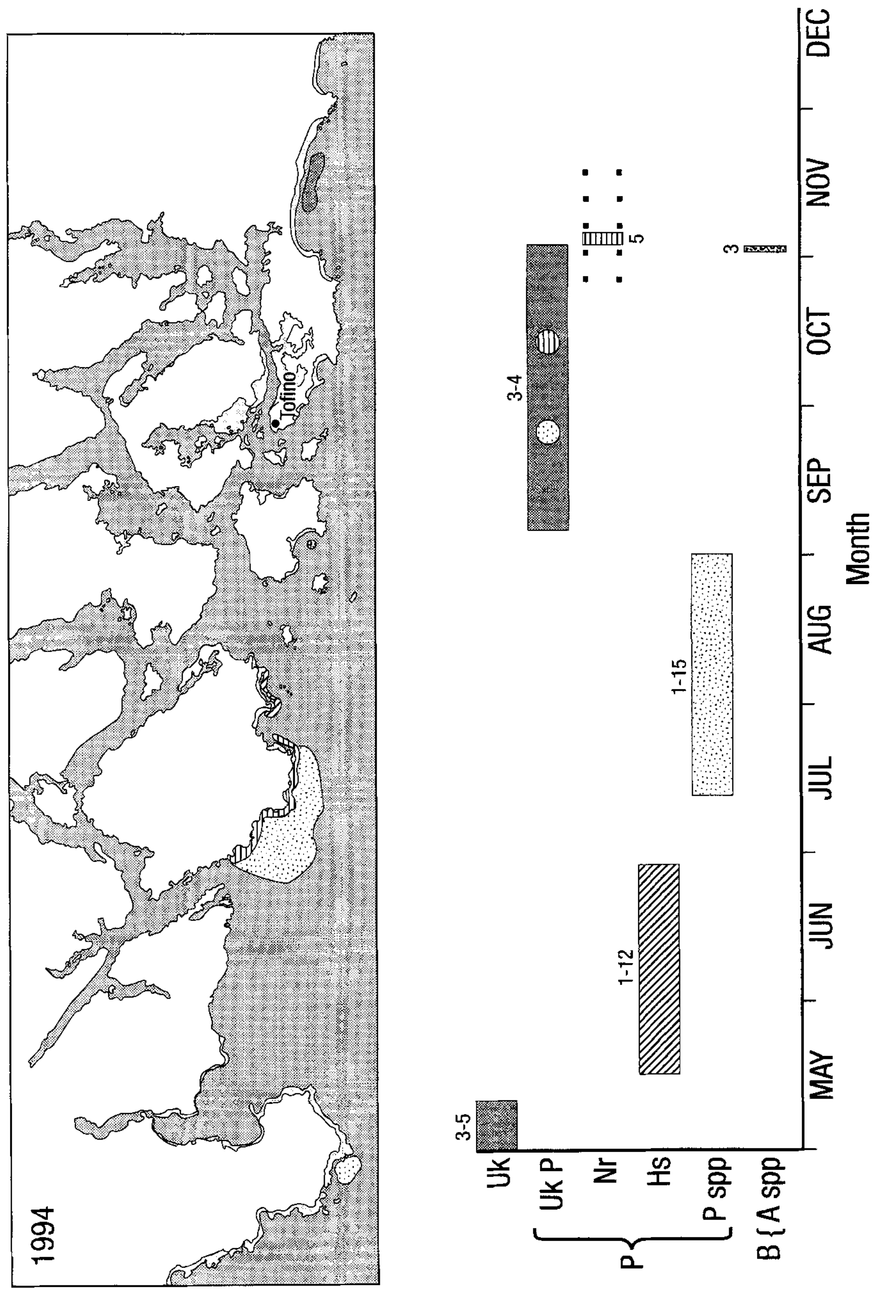
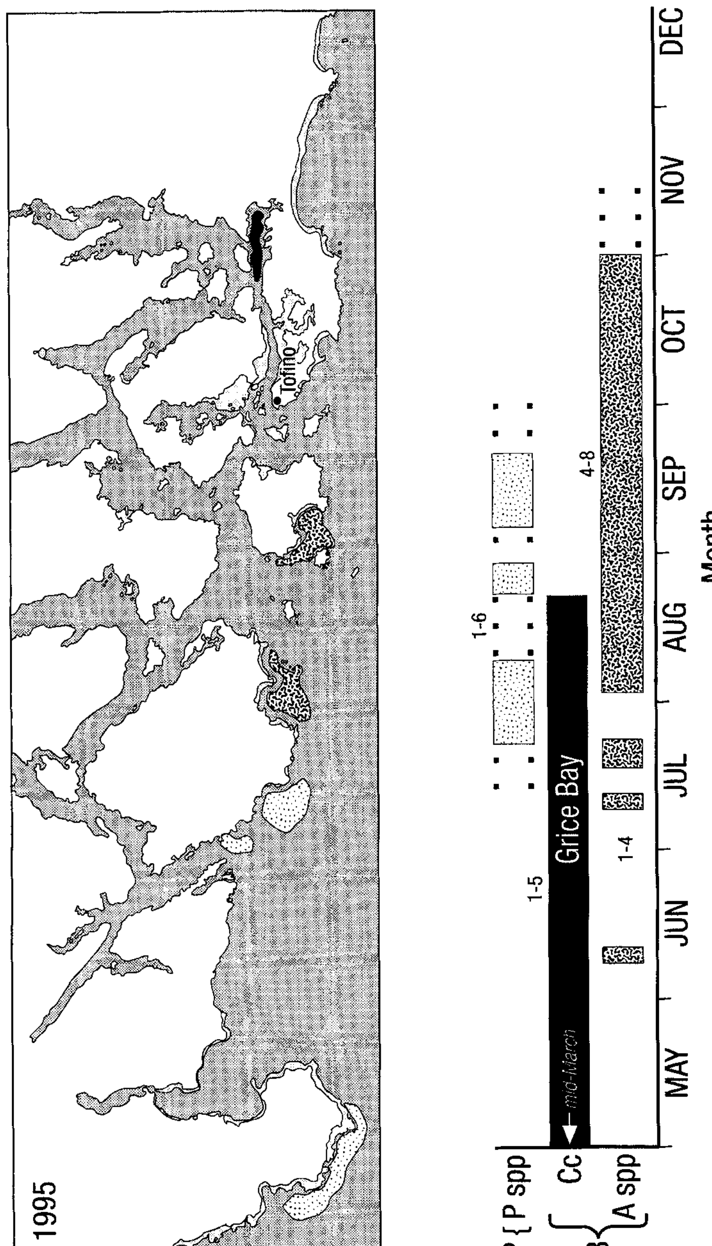


Figure 4. Continued.



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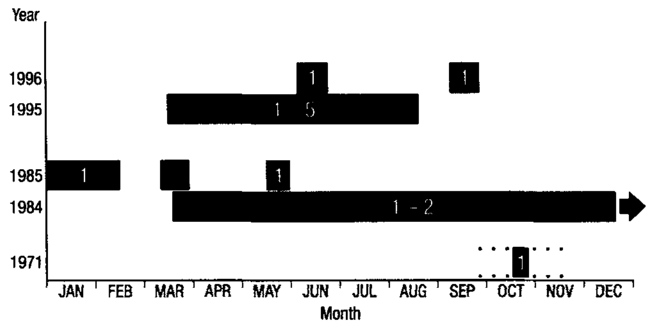

Figure 5. Utilization of Grice Bay, 1971–1996. Only young whales were found in this site in each occupation over 26-yr period, feeding on ghost shrimp (*Callianassa californiensis*). Whale present in 1985 was one of individuals present in 1984 and apparently stayed through winter. Whale present in 1996 was one of five present in 1995.

1994, and occurred for part of the summer in the other two years. Whales were present throughout the entire summer in 1994 due to successive plankton events, whereas in 1992 whales were rare for the first half of the season except for isolated, short-lived plankton events. Mysids were an important part of the prey for two years (1993 and 1994) but were not recorded as prey in the other two years. Early season mobile-amphipod-feeding occurred in essentially the same location for two years (1992, 1993) but over different lengths of time, then was absent in the following two years. Year-to-year variability in timing, prey type, and feeding location is the key feature of observations to date.

Several very generalized patterns may be emerging; these may or may not prove to be significant over the longer term. They are (1) a greater likelihood of feeding on benthic amphipods in the latter half of the season, (2) if there is steady whale-feeding activity in early and mid-season, it is more likely to be on plankton than benthic species, and (3) the Grice Bay ground may be

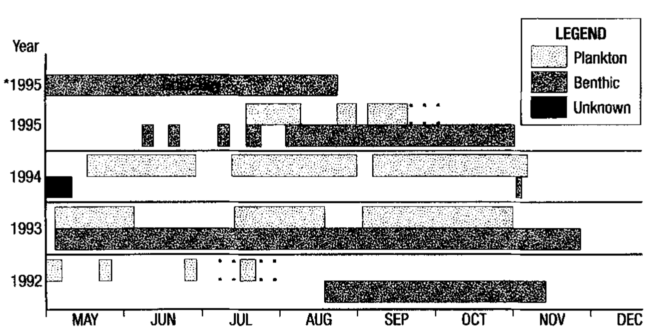

Figure 6. Comparison of gray whale presence and prey types between years, 1992–1995. All locations, except Grice Bay, combined; prey divided only into plankton and benthic types.

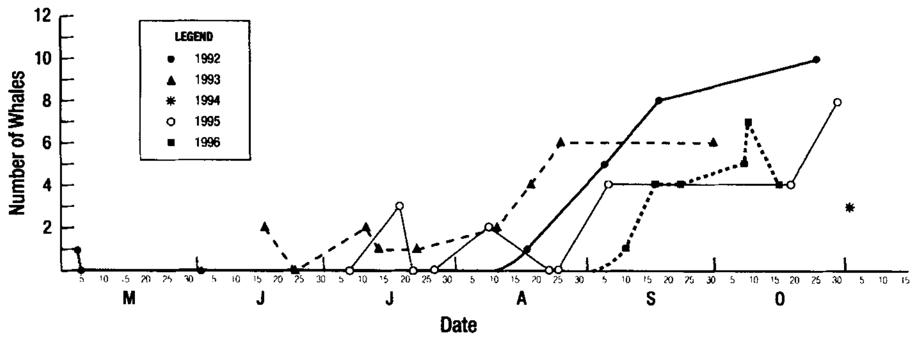

Figure 7. Number of benthic feeding whales in Ahous and Cow Bay combined, through seasons, 1992–1996. Note that in 1994 there was just one sighting of benthic feeding.

utilized by young whales steadily for one- to two-year periods separated by extended periods of non-use.

Our observations (Fig. 4) suggest that the predominant prey species for adult whales were crab larvae and benthic amphipods in 1992, swarming amphipods and benthic amphipods in 1993, mysids and crab larvae in 1994, and crab larva and benthic amphipods in 1995. It should be noted that our study area is only a portion of the animals' overall summer range.

Different Prey Species Utilized Simultaneously

On several occasions adult whales a few km from each other were observed feeding on different prey species. Examples are (1) on 11 August 1993 two whales were feeding on mysids (*H. sculpta*) in kelp off Rafael Point, and two whales were feeding on benthic amphipods (*Ampelisca* spp.) in Cow Bay, 4–5 km distant; (2) on 5 September 1996 two whales were feeding on mysids (*H. sculpta*) off Siwash Point and four to five whales were feeding on crab larvae (*Pachycheles* spp.) of Dagger Point 4 km distant; (3) on 19 October 1996 two to four whales were feeding on mysids between Siwash and Rafael Points, and two to eight whales were feeding on benthic amphipods (*Ampelisca* spp.) in Cow Bay, 3–4 km distant.

Changes in Density of Feeding Whales

The numbers of whales involved in each feeding event could vary substantially in a 24-h period (Fig. 4 A–D). Over the study period (1989–1996), at any one time and location, 1–14 whales were observed preying on mysids, 1–15+ on crab larvae, and 1–12 on benthic amphipods. Changing prey density could have been a factor but was not measured in this study.

A pattern repeated in several of the years was an increase in numbers of benthic feeding whales in late season (mid-August and later; Fig. 7). The numbers clearly increased after mid-August and remained high through the fall. An example of this increase in numbers occurred in 1995 in Ahous Bay. No whales were present through most of the year; then numbers increased from one or two in mid-September to seven to eight by the end of October. In 1994, the "odd" year in terms of benthic feeding, the only record of such feeding occurred in early November.

Longterm Change in Use of a Feeding Ground

Wickaninnish Bay is a 12-km-long open bay, with shallow sandy bottom at the eastern end of the Clayoquot Sound study area (Fig. 2). Sighting effort varied over the 30-yr period, ranging from intensive to sporadic in any one year (Table 2).

A change in use of Wickaninnish Bay as a feeding ground has clearly occurred over the last 30 yr. During the first decade of reports, from 1966–1977, whales were present throughout most summers. The period of most consistent observation was from 1972 to 1976, due to a whale-watch operation operating in the bay and Darling's (1978) observation that whales consistently used the area from May to September. From 1977 to 1979, whale presence became less consistent. From 1980 to 1996, gray whale utilization in summer was sporadic to absent. In some of these later years, whales utilized the area in May and early June. Since 1989 the whales in this region were observed feeding on plankton (crab larvae) or swarming amphipods more often than on benthic amphipods. Occasional bouts of benthic feeding occurred throughout this time, such as in April 1996, when several well-known resident whales (one of which was present in the 1970s when the site was used regularly) were observed in Wickaninnish Bay clearly bottom feeding. Nonetheless, consistent, season-long use has not occurred in the last 20 yr.

Discussion

Broad Utilization of Coastal Habitat

Hatler and Darling (1974) speculated that "pockets" of gray whale habitat occur along the North American coast, and Votrogov and Bogoslovskaya (1980) and Bogoslovskaya *et al.* (1981) discussed "divisions" of gray whale habitat on the Asian coast, separated by empty areas through which whales passed rapidly. These terms were not defined or given scale and so may inadvertently leave the impression of discrete gray whale habitat within a section of coastline, say the length of Vancouver Island. Kvitek and Oliver (1986) described benthic feeding grounds of Vancouver Island as "discrete isolated habitats . . . separated by many kilometers of coast," leaving a specific impression of uneven coastal use. Our review of feeding locations over a 26-yr period questions the perception of an uneven use of coastal habitat by gray whales. At any one time, whales utilized discrete pockets of habitat depending on prey availability, but over the extended period virtually *all* of the southern half of the Vancouver Island west coast was used by feeding gray whales. We

Table 2. Utilization of Wickaninnish Bay by feeding gray whales, 1965–1996.

Years	Type of survey effort	Remarks
1965–1973	Park naturalist and whale watch reports	Present throughout summer in all years except 1966 and 1967 (Darling 1973, Hatler and Darling 1974)
1974–1976	Ongoing monitoring, regular surveys	Present throughout summer; no surveys without sightings (1–14) in May–September 1975–1976 (J. Darling, unpublished data; Darling 1978)
1977–1979	Regular surveys	Presence more sporadic: In 1977 present from May to September except for 6-wk period from July to mid-August. Long periods without sightings in 1978 until August. At least one sighting each summer month, but long periods of absence (J. Darling, unpublished data).
1980–1988	Sporadic surveys	Whales generally not present. In some years (1985, 1986) present in May and not thereafter. Occasional sightings in summer (J. Darling, unpublished data)
1989–1996	Present study	Whales present in May in most years but sightings rare throughout summer season.

suggest that the idea of a "foraging route or range" that covers extended sections of coastline provides a more accurate view of gray whale habitat utilization than the concept of discrete pockets of habitat.

Clayoquot Sound may provide a representative sample of the Vancouver Island gray whale foraging range. Virtually all of the outer Sound was used by gray whales over the study period. Different areas and habitat were used for different purposes, such as herring-egg feeding, benthic feeding, plankton feeding, and "rubbing." In one case, the use was by young whales only. Some habitats were used on a regular basis, often annually, others on some irregular basis that may have included ten or more years between use. Whales likely traveled between different habitats as prey availability and abundance, social behavior, or rubbing activity dictated. The specific function and importance of presumed rubbing behavior and hence habitat has not been investigated. The activity is common in specific areas and may serve a "grooming" or "recreation" function (Hatler and Darling 1974; Darling 1978, 1984).

Variety of Prey Resources: Benthic and Planktonic

Nerini (1984), in a definitive review of gray whale prey and feeding behavior, concluded that "the most extraordinary aspect of the gray whale's feeding ecology is its apparent dietary flexibility" and noted that with three modes of feeding (benthic suction, engulfing, and skimming) the gray whale has perhaps a greater range of foraging techniques than any other great whale. Benthic amphipods are generally considered the predominant prey species in northern seas, but numerous observations of gray whales feeding on fish and planktonic crustaceans exist throughout their range (Pike 1962, Rice and Wolman 1971, Nerini 1984, Kim and Oliver 1989). A review of examinations of gray whale stomach contents since 1874 indicated a broad array of some 70 genera of both benthic and pelagic organisms (Nereni 1984).

The most striking feature of our observations, consistent with Nerini's (1984) review, was the variety of prey and foraging techniques utilized by the whales. Since collections began, at least nine prey species supported the gray whale population in this region. Previous reports of gray whales feeding on benthic amphipods (Oliver *et al.* 1984, Kivetek and Oliver 1986), mysids (Murrison *et al.* 1984, Guererro 1989), and ghost shrimp (Plewes *et al.* 1984) are confirmed in this study. In addition, one species of mobile amphipod (*A. borealis*), at least two species of crab larvae (*C. magister* megalops and *Pachycheles* spp. zoea), and herring eggs and larva (*Clupea harengus* pallasi) were added to the list of Vancouver Island prey species. All three feeding techniques described by Nerini (1984) were utilized by the Vancouver Island whales to exploit these prey.

The polychaete worm, *Onuphis elegans*, has been discussed as a prey species off Vancouver Island in several reports (Darling 1977, 1978; Oliver *et al.* 1984; Kvitek and Oliver 1986; Kim and Oliver 1989; Weitkamp *et al.* 1992), but we do not believe this has been confirmed and therefore leave it in the unconfirmed category with juvenile rockfish and sand lance at this time. All of the prey species reported for Vancouver Island have been reported previously as prey of gray whales somewhere in their range, albeit in some cases from a single observation (Nerini 1984).

The current importance of planktonic prey off Vancouver Island *vs.* earlier observations of extensive bottom feeding (*e.g.*, Hatler and Darling 1974, Darling 1978) raises the question whether a change in prey species has occurred over the last 20 yr, or whether observations have simply become more complete. We lean towards the latter explanation for several reasons: most observations in 1960s and 1970s were in Wickaninnish or Ahous Bay, now well known as bottom-feeding grounds, and whales were documented in locations along the West Coast Trail (now known as a plankton-feeding area) as early as 1972 (Darling 1973). However, two points make us hesitant to entirely discount the idea that predominant prey species may have changed. These are (1) the virtual abandonment of Wickaninnish Bay and adjacent waters as a primary benthic feeding area by the early 1980s, and (2) Highsmith and Coyles' (1992) suggestion of the potential for long-term loss of amphipod habitat, and alterations of ecosystem structure, caused by feeding gray whales.

Overall, the literature has emphasized the benthic feeding behavior and prey of gray whales (Scammon 1869, Nemoto 1959, Pike 1962, Walker 1971, Rice and Wolman 1971). Nerini (1984) revisited this view and noted that observations of feeding in the water column were concentrated in southern regions, whereas whales feeding while migrating or summering along the northern half of the migration route were nearly always consuming benthic resources—that is to say, prey types could be region-specific. Kim and Oliver (1988) furthered this idea and proposed primary, secondary, and tertiary feeding grounds defined by location and predominant prey, with more planktonic prey species farther south in the range. Our Vancouver Island work suggests another view of gray whale feeding behavior. Rather than a region-specific prey regime (Nerini 1984, Kim and Oliver 1988), the whales utilize a variety of prey resources, both benthic and pelagic, within a feeding range. We propose they exploit the most suitable prey species at any one time, on a cyclic or otherwise recurring basis. In this view, pelagic feeding and prey may have equal importance to benthic feeding and prey overall. This clearly was the case on Vancouver Island during this study. Further, it may account for the numerous observations of plankton feeding and the variety of prey species found in gray whale stomachs in other parts of their range (Nerini 1984).

In related discussions, several authors have indicated that one or another prey species was the "most important" for gray whales. Benthic or near-benthic amphipods were often listed as the primary prey (Pike 1962, Rice and Wolman 1971, Nerini 1984) at least in northern seas, and Kivitek and Oliver (1986) and Kim and Oliver (1988) stated that mysids are the major prey along the coast of British Columbia. The species noted may well have been the predominant or most important prey at the time of collection or observation, but our study strongly suggests that such results should not be generalized over time and place. We propose that rather than a single species, it is an assemblage of species that is important to the whale. We speculate that the whales are attuned to natural patterns of abundance and absence occurring within this prey assemblage, and that different species play equal roles over a season or several years.

Variable Patterns of Utilization of Resources and Habitat

Gray whale feeding has been proposed as a major source of physical disturbance to the benthic community, with the activity being part of a cycle of exploitation, recolonization, succession, and maturing of the prey community (Nerini 1984, Oliver *et al.* 1984, Oliver and Slattery 1985). Periods of non-use by whales are presumed to correspond to recovery and maturing of the prey species. Highsmith and Coyle (1992) and Weitkamp *et al.* (1992) raised the possibility that gray whale exploitation may, in some circumstances, be a one-way street and lead to permanent loss of the amphipod or other prey communities and, hence, changing feeding patterns. The virtual abandonment of Wickaninnish Bay as a primary benthic feeding area since the 1980s may be such an example, although it should be noted that the current status of prey species there has not been investigated.

An additional explanation for variable use of benthic grounds arises from the idea that an assemblage of prey species is potentially available and utilized over a season. A whale may change location and habitat to exploit the "optimum" prey species at any one time. The optimum prey is probably determined by factors such as abundance, density, size, caloric content, and predation pressure, all which may vary throughout the season and year to year, depending on environmental factors and life cycles. This study suggests that a progression from one prey species to the next may occur through the season. A generalized progression of gray whale prey in Clayoquot Sound from spring to fall was seen (herring eggs, mobile amphipods, mysids, porcilid crab larvae, and benthic amphipods), as each presumably became the optimum species to "harvest." A shift from one habitat and prey species to another may not necessarily reflect the loss of the initial prey, only that a better option has developed.

Several authors have noted differences in caloric content among gray whale prey species and within species at different times of their life cycles, especially in relation to reproductive condition. This information combined with bioenergetic considerations in foraging effort may well explain variable use of resources (Guerrero 1989, Highsmith and Coyle 1992, Weitkamp *et al.* 1992). For example, in the Bering Sea, the dry weight, energy content per unit weight, and caloric content of the benthic amphipod, *Ampelisca macrocephala,* increased significantly throughout the summer, with highest values in September–November (Highsmith and Coyle 1992). If the *Ampelisca* spp. in the study area grow similarly, this may explain the later-season progression to this prey species in Clayoquot Sound.

Our observation that patterns of utilization of resources and habitat were highly variable refers to utilization of a specific prey species and its habitat. However, if the assemblage of prey species is considered as a whole, the observation changes substantially. Utilization of the prey assemblage and its overall habitat was remarkably consistent and resulted in the highly predictable presence of gray whales in the region each summer. We speculate that it is the assemblage of prey species that allows the ongoing use of a specific feeding range over time.

Whale Age a Factor in Habitat or Prey Use

Very young whales, apparently ranging from several months in age and recently weaned to a 1-yr-old, made up a portion of the Vancouver Island population each year (Hatler and Darling 1974; Darling 1978, 1984; Oliver 1984; Rice and Wolman 1971; JDD, unpublished data.) The relationship of these whales with other adults in the area is yet to be determined. Darling (1978) noted "small whale characteristics" off Vancouver Island, including occupation of areas not frequented by larger feeding whales and an apparent affinity for kelp beds. Since then, some degree of separation of young whales from adults has been a recurring observation each year (JDD, unpublished data). The periodic use of Grice Bay by young whales best illustrates the apparent age-specific utilization of habitat (Hatler and Darling 1974, Plewes *et al.* 1984, this study).

Zenkovich (1937) suggested that specific areas along the Russian coast may be permanent feeding grounds for younger, apparently recently weaned, animals. Almost all whales captured in these areas were less than two years old, an observation from which he concluded that young gray whales form separate schools at weaning. Bogoslovskaya *et al.* (1981), from investigations in the same region, suggested that such separation does exist but may not be so well defined. Our observations of separation of adults and young, at times very distinct and at other times subtle, are consistent with these reports.

The reason for different habitat utilization patterns by young animals is not known. The Grice Bay young whales were feeding primarily on ghost shrimp at the same time that adults were feeding on other prey species in other parts of the study area. Weitkamp *et al.* (1992) suggested from a study of gray whale predation on ghost shrimp in Puget Sound that, due to density of this species, less foraging time was necessary than with benthic amphipods to obtain comparable bioenergetic gain. If true, this may be of significant benefit to young whales that are possibly learning how to feed and which may have high energy requirements. However, to complicate this view, young whales were commonly sighted in kelp beds in the general vicinity of adult whales feeding on mysids and in benthic grounds near whales feeding on benthic amphipods, and were observed to skim feed crab larvae (JDD, unpublished data). Oliver *et al.* (1984) reported that the small whale he observed was feeding on the benthic *Ampelisca* community. Apparent attributes of Grice Bay are shallow water, protection from storms, and possibly increased protection from predators, as well as abundant food supply. This is also true of kelp beds. Perhaps young whales seek out these relatively protective and productive habitats after weaning.

Management Considerations

1. The determination of the relative importance of specific locations and habitat to gray whales is complex. It is confounded by the whales utilizing different locations and habitat at different times within one season and from year to year. A coastal foraging route extending over hundreds of kilometers may be the appropriate view of gray whale habitat use. Certainly some locations are utilized more regularly than others, but at any one time or season the lesser-used locations may be critical to the survival of the whales, when food in the prime area is less abundant or if used for other purposes such as young whale care. Therefore, efforts to designate priority gray whale habitat within the overall coastline for management purposes may not be meaningful.

2. Determination of impacts of pollution or other human activity on gray whales is complicated by the highly variable patterns of specific habitat and prey utilization. The apparent potentially high natural variability in prey status due to normal environmental and biological fluctuations will likely lead to a corresponding variability in the distribution and behavior of the whales. The separation of natural and human impacts on the whales' distribution and behavior with current knowledge will be difficult below the lethal stage.

3. The ability of gray whales to exploit a variety of prey species, combined with a feeding range that may extend over hundreds of kilometers, may enhance the population's chances of surviving temporary catastrophic impacts on specific prey species or highly localized and contained pollution events or other disturbances. However this "enhancement" relies on the chance that the species or habitat affected is not critical at the time of impact.

4. The variable utilization of habitat and prey resources by gray whales over a large section of coastline strongly indicates that information from partial-season and single-site research projects must be taken in context. Such studies may well determine what is occurring at the particular time or place, or in a specific age class, but they may not be adequate to draw general conclusions about the entire population over time. These limitations should be noted when considering some of the inferences and conclusions in Oliver *et al.* 1984, Kivetek and Oliver (1986), and Duffus (1996).[2]

5. The information presented provides a broad-stroke, preliminary outline of feeding patterns in Clayoquot Sound. Several avenues of research would significantly further our insight into gray whale behavior in the region. These include (1) studies of factors influencing prey life cycles, distribution, and abundance; (2) quantitative studies of prey density and quality (in terms of caloric content) in relation to whale utilization patterns; (3) studies of the means by which whales locate prey, including potential communication between animals; and (4) investigation as to how social factors such as age, status and genetic relatedness may govern feeding distribution and behavior.

[2] Duffus (1996) studied gray whales in Clayoquot Sound and reported on "shifts" in whale distribution and prey from 1992–1994. He then proposed a pattern of whales moving away from Tofino and the center of "commercial" activity. His observations were limited in time and area and led to different interpretations than would occur with a broader database.

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Appendix 1. Prey Collection Record in Clayoquot Sound, 1984–1996. All collections were made by plankton net except where noted: (D) = low tide digs; (S) = suction hose; (F) = fecal sample. An asterisk * indicates a series of collections on that date, treated as one collection in the analysis.

Year	Date	Location	Prey species
1984	Summer* (D)	Grice Bay	*C. californiensis*
1989	6 April	Hesquiat Harbour	*C. harengus* pallasi (eggs)
	1 June	Wickanninish Bay	*C. magister* megalops
	15 July* (S)	Cow & Ahous Bay	*Ampelisca* spp.
1992	22 May	Cox Point	*A. borealis*
	7 June	Dagger Point	*Pachycheles* spp. zoea
	21 July	Estevan Point	*Pachycheles* spp. zoea
1993	10 March	Hesquiat Harbour	*C. harengus* pallasi (eggs)
	13 March	Hesquiat Harbour	*C. harengus* pallasi (eggs/larvae)
	12 May	Wickaninnish Bay	*A. borealis*
	23 May	Gowland Rocks	*A. borealis*
	2 June	Gowland Rocks	*A. borealis*
	28 July	Estevan Point	*N. rayii*
	11 August	Dagger Point	*H. sculpta*
	19 August* (S)	Cow & Ahous Bay	*Ampelisca* spp.
1994	18 May	Cow Bay	*H. sculpta*
	3 June	Cow Bay	*H. sculpta*
	7 June	Cow Bay	*H. sculpta*
	22 June	Cow Bay	*H. sculpta*
	13 July	Dagger Point	*Pachycheles* spp. zoea
	6 August (F)	Rafael Point	*Pachycheles* spp. zoea & "mysids"
	11 August (F)	Rafael Point	mysids
	15 August	Rafael Point	*Pachycheles* spp. zoea
	30 August	Rafael Point	*Pachycheles* spp. zoea
	2 Nov.	Siwash Point	*N. rayii & Acanthomysis* spp.
	2 Nov.	Ahous Bay	*Ampelisca* spp.

Appendix 1. Continued.

Year	Date	Location	Prey species
1995	21 April (D)	Grice Bay	*C. californiensis*
	20 June (D)	Grice Bay	*C. californiensis*
	22 July	Dagger Point	*Pachycheles* spp. zoea
	9 August	Dagger Point	*Pachycheles* spp. zoea
	23 August	Dagger Point	*Pachycheles* spp. zoea
	25 August	Rafael Point	*Pachycheles* spp. zoea
	6 Sept.	Estevan Point	*Pachycheles* spp. zoea
	19 Sept.	Estevan Point	*Pachycheles* spp. zoea
1996	7 June (D)	Grice Bay	*C. californiensis*
	2 July	Cow Bay	*H. sculpta*
	11 July	Cow Bay	*H. sculpta*
	17 August	Dagger Point	*H. sculpta*
	20 August	Dagger Point	*Pachycheles* spp. zoea
	22 August	Dagger Point	*Pachycheles* spp. zoea
	4 Sept.	Siwash Point	*H. sculpta*
	5 Sept.	Dagger Point	*Pachycheles* spp. zoea
	10 Sept.	West Dagger Point	*H. sculpta*

Estimating gray whale abundance from shore-based counts using a multilevel Bayesian model

J.W. DURBAN, D.W. WELLER, A.R. LANG AND W.L. PERRYMAN

Marine Mammal and Turtle Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 8901 La Jolla Shores Dr., La Jolla, CA 92037,USA

Contact e-mail: john.durban@noaa.gov

ABSTRACT

Counts of southbound migrating whales off California form the basis of abundance estimation for the eastern North Pacific stock of gray whales (*Eschrichtius robustus*). Previous assessments (1967–2007) have estimated detection probability (p) from the detection-non detection of pods by two independent observers. However, tracking distinct pods in the field can be difficult for single observers; resulting in biased estimates of pod sizes that needed correcting, and matching observations of the same pod by both observers involved key assumptions. Due to these limitations, a new observation approach has been adopted wherein a paired team of observers work together and use a computerised mapping application to better track and enumerate distinct pods and tally the number of whales passing during watch periods. This approach has produced consistent counts over four recently monitored migrations (2006/7, 2007/8, 2009/10 and 2010/11), with an apparent increase in p compared to the previous method. To evaluate p and estimate abundance in these four years, counts from two independent stations of paired observers operating simultaneously were compared using a hierarchical Bayesian '*N*-mixture' model to jointly estimate p and abundance without the challenge of matching pods between stations. The baseline detectability p_o was estimated as 0.80 (95% Highest Posterior Density Interval [HPDI] = 0.75–0.85), which varied with observation conditions, observer effects and changes in whale abundance during the migration. Abundance changes were described using Bayesian model selection between a parametric model for a normally distributed common migration trend and a semi-parametric model that estimated the time trends independently for each year; the resultant migration curve was a weighted compromise between models, allowing for key departures from the common trend. The summed estimates of migration abundance ranged from 17,820 (95% HPDI = 16,150–19,920) in 2007/08 to 21,210 (95% HPDI = 19,420–23,230) in 2009/10, consistent with previous estimates and indicative of a stable population.

KEYWORDS: ABUNDANCE ESTIMATE; MIGRATION; MODELLING; GRAY WHALE; SURVEY – SHORE BASED; PACIFIC OCEAN; NORTHERN HEMISPHERE

INTRODUCTION

The eastern North Pacific stock of gray whales migrates annually along the west coast of North America from high latitude feeding grounds to winter breeding grounds in the lagoons and adjacent ocean areas off Baja California, Mexico (Rugh *et al.*, 2001). This nearshore migration pattern has enabled repeated abundance estimates from shore-based counts off Granite Canyon, central California. In 23 years, between 1967 and 2007, counts of the number of observed pods travelling southbound have been rescaled using estimates of pods undetected during watch periods, pods passing outside watch periods, and night travel rate (Buckland and Breiwick, 2002; Buckland *et al.*, 1993; Hobbs *et al.*, 2004; Laake *et al.*, 2012; Laake *et al.*, 1994; Rugh *et al.*, 2005). Population models based on these estimates indicate that gray whales have increased substantially in population size, recovering from whaling operations in the 19th and 20th centuries, and are now close to carrying capacity and likely pre-exploitation levels (Punt and Wade, 2012). The most recent population estimate from abundance counts in 2006/07 was approximately 19,000 whales (Laake *et al.*, 2012).

To facilitate continued population monitoring, the abundance estimation approach has seen continual evolution throughout this time series to more realistically estimate detection probability (p) to link observed counts to true abundance; this paper describes the latest modification. Notably, previous assessments have estimated p from the detection and non-detection of pods by independent observers using an analytical mark-recapture approach. However, tracking distinct pods in the field is difficult (Rugh *et al*. 2008), particularly for a single observer using just hand-recorded entries onto a paper data form. As a result, matching observations of the same pod by both observers involved key (and untestable) assumptions and limited observations of a given pod required corrections for bias in pod size estimation (Rugh *et al*. 2008; Laake *et al.*, 2012). Due to these limitations, a new observation approach has been developed wherein a paired team of observers work together and use a computerised mapping application to help better track distinct pods and tally the number of whales passing during watch periods (Durban *et al.*, 2010). This approach has a number of advantages, including open communication between observers, enabling observers to search for whales continually without the distraction of looking down to record data, and easier separation and tracking of distinct pods due to the precise computerised data recording and visualisation. As a result, this approach enables more repeated observations of each pod, leading to larger (and presumably less biased) estimates of pod size (Durban *et al.*, 2010) and has produced consistent counts over four recently monitored migrations (2006/07, 2007/08, 2009/10 and 2010/11), with an apparent increase in p compared to the previous method (Durban *et al.*, 2011).

To evaluate p for this new approach, watch period counts from two independent stations of paired observers operating simultaneously were compared during two of the four years (2009/10 and 2010/11), using a hierarchical Bayesian '*N*-mixture' model (Royle, 2004) to jointly estimate the probability of detection and abundance in all four years, without the challenge of matching pods between stations.

This '*N*-mixture' approach has been successfully used to estimate abundance and detectability from replicate count data for a range of wildlife species where it has not been possible to match repeat sightings of individuals (e.g. Chelgren *et al.*, 2011; Joseph *et al.*, 2009; Kery *et al.*, 2005). The untility of this approach to extend the time series of abundance estimates for eastern North Pacific gray whales is demonstrated in this paper.

METHODS

Data samples

Counts of gray whales were conducted from shore-based watch stations at Granite Canyon, California, during the 2006/07, 2007/08, 2009/10 and 2010/11 southbound migrations (see Table 1). Counts were made by rotating teams of observer pairs using naked eye aided by 7×50 binoculars; the primary observer in the pair kept continual visual watch while the secondary observer served as a data recorder but also kept watch and assisted with tracking already identified pods whenever possible. Each observer had one 90 minute shift as primary observer, followed by a second 90 minute shift as secondary observer and then a 90 minute break. Sightings were entered into a real-time data logging PC program, which had a mapping screen to help track repeated sightings of the same pod. The map projected the likely movement tracks (and error ellipses) of the pods using predicted swimming speeds (1.44–1.95 ms^{-1}), allowing re-sightings and new sightings to be queried. Up to six lots of 1.5 hour watch periods were used to cover daylight hours from 07:30 to 16:30 local time, during which the observers recorded passing whales and environmental conditions, specifically visibility (subjectively categorised from 1–6 for excellent to unusable) and sea state (Beaufort scale). To control for weather conditions and for consistency with previous abundance estimations, only counts during watch periods with acceptable weather conditions throughout their entire duration were used, specifically visibility code <5 (excellent to fair) and Beaufort Scale <5.

Estimating detection probability

The '*N*-mixture' approach was used (Royle, 2004) to simultaneously estimate detection probability p_{ijt} and abundance N_{jt} for each watch period j in each year t, based on the total aggregated counts n_{ijt} of passing whales recorded by each of i = 1:2 watch stations in each period. The observed counts n_{ijt} were modelled as a binomial outcome conditional on the unknown true number of whales passing N_{jt} and the detection probability p_{ijt} with hierarchical models assumed to describe variability in both N and p (e.g. Chelgren *et al.*, 2011). The power to estimate detectability was achieved by comparing gray whale counts from two independent stations of paired observers operating simultaneously during two years (2009/10 and 2010/11) from watch stations that were positioned 35m apart at the same elevation (22.5m) above sea level. In 2009/10 counts were compared from the two watch stations operating simultaneously during 70 lots of 1.5 hour watch periods with acceptable weather conditions, covering 20 different days of the migration; in 2010/11 simultaneous counts were available from 94 watch periods over 24 different days (see Table 1). However, detectability was extrapolated for all monitored watch periods in each of the four years based on the fitted model for detectability. In order to accomplish this, the counts for the south watch station were treated as zero-inflated binomial outcomes, with the binomial probability specified as a function $u_{ijt}\, p_{ijt}$ where u = 1 or 0 to indicate whether or not count data were actually collected from that station, thus ensuring that structural zero counts from periods without a second watch did not contribute to the likelihood for estimation of p or N.

Consistent with Laake *et al.* (2012), the model for detectability incorporated fixed effects β for visibility (VS) and Beaufort Scale (BF), as well as random effects associated with each observer o in 1:OB observers. These were modelled as additive effects on a general intercept so that the direction and magnitude of the estimated effects away from zero (no effect) could be assessed. The selection for the inclusion of these effects using Bayesian model selection with stochastic binary indicator variables g to switch each of the three possible effects either in or out of the model depending on their relevance to the observed data (Kuo and Mallick, 1998):

$$\text{logit}\,(p_{ijt}) = \text{logit}(p_o) + g^{bf}\beta^{bf}\,\text{BF}_{jt} + g^{vs}\beta^{vs}\,\text{VS}_{jt} + g^{ob}\boldsymbol{\beta}^{ob}_{ijt=o}$$

where the intercept p_o was the base detection probability in the absence of covariate effects, assigned a Uniform(0,1) prior distribution, and $\text{logit}(p_o) = \ln(p_o/1-p_o)$. Centred around this base detectability, each of the fixed effects β^{bf} and β^{vs} was assigned a Normal prior distribution with mean zero and large standard deviation of 10; this prior value was smaller than the corresponding posterior estimates of standard deviation, and as such this was vague prior distribution that allowed any non-zero effects to emerge if supported. The random effect for each observer was drawn from a Normal distribution with mean zero and standard deviation σ^{ob}~Uniform(0,10). Each of the binary indicator variables, g, was assigned a Bernoulli(0.5) distribution to specify equal probability of inclusion or not of the effect in the model.

Table 1

The number of whales recorded during the southbound gray whale surveys from 2006/07 to 2010/11. Data are the total counts, hours and distinct days for watches during acceptable observation conditions.

	North Station			South Station		
Migration	Dates	Whales	Hours (days)	Dates	Whales	Hours (days)
2006/07	02/01–03/02	2,691	204 (34)	–	–	–
2007/08	02/01–09/02	2,079	202.5 (34)	–	–	–
2009/10	30/12–19/02	2,034	246 (43)	11/01–06/02	1,551	105 (20)
2010/11	03/01–18/02	2,885	265 (45)	10/01–04/02	1,754	141 (24)

Fitting migration curves

The *N*-mixture approach also accounted for variation in *p* relative to changes in *N* (latent watch period abundances) during the migration. So, some power to estimate detectability was achieved by assuming a model for changes in watch period abundance over the course of the migration. A Poisson distribution $N_{jt} \sim \text{Poisson}(\lambda_{jt})$ was adopted as a hierarchical prior for the distribution of abundances, and a model was specified for the Poisson mean λ in terms of the number of whales passing each day (*d*), with an offset for the effort duration of each watch period, E_{jt} in decimal days (e.g. Laake *et al.*, 2012):

$$\log(\lambda_{jt}) = \log(E_{jt}) + \text{model}_{d(j)t}$$

$$\text{model}_{dt} = z_{dt}\text{Common}_{dt} + (1 - z_{dt})\ \text{Specific}_{dt}$$

Days were specified as $d = 0$ to D_t. In all four years *t* we used $D_t = 90$, where days were counted from 12:00am on 1 December, and we added an abundance of 0 whales passing for day 0 and D_t to anchor the fitted model when we assumed whales did not pass (following Buckland *et al.,* 1993). Estimates from the remaining days were derived from a mixture (or compromise) of two competing models ('Common' and 'Specific', e.g. Li *et al.*, 2012) describing changes in abundance across each annual migration. The model contributing each daily estimate was indicated using stochastic binary indicator variables z_{dt}, each assigned a non-informative Bernoulli(0.5) prior distribution. As such, each z_{dt} indicated the probability of a daily estimate conforming to the common trend, allowing flexibility for departures from this trend that may only exist on certain days in certain years to be identified and modelled (rather than assuming all counts from an entire year conform to or depart from a common trend, which would be represented by z_t). The total number of whales passing during each migration was then estimated by summing the expected value from the model-averaged number of whales passing each day from time 0 to D_t (e.g. Laake *et al.*, 2012). These estimates were then rescaled to account for the differential passage rate at night (Perryman *et al.*, 1999), based on the nine hour day multiplicative correction factor of Rugh *et al.* (2005). Specifically, we applied a constant night time correction factor that was assumed to be a Normally distributed fixed effect with mean of 1.0875 and standard deviation of 0.037.

For the 'Common model', we assumed a typical trend in abundance throughout each annual migration (e.g. Buckland *et al.*, 1993), with abundance changes assumed Normally distributed around a migration mid-point, with a Normal distribution specified as a quadratic function of days, on the log scale:

$$\text{Common}_{dt} = a_t + b_t d_t + c_t d_t^2$$

where the mid-point of the migration curve for each year *t* was derived by $-b_t/2a_t$. This assumed common migration curve allowed information to be 'borrowed' across years when needed, specifying association across years to strengthen inference about migration curves in years with relatively sparse counts. However, we specified each of the curve parameters a_t, b_t and c_t to be drawn from hierarchical Normal distributions with means μ^a, μ^b, $\mu^c \sim N(0, 10)$ and standard deviations σ^a, σ^b, σ^c ~Uniform(0,10); hyper-parameters that were common across years, rather than assuming that the parameters themselves were constant. This random effects formulation allowed the timing, level and extent of the Normal migration curve to vary annually around the general pattern, if supported by the data.

Although it is likely that there is a typical pattern to the migration, it was acknowledged that abrupt departures may occur at any time in any particular year. To incorporate unusual patterns, the selection of an alternative 'Specific' migration model was allowed; a semi-parametric model that estimated the time trends independently for each year (e.g. Laake *et al.*, 2012). A method in which the shape of the relationship of abundance across days was determined by the data was adopted without making any prior assumptions about its form, by using penalised splines (Ruppert, 2002). Following Crainiceanu *et al.* (2005) a linear (on the log scale) penalised spline was used to describe this relationship:

$$\text{Specific}_{dt} = S_{0t} + S_{1t}d_t + \Sigma_{k=1}^{m} \lambda_{kt}\,(d_t - \kappa_{kt})$$

Where S_{0t}, S_{1t}, ${}_{1t}, \ldots, {}_{kt}$ were regression coefficients to be estimated separately for each year and $\kappa_{1t} < \kappa_{2t} < \ldots < \kappa_{kt}$ were fixed knots. We used $m = 15$ knots, a relatively large number to ensure the desired flexibility, and let κ_{kt} be the sample quantile of 's corresponding to probability $k/(m + 1)$. To avoid overfitting, the λ's were penalised by assuming that these coefficients were Normally distributed random variables with mean 0 and standard deviation ~Uniform(0,10). The parameters S_{0t}, S_{1t} were modeled as fixed effects with Normal(0, 10) prior distributions.

Bayesian inference using MCMC

The multi-level model was fit using Markov Chain Monte Carlo (MCMC) sampling using the WinBUGS software (Lunn *et al.*, 2000). Inference was based on 15,000 repeated draws from the posterior distribution of each model parameter conditional on the observed data, following 5,000 iterations that were discarded as burn-in. Convergence of parameters within these initial 5,000 iterations was determined based on Gelman-Rubin statistics below 1.05 (Brooks and Gelman, 1998) calculated from three independent chains begun from over-dispersed starting values. To gauge the adequacy of the model for each annual set of count data, Bayesian P-values were computed (Gelman *et al.*, 1996) by using the same MCMC sampler to predict a distribution for each watch-period count from the posterior estimates of model parameters and comparing the total predicted and observed counts. For each year, there was good agreement between the model predictions and observed counts, with Bayesian P-values ranging from 0.45 to 0.53; values close to 0.5 would indicate that the data was consistent with replications under the model, with the distribution of the predicted count symmetrically overlapping the observed count (Gelman *et al.*, 1996).

The MCMC sampling approach allowed uncertainty to be propagated across levels of the model. Notably, estimates of parameter values across MCMC iterations were used to estimate the probability of inclusion of covariate effects in the model for detectability, given by the posterior probability $p(g = 1)$ of each indicator variable *g*. Fitting and selection of the two competing migration models was achieved within the same MCMC run using the 'cut' function in WinBUGS to ensure that estimation of the two models was not affected by the selection of the model indicator (e.g. Li *et al.*, 2012). The posterior probability of conforming to the common trend model was then calculated by the relative frequency that each model was selected by the indicator z_{dt} in the overarching mixture model, and inference about abundance on each day was based on a weighted compromise between the competing models by sampling across the posterior distribution of z_{dt}.

RESULTS

The base detectability was estimated as p_o = 0.80 (95% Highest Posterior Density Interval [HPDI] = 0.75–0.85), which was modified by observation conditions and observer effects (see Table 2). The posterior distribution for the effect of sea state β^{bf}, measured using the Beaufort scale, largely overlapped with zero and there was therefore low support for including this effect in the model with $p(g^{bf} = 1) = 0.004$. In contrast, there was a relatively strong negative effect of visibility on detectability (higher visibility code = lower visibility = lower detectability), with the entire distribution for β^{vs} falling below zero [$p(g^{vs} = 1) = 1$]. There was also support for inclusion of observer effects [$p(g^{bs} = 1) = 1$], with both positive and negative effects reflecting relatively high and low counts by different observers. A total of 35 different observers were used over 4 years between North and South stations; 15/35 counted in multiple years (2 years = 7, 3 years = 4, 4 years = 4). The Posterior medians for observers' effects ranged from –0.59 to 0.80, but only five observer effects (all positive) had posterior distributions that did not include zero.

Detectability also varied with changes in whale abundance during the migration, as shown by the extent of extrapolation from the daily summed counts (effort adjusted) to the estimated daily abundances (Fig. 1). Detectability declined with increasing abundance, with a greater proportion of whales estimated to be missed as more whales passed during busy watch periods. In general, changes in abundance during the migrations were adequately described by a Normal curve over time, but there was greater uncertainty in the tails of the distribution resulting from generally sparse coverage. The Normal trend was useful for comparing migration timing: the median of the curve midpoints was 53.5 days since December 01 (23–24 January), ranging between 49–57 days. However, there were some notable deviations from the Normal trend, with estimates from the year-specific non-parametric trend model being favoured for some days in each of the four years. In particular, there was a high probability in favour of the Specific model [$p(z = 0) > 0.75$] on 9 days in 2006/07, 9 days in 2007/08, 16 days in 2009/10 and 11 days in 2010/11, representing key departures from the Normal migration trend. The summed (model-averaged) estimates of migration abundance ranged from a posterior median of 17,820 (95% HPD = 16,150–19,920) in 2007/08 to 21,210 (95% HPDI = 19,420–23,230) in 2009/10, consistent with previous estimates (Fig. 2). These new estimates were also relatively precise with coefficients of variation (CV = Posterior Standard Deviation/Posterior Median) ranging from 0.04 to 0.06 (median = 0.05), but nonetheless the 95% HDPI's of all four estimates overlapped.

DISCUSSION

The new counting method adopted here was intended to reduce reliance on the ability of single observers acting independently to record and track distinct whale groups. By adopting teams of paired observers working together, with the benefit of a real-time computerised tracking and

Table 2

Parameters of models for detectability, *p*. All estimates are presented as the 2.5%, 50%, 97.5% highest density posterior probability intervals, plus the probability of inclusion in a model (if tested), given by the posterior probability $p(g = 1)$ of each indicator variable *g*. Observers are arbitrarily numbered, differently for each year.

Detection model	2006/07	2007/08	2009/10	2010/11
p_o	0.75, **0.80**, 0.85	0.75, **0.80**,0.85	0.75, **0.80**,0.85	0.75, **0.80**,0.85
β^{bf} [$p(g^{bf} = 1)$]	–19.34, **–0.003**, 19.98 [0.004]	–19.34, **–0.003**, 19.98 [0.004]	–19.34, **–0.003**, 19.98 [0.004]	–19.34, **–0.003**, 19.98 [0.004]
β^{vs} [$p(g^{vs} = 1)$]	–0.38, **–0.30**, –0.20 [1]	–0.38, **–0.30**, –0.20 [1]	–0.38, **–0.30**, –0.20 [1]	–0.38, **–0.30**, –0.20 [1]
σ^{ob} [$p(g^{bs} = 1)$]	0.26, **0.37**, 0.54 [1]	0.26, **0.37**, 0.54 [1]	0.26, **0.37**, 0.54 [1]	0.26, **0.37**, 0.54 [1]
Observer 1	–0.36, **0.02**, 0.49	0.03, **0.37**, 0.81	–0.42,**–0.24**, 0.06	–0.13, **0.08**, 0.30
Observer 2	0.03, **0.37**, 0.81	–0.78, **–0.03**, 0.70	–0.09, **0.30**, 0.81	–0.36, **0.02**, 0.46
Observer 3	–0.24, **–0.07**, 0.11	–0.24, **–0.07**, 0.11	0.03, **0.37**, 0.81	–0.42, **–0.24**, 0.06
Observer 4	–0.42, **–0.01**, 0.49	–0.42, **–0.24**, 0.06	–0.13, **0.08**, 0.30	–0.25, **0.01**, 0.29
Observer 5	–0.04, **0.14**, 0.35	–0.13, **0.08**, 0.30	–0.24, **–0.07**, 0.11	0.16, **0.43**, 0.73
Observer 6	0.06, **0.42**, 0.83	–0.04, **0.14**, 0.35	–0.27, **–0.06**, 0.18	–0.04, **0.14**, 0.35
Observer 7	–0.17, **0.11**, 0.46	–0.18, **0.19**, 0.61	–0.04, **0.14**, 0.35	–0.50, **–0.13**, 0.26
Observer 8	–0.39, **–0.16**, 0.07	–0.17, **0.11**, 0.46	0.12, **0.33**, 0.59	–0.39, **–0.16**, 0.07
Observer 9	0.12, **0.33**, 0.59	0.12, **0.33**, 0.59	–0.25, **0.01**, 0.29	–0.09, **0.23**, 0.60
Observer 10	–	–0.39, **–0.16**, 0.07	–0.08, 0.26, 0.64	–0.27, **–0.06**, 0.18
Observer 11	–	–	–0.71, **–0.43**, 0.13	0.31, **0.80**, 1.46
Observer 12	–	–	–0.66, **–0.37**, 0.07	–0.54, **–0.29**, 0.04
Observer 13	–	–	–0.42, **0.00**, 0.49	–0.75, **–0.22**, 0.33
Observer 14	–	–	–0.63, **–0.13**, 0.40	0.12, **0.33**, 0.59
Observer 15	–	–	0.31, **0.80**, 1.46	–0.73, **–0.29**, 0.14
Observer 16	–	–	–0.18, 0.19, 0.61	–0.18, **0.19**, 0.61
Observer 17	–	–	0.16, **0.43**,0.72	–0.70, **0.02**, 0.76
Observer 18	–	–	–0.39, **–0.16**, 0.07	–0.63, **–0.13**, 0.40
Observer 19	–	–	–0.22, **0.22**, 0.72	–0.83, **–0.59**, 0.36
Observer 20	–	–	–0.28, **0.14**, 0.59	–0.24, **–0.07**, 0.11
Observer 21	–	–	–0.18, **0.28**, 0.83	–0.21, **0.11**, 0.47
Observer 22	–	–	–	–1.05, **–0.49**, 0.06

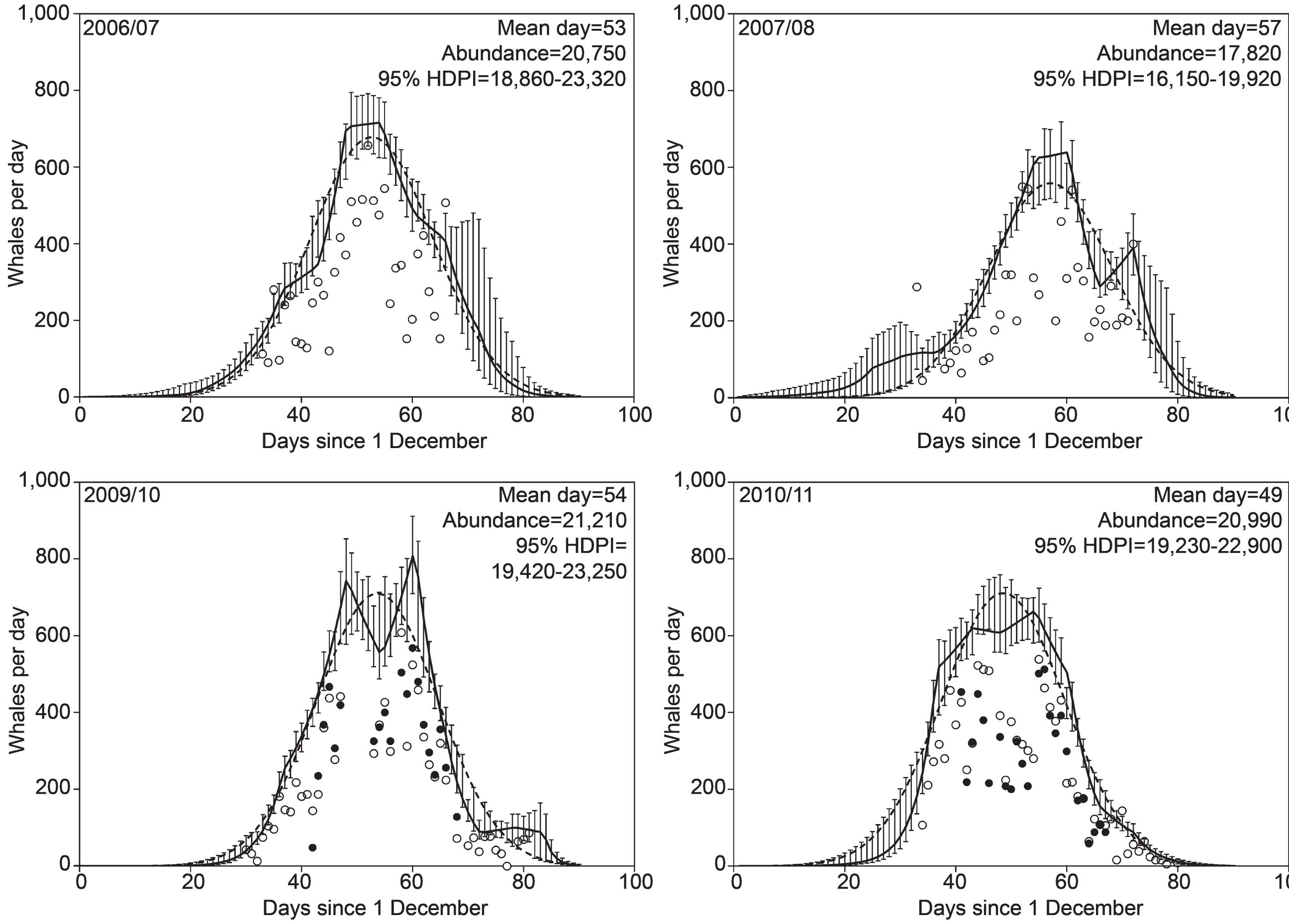

Fig. 1. Observed whale passage rates expressed as total counts per day/ proportion of day observed (circles) and fitted migrations models (lines) for the four southbound gray whale migration counts from 2006/07 to 2010/11. Solid circles represent counts from a second watch station, when operating. The broken line represents the median estimates from a hierarchical Normal model for migration and the solid line represents a semi-parametric model of penalised splines; the abundance estimate for each day (95% highest posterior density interval shown by vertical lines) is a model averaged compromise between the migration models, and these were summed to estimate the overall abundance for the migrations.

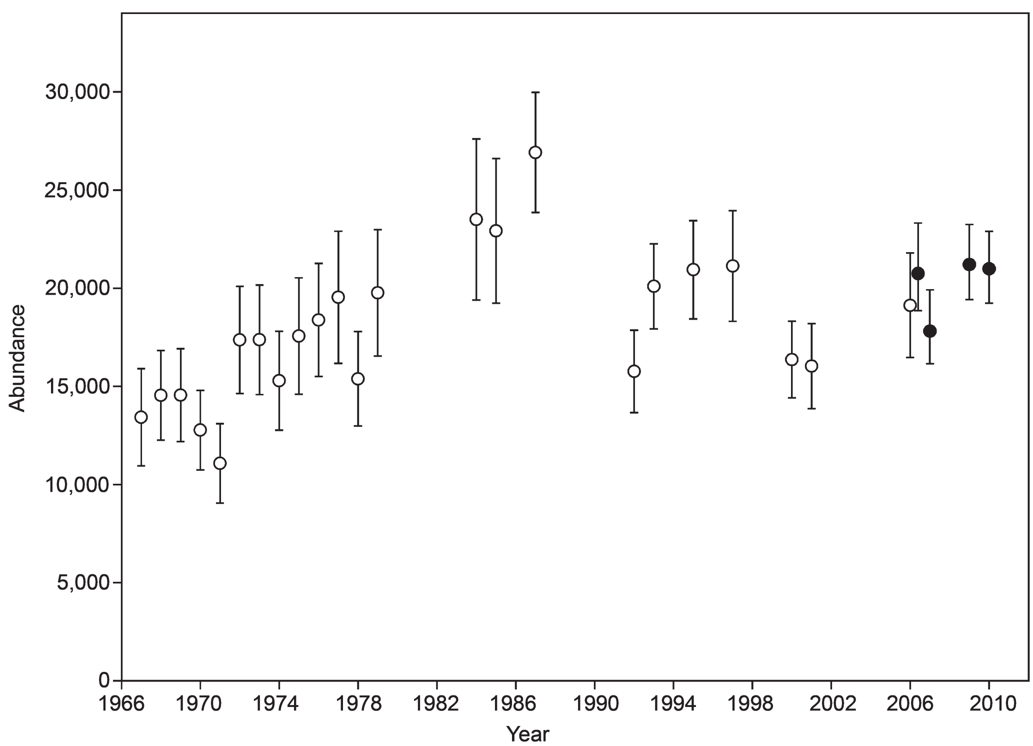

Fig. 2. Gray whale abundance estimates for each of 23 southbound migrations with an end year between 1967 and 2007 (open circles, with 95% confidence intervals; from Laake *et al.,* 2012) together with the four recent migrations reported here (closed circles show posterior medians, lines are 95% highest posterior density intervals).

visualisation tool, this approach has proved successful in increasing detection probability (Durban *et al.*, 2011) and also reducing variability in detections due to observer effects. Although still present, the magnitude of observer effects estimated from the new counts (see Table 2) was generally not as great as those apparent with the traditional counting approach (see Laake *et al.*, 2012, table 7).

Furthermore, our method for estimating detectability departed from the mark-recapture approach of matching detections and non-detections of specific pods by independent observers. Instead, inference was based on total watch period counts that were not sensitive to differential lumping and splitting of pods by observers, and avoided the assumptions required to match observed pods between pairs of observers. As an alternative to the mark-recapture analytic approach, we have shown how tallied watch period counts from two observer pairs counting simultaneously can lead to similar inference when analysed using with the *N*-mixture approach (Royle, 2004).

The *N*-mixture approach is conceptually simple: multiple observations of watch period counts, *n*, from the different observer teams represented different samples from an unknown binomial distribution with total population size *N* and detection probability *p*. A binomial likelihood function could then be easily used to estimate *N* and *p* from the sample of *n*'s. Although there were only a maximum of two samples of *N* during any specific watch period, a large sample of *n*'s was built up across many watch periods, allowing the estimation of the parameters. Layered on top of this core estimation process were both a trend model for true daily abundance through time based on the migration pattern and a model for how detection varied according to environmental conditions and different observers. Specifically, a hierarchical model fit to the replicate count samples allowed us to link detectability to key covariates, as in previous gray whale assessments (e.g. Laake *et al.*, 2012), and also extrapolate detectability based on these covariate relationships for watch periods without replicate counts. Similarly, by assuming a common underlying model for the migration pattern, this approach notably accounted for variation in *p* relative to changes in abundance *N* during the migration. Furthermore, this joint modelling of data from multiple years allowed the borrowing of strength across years to better parameterise the migration during years with sparse data.

Previously, two contrasting approaches have been used to model changes in abundance over the course of the annual gray whale migration: either by assuming a parametric model to determine the shape of the migration curve (Buckland *et al.*, 1993) or by fitting a non-parametric smoother to allow the data to determine the trend in abundance over time (Laake *et al.*, 2012). Here we drew on elements of both these approaches in a flexible framework using Bayesian model selection between a parametric model for a common migration trend and a semi-parametric model that estimated the time trends independently for each year; the resultant migration curve was a weighted compromise between models, allowing for key departures from the common trend.

The abundance estimates produced for 2006/07, 2007/08, 2009/10 and 2010/11 were internally consistent, consistent with previous estimates and indicative of a stable population (Fig. 2). The 95% HDPI's of all four estimates overlapped, and there was substantial overlap between the 95% HDPI from the 2006/7 estimate with the 95% confidence intervals of the estimate for the same migration produced using the previous counting and estimation approach (Laake *et al.* 2012). Further, our estimates are very similar to the predictions of Punt and Wade (2012) based on assessment models for the full time series; their baseline model prediction for 2009/10 had 90% posterior density intervals ranging from 17,726 to 23,247; the posterior distribution for our 2009/10 estimate was centered within these intervals at 21,210 (95% HPDI = 19,420–23,250). It is noteworthy that the estimates produced using our approach were relatively precise with CVs ranging from 0.04 to 0.06 (median = 0.05) in contrast to CVs ranging from 0.06 to 0.09 (median = 0.08) for the 23 previous estimates.

This consistency provides a level of confidence in our approach and resultant estimates, but nonetheless there are limitations to address. Our approach makes a number of important modelling assumptions, both in terms of distributional forms and model structure. It was assumed that the detectability relationships described by modelling repeated counts during two years were also applicable in the remaining two years with no replicate counts. We also assumed observer effects remained constant, although in reality this may change with experience. Additionally, the definition of what constituted the common migration trend was dependent on the joint modelling of just four years of data, and precise inference about the shape of the migration curve relies on count data being collected from throughout the migration time span. During at least 3/4 of the years reported here, count data were sparse (or non-existent) during the tails of the migration, resulting in uncertainty over the shape of the abundance curve. While this uncertainty was propagated into inference about overall abundance in our Bayesian inference using MCMC sampling, the resulting imprecision will ultimately constrain power to detect between-year changes in migration patterns and abundance. Data collected during further migrations will be incorporated into this hierarchical model and therefore used to refine parameter estimates; this will benefit from replicate counting experiments, repeated when possible. As the time series grows, specific goodness-of-fit tests should be adopted to investigate aspects of model structure and suggested changes as necessary.

There are also practical considerations as well as modelling assumptions. Previous work has shown that the new counting approach produces estimates of pod size that are typically larger (and presumably less biased) than the traditional counting approach (Durban *et al.*, 2010), likely because the computerised tracking software facilitates more repeated observations of the same groups. In fact, it has been assumed that estimates of pod size using this observation approach are effectively unbiased and have not been rescaled to tally watch period counts. This is an assumption that remains to be tested, but suitable calibration experiments are difficult to design and implement, particularly due to the inherently subjective differences between observers in lumping and splitting whales to define groups. Similarly, although observer effects have been accommodated in the model for detectability, it is clear that too many observers

(35 in total) counted too infrequently to allow precise parameterisation of their relative effects on detectability in many cases. This will have resulted in further imprecision.

Although there may be field protocols that could be adapted to address these limitations within the current approach, further modernisation of the observation process is recommended. Specifically, more accurate information could be gleaned from observations recorded with high-definition video files to allow subsequent review and re-review, rather than relying on instantaneous assessment by visual observers. The use of infra-red sensors would further allow for 24 hour monitoring (e.g. Perryman *et al*., 1999) and provide greater coverage of the entire migration during acceptable weather conditions; automated blow detectors (e.g. Santhaseelan *et al*., 2012) can be developed to eliminate observer effects and standardise detectability to provide counts with minimal (and quantifiable) bias. These extensions would further serve to build a more robust and automated observation model to combine with the flexible abundance model for the migration process described in this paper.

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Gray whale abundance estimates from shore-based counts off California in 2014/15 and 2015/2016.

John W. Durban, David W. Weller, Wayne L. Perryman

INTERNATIONAL
WHALING COMMISSION

Gray whale abundance estimates from shore-based counts off California in 2014/15 and 2015/2016.

JOHN W. DURBAN, DAVID W. WELLER, WAYNE L. PERRYMAN

Marine Mammal and Turtle Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 8901 La Jolla Shores Dr., La Jolla, CA 92037,USA.

Contact email: john.durban@noaa.gov

METHODS AND COUNT DATA

This paper presents updated counts and abundance estimates for gray whales (*Eschrichtius robustus*) migrating southbound off the central California coast between December and February 2014/15 and 2015/16. Counting and analytical methods followed those described by Durban *et al*. (2015) for four previous abundance estimates between 2006/7 and 2011/12. Counts were made from a shore-based watch station at Granite Canyon, California, by teams of observer pairs rotating from a larger pool. A total of 16 observers were used over the two years, 10 in 2014/15 and 12 in 2015/16; six observers counted in both years. Only five of these 16 observers were not involved in the previous independent counting experiments when the detection models were parameterized; in these cases, observer effects were predicted (with uncertainty) from the hierarchical model for observer effects (Durban *et al*. 2015).

Data were the total counts of whales from each 1.5-hour watch period that had acceptable weather conditions (see Durban *et al*. 2015). These comprised 179 watch periods in 2014/15 and 151 in 2015/16, totaling 269 and 226 hours of watch effort over 39 and 37 days, respectively (Table 1). The result was 2978 and 2666 whales counted in each of these years, the former representing the highest count since our new watch protocol was started in 2006/2007 (Durban et al. 2015).

Table 1: The number of whales recorded during the southbound gray whale surveys in 2014/15 and 2015/16. Data are the total counts of whales, hours and distinct days for watches during acceptable observation conditions.

Migration	Dates	Hours	Days	Whales
2014/2015	30-Dec-14 to 13-Feb-15	269	39	2978
2015/2016	30-Dec-15 to 12-Feb-16	227	37	2666

ABUNDANCE ESTIMATES AND DISCUSSION

Bayesian Markov Chain Monte Carlo (MCMC) sampling was used to simultaneously rescale counts for detectability and also smooth to abundance changes over the course of each migration (Durban *et al*. 2015). These abundance changes were described using Bayesian model selection between a parametric model for a Normally distributed migration trend that borrowed strength across years and a semi-parametric model that estimated the time trends independently for each year; the resultant migration curve was a weighted compromise between models, allowing for key departures from the common trend. The total number of whales passing during each migration was then estimated by summing the expected value (along with associated uncertainty, see error bars in Fig 1) from the model-averaged number of whales passing each day from time 0 (01 December) to 90 days, and these estimates were then rescaled to account for the differential passage rate at night (see Durban et al. 2015).

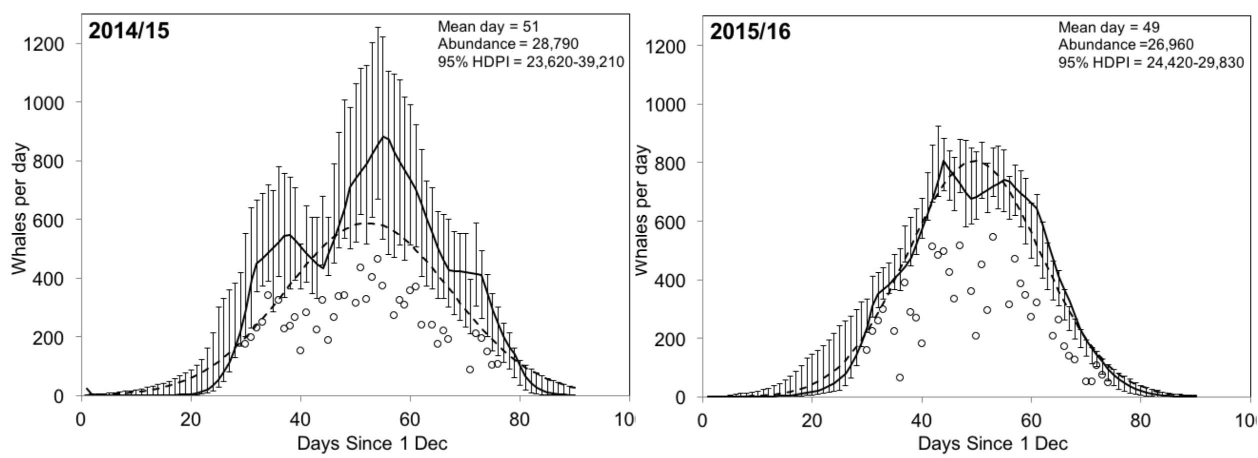

Figure 1. Observed whale passage rates expressed as total counts per day / proportion of day observed (circles) and fitted migrations models (lines) for two gray whale migration counts in 2014/15 and 2015/16. The broken line represents the median estimates from a hierarchical Normal model for migration and the solid line represents a semi-parametric model of penalized splines (see Durban et al. 2015). The abundance estimate for each day (95% highest posterior density interval shown by vertical lines) is a model averaged compromise between the migration models, and these were summed to estimate the overall abundance for the migrations.

To sample the full extent of the uncertainty associated with model parameters, inference was based on each 10^{th} iteration of the MCMC sampler to generate a sample of 30,000 iterations following a burn-in of 10,000. There was consistency between the model predictions and observed counts for both years, with Bayesian P-values of 0.49 and 0.54, respectively; values close to 0.5 would indicate that the data were consistent with replications under the model such that the distribution of the predicted count would symmetrically overlap the observed count (Gelman *et al*. 1996). However, daily and total abundance in 2014/15 were subject to considerable uncertainty, as shown by the large error bars associated with each of the daily estimates (Figure 1) and the large coefficient of variation (CV = posterior standard deviation / posterior median; CV^{2015} = 0.13). This is likely explained in part by the results of model fitting, as significant departures from the Normal migration model (probability of Normal model <0.25) were estimated in 18/90 days in 2014/2015 compared to only 9/90 days in 2015/16. These departures, and the uncertainty associated with estimating an independent migration curve, constrained estimation of a precise migration curve. In contrast the CV^{2016} = 0.05 was consistent with previous estimates using this counting approach and model (CV = 0.04-0.06 for four previous estimates since 2006/2007), and this estimate was therefore more useful for interpreting in the context of the abundance time series. Differences in the CVs from the two years demonstrated the value of completing two counts and abundance estimates in back-to-back years, which provided a measure of redundancy.

The 2015/16 estimate of 26,960 (95% highest posterior density interval = 24,420-29,830) represented a 22% (5970 whales) increase in the five years since the 2010/11 estimate of 20,990. This is consistent with high estimates of calf production (Perryman *et al*. SC/67a), with a total of >6000 calves estimated during this period, including four of the highest years of calf production (>1000 calves per year) since our calf counts began in 1994. This increase in gray whale abundance also supports inference that gray whales have been experiencing a period of favorable feeding conditions in the Arctic due to a combination of expanding ice-free habitat (Moore 2016), increased primary production (Arrigo and Dijken 2015) and increased flow of nutrient-rich waters through the Bering Strait (Woodgate et al. 2012).

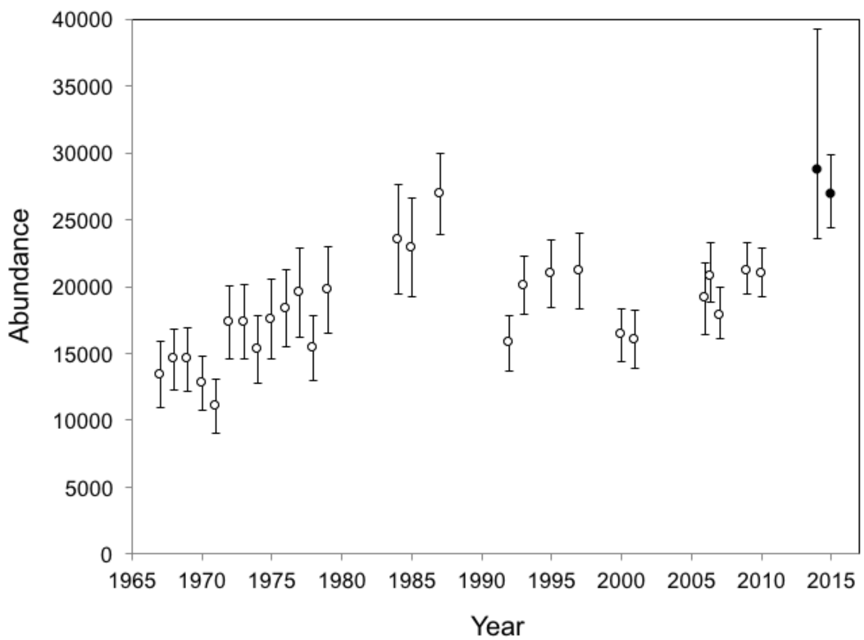

Figure 2: Gray whale abundance estimates for southbound migrations with an end year between 1967 and 2011 (open circles, with 95% confidence intervals; from Laake *et al.,* 2012 and Durban et al. 2015) together with the two recent migrations reported here for 2015 and 2016.

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Population structure in the eastern North Pacific gray whale: Implications for management of aboriginal whaling

Timothy R. Frasier[1,2,*], Sharlene M. Koroscil[1], Bradley N. White[1], James D. Darling[3]

[1]Natural Resources DNA Profiling and Forensic Centre, Department of Biology, Trent University, Peterborough, Ontario, K9J 7B8, Canada
[2]Department of Biology, Saint Mary's University, Halifax, Nova Scotia, B3H 3C3, Canada
[3]Pacific Wildlife Foundation, Vancouver, British Columbia, V3H 1V6, Canada
*Current address: Department of Biology, Saint Mary's University, Halifax, Nova Scotia, B3H 3C3, Canada, timothy.frasier@smu.ca

ABSTRACT

The eastern North Pacific gray whale (*Eschrichtius robustus*) was removed from the Endangered Species List in 1994, and as a result several aboriginal groups in Washington and British Columbia have proposed to resume whaling. In particular, the Makah are currently in litigation with the National Marine Fisheries Service regarding this issue. Although the majority of whales in this population migrate to summer feeding grounds in the Bering, Chukchi, and Beaufort Seas, a small number of individuals (~200) spend the summers feeding in the waters of Oregon, Washington, and British Columbia. The relationship of these "southern feeding group" whales to the rest of the population is unknown. This information is key to making appropriate management decisions, because these whales would represent the primary target of the aboriginal hunt. We compared mitochondrial sequence data from 53 southern feeding group individuals to sequences from 87 individuals representing the larger population. We found small but significant differences in haplotype frequencies between the two groups (Fst = 0.0189, P = 0.00090; ϕ_{ST} = 0.0169, P = 0.0030), with estimated migration rates << 1%. Moreover, estimates of Θ ($Ne\mu$ for mtDNA data) were significantly different between the two groups (P = 0.0249), indicating that the maternal lineages of the southern feeding group are demographically independent of those from the rest of the population. Combined, these data show that the southern feeding group of gray whales qualifies as a separate management unit (MU), which should be considered when making conservation decisions.

INTRODUCTION

The eastern North Pacific gray whale (*Eschrichtius robustus*) represents one of the few populations that have been removed from the Endangered Species List, with the classification changing from "Endangered" to "Recovered" in 1994. Commercial whaling targeting gray whales in the eastern Pacific began in ~1845 (Henderson 1984), and reduced the population from an estimate of 12,000-15,000 individuals to as low as 1,500-1,900 individuals by 1900 (Henderson 1984; Reilly 1992; Butterworth et al. 2002). International protection began in 1937, when the United States and Norway ended their gray whale hunts, but it was not until 1951 that all modern whaling countries agreed to stop hunting gray whales (Reeves 1984). Systematic surveys from 1967-1998 showed that the population increased at an annual rate of ~ 2.6%, reaching as many as 30,000 individuals (Shelden & Laake 2002; Rugh et al. 2005). Current estimates hover around 20,000 individuals, and there are even some suggestions that the population has reached carrying capacity (Moore et al. 2001; Wade 2002; Rugh et al. 2005).

During the late fall and early winter, whales migrate to the lagoons of Baja California and the Gulf of California, which represent the winter breeding and calving grounds for this population (Swartz 1986; Findley & Vidal 2002; Swartz et al. 2006). During the spring, the majority of whales migrate to their northern feeding grounds in the Bering, Chukchi, and Beaufort Seas (Moore & Ljungblad 1984). However, a small subset of the population (~200 individuals) remains in more southerly feeding grounds along the coasts of Oregon, Washington, and British Columbia (Pike 1962; Hatler & Darling 1974; Darling 1984; Calambokidis et al. 2002; Swartz et al. 2006). These two subsets of the population will be referred to as the northern and southern feeding groups, respectively.

Subdivision with respect to summer feeding ground use is common in baleen whales, and results from maternally-directed site fidelity to different feeding grounds. For example, in humpback whales (*Megaptera novaeangliae*) and North Atlantic right whales (*Eubalaena glacialis*) calves nurse for ~ 11 months (and occasionally longer), and learn migration routes and the location of summer feeding grounds through cultural transmission from their mother (e.g. Baker et al. 1990; Malik et al. 1999). Thus, if there is differential use of feeding grounds by mothers, these preferences will be passed on to their offspring and result in substructuring with respect to summer feeding ground use. Gray whale calves nurse for a much shorter period of time (~ 6 months) (Swartz 1986). Although this is still long enough to learn migratory routes and the location of summer feeding grounds, it is not yet clear whether or not gray whales show this maternally-directed site fidelity. Because of its maternal inheritance, patterns of mitochondrial DNA (mtDNA) diversity should reflect any maternally-based patterns of movement and distribution. Therefore, analysis of mtDNA is ideal for testing hypotheses of maternally-based site fidelity and subsequent population structure in baleen whales.

The relationship between the northern and southern feeding groups is unknown. It is currently assumed that both of these groups use the same breeding ground, and therefore represent the same breeding population (e.g. Swartz et al. 2006). Given the known patterns in other baleen whale species, it seems likely that the northern and southern feeding groups result from maternally-directed site fidelity to different feeding grounds by gray whale mothers. Photo-identification data are consistent with this hypothesis, showing that the majority of whales sighted in the southern feeding areas are re-sighted there in subsequent years, and therefore show the expected site fidelity (Darling 1984; Calambokidis et al. 2002). However, preliminary genetic analyses based on mtDNA were inconclusive (Steeves et al. 2001).

Understanding the relationship between the northern and southern feeding groups is becoming of increasing importance due to the desire of some aboriginal communities in Washington and British Columbia to resume hunting the gray whale. Several aboriginal groups historically hunted gray whales in this area, but voluntarily stopped hunting as whale numbers decreased and/or were required to stop when the population received international protection (O'Leary 1984; Russell 2004). The one exception was aboriginal whaling in Chukotka, Russia, which was allowed to continue. In 1999 the Makah (in Washington State) resumed whaling, but have since been prevented from doing so by litigation. Specifically, the Makah were given the right to hunt gray whales at traditional sites under the Treaty of Neah Bay in 1855. However, they have been prevented from doing so under the court ruling (in 2004) that in order to continue their hunt they must follow the necessary procedures for obtaining authorization to "take" whales under the Marine Mammal Protection Act (MMPA). The Makah have applied for a waiver from the MMPA regulations, and this request is still in litigation. The outcome of the Makah lawsuit will have large implications for the resumption of whaling by other aboriginal communities in the area as well (Russell 2004).

The majority of the proposed aboriginal whaling will take place in the waters of Washington and British Columbia – the feeding ground of the much smaller southern feeding group. The negative consequences of ignoring potential population structure when making management decisions are well known (e.g. Daugherty et al. 1990; Taylor 1997; Frankham et al. 2002). Therefore, if informed management decisions are to be made regarding resuming this hunt, it is first necessary to understand the relationship of this southern feeding group to the rest of the larger population. Here, we conducted analyses of the mitochondrial DNA of gray whales from the both the southern and northern feeding groups in order to better understand their relationship, and therefore guide management decisions.

MATERIALS AND METHODS

Skin samples were collected from whales representing the southern feeding group in Clayoquot Sound, British Columbia from 1995-2008, using a crossbow and modified bolt (e.g. Lambertsen 1987; Palsbøll et al. 1991) or a pneumatic rifle biopsy system (Barrett-Lennard et al. 1996). Tissue samples were stored in a 20% dimethyl sulfoxide (DMSO) solution (Seutin et al. 1991). Approximately 40 mg from each sample was used for subsequent DNA extraction procedures. The skin was frozen in liquid nitrogen, ground to a fine powder, and transferred to a tube with 500 μl of lysis buffer (4 M urea, 0.2 M NaCl, 0.5% *n*-lauroyl sarcosine, 10 mM 1,2-cyclohexanediaminetetraacetic acid, 100 mM Tris-HCL, pH 8.0). Samples were rotated in the lysis buffer at room temperature for ≥ 5 days, after which time they were subjected to three aliquots of proteinase K, each at a concentration of 0.5 U of proteinase K per milligram of tissue. The addition of proteinase K was as follows: after adding the first aliquot, samples were rotated at room temperature overnight; after adding the second aliquot the samples were placed in a 65°C waterbath for 1 hour, then transferred to a 37°C incubator for 1 hour; after adding the third aliquot, the samples were rotated at room temperature overnight. Approximately 250 μl of the tissue/lysis buffer solution was subsequently extracted using Qiagen DNeasy Tissue Extraction Kits (Qiagen Inc., Mississauga, Ontario, Canada). DNA quantity was estimated using PicoGreen (Singer et al. 1997). Extracted samples included those previously analyzed by Steeves et al. (2001), which were re-extracted and analyzed here along with the newly collected samples.

A 345 bp portion of the mitochondrial DNA control region was amplified using the primers t-PRO and Primer-2 from Yoshida et al. (2001). PCR cycling conditions consisted of: (*i*) an initial denaturation step of 5 minutes at 94°C; (*ii*) 30 cycles of 94°C for 30 seconds, 57°C for 1 minute, and 72°C for 1 minute; and (*iii*) a final extension step of 60°C for 45 minutes. Reactions were carried out in 20 μl volumes containing 1X PCR Buffer (20 mM Tris-HCl pH 8.0, 50 mM KCl), 0.05 U μl^{-1} *Taq* polymerase (Invitrogen), 1.5 mM $MgCl_2$, 0.2 mM each dNTP (Invitrogen), and 10 ng of DNA. After amplification, primers and unincorporated dNTPs were degraded using EXOSAP-IT (Dugan et al. 2002), and products were sequenced using the DYEnamic dye terminator kit (GE Healthcare, Piscataway, NJ, USA). Products were size-separated and visualized on a MegaBACE 1000 (GE Healthcare). Sequences were edited using MEGA 4 (Kumar et al. 2008).

To compare the data from southern feeding group whales to those of the northern feeding group, we compared our mitochondrial sequence data to those reported in Goerlitz et al. (2003). These samples were collected from 83 individuals in the winter calving and breeding lagoons around Baja California. The rationale is that although whales with different summer feeding distributions may congregate on the same area in the winter, the probability of one of these samples representing a southern feeding group individual is low; given that the total population size estimate is ~ 20,000 individuals (Swartz et al. 2006), and the estimate for the southern feeding group is ~ 200 (Calambokidis et al. 2002). This approach would also make our results conservative – where true differentiation will likely be greater than that observed due to this potential for some southern feeding group whales to be represented in the winter sample set.

Sequences were aligned with CLUSTALX (Thompson et al. 1994). Alignments were conducted under a range of gap opening and extension penalties and compared by eye to establish the optimal alignment. The sequences were very similar, and all alignments were the same under the tested conditions. Haplotype and nucleotide diversity (π) (Nei 1987) were estimated using Arlequin ver. 3.1 (Excoffier et al. 2005). Variations between mtDNA sequences were recorded and identical sequences were grouped into haplotypes. Final haplotype assignments were confirmed with FaBox ver. 1.35 (Villesen 2007). Population differentiation of the mtDNA sequences between the southern feeding group and the winter samples was estimated using the analysis of molecular variance approach described in Excoffier et al. (1992) as implemented in the program Arlequin. The significance of the resulting estimates of F_{ST} and ϕ_{ST} was tested using 1000 permutations. Relationships between haplotypes were visualized via a median-joining network using the program Network 4.5.1.6 (Fluxus Technology Ltd.).

To gain insight into the nature of the observed population structure, we estimated effective population sizes, migration rates, time since divergence, and growth rates for the two feeding groups using the Isolation with Migration program (IM, Nielsen & Wakely 2001; Hey & Nielsen 2004; Hey et al. 2004). However, repeated trials with various parameter options suggested that there was not enough information in our data set to obtain accurate estimates for all of these values (data not shown). Instead, we focused on estimating just the effective population sizes and migration rates using the program MIGRATE (Beerli & Felsenstein 2001; Beerli 2006). The Bayesian inference approach was implemented, using a transition/transversion ratio of 11.22 and an α estimate of 0.09 for the gamma distribution of mutation rate heterogeneity among sites (both estimated using TREE-PUZZLE, Schmidt et al. 2002). We used the Metropolis method of generating posterior distributions. The program was run with uniform prior distributions and one long chain. To ensure consistency between runs, MIGRATE was run four times with a burn-in of 100,000 steps, and a run length of 10,000,000 steps with data recorded every 500 steps. The likelihood ratio test option of MIGRATE was also used to test the hypothesis that the northern and southern feeding groups have different effective population sizes. Specifically, the hypothesis tested was $\Theta_{southern} = \Theta_{northern}$, where $\Theta = N_e\mu$ for mitochondrial data, where μ is the mutation rate per site per generation.

RESULTS

DNA was extracted and mtDNA control regions sequenced from 57 summer resident gray whales. The sequencing protocol resulted in 336 bp of comparable sequence between individuals. Twenty-seven polymorphic sites were identified, which resulted in 18 haplotypes in the summer resident whales (Tables 1 and 2). None of the variable sites identified in the southern feeding group were new - all were also represented by the sequences described by Goerlitz et al. (2003) (Table 2).

The sequenced region from the summer resident whales was slightly different than those in Goerlitz et al. (2003), and therefore to align all sequences for analyses 15 bp were excluded from one end of the sequences from the Goerlitz et al. (2003) sequences, and 45 bp were excluded from the opposite end of the southern feeding group sequences. This resulted in a total of 291 bp that could be compared between the two sample sets. Trimming the sequences in this manner did not remove any variable sites within the southern feeding group samples, but did remove the variation differentiating sequences 1, 2 and 28 from Goerlitz et al. (2003), which were subsequently collapsed into one haplotype for these analyses. For the purposes of this study, these 'collapsed' sequences are referred to as haplotype 1.

Fifteen of the 29 haplotypes (52%) were shared between both groups, 11 (38%) were only found in the northern feeding group, and three (10%) were found only in the southern feeding group (Table 2). Estimates of differentiation for haplotype frequencies between groups were small but significant, with values of 0.01890 for F_{ST} (P = 0.00090) and 0.01688 for ϕ_{ST} (P = 0.0030). The median-joining network shows that although there is some evolutionary differentiation between the haplotypes from the two feeding groups, for the most part the haplotypes from each are scattered throughout the network (Fig. 1). Haplotype and nucleotide diversity (π) were estimated at 0.9279 and 0.019910, respectively for the southern feeding group. These values are very similar to estimates obtained based on samples from the winter breeding/calving ground, which were 0.95 and 0.02, respectively (Goerlitz et al. 2003).

The results from the MIGRATE analyses are shown in Table 3. Estimates for each value are very similar across iterations, suggesting that the program was run long enough to reach convergence on the estimates. The estimates of Θ for the northern and southern feeding groups are clearly different. This observation was confirmed by the likelihood ratio test, which rejected the hypothesis of $\Theta_{southern} = \Theta_{northern}$ (P = 0.024878). The 95% confidence intervals for the migration rate estimates are extremely large, making them uninformative. This result is not surprising, however, because the approach implemented by MIGRATE is known to recover precise and accurate estimates of Θ even in situations where there is not enough information in the data to recover meaningful migration rate estimates (Beerli 2006).

DISCUSSION

The conservation and/or management of wildlife populations requires knowledge of how individuals are subdivided into separate entities that have relatively independent demographic processes, which are often referred to as "management units". Such information is required to identify how each unit, and the population as a whole, will respond to exploitation and/or unintentional impacts. Moritz (1994) was the first to provide a working definition of a management unit (MU) in a population genetics context, and defined them as "…populations with significant divergence of allele frequencies at nuclear or mitochondrial loci, regardless of the phylogenetic distinctiveness of the alleles." While this definition has been widely applied in population genetics studies, it has recently been argued that management units should be defined based on criteria demonstrating demographic isolation rather than simply rejecting the hypothesis of panmixia (Palsbøll et al. 2007). This idea makes intuitive sense, because the true question for management is whether or not the units will respond differently to the pressures of concern (e.g. exploitation and/or unintentional mortality).

The data presented here show that the southern feeding group of gray whales represents a distinct management unit under both of these criteria. The analysis showing statistically significant differentiation of mitochondrial haplotypes demonstrates qualification as an MU under the criteria of Mortiz (1994). Moreover, the analysis showing that the effective sizes of both groups are different ($\Theta_{southern} \neq \Theta_{northern}$) shows that the maternal lineages of the southern feeding group are demographically independent of those of the northern feeding group. Indeed, if they were not an independent unit, then estimates of Θ from the two data sets should converge on the same value. Thus, the southern feeding group qualifies as a separate management unit under the criterion of Palsbøll et al. (2007). Combined, these data show that the southern feeding group requires separate management consideration with regards to resuming aboriginal (or any) whaling.

Hastings (1993) showed that populations behave in a demographically independent manner when migration rates are less than ~ 10%. We have intentionally not converted Θ estimates to N_e estimates (where $\Theta = N_e\mu$ for mtDNA data) because this requires knowledge of the substitution rate (μ). Estimates of μ for the control region of baleen whale mtDNA vary by over an order of magnitude (e.g. Rooney et al. 2001). Moreover, μ, whatever its true value is, is undoubtedly the same for the northern and southern feeding groups, and therefore comparing estimates of Θ is an appropriate and less controversial method for comparing N_e. Regardless, if we apply the μ estimate of 1.8×10^{-8} from Rooney et al. (2001) to our data, the resulting estimates of migration rates are << 1%. Again, this result shows that the southern feeding group is demographically independent.

Previous studies have suggested that the haplotype diversity in the southern feeding group is too high to have resulted from strict maternally-directed site fidelity beginning with a few founders after the cessation of commercial whaling within the past century (Ramakrishnan et al. 2001). Our results are consistent with this interpretation. Under that hypothesis only a few closely related haplotypes should be represented within the southern feeding group, as opposed to the pattern seen in Figure 1. However, the hypothesis of a founding event within the past century is not consistent with the known sighting information. Indeed, gray whales have been seen in the southern feeding grounds throughout their history, including in times of lowest abundance (Swartz et al. 2006, and references therein). Moreover, if a few individuals recently founded the southern feeding group then the estimate of $\Theta_{southern}$ should be substantially smaller, as effective population size estimates are heavily influenced by bottlenecks.

Instead, what the sighting and genetic data suggest is that the southern feeding group of gray whales pre-dates whaling. Under this hypothesis, the haplotype diversity is expected to be high, because those lineages that survived whaling would be a random sample from a much larger population. Substantial gaps would also be expected between existing haplotypes resulting from the removal of haplotypes by whaling. This pattern is exactly what is seen in Figure 1. The similarity of haplotypes, and the degree of haplotype sharing between the northern and southern feeding groups, suggest that there is some degree of migration between the two. However, although reliable estimates of migration rates could not be obtained here, the data clearly show that the rate of migration is low enough that the two groups represent independent demographic entities. The southern feeding group therefore qualifies as a separate management unit, and requires separate management consideration.

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Table 1. Characteristics of the data for the northern and southern feeding groups, and for the combined data set.

Group	Individuals	Sequence Length (bp)	Polymorphic Sites	Haplotypes
Northern	83	306	30	28
Southern	57	336	27	18
Combined	140	291	27	29

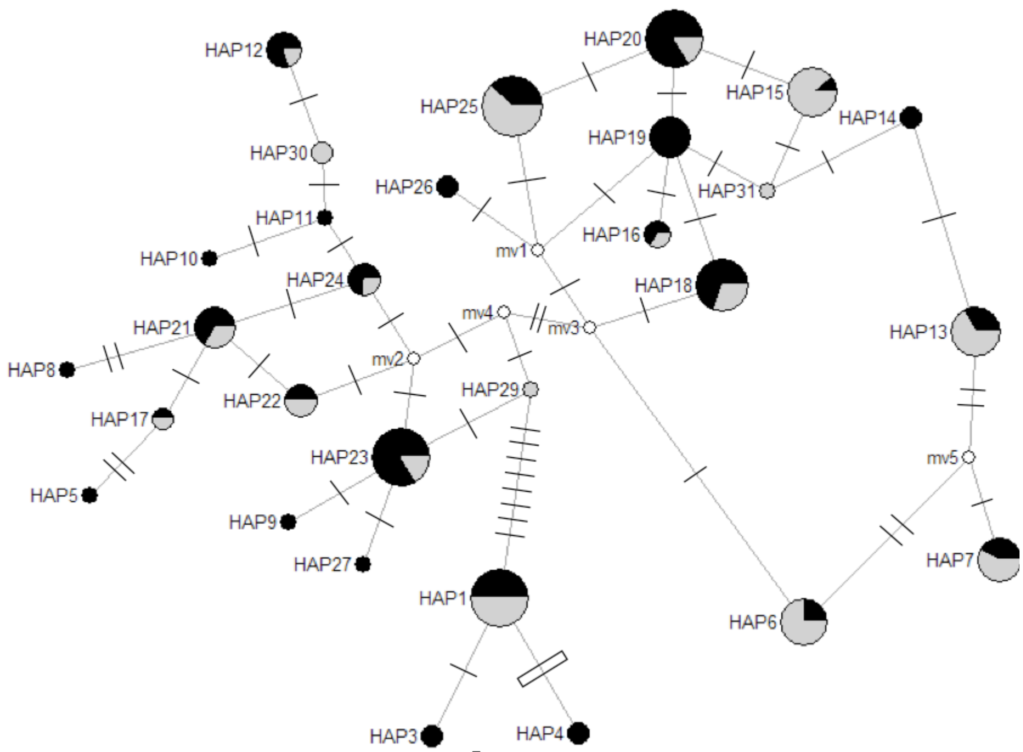
Table 2. Variable sites characterizing haplotypes from both sample sets of gray whales. Variable site positions are numbered to correspond with those in Goerlitz et al. (2003). The columns labeled NFG and SFG indicate the number of individuals from the northern feeding group and the southern feeding group, respectively.

Hap	26	67	68	80	88	89	90	91	93	98	102	104	105	106	124	129	171	220	248	264	265	266	271	284	288	289	290	NFG	SFG	Total
1	A	T	C	T	T	T	C	G	G	T	T	T	T	T	A	A	T	A	C	G	C	G	T	C	G	T	C	6	6	12
3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	G	.	.	.	.	.	.	.	.	.	.	.	2	0	2
4	.	.	.	G	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	0	2
5	.	C	T	.	C	.	T	.	.	.	.	C	C	.	G	G	C	.	T	.	T	.	C	.	.	.	T	1	0	1
6	.	.	T	.	C	C	T	.	.	.	.	C	.	.	G	.	.	.	T	.	T	A	.	T	.	.	.	2	6	8
7	.	.	T	.	C	C	T	.	.	.	C	C	.	.	G	.	.	.	T	A	T	A	.	T	.	C	.	3	4	7
8	.	.	T	.	C	.	.	A	.	.	.	C	.	.	G	.	C	.	T	.	T	.	C	.	.	.	T	1	0	1
9	.	.	T	.	C	.	T	.	A	.	.	C	.	.	G	.	.	.	T	.	.	.	.	.	.	.	T	1	0	1
10	.	.	T	.	C	.	T	.	.	C	.	C	.	.	G	.	.	G	T	.	T	.	C	.	.	.	T	1	0	1
11	.	.	T	.	C	.	T	.	.	C	.	C	.	.	G	.	.	.	T	.	T	.	C	.	.	.	T	1	0	1
12	.	.	T	.	C	.	T	.	.	C	.	C	.	C	G	.	.	.	T	.	T	.	C	.	.	.	.	4	1	5
13	.	.	T	.	C	.	T	.	.	.	C	C	.	C	G	.	.	.	T	A	T	A	.	T	.	.	.	3	6	9
14	.	.	T	.	C	.	T	.	.	.	C	C	.	C	G	.	.	.	T	A	T	A	C	T	.	.	.	2	0	2
15	.	.	T	.	C	.	T	.	.	.	C	C	.	C	G	.	.	.	T	.	T	A	C	T	A	.	.	1	8	9
16	.	.	T	.	C	.	T	.	.	.	.	C	C	C	G	.	.	.	T	.	T	A	C	T	.	.	.	2	1	3
17	.	.	T	.	C	.	T	.	.	.	.	C	C	.	G	.	C	.	T	.	T	.	C	.	.	.	T	1	1	2
18	.	.	T	.	C	.	T	.	.	.	.	C	.	C	G	.	.	.	T	.	T	A	.	T	.	.	.	7	3	10
19	.	.	T	.	C	.	T	.	.	.	.	C	.	C	G	.	.	.	T	.	T	A	C	T	.	.	.	6	0	6
20	.	.	T	.	C	.	T	.	.	.	.	C	.	C	G	.	.	.	T	.	T	A	C	T	A	.	.	10	2	12
21	.	.	T	.	C	.	T	.	.	.	.	C	.	.	G	.	C	.	T	.	T	.	C	.	.	.	T	4	2	6
22	.	.	T	.	C	.	T	.	.	.	.	C	.	.	G	.	C	.	T	.	T	.	.	.	.	.	T	2	2	4
23	.	.	T	.	C	.	T	.	.	.	.	C	.	.	G	.	.	.	T	.	.	.	.	.	.	.	T	10	2	12
24	.	.	T	.	C	.	T	.	.	.	.	C	.	.	G	.	.	.	T	.	T	.	C	.	.	.	T	3	1	4
25	.	.	T	.	C	.	T	.	.	.	.	C	.	.	G	.	.	.	T	.	T	A	C	T	A	.	.	5	8	13
26	.	.	T	.	C	.	T	.	.	.	.	C	.	.	G	.	.	.	T	.	T	A	C	T	.	C	.	2	0	2
27	G	.	T	.	C	.	T	.	.	.	.	C	.	.	G	.	.	.	T	.	.	.	.	.	.	.	T	1	0	1
29	.	.	T	.	C	.	T	.	.	.	.	C	.	.	G	.	.	.	T	.	.	.	.	.	.	.	.	0	1	1
30	.	.	T	.	C	.	T	.	.	C	.	C	.	C	G	.	.	.	T	.	T	.	C	.	.	.	T	0	2	2
31	.	.	T	.	C	.	T	.	.	.	C	C	.	C	G	.	.	.	T	.	T	A	C	T	.	.	.	0	1	1

Table 3. Results from the MIGRATE analysis. Included is the estimated mode for each parameter, as well as the 95% confidence intervals in parentheses. *M* is the immigration rate *m* divided by the mutation rate μ. For mitochondrial DNA data, the number of immigrants per generation can be calculated by multiplying *M* by Θ. Included are the estimates for each of the four runs, as well as the average across all four runs.

Iteration	$\Theta_{northern}$	$\Theta_{southern}$	$M_{southern\text{-}northern}$	$M_{northern\text{-}southern}$
1	0.0388 (0.0200-0.0800)	0.0158 (0.00650-0.0365)	393 (130-740)	433 (170-860)
2	0.0388 (0.0205-0.0790)	0.0163 (0.00700-0.0365)	373 (130-705)	448 (170-865)
3	0.0403 (0.0180-0.0800)	0.0173 (0.00700-0.0390)	348 (125-700)	428 (155-820)
4	0.0358 (0.0195-0.0840)	0.0168 (0.00700-0.0360)	408 (175-765)	463 (165-900)
Avg	**0.0384 (0.0195-0.0808)**	**0.0166 (0.00688-0.0370)**	**381 (140-728)**	**443 (165-861)**

Figure 1. Median-joining network for the gray whale sequences. Transitional mutations are indicated with a line, and transversions are indicated with a box. Sizes of the circles are proportional to the haplotype frequencies in the entire data set. Pie charts indicate the proportion of that haplotype found in the northern (black) and southern (gray) feeding groups.



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US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2016

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US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2016

Sean A. Hayes[1], Elizabeth Josephson[1], Katherine Maze-Foley[2], and Patricia E. Rosel[3], Editors

with contributions from (listed alphabetically)

Barbie Byrd[4], Timothy V.N. Cole[1], Laura Engleby[5], Lance P. Garrison[6], Joshua Hatch[1], Allison Henry[1], Stacey C. Horstman[5], Jenny Litz[6], Marjorie C. Lyssikatos[1], Keith D. Mullin[2], Christopher Orphanides[1], Richard M. Pace[1], Debra L. Palka[1], Melissa Soldevilla[6], and Frederick W. Wenzel[1].

[1]NOAA Fisheries, Northeast Fisheries Science Center, 166 Water St, Woods Hole, MA 02543
[2]NOAA Fisheries, P.O. Drawer 1207, Pascagoula, MS 39568
[3]NOAA Fisheries, 646 Cajundome Blvd. Suite 234, Lafayette, LA 70506
[4]NOAA Fisheries, 101 Pivers Island, Beaufort, NC 28516
[5] NOAA Fisheries, 263 13th Ave. South, St. Petersburg, FL 33701
[6]NOAA Fisheries, 75 Virginia Beach Drive, Miami, FL 33149

US DEPARTMENT OF COMMERCE
Wilbur L. Ross, Secretary
National Oceanic and Atmospheric Administration
Benjamin Friedman, Acting Administrator
National Marine Fisheries Service
Samuel D. Rauch III, Acting Assistant Administrator for Fisheries
Northeast Fisheries Science Center
Woods Hole, Massachusetts

June 2017

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EXECUTIVE SUMMARY

Under the 1994 amendments of the Marine Mammal Protection Act (MMPA), the National Marine Fisheries Service (NMFS) and the United States Fish and Wildlife Service (USFWS) were required to generate stock assessment reports (SARs) for all marine mammal stocks in waters within the U.S. Exclusive Economic Zone (EEZ). The first reports for the Atlantic (includes the Gulf of Mexico) were published in July 1995 (Blaylock *et al.* 1995). The MMPA requires NMFS and USFWS to review these reports annually for strategic stocks of marine mammals and at least every 3 years for stocks determined to be non-strategic. Included in this report as appendices are: 1) a summary of serious injury/mortality estimates of marine mammals in observed U.S. fisheries (Appendix I), 2) a summary of NMFS records of large whale human-caused serious injury and mortality (Appendix II), 3) detailed fisheries information (Appendix III), 4) summary tables of abundance estimates generated over recent years and the surveys from which they are derived (Appendix IV), a summary of observed fisheries bycatch (Appendix V), and a list of reports not updated in the current year (Appendix VI).

Table 1 contains a summary, by species, of the information included in the stock assessments, and also indicates those that have been revised since the 2015 publication. Most of the changes incorporate new information into sections on population size and/or mortality estimates. A total of 18 of the Atlantic and Gulf of Mexico stock assessment reports were revised for 2016. The revised SARs include 6 strategic and 12 non-strategic stocks.

This report was prepared by staff of the Northeast Fisheries Science Center (NEFSC) and Southeast Fisheries Science Center (SEFSC). NMFS staff presented the reports at the February 2016 meeting of the Atlantic Scientific Review Group (ASRG), and subsequent revisions were based on their contributions and constructive criticism. This is a working document and individual stock assessment reports will be updated as new information becomes available and as changes to marine mammal stocks and fisheries occur. The authors solicit any new information or comments which would improve future stock assessment reports.

INTRODUCTION

Section 117 of the 1994 amendments to the Marine Mammal Protection Act (MMPA) requires that an annual stock assessment report (SAR) for each stock of marine mammals that occurs in waters under USA jurisdiction, be prepared by the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS), in consultation with regional Scientific Review Groups (SRGs). The SRGs are a broad representation of marine mammal and fishery scientists and members of the commercial fishing industry mandated to review the marine mammal stock assessments and provide advice to the NOAA Assistant Administrator for Fisheries. The reports are then made available on the *Federal Register* for public review and comment before final publication.

The MMPA requires that each SAR contain several items, including: (1) a description of the stock, including its geographic range; (2) a minimum population estimate, a maximum net productivity rate, and a description of current population trend, including a description of the information upon which these are based; (3) an estimate of the annual human-caused mortality and serious injury of the stock, and, for a strategic stock, other factors that may be causing a decline or impeding recovery of the stock, including effects on marine mammal habitat and prey; (4) a description of the commercial fisheries that interact with the stock, including the estimated number of vessels actively participating in the fishery and the level of incidental mortality and serious injury of the stock by each fishery on an annual basis; (5) a statement categorizing the stock as strategic or not, and why; and (6) an estimate of the potential biological removal (PBR) level for the stock, describing the information used to calculate it. The MMPA also requires that SARs be updated annually for stocks which are specified as strategic stocks, or for which significant new information is available, and once every three years for non-strategic stocks.

Following enactment of the 1994 amendments, the NMFS and USFWS held a series of workshops to develop guidelines for preparing the SARs. The first set of stock assessments for the Atlantic Coast (including the Gulf of Mexico) were published in July 1995 in the *NOAA Technical Memorandum* series (Blaylock *et al.* 1995). In April 1996, the NMFS held a workshop to review proposed additions and revisions to the guidelines for preparing SARs (Wade and Angliss 1997). Guidelines developed at the workshop were followed in preparing the 1996 through 2015 SARs. In 1997 and 2004 SARs were not produced.

In this document, major revisions and updating of the SARs were completed for stocks for which significant new information was available. These are identified by the February 2017 date-stamp at the top right corner at the beginning of each report. Stocks not updated in 2016 are listed in Appendix VI.

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Blaylock, R.A., J.W. Hain, L.J. Hansen, D.L. Palka and G.T. Waring 1995. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments. NOAA Tech. Memo. NMFS-SEFSC-363, 211 pp.

Wade, P.R. and R.P. Angliss 1997. Guidelines for assessing marine mammal stocks: Report of the GAMMS workshop April 3-5, 1996, Seattle, Washington. NOAA Tech. Memo. NMFS-OPR-12, 93 pp.

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TABLE 1. A SUMMARY (including footnotes) OF ATLANTIC MARINE MAMMAL STOCK ASSESSMENT REPORTS FOR STOCKS OF MARINE MAMMALS UNDER NMFS AUTHORITY THAT OCCUPY WATERS UNDER USA JURISDICTION.

Total Annual S.I. (serious injury) and Mortality and Annual Fisheries S.I. and Mortality are mean annual figures for the period 2010-2014. The “SAR revised” column indicates 2016 stock assessment reports that have been revised relative to the 2015 reports (Y=yes, N=no). If abundance, mortality, PBR or status have been revised, they are indicated with the letters “a”, “m”, “p” and “status” respectively. For those species not updated in this edition, the year of last revision is indicated. Unk = unknown and undet=undetermined (PBR for species with outdated abundance estimates is considered "undetermined").

Species	Stock Area	NMFS Ctr.	Nbest	Nbest CV	Nmin	Rmax	Fr	PBR	Total Annual S.I and Mort.	Annual Fish. S.I. and Mort. (cv)	Strategic Status	SAR Revised
North Atlantic right whale	Western North Atlantic	NEC	440	0	440	0.04[a]	0.1	1	5.66[a]	4.65[a]	Y	Y (a, m)
Humpback whale	Gulf of Maine	NEC	823	0	823	0.065	0.5	13	9.05[b]	7.25[b]	N	Y (m, p, status)
Fin whale	Western North Atlantic	NEC	1,618	0.33	1,234	0.04	0.1	2.5	3.8[c]	1.8[c]	Y	Y (m)
Sei whale	Nova Scotia	NEC	357	0.52	236	0.04	0.1	0.5	0.8[d]	0 [d]	Y	Y (m)
Minke whale	Canadian east coast	NEC	2,591	0.81	1,425	0.04	0.5	14	8.25[e]	6.45 [e]	N	Y (a, m, p)
Blue whale	Western North Atlantic	NEC	unk	unk	440	0.04	0.1	0.9	unk	unk	Y	N (2010)
Sperm whale	North Atlantic	NEC	2,288	0.28	1,815	0.04	0.1	3.6	0.8	0.8	Y	N (2014)
Dwarf sperm whale	Western North Atlantic	SEC	3,785[j]	0.47 [k]	2,598 [j]	0.04	0.4	21	3.5	3.5 (1.0)	N	Y (m, p)
Pygmy sperm whale	Western North Atlantic	SEC	3,785 [j]	0.47 [k]	2,598 [j]	0.04	0.4	21	3.5	3.5 (1.0)	N	Y (m, p)
Killer whale	Western North Atlantic	NEC	unk	unk	unk	0.04	0.5	unk	0	0	N	N (2014)
Pygmy killer whale	Western North Atlantic	SEC	unk	unk	unk	0.04	0.5	unk	0	0	N	N (2007)
False killer whale	Western North Atlantic	SEC	442	1.06	212	0.04	0.5	2.1	unk	unk	Y	N (2014)
Northern bottlenose whale	Western North Atlantic	NEC	unk	unk	unk	0.04	0.5	unk	0	0	N	N (2014)
Cuvier's beaked whale	Western North Atlantic	NEC	6,532	0.32	5,021	0.04	0.5	50	0.4	0.2	N	N (2013)
Blainville’s beaked whale	Western North Atlantic	NEC	7,092[i]	0.54	4,632 [i]	0.04	0.5	46	0.2	0.2	N	N (2013)
Gervais beaked whale	Western North Atlantic	NEC	7,092[i]	0.54	4,632 [i]	0.04	0.5	46	0	0	N	N (2013)
Sowerby’s beaked whale	Western North Atlantic	NEC	7,092[i]	0.54	4,632 [i]	0.04	0.5	46	0	0	N	N (2014)
True’s beaked whale	Western North Atlantic	NEC	7,092[i]	0.54	4,632 [i]	0.04	0.5	46	0	0	N	N (2013)

Species	Stock Area	NMFS Ctr.	Nbest	Nbest CV	Nmin	Rmax	Fr	PBR	Total Annual S.I and Mort.	Annual Fish. S.I. and Mort. (cv)	Strategic Status	SAR Revised
Melon-headed whale	Western North Atlantic	SEC	unk	unk	unk	0.04	0.5	unk	0	0	N	N (2007)
Risso's dolphin	Western North Atlantic	NEC	18,250	0.46	12,619	0.04	0.48	126	53.6	53 (0.28)	N	Y (m)
Pilot whale, long-finned	Western North Atlantic	NEC	5,636	0.63	3,464	0.04	0.5	35	38	38 (0.15)	Y	Y (m, status)
Pilot whale, short-finned	Western North Atlantic	SEC	21,515	0.37	15,913	0.04	0.5	159	192	192 (0.17)	Y	Y (m, status)
Atlantic white-sided dolphin	Western North Atlantic	NEC	48,819	0.61	30,403	0.04	0.5	304	74	74 (0.2)	N	Y (m)
White-beaked dolphin	Western North Atlantic	NEC	2,003	0.94	1,023	0.04	0.5	10	0	0	N	N (2007)
Common dolphin	Western North Atlantic	NEC	70,184	0.28	55,690	0.04	0.5	557	409	409 (0.10)	N	Y (a, m, p)
Atlantic spotted dolphin	Western North Atlantic	SEC	44.715	0.43	31,610	0.04	0.5	316	0	0	N	N (2013)
Pantropical spotted dolphin	Western North Atlantic	SEC	3,333	0.91	1,733	0.04	0.5	17	0	0	N	N (2013)
Striped dolphin	Western North Atlantic	NEC	54,807	0.3	42,804	0.04	0.5	428	0	0	N	N (2013)
Fraser's dolphin	Western North Atlantic	SEC	unk	unk	unk	0.04	0.5	unk	0	0	N	N (2007)
Rough-toothed dolphin	Western North Atlantic	SEC	271	1.0	134	0.04	0.5	1.3	0	0	N	N (2013)
Clymene dolphin	Western North Atlantic	SEC	unk	unk	unk	0.04	0.5	undet	0	0	N	N (2013)
Spinner dolphin	Western North Atlantic	SEC	unk	unk	unk	0.04	0.5	unk	0	0	N	N (2013)
Common bottlenose dolphin	Western North Atlantic, offshore	SEC	77,532 [g]	0.40	56,053[g]	0.04	0.5	561	39.4	39.4 (0.29)	N	Y (m)
Common bottlenose dolphin	Western North Atlantic, northern migratory coastal	SEC	11,548	0.36	8,620	0.04	0.5	86	1-7.5	1-7.5	Y	N (2015)
Common bottlenose dolphin	Western North Atlantic, southern migratory coastal	SEC	9,173	0.46	6,326	0.04	0.5	63	0-12	0-12	Y	N (2015)
Common bottlenose dolphin	Western North Atlantic, S. Carolina/Georgia coastal	SEC	4,377	0.43	3,097	0.04	0.5	31	1.2-1.6	1.2-1.6	Y	N (2015)
Common bottlenose dolphin	Western North Atlantic, northern Florida coastal	SEC	1,219	0.67	730	0.04	0.5	7	0.4	0.4	Y	N (2015)
Common bottlenose dolphin	Western North Atlantic, central Florida coastal	SEC	4,895	0.71	2,851	0.04	0.5	29	0.2	0.2	Y	N (2015)

Species	Stock Area	NMFS Ctr.	Nbest	Nbest CV	Nmin	Rmax	Fr	PBR	Total Annual S.I and Mort.	Annual Fish. S.I. and Mort. (cv)	Strategic Status	SAR Revised
Common bottlenose dolphin	Northern North Carolina Estuarine System	SEC	823	0.06	782	0.04	0.5	7.8	1.0-16.7	1.0-16.7	Y	N (2015)
Common bottlenose dolphin	Southern North Carolina Estuarine System	SEC	unk	unk	unk	0.04	0.5	undet	0-0.4	0-0.4	Y	N (2015)
Common bottlenose dolphin	Northern South Carolina Estuarine System	SEC	unk	unk	unk	0.04	0.5	unk	0.2	0.2	Y	N (2015)
Common bottlenose dolphin	Charleston Estuarine System	SEC	unk	unk	unk	0.04	0.5	undet	unk	unk	Y	N (2015)
Common bottlenose dolphin	Northern Georgia/ Southern South Carolina Estuarine System	SEC	unk	unk	unk	0.04	0.5	unk	1.4	1.4	Y	N (2015)
Common bottlenose dolphin	Central Georgia Estuarine System	SEC	192	0.04	185	0.04	0.5	1.9	unk	unk	Y	N (2015)
Common bottlenose dolphin	Southern Georgia Estuarine System	SEC	194	0.05	185	0.04	0.5	1.9	unk	unk	Y	N (2015)
Common bottlenose dolphin	Jacksonville Estuarine System	SEC	unk	unk	unk	0.04	0.5	unk	1.2	1.2	Y	N (2015)
Common bottlenose dolphin	Indian River Lagoon Estuarine System	SEC	unk	unk	unk	0.04	0.5	unk	4.4	4.4	Y	N (2015)
Common bottlenose dolphin	Biscayne Bay	SEC	unk	unk	unk	0.04	0.5	unk	unk	unk	Y	N (2013)
Common bottlenose dolphin	Florida Bay	SEC	unk	unk	unk	0.04	0.5	undet	unk	unk	N	N (2013)
Harbor porpoise	Gulf of Maine/Bay of Fundy	NEC	79,833	0.32	61,415	0.046	0.5	706	437	437 (0.18)	N	Y (m)
Harbor seal	Western North Atlantic	NEC	75,834	0.15	66,884	0.12	0.5	2,006	389	377 (0.13)	N	Y (m)
Gray seal	Western North Atlantic	NEC	unk	unk	unk	0.12	1.0	unk	4,937	1,162 (0.11)	N	Y (m)
Harp seal	Western North Atlantic	NEC	unk	unk	unk	0.12	1.0	unk	306,082[g]	271 (0.19)	N	N (2013)
Hooded seal	Western North Atlantic	NEC	unk	unk	unk	0.12	0.75	unk	5,199[h]	25(0.82)	N	N (2007)
Sperm whale	Gulf of Mexico	SEC	763	0.38	560	0.04	0.1	1.1	0	0	Y	N (2015)
Bryde's whale	Gulf of Mexico	SEC	33	1.07	16	0.04	0.1	0.03	0.2	0	Y	N (2015)
Cuvier's beaked whale	Gulf of Mexico	SEC	74	1.04	36	0.04	0.5	0.4	0	0	N	N (2012)
Blainville's beaked whale	Gulf of Mexico	SEC	149[i]	0.91	77	0.04	0.5	0.8	0	0	N	N (2012)
Gervais' beaked whale	Gulf of Mexico	SEC	149[i]	0.91	77	0.04	0.5	0.8	0	0	N	N (2012)
Common bottlenose dolphin	Gulf of Mexico, Continental shelf	SEC	51,192	0.10	46,926	0.04	0.5	469	0.8	0.6	N	N (2015)
Common bottlenose dolphin	Gulf of Mexico, eastern coastal	SEC	12,388	0.13	11,110	0.04	0.5	111	1.6	1.6	N	N (2015)

Species	Stock Area	NMFS Ctr.	Nbest	Nbest CV	Nmin	Rmax	Fr	PBR	Total Annual S.I and Mort.	Annual Fish. S.I. and Mort. (cv)	Strategic Status	SAR Revised
Common bottlenose dolphin	Gulf of Mexico, northern coastal	SEC	7,185	0.21	6,044	0.04	0.5	60	0.4	0.4	N	N (2015)
Common bottlenose dolphin	Gulf of Mexico, western coastal	SEC	20,161	0.17	17,491	0.04	0.5	175	0.6	0.6	N	N (2015)
Common bottlenose dolphin	Gulf of Mexico, Oceanic	SEC	5,806	0.39	4,230	0.04	0.5	42	6.5	6.5 (0.65)	N	N (2014)
Common bottlenose dolphin	Gulf of Mexico, bay, sound and estuary (27 stocks)	SEC	unk for all but 3 stocks	unk	unk for all but 3 stocks	0.04	0.5	undet for all but 3 stocks	unk	unk	Y for all	Y stranding and fishery data
Common bottlenose dolphin	Barataria Bay	SEC	unk	unk	unk	0.04	0.5	undet	0.8	0.8	Y	N (2015)
Common bottlenose dolphin	Mississippi Sound, Lake Borgne, Bay Boudreau	SEC	901	0.63	551	0.04	0.5	5.6	2.2	1.6	Y	N (2015)
Common bottlenose dolphin	St. Joseph Bay	SEC	152	0.08	unk[l]	0.04	0.5	undet[l]	unk	unk	Y	N (2015)[l]
Common bottlenose dolphin	Choctawhatchee Bay	SEC	179	0.04	unk[l]	0.04	0.5	undet[l]	0.4	0.4	Y	N (2015)[l]
Atlantic spotted dolphin	Gulf of Mexico	SEC	unk	unk	unk	0.04	0.5	undet	42	42 (0.45)	N	N (2015)
Pantropical spotted dolphin	Gulf of Mexico	SEC	50,880	0.27	40,699	0.04	0.5	407	4.4	4.4	N	N (2015)
Striped dolphin	Gulf of Mexico	SEC	1,849	0.77	1,041	0.04	0.5	10	0	0	N	N (2012)
Spinner dolphin	Gulf of Mexico	SEC	11,441	0.83	6,221	0.04	0.5	62	0	0	N	N (2012)
Rough-toothed dolphin	Gulf of Mexico	SEC	624	0.99	311	0.04	0.4	3	0.8	0.8 (1.0)	N	Y (m)
Clymene dolphin	Gulf of Mexico	SEC	129	1.00	64	0.04	0.5	0.6	0	0	N	N (2012)
Fraser's dolphin	Gulf of Mexico	SEC	unk	unk	unk	0.04	0.5	undet	0	0	N	N (2012)
Killer whale	Gulf of Mexico	SEC	28	1.02	14	0.04	0.5	0.1	0	0	N	N (2012)
False killer whale	Gulf of Mexico	SEC	unk	unk	unk	0.04	0.5	undet	0	0	N	N (2012)
Pygmy killer whale	Gulf of Mexico	SEC	152	1.02	75	0.04	0.5	0.8	0	0	N	N (2012)
Dwarf sperm whale	Gulf of Mexico	SEC	186[j]	1.04	90	0.04	0.5	0.9	0	0	N	N (2012)
Pygmy sperm whale	Gulf of Mexico	SEC	186[j]	1.04	90	0.04	0.5	0.9	0.3	0.3 (1.0)	N	N (2012)
Melon-headed whale	Gulf of Mexico	SEC	2,235	0.75	1,274	0.04	0.5	13	0	0	N	N (2012)
Risso's dolphin	Gulf of Mexico	SEC	2,442	0.57	1,563	0.04	0.5	16	7.9	7.9 (0.85)	N	N (2015)
Pilot whale, short-finned[l]	Gulf of Mexico	SEC	2,415	0.66	1456	0.04	0.5	15	0.5	0.5 (1.0)	N	N (2015)
Sperm Whale	Puerto Rico and US Virgin Islands	SEC	unk	unk	unk	0.04	0.1	unk	unk	unk	Y	N (2010)
Common bottlenose dolphin	Puerto Rico and US Virgin Islands	SEC	unk	unk	unk	0.04	0.5	unk	unk	unk	Y	N (2011)
Cuvier's beaked whale	Puerto Rico and US Virgin Islands	SEC	unk	unk	unk	0.04	0.5	unk	unk	unk	Y	N (2011)

Species	Stock Area	NMFS Ctr.	Nbest	Nbest CV	Nmin	Rmax	Fr	PBR	Total Annual S.I and Mort.	Annual Fish. S.I. and Mort. (cv)	Strategic Status	SAR Revised
Pilot whale, short-finned	Puerto Rico and US Virgin Islands	SEC	unk	unk	unk	0.04	0.5	unk	unk	unk	Y	N (2011)
Spinner dolphin	Puerto Rico and US Virgin Islands	SEC	unk	unk	unk	0.04	0.5	unk	unk	unk	Y	N (2011)
Atlantic spotted dolphin	Puerto Rico and US Virgin Islands	SEC	unk	unk	unk	0.04	0.5	unk	unk	unk	Y	N (2011)

a. The R given for right whales is the default Rmax of 0.04. The total estimated human-caused mortality and serious injury to right whales is estimated at 5.66 per year. This is derived from two components: 1) non-observed fishery entanglement records at 4.65 per year, and 2) ship strike records at 1.01 per year.

b. The total estimated human-caused mortality and serious injury to the Gulf of Maine humpback whale stock is estimated as 9.05 per year. This average is derived from two components: 1) incidental fishery interaction records 7.25; 2) records of vessel collisions, 1.8.

c. The total estimated human-caused mortality and serious injury to the Western North Atlantic fin whale stock is estimated as 3.8 per year . This average is derived from two components: 1) incidental fishery interaction records 1.8; 2) records of vessel collisions, 2.0.

d. The total estimated human-caused mortality and serious injury to the Nova Scotia sei whale stock is estimated as 0.8 per year. This average is derived from two components: 1) incidental fishery interaction records 0; 2) records of vessel collisions, 0.8.

e. The total estimated human-caused mortality and serious injury to the Canadian East Coast minke whale stock is estimated as 8.25 per year. This average is derived from three components: 1) 0.2 minke whales per year from observed U.S. fisheries; 2) 6.45 minke whales per year (unknown CV) from U.S. and Canadian fisheries using strandings and entanglement data; and 3) 1.6 per year from ship strikes.

f. Estimates may include sightings of the coastal form.

g. The total estimated human caused annual mortality and serious injury to harp seals is 306,082. Estimated annual human caused mortality in US waters is 271 harp seals (CV=0.19) from the observed US fisheries. The remaining mortality is derived from five components: 1) 2007-2011 average catches of Northwest Atlantic harp seals by Canada, 125,751; 2) 2007-2011 average Greenland Catch, 79,181; 3) 1,000 average catches in the Canadian Arctic; 4) 12,330 average bycatches in the Newfoundland lumpfish fishery; and 5) 87,546 average struck and lost animals.

h. This is derived from three components: 1) 5,173 from 2001-2005 (2001 = 3,960; 2002 = 7,341; 2003 = 5,446, 2004=5,270; and 2005=3,846) average catches of Northwest Atlantic population of hooded seals by Canada and Greenland; 2) 25 hooded seals (CV=0.82) from the observed U.S. fisheries; and 3) one hooded seal from average 2001-2005 stranding mortalities resulting from non-fishery human interactions.

i. This estimate includes Gervais' beaked whales and Blainville's beaked whales for the Gulf of Mexico stocks, and all species of *Mesoplodon* in the Atlantic.

j. This estimate includes both the dwarf and pygmy sperm whales.

k. This estimate includes all *Globicephala sp.*, though it is presumed that only short-finned pilot whales are present in the Gulf of Mexico.

l. The individual SAR for this stock was not updated; however, Table 1 within the "Northern Gulf of Mexico Bay, Sound and Estuary Stocks" SAR, that includes basic information for all individual bay, sound and estuary stocks, was updated to reflect the changes in Nmin and PBR.

NORTH ATLANTIC RIGHT WHALE (*Eubalaena glacialis*): Western Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The western North Atlantic right whale population ranges primarily from calving grounds in coastal waters of the southeastern United States to feeding grounds in New England waters and the Canadian Bay of Fundy, Scotian Shelf, and Gulf of St. Lawrence. Mellinger *et al.* (2011) reported acoustic detections of right whales near the nineteenth-century whaling grounds east of southern Greenland, but the number of whales and their origin is unknown. However, Knowlton *et al.* (1992) reported several long-distance movements as far north as Newfoundland, the Labrador Basin, and southeast of Greenland. In addition, resightings of photographically identified individuals have been made off Iceland, in the old Cape Farewell whaling ground east of Greenland (Hamilton *et al.* 2007), northern Norway (Jacobsen *et al.* 2004), and the Azores (Silva *et al.* 2012). The September 1999 Norwegian sighting represents one of only two published sightings in the 20th century of a right whale in Norwegian waters, and the first since 1926. Together, these long-range matches indicate an extended range for at least some individuals and perhaps the existence of important habitat areas not presently well described. A few published records from the Gulf of Mexico (Moore and Clark 1963; Schmidly *et al.* 1972; Ward-Geiger *et al.* 2011) likely represent occasional wanderings of individual female and calf pairs beyond the sole known calving and wintering ground in the waters of the southeastern United States. Whatever the case, the location of much of the population is unknown during the winter. Surveys flown in an area from 17 to 86 miles from the shoreline off northeastern Florida and southeastern Georgia from 1996 to 2001 had 3 sightings in 1996, 1 in 1997, 13 in 1998, 6 in 1999, 11 in 2000, and 6 in 2001 (within each year, some were repeat sightings of previously recorded individuals). All but 1 of the sightings occurred within 49 miles of the shoreline –the remaining sighting occurred ~75 miles offshore (search effort was unevenly distributed). An offshore survey in March 2010 observed the birth of a right whale in waters 40 miles off Jacksonville, Florida (Foley *et al.* 2011). Several years of aerial survey counts for calves and adults were the lowest recorded since comprehensive surveys began in the Southeast calving grounds. Although habitat models predict right whales are not likely to occur further than 49 miles from the shoreline (Gowan and Ortega-Ortiz, 2015), the frequency with which right whales occur in offshore waters in the southeastern United States remains unclear.

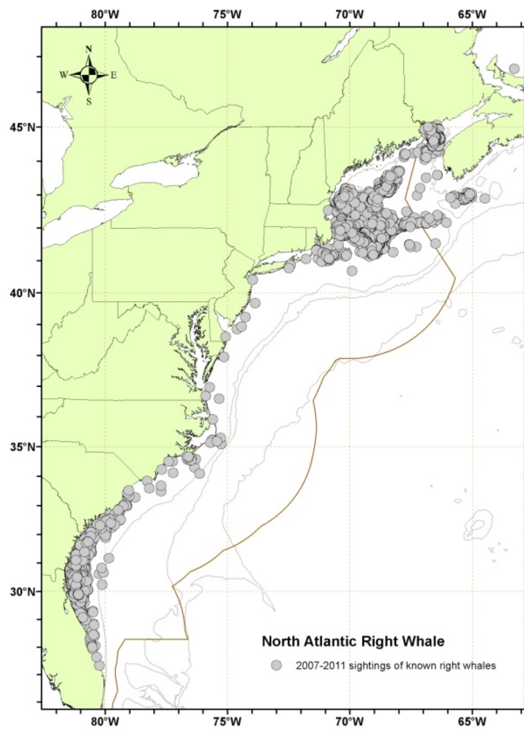

Figure 1. *Distribution of sightings of known North Atlantic right whales, 2007-2011. Isobaths are the 100-m, 1000-m and 4000-m depth contours.*

Visual and acoustic surveys have demonstrated the existence of seven areas where western North Atlantic right whales aggregate seasonally: the coastal waters of the southeastern United States; the Great South Channel; Jordan Basin; Georges Basin along the northeastern edge of Georges Bank; Cape Cod and Massachusetts Bays; the Bay of Fundy; and the Roseway Basin on the Scotian Shelf (Brown *et al*. 2001; Cole *et al.* 2013). Passive acoustic studies of right whales have demonstrated their year-round presence in the Gulf of Maine (Morano *et al.* 2012; Bort *et al.* 2015), New Jersey (Whitt *et al*. 2013)), and Virginia (Salisbury *et al*. 2015). Additionally, right whales were acoustically detected off Georgia and North Carolina in 7 of 11 months monitored (Hodge *et al*. 2015),). All of this work further demonstrates the highly mobile nature of right whales. Movements within and between habitats are extensive and the area off the mid-Atlantic states is an important migratory corridor. In 2000, one whale was photographed in Florida waters on 12 January, then again 11 days later (23 January) in Cape Cod Bay, less than a month later off Georgia (16 February), and back in Cape Cod Bay on 23 March, effectively making the round-trip migration to the Southeast and back at least twice during the winter season (Brown and Marx 2000). Results from satellite tagging studies clearly indicate that sightings separated by perhaps two weeks should not necessarily be assumed to indicate a stationary or resident animal. Instead, telemetry data have shown rather lengthy and somewhat distant excursions, including into deep water off the continental shelf (Mate *et al.* 1997; Baumgartner and Mate 2005). Systematic visual surveys conducted off the coast of North Carolina during the winters of 2001 and 2002 sighted 8 calves, suggesting the calving grounds may extend as far north as Cape Fear (McLelland, et al., 2008, Contract report available from SE regional Office, NMFS). Four of those calves were not sighted by surveys conducted further south. One of the females photographed was new to researchers, having effectively eluded identification over the period of its maturation. In 2016 the Southeastern U.S. Calving Area Critical Habitat was expanded north to Cape Fear, North Carolina. There is also at least one recent case of a calf apparently being born in the Gulf of Maine (Patrician *et al*. 2009) and another newborn was detected in Cape Cod Bay in 2013.

New England waters are important feeding habitats for right whales, where they feed primarily on copepods (largely of the genera *Calanus* and *Pseudocalanus*). Right whales must locate and exploit extremely dense patches of zooplankton to feed efficiently (Mayo and Marx 1990). These dense zooplankton patches are likely a primary characteristic of the spring, summer, and fall right whale habitats (Kenney *et al.* 1986, 1995). While feeding in the coastal waters off Massachusetts has been better studied than in other areas, right whale feeding has also been observed on the margins of Georges Bank, in the Great South Channel, in the Gulf of Maine, in the Bay of Fundy, and over the Scotian Shelf (Baumgartner *et al.* 2007). The characteristics of acceptable prey distribution in these areas are beginning to emerge (Baumgartner *et al.* 2003; Baumgartner and Mate 2003). NMFS (National Marine Fisheries Service) and Center for Coastal Studies aerial surveys during springs of 1999–2006 found right whales along the Northern Edge of Georges Bank, in the Great South Channel, in Georges Basin, and in various locations in the Gulf of Maine including Cashes Ledge, Platts Bank, and Wilkinson Basin. Analysis of the sightings data has shown that utilization of these areas has a strong seasonal component (Pace and Merrick 2008). Although right whales are consistently found in these locations, studies also highlight the high interannual variability in right whale use of some habitats (Pendleton *et al.* 2009). In 2016, the Northeastern U.S. Foraging Area Critical Habitat was expanded to include all U.S. waters of the Gulf of Maine. In the most recent years (2012–2015), surveys have detected fewer individuals in the Great South Channel and the Bay of Fundy, indicating an important shift in habitat use patterns.

Right whale calls have been detected by autonomous passive acoustic sensors deployed between 2005 and 2010 at three sites (Massachusetts Bay, Stellwagen Bank, and Jeffreys Ledge) in the southern Gulf of Maine (Morano *et al*. 2012, Mussoline *et al*. 2012). Comparisons between detections from passive acoustic recorders and observations from aerial surveys in Cape Cod Bay between 2001 and 2005 demonstrated that aerial surveys found whales on approximately two-thirds of the days during which acoustic monitoring detected whales (Clark *et al*. 2010). These data suggest that the current understanding of the distribution and movements of right whales in the Gulf of Maine and surrounding waters is incomplete.

Genetic analyses based upon direct sequencing of mitochondrial DNA (mtDNA) have identified 7 mtDNA haplotypes in the western North Atlantic right whale, including heteroplasmy that led to the declaration of the 7th haplotype (Malik *et al.* 1999, McLeod and White 2010). Schaeff *et al.* (1997) compared the genetic variability of North Atlantic and southern right whales (*E. australis*), and found the former to be significantly less diverse, a finding broadly replicated by Malik *et al.* (2000). The low diversity in North Atlantic right whales might be indicative of inbreeding, but no definitive conclusion can be reached using current data. Modern and historic genetic population structures were compared using DNA extracted from museum and archaeological specimens of baleen and bone. This work suggested that the eastern and western North Atlantic populations were not genetically distinct (Rosenbaum *et al.* 1997, 2000). However, the virtual extirpation of the eastern stock and its lack of recovery in the last hundred years strongly suggest population subdivision over a protracted (but not evolutionary) timescale. Genetic studies concluded that the principal loss of genetic diversity occurred prior to the 18th century (Waldick *et al.* 2002). However, revised conclusions that nearly all the remains in the North American Basque whaling archaeological sites were bowhead whales (*Balaena mysticetus*) and not right whales (Rastogi *et al.* 2004; McLeod *et al.* 2008) contradict the previously held belief that Basque whaling during the 16th and 17th centuries was principally responsible for the loss of genetic diversity.

High-resolution (i.e., using 35 microsatellite loci) genetic profiling has been completed for 66% of all North Atlantic right whales identified through 2001. This work has improved our understanding of genetic variability, number of reproductively active individuals, reproductive fitness, parentage, and relatedness of individuals (Frasier *et al.* 2007).

One emerging result of the genetic studies is the importance of obtaining biopsy samples from calves on the calving grounds. Only 60% of all known calves are seen with their mothers in summering areas, when their callosity patterns are stable enough to reliably make a photo-ID match later in life. The remaining 40% are not seen on a known summering ground. Because the calf's genetic profile is the only reliable way to establish parentage, if the calf is not sampled when associated with its mother early on, then it is not possible to link it with a calving event or to its mother, and information such as age and familial relationships is lost. From 1980 to 2001, there were 64 calves born that were not sighted later with their mothers and thus unavailable to provide age-specific mortality information (Frasier *et al.* 2007). An additional interpretation of paternity analyses is that the population size may be larger than was previously thought. Fathers for only 45% of known calves have been genetically determined. However, genetic profiles were available for 69% of all photo-identified males (Frasier 2005). The conclusion was that the majority of these calves must have different fathers that cannot be accounted for by the unsampled males, therefore the population of males must be larger (Frasier 2005). This inference of additional animals that have never been captured photographically and/or genetically suggests the existence of potentially important habitats that remain to be described.

POPULATION SIZE

The western North Atlantic minimum stock size is based on a census of individual whales identified using photo-identification techniques. A review of the photo-ID recapture database as it existed on 17 November 2015 indicated that 440 individually recognized whales in the catalog were known to be alive during 2012. This number represents a minimum population size. This is a direct count and has no associated coefficient of variation.

Historical Abundance

An estimate of pre-exploitation population size is not available. Basque whalers were thought to have taken right whales during the 1500s in the Strait of Belle Isle region (Aguilar 1986), however, genetic analysis has shown that nearly all of the remains found in that area are, in fact, those of bowhead whales (Rastogi *et al.* 2004; Frasier *et al.* 2007). The stock of right whales may have already been substantially reduced by the time whaling was begun by colonists in the Plymouth area in the 1600s (Reeves *et al.* 2001, 2007). A modest but persistent whaling effort along the coast of the eastern U.S. lasted three centuries, and the records include one report of 29 whales killed in Cape Cod Bay in a single day during January 1700. Reeves *et al.* (2007) calculated that a minimum of 5500 right whales were taken in the western North Atlantic between 1634 and 1950, with nearly 80% taken in a 50-year period between 1680 and 1730. They concluded "there were at least a few thousand whales present in the mid-1600s." The authors cautioned, however, that the record of removals is incomplete, the results were preliminary, and refinements are required. Based on back calculations using the present population size and growth rate, the population may have numbered fewer than 100 individuals by 1935 when international protection for right whales came into effect (Hain 1975; Reeves *et al.* 1992; Kenney *et al.* 1995). However, little is known about the population dynamics of right whales in the intervening years.

Minimum Population Estimate

The western North Atlantic population size was estimated to be at least 440 individuals in 2012.

Current Population Trend

The population growth rate reported for the period 1986–1992 by Knowlton *et al.* (1994) was 2.5% (CV=0.12), suggesting that the stock was recovering slowly, but that number may have been influenced by discovery phenomenon as existing whales were recruited to the catalog. Work by Caswell *et al.* (1999) suggested that crude survival probability declined from about 0.99 in the early 1980s to about 0.94 in the late 1990s. The decline was statistically significant. Additional work conducted in 1999 was reviewed by the IWC workshop on status and trends in this population (Best *et al.* 2001); the workshop concluded based on several analytical approaches that survival had indeed declined in the 1990s. Although capture heterogeneity could negatively bias survival estimates, the workshop concluded that this factor could not account for the entire observed decline, which appeared to be particularly marked in adult females. Another workshop was convened by NMFS in September 2002, and it reached similar conclusions regarding the decline in the population (Clapham 2002). At the time, the early part of the recapture series had not been examined for excessive retrospective recaptures which had the potential to positively bias survival as the catalog was being developed.

An increase in carcass detections in 2004 and 2005 was cause for serious concern (Kraus *et al.* 2005). Of those mortalities, six were adult females, three of which were carrying near-term fetuses. Furthermore, four of these females were just starting to bear calves, losing their complete lifetime reproduction potential. Calculations based on demographic data through 1999 (Fujiwara and Caswell 2001) indicated that this mortality rate increase would reduce population growth by approximately 10% per year (Kraus *et al.* 2005). Strong evidence for flat or negative growth exists in the time series of minimum number alive during 1998-2000, which coincided with very low calf production in 2004. However, the population continued to grow since that apparent interval of decline until the most recent year included in this analysis (Figure 2).

Examination of the minimum number alive calculated from the individual sightings database, as it existed on 27 October 2015, for the years 1990–2012 (Figure 2) suggests that abundance has declined. As noted above, there seems to have been a considerable change in right whale habitat use patterns in areas where most of the population has been observed in previous years. This apparent change in habitat use has the effect that, despite relatively constant effort to find whales, the chance of seeing an individual that is alive has decreased. Some caution is advised in interpreting the apparent downward trend in abundance in 2012, but without evidence to the contrary, it is possible that this deflection represents a true population decline.

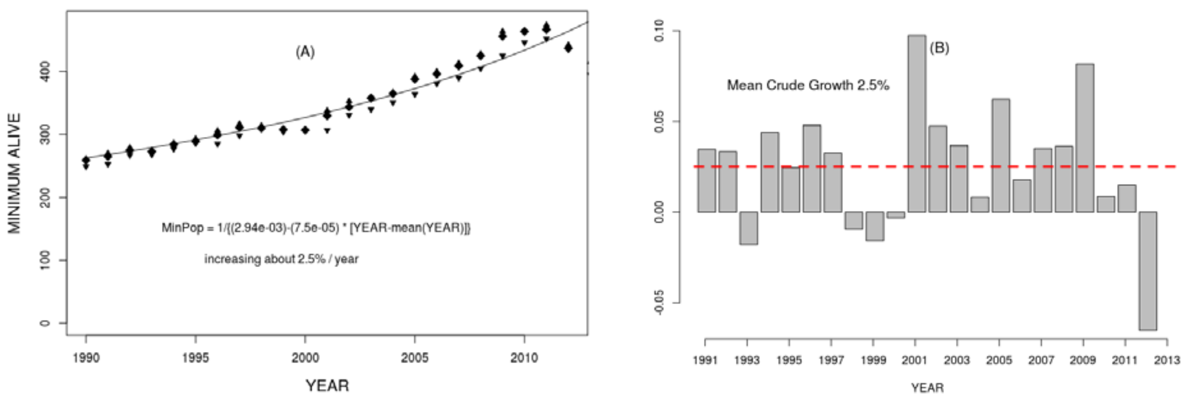

Figure 2. Minimum number alive (a) for North Atlantic right whales. Minimum number alive (diamonds) of cataloged individuals known to be alive in any given year includes all whales known to be alive prior to that year and seen in that year or subsequently plus all whales newly cataloged that year. Cataloged whales may include some but not all calves produced each year. Bracketing the minimum number of cataloged whales is the number without calves (below) and that plus calves above, the latter which yields Nmin for purposes of stock assessment. (b) Crude annual growth rates from the minimum number alive values. Mean crude growth rate (dashed line) is the exponentiated mean of $\log_e [(N_{t+1}-N_t)/N_t]$ *for each year (t), where* N_t *is the max of the accounting procedure and the estimated abundance for year t.*

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

During 1980–1992, at least 145 calves were born to 65 identified females. The number of calves born annually ranged from 5 to 17, with a mean of 11.2 (SE=0.90). The reproductively active female pool was static at approximately 51 individuals during 1987–1992. Mean calving interval, based on 86 records, was 3.67 years. There was an indication that calving intervals may have been increasing over time, although the trend was not statistically significant (P=0.083) (Knowlton *et al.* 1994). Since 1993, calf production has been more variable than a simple stochastic model would predict.

During 1990–2014, at least 411 calves were born into the population. The number of calves born annually ranged from 1 to 39, and averaged 16.4 but was highly variable (SD=9.2). The fluctuating abundance observed from 1990 to 2014 makes interpreting a count of calves by year less clear than measuring population productivity, which we index by the number of calves detected/Nmin. Productivity for this stock has been highly variable over time and has been characterized by periodic swings in per capita birth rates (Figure 3). Notwithstanding the high variability observed, which might be expected from a small population, productivity in North Atlantic right whales lacks a definitive trend.

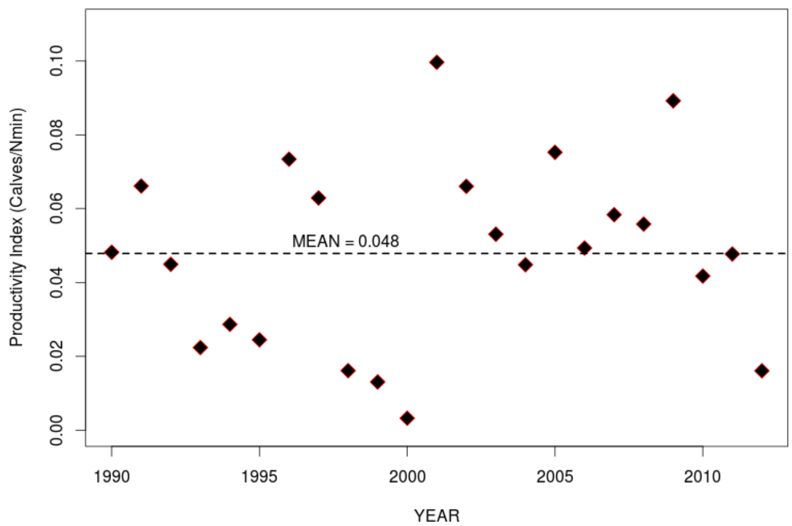

Figure 3. Productivity in the North Atlantic right whale population as characterized by calves detected/(N_{min}). Note that because Nmin is likely biased somewhat low, the values shown in the graph likely overstate actual per capita production.

North Atlantic right whales have thinner blubber than southern right whales off South Africa (Miller *et al.* 2011). Blubber thickness of male North Atlantic right whales (males were selected to avoid the effects of pregnancy and lactation) varied with *Calanus* abundance in the Gulf of Maine (Miller *et al.* 2011). Sightings of North Atlantic right whales correlated with satellite-derived sea-surface chlorophyll concentration (as a proxy for productivity), and calving rates correlated with chlorophyll concentration prior to gestation (Hlista *et al.* 2009). On a regional scale, observations of North Atlantic right whales correlate well with copepod concentrations (Pendleton *et al*. 2009). The available evidence suggests that at least some of the observed variability in the calving rates of North Atlantic right whales is related to variability in nutrition.

An analysis of the age structure of this population suggests that it contains a smaller proportion of juvenile whales than expected (Hamilton *et al.* 1998; Best *et al.* 2001), which may reflect lowered recruitment and/or high juvenile mortality. Calf and perinatal mortality was estimated by Browning *et al.* (2010) to be between 17 and 45 animals during the period 1989 and 2003. In addition, it is possible that the apparently low reproductive rate is due in part to an unstable age structure or to reproductive dysfunction in some females. However, few data are available on either factor and senescence has not been documented for any baleen whale.

The maximum net productivity rate is unknown for this stock. For purposes of this assessment, the maximum net productivity rate was assumed to be the default value of 0.04. This value is based on theoretical modeling showing that cetacean populations may not grow at rates much greater than 4% given the constraints of their reproductive life history (Barlow *et al.* 1995).

POTENTIAL BIOLOGICAL REMOVAL

Potential biological removal (PBR) is the product of minimum population size, one-half the maximum net productivity rate and a recovery factor for endangered, depleted, threatened stocks, or stocks of unknown status relative to OSP (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The recovery factor for right whales is 0.10 because this species is listed as endangered under the Endangered Species Act (ESA). The minimum population size is 440. The maximum productivity rate is 0.04, the default value for cetaceans. PBR for the Western Atlantic stock of the North Atlantic right whale is 1.

ANNUAL HUMAN-CAUSED SERIOUS INJURY AND MORTALITY

For the period 2010 through 2014, the minimum rate of annual human-caused mortality and serious injury to right whales averaged 5.66 per year. This is derived from two components: 1) incidental fishery entanglement records at 4.65 per year, and 2) vessel strike records at 1.01 per year. Early analyses of the effectiveness of the ship strike rule were reported by Silber and Bettridge (2012). Recently, van der Hoop *et al.* (2015) concluded that large whale mortalities due to vessel strikes decreased inside active SMAs and increased outside inactive SMAs. Analysis by Laist *et al.* (2014) incorporated an adjustment for drift around areas regulated under the ship strike rule and produced weak evidence that the rule was effective inside the SMAs.

Beginning with the 2001 Stock Assessment Report, Canadian records have been incorporated into the mortality and serious injury rates to reflect the effective range of this stock. It is also important to stress that serious injury determinations are made based upon the best available information; these determinations may change with the availability of new information (Henry *et al.* 2016). For the purposes of this report, discussion is primarily limited to those records considered confirmed human-caused mortalities or serious injuries. Annual rates calculated from detected mortalities should not be considered an unbiased estimate of human-caused mortality, but they represent a definitive lower bound. Detections are haphazard, incomplete, and not the result of a designed sampling scheme. As such they represent a minimum estimate of human-caused mortality, which is biased low.

Background

The details of a particular mortality or serious injury record often require a degree of interpretation (Moore *et al.* 2005). The assigned cause is based on the best judgment of the available data; additional information may result in revisions. When reviewing Table 1 below, several factors should be considered: 1) a vessel strike or entanglement may have occurred at some distance from the location where the animal is detected/reported; 2) the mortality or injury may involve multiple factors; for example, whales that have been both vessel struck and entangled are not uncommon; 3) the actual vessel or gear type/source is often uncertain; and 4) in entanglements, several types of gear may be involved.

Further, the small population size and low annual reproductive rate of right whales suggest that human sources of mortality may have a greater effect relative to population growth rates than for other whales. The principal factors believed to be retarding growth and recovery of the population are vessel strikes and entanglement with fishing gear. Between 1970 and 1999, a total of 45 right whale mortalities was recorded (IWC 1999; Knowlton and Kraus 2001; Glass *et al.* 2009). Of these, 13 (28.9%) were neonates that were believed to have died from perinatal complications or other natural causes. Of the remainder, 16 (35.6%) resulted from vessel strikes, 3 (6.7%) were related to entanglement in fishing gear (in two cases lobster gear, and one gillnet gear), and 13 (28.9%) were of unknown cause. At a minimum, therefore, 42.2% of the observed total for the period and 50% of the 32 non-calf deaths was attributable to human impacts (calves accounted for three deaths from ship strikes). Young animals, ages 0-4 years, are apparently the most impacted portion of the population (Kraus 1990).

Finally, entanglement or minor vessel collisions may not kill an animal directly, but may weaken or otherwise affect it so that it is more likely to become vulnerable to further injurySerious injury determinations for large whales commonly include animals carrying gear when these entanglements are constricting or appear to interfere with foraging (Henry *et al*. 2016).

Fishery-Related Mortality and Serious Injury

Reports of mortality and serious injury relative to PBR as well as total human impacts are contained in records maintained by the New England Aquarium and the NMFS Northeast and Southeast Regional Offices (Table 1). From 2010 through 2014, 24 records of mortality or serious injury (including records from both U.S. and Canadian waters, pro-rated to 23.25 using serious injury guidelines) involved entanglement or fishery interactions. For this time frame, the average reported mortality and serious injury to right whales due to fishery entanglement was 4.65 whales per year. Information from an entanglement event often does not include the detail necessary to assign the entanglements to a particular fishery or location.

Although disentanglement is often unsuccessful or not possible for many cases, there are several documented cases of entanglements for which the intervention of disentanglement teams averted a likely serious-injury determination. Four serious injuries were prevented by intervention during 2010–2014 (Henry *et al.* 2016). Sometimes, even with disentanglement, an animal may die of injuries sustained from fishing gear. A female yearling right whale, #3107, was first sighted with gear wrapping its caudal peduncle on 6 July 2002 near Briar Island, Nova Scotia. Although the gear was removed on 1 September by the New England Aquarium disentanglement team, and the animal seen alive during an aerial survey on 1 October, its carcass washed ashore at Nantucket on 12 October 2002 with deep entanglement injuries on the caudal peduncle. Additionally, but infrequently, a whale listed as seriously injured becomes gear-free without a disentanglement effort and is seen later in reasonable health. Such was the case for whale #1980, listed as a serious injury in 2008 but seen gear-free and apparently healthy in 2011.

The only bycatch of a right whale observed by the Northeast Fisheries Observer Program was in the pelagic drift gillnet fishery in 1993. No mortalities or serious injuries have been documented by fisheries observers in any of the other fisheries monitored by NMFS.

Whales often free themselves of gear following an entanglement event, and as such scarring may be a better indicator of fisheries interaction than entanglement records. A review of scars detected on identified individual right whales over a period of 30 years (1980–2009) documented 1032 definite, unique entanglement events on the 626 individual whales identified (Knowlton *et al*. 2012). Most individual whales (83%) were entangled at least once, and almost half of them (306 of 626) were entangled more than once. About a quarter of the individuals identified in each year (26%) were entangled in that year. Juveniles and calves were entangled at higher rates than were adults. Scarring rates suggest that entanglements are occurring at about an order of magnitude greater than that detected from observations of whales with gear on them. More recently, analyses of whales carrying entangling gear also suggest that entanglement wounds have become more severe since 1990, possibly due to increased use of stronger lines in fixed fishing gear (Knowlton *et al*. 2015).

Knowlton *et al.* (2012) concluded from their analysis of entanglement scarring rates over time that efforts made since 1997 to reduce right whale entanglement had not worked. Working from a completely different data source (observed mortalities of eight large whale species, 1970–-2009), van der Hoop *et al*. (2012) arrived at a similar conclusion. Vessel strikes and entanglements were the two leading causes of death for known mortalities of right whales for which a cause of death could be determined. Across all 8 species of large whales, there was no detectable change in causes of anthropogenic mortality over time (van der Hoop *et al*. 2012). Pace *et al.* (2015) analyzed entanglement rates and serious injuries due to entanglement during 1999-2009 and found no support that mitigation measures that were implemented prior to 2009 were effective at reducing takes due to commercial fishing.

Incidents of entanglements in waters of Atlantic Canada and the U.S. east coast were summarized by Read (1994) and Johnson *et al.* (2005). In six records of right whales that were entangled in groundfish gillnet gear in the Bay of Fundy and Gulf of Maine between 1975 and 1990, the whales were either released or escaped on their own, although several whales were observed carrying net or line fragments. A right whale mother and calf were released alive from a herring weir in the Bay of Fundy in 1976. Gillnet gear entanglements in the U.S. can also be fatal. A calf died in 2006, apparently victim of a gillnet entanglement, and other whales initially detected in gillnet gear have subsequently not been seen alive (NMFS unpub. data).

For all areas, specific details of right whale entanglement in fishing gear are often lacking. When direct or indirect mortality occurs, some carcasses come ashore and are subsequently examined, or are reported as "floaters" at sea. The number of unreported and unexamined carcasses is unknown, but may be significant in the case of floaters. More information is needed about fisheries interactions and where they occur.

Other Mortality

Vessel strikes are a major cause of mortality and injury to right whales (Kraus 1990; Knowlton and Kraus 2001, van der Hoop *et al.* 2012). Records from 2010 through 2014 have been summarized in Table 1. For this time frame, the average reported mortality and serious injury to right whales due to vessel strikes was 1.01 whales per year.

Table 1. Confirmed human-caused mortality and serious injury records of North Atlantic right whales (*Eubalaena glacialis*) where the cause was assigned as either an entanglement (EN) or a vessel strike (VS): 2010-2014 [a]

Date[b]	Injury Determination	ID	Location[b]	Asigned Cause	Value against PBR[c]	Country[d]	Gear Type[e]	Description
6/27/2010	Mortality	1124	off Cape May, NJ	EN	1	XU	NR	Evidence of constricting rostrum, mouth & pectoral wraps w/associated hemorrhage & bone damage.
7/2/2010	Mortality	3901	off Great Wass Island, ME	VS	1	XU	-	2 large lacerations from dorsal to ventral surface.
8/12/2010	Mortality	1113	Digby Neck, NS	EN	1	XC	NP	Evidence of entanglement w/associated hemorrhaging around right pectoral.
9/10/2010	Serious Injury	1503	Jeffreys Ledge, NH	EN	1	XU	NR	Constricting wrap on rostrum. Poor health.

12/25/2010	Mortality	3911	off Jacksonville Beach, FL	EN	1	XU	GU	Constricting wraps w/ severe health decline. Sedation & partial disentanglement. Carcass recovered w/ embedded line on flipper & in mouth.
1/20/2011	Serious Injury	3853	off Edisto Island, SC	VS	1	US	-	Sixteen deep lacerations across back, potentially penetrating body cavity.
2/13/2011	Serious Injury	3993	off Tybee Island, GA	EN	1	XU	NR	Right pectoral compromised, likely necrotic. Emaciated & poor skin condition.
3/16/2011	Mortality	-	Cape Romain, SC	EN	1	XU	GU	Multiple wraps embedded in right pectoral bones.
3/27/2011	Mortality	1308	Nags Head, NC	VS	1	US	-	Fractured right skull.
3/27/2011	Serious Injury	2011 Calf of 1308	Nags Head, NC	VS	1	US	-	Dependent calf of mom that was killed by ship strike.
4/22/2011	Serious Injury	3302	off Martha's Vineyard, MA	EN	1	XU	NR	Constricting wrap on head.

9/3/2011	Serious Injury	2660	Gaspe Bay, QC	EN	1	XC	NP	Evidence of extensive, constricting entanglement. Significant health decline: cyamids, sloughing skin. Right blow hole not functional.
9/18/2011	Prorated Injury	4090	Jeffreys Ledge, NH	EN	0.75	XU	NR	Full configuration unknown.
9/27/2011	Prorated Injury	3111	off Grand Manan Island, NB	EN	0.75	XC	NR	Constricting wrap on left flipper. Disentanglement attempted, but unsure if any cuts made. Final entanglement configuration unknown. Resight in 2012 did not confirm configuration or if still entangled, but health apparently improved.
2/15/2012	Serious Injury	3996	off Provincetown, MA	EN	1	XU	NR	Constricting gear across head and health decline.
7/19/2012	Mortality	-	Clam Bay, NS	EN	1	XC	GU	Multiple constricting wraps on peduncle; COD - peracute underwater entrapment.
9/24/2012	Serious Injury	3610	Bay of Fundy	EN	1	XC	NP	New significant raw & healing entanglement wounds on head, dorsal & ventral peduncle, and leading fluke edges. Health decline: moderate cyamid load, thin.

12/7/2012	Prorated Injury	-	off Wassaw Island, GA	VS	0.52	US	-	46' vessel, 12-13 kts struck whale. Animal not resighted but large expanding pool of blood at surface.
12/18/2012	Mortality	4193	off Palm Coast, FL	EN	1	US	PT	Constricting & embedded wraps w/ associated hemorrhaging at peduncle, mouthline, tongue, oral rete, rostrum & pectoral; malnourished.
7/12/2013	Prorated Injury	3123	off Virginia Beach, VA	EN	0.75	XU	NR	Constricting gear cutting into mouthline; Partially disentangled; final configuration unknown.
1/15/2014	Serious Injury	4394	off Ossabaw Island, GA	EN	1	XU	NR	Injuries indicating prior constricting gear on both pectorals and at fluke insertion. Injury to left ventral fluke. Evidence of health decline.
4/1/2014	Serious Injury	1142	off Atlantic City, NJ	EN	1	XU	NR	Constricting rostrum wrap with line trailing to at least mid-body.
4/2/2014	Serious Injury	3390	Cod Cape Bay	EN	1	XU	NP	Evidence of a rostrum wrap, body wrap just aft of blowholes, and damage to right pectoral, peduncle and leading fluke edges. Resights indicate health decline.

4/9/2014	Prorated Injury	-	Cape Cod Bay	VS	0.52	US	-	Animal surfaced underneath R/V Shearwater (39ft) while it was underway @ 9 kts. Small amount of blood and some lacerations of unknown depth on lower left flank.
6/29/2014	Serious Injury	1131	off Yarmouth, NS	EN	1	XC	NR	At least 1, possibly 2, embedded rostrum wraps. Remaining configuration unclear but extensive. Animal in extremely poor condition: emaciated, heavy cyamid coverage, overall pale skin.
9/4/2014	Serious Injury	4001	off Grand Manan, NB	EN	1	XC	NR	Free-swimming with constricting rostrum wrap.
9/4/2014	Mortality	-	off St. Pierre & Miquelon, NL	EN	1	XC	NR	No necropsy conducted, but evidence of extensive, constricting entanglement - constricting line around rostrum and body.
9/17/2014	Serious Injury	3279	off Grand Manan, NB	EN	1	XC	NR	Free-swimming with heavy, green line over head cutting into nares. In poor overall condition: heavy cyamids on head and blowholes. Left blowhole appears compromised.

9/27/2014	Mortality	-	off Nantucket, MA	EN	1	US	NR	No necropsy conducted, but fresh carcass with evidence of extensive, constricting entanglement - multiple line wraps around head, pectoral and peduncle.
12/18/2014	Serious Injury	3670	off Sapelo Sound, GA	EN	1	XU	NP	Portion of right lip torn away leaving an opening in mouth. Severe injuries to peduncle and leading & trailing fluke edges. Wrapping injuries on head and body. Possible damage to right pectoral. Resights indicate health decline.
Five-year averages		Vessel strike (US/CN/XU/XC)		1.01 (0.81/ 0.00/ 0.20/ 0.00)				
		Entanglement (US/CN/XU/XC)		4.65 (0.40/ 0.00/ 2.5/ 1.75)				
a. For more details on events please see Henry *et al.* 2016.								
b. The date sighted and location provided in the table are not necessarily when or where the serious injury or mortality occurred; rather, this information indicates when and where the whale was first reported beached, entangled, or injured.								
c. Mortality events are counted as 1 against PBR. Serious injury events have been evaluated using NMFS guidelines (NOAA 2012)								
d. CN=Canada, US=United States, XC=Unassigned 1st sight in CN, XU=Unassigned 1st sight in US								
e. H=hook, GN=gillnet, GU=gear unidentifiable, MF=monofilament, NP=none present, NR=none recovered/received, PT=pot/trap, WE=weir								

STATUS OF STOCK

The size of this stock is considered to be extremely low relative to OSP in the U.S. Atlantic EEZ, and this species is listed as endangered under the ESA. The North Atlantic right whale is considered one of the most critically endangered populations of large whales in the world (Clapham *et al.* 1999). Status review by the National Marine Fisheries Service affirms endangered status (NMFS Northeast Regional Office 2012). The total level of human-caused mortality and serious injury is unknown, but reported human-caused mortality and serious injury was a minimum of 5.65 right whales per year from 2010 through 2014. Given that PBR has been calculated as 1, any human-caused mortality or serious injury for this stock can be considered significant. This is a strategic stock because the average annual human-related mortality and serious injury exceeds PBR, and also because the North Atlantic right whale is an endangered species.

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HUMPBACK WHALE (*Megaptera novaeangliae*): Gulf of Maine Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the western North Atlantic, humpback whales feed during spring, summer and fall over a geographic range encompassing the eastern coast of the United States (including the Gulf of Maine), the Gulf of St. Lawrence, Newfoundland/Labrador, and western Greenland (Katona and Beard 1990). Other North Atlantic feeding grounds occur off Iceland, the Norwegian Sea, and northern Norway, including off Bear Island, Jan Mayen, and Franz Josef Land (Christensen *et al.* 1992; Palsbøll *et al.* 1997). These six regions represent relatively discrete subpopulations, fidelity to which is determined matrilineally (Clapham and Mayo 1987), which is supported by studies of the mitochondrial genome (Palsbøll *et al.* 1995; Palsbøll *et al.* 2001) and individual animal movements (Stevick *et al*. 2006). In early stock assessment reports, the North Atlantic humpback whale population was treated as a single stock for management purposes (Waring *et al.* 1999). Subsequently, a decision was made to reclassify the Gulf of Maine as a separate feeding stock (Waring *et al.* 2000) based upon the strong fidelity by individual whales to this region, and the attendant assumption that, were this subpopulation wiped out, repopulation by immigration from adjacent areas would not occur on any reasonable management timescale. During the 2002 Comprehensive Assessment of North Atlantic humpback whales, the International Whaling Commission acknowledged the evidence for treating the Gulf of Maine as a separate management unit (IWC 2002). During the summers of 1998 and 1999, the Northeast Fisheries Science Center conducted surveys for humpback whales on the Scotian Shelf to establish the occurrence and population identity of the animals found in this region, which lies between the well-studied populations of the Gulf of Maine and Newfoundland. Photographs from both surveys were compared to both the overall North Atlantic Humpback Whale Catalogue and a large regional catalogue from the Gulf of Maine (maintained by the College of the Atlantic and the Center for Coastal Studies, respectively); this work is summarized in Clapham *et al.* (2003). The match rate between the Scotian Shelf and the Gulf of Maine was 27% (14 of 52 Scotian Shelf individuals from both years). Comparable rates of exchange were obtained from the southern (28%, n=10 of 36 whales) and northern (27%, *n*=4 of 15 whales) ends of the Scotian Shelf (one whale was observed in both areas). In contrast, all of the 36 humpback whales identified by the same NMFS surveys elsewhere in the Gulf of Maine (including Georges Bank, southwestern Nova Scotia and the Bay of Fundy) had been previously observed in the Gulf of Maine region. The sighting histories of the 14 Scotian Shelf whales matched to the Gulf of Maine suggested that many of them were transient through the latter area. There were no matches between the Scotian Shelf and any other North Atlantic feeding ground, except the Gulf of Maine; however, instructive comparisons are compromised by the often low sampling effort in other regions in recent years. Overall, it appears that the northern range of many members of the Gulf of Maine stock does not extend onto the Scotian Shelf.

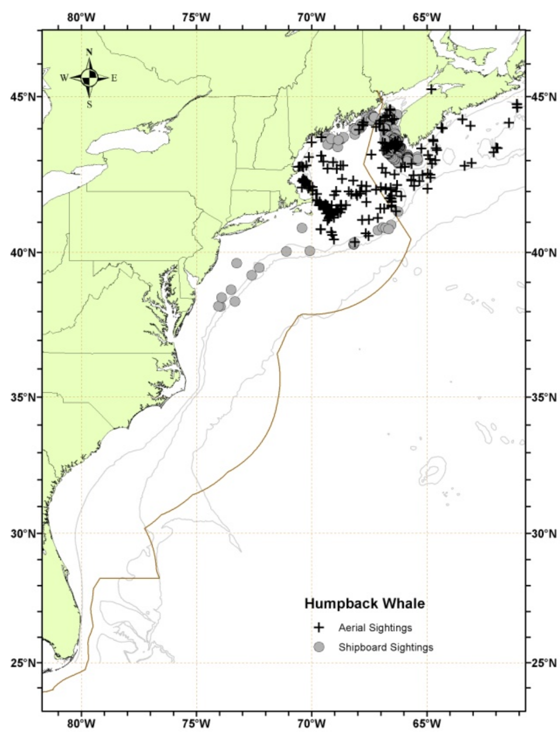

Figure 1. *Distribution of humpback whale sightings from NEFSC and SEFSC shipboard and aerial surveys during the summers of 1995, 1998, 1999, 2002, 2004, 2006, 2007, 2008, 2010 and 2011. Isobaths are the 100-m, 1000-m and 4000-m depth contours.*

During winter, whales from most North Atlantic feeding areas (including the Gulf of Maine) mate and calve in the West Indies, where spatial and genetic mixing among feeding groups occurs (Katona and Beard 1990; Clapham *et al.* 1993; Palsbøll *et al.* 1997; Stevick *et al.* 1998). Some whalesusing eastern North Atlantic feeding areas migrate to the Cape Verde Islands (Reiner *et al.* 1996; Wenzel *et al.* 2009, Stevick *et al.* 2016), and some individuals have been recorded in both the Cape Verde Islands and the Caribbean (Stevick e*t al*. 2016). In the West Indies, the majority of whales are found in the waters of the Dominican Republic, notably on Silver Bank and Navidad Bank, and in Samana Bay (Balcomb and Nichols 1982; Whitehead and Moore 1982; Mattila *et al.* 1989, 1994). Humpback whales are also found at much lower densities throughout the remainder of the Antillean arc (Winn *et al.* 1975; Levenson and Leapley 1978; Price 1985; Mattila and Clapham 1989). Although recognition of 2 breeding areas for North Atlantic humpbacks is the prevailing model, our knowledge of breeding season distribution is far from complete (see Smith and Pike 2009, Stevick *et al.* 2016).

All whales from this stock do not migrate to the West Indies every winter, because significant numbers of animals are found in mid- and high-latitude regions at this time (Clapham *et al.* 1993; Swingle *et al.* 1993) and some individuals have been sighted repeatedly within the same winter season (Clapham *et al.* 1993; Robbins 2007). Acoustic recordings made within the Massachusetts Bay area detected some level of humpback song and non-song detections in almost all months, with two prominent periods, March through May and September through December (Clark and Clapham 2004, Vu *et al*. 2012, Murray *et al.* 2013). This pattern of acoustic occurrence, especially for song, confirms the presence of male humpback whales in the area (a mid-latitude feeding ground) during periods that bracket male occurrence in the Caribbean region, where singing is highest during winter months. A complementary pattern of humpback singer occurrence was observed during the January – May period in the deep-ocean region north of the Caribbean and to the east of Bermuda during April (Clark and Gagnon 2002). These acoustic observations from both coastal and deep-ocean regions support the conclusion that at least male humpbacks are seasonally distributed throughout broad regions of the western North Atlantic. In addition, photographic records from Newfoundland have shown a number of adult humpbacks remain there year-round, particularly on the island's north coast. In collaboration with colleagues in the French islands of St. Pierre and Miquelon, a new photographic catalogue and concurrent matching effort is being undertaken for this region (J. Lawson, DFO, pers. comm.).

Within the U.S. Atlantic EEZ, humpback whales have been sighted well away from the Gulf of Maine. Sightings of humpback whales in the vicinity of the Chesapeake and Delaware Bays occurred in 1992 (Swingle *et al.* 1993). Wiley *et al.* (1995) reported that 38 humpback whale strandings occurred during 1985–1992 in the U.S. mid-Atlantic and southeastern states. Humpback whale strandings increased, particularly along the Virginia and North Carolina coasts, and most stranded animals were sexually immature; in addition, the small size of many of these whales strongly suggested that they had only recently separated from their mothers. Wiley *et al.* (1995) concluded that these areas were becoming an increasingly important habitat for juvenile humpback whales and that anthropogenic factors may negatively impact whales in this area. There have also been a number of wintertime humpback sightings in coastal waters of the southeastern U.S. Whether the increased numbers of sightings represent a distributional change, or are simply due to an increase in sighting effort and/or whale abundance, is unknown. Other sightings of note include multiple humpbacks feeding off Long Island during July of 2016 (https://www.greateratlantic.fisheries.noaa.gov/mediacenter/2016/july/26_humpback_whales_visit_new_york.html, accessed 28 April 2017) and sightings during November-December 2016 near New York City (https://www.greateratlantic.fisheries.noaa.gov/mediacenter/2016/december/09_humans_and_humpbacks_of_new_york_2.html, accessed 28 April 2017).

A key question with regard to humpback whales off the southeastern and mid-Atlantic states is their population identity. This topic was investigated using fluke photographs of living and dead whales observed in the region (Barco *et al.* 2002). In this study, photographs of 40 whales (alive or dead) were of sufficient quality to be compared to catalogs from the Gulf of Maine (i.e., the closest feeding ground) and other areas in the North Atlantic. Of 21 live whales, 9 (43%) matched to the Gulf of Maine, 4 (19%) to Newfoundland, and 1 (4.8%) to the Gulf of St Lawrence. Of 19 dead humpbacks, 6 (31.6%) were known Gulf of Maine whales. Although the population composition of the mid-Atlantic is apparently dominated by Gulf of Maine whales, lack of photographic effort in Newfoundland makes it likely that the observed match rates under-represent the true presence of Canadian whales in the region. A new photographic catalog and concurrent matching effort is being undertaken for this region which may improve knowledge in this regard. Barco *et al.* (2002) suggested that the mid-Atlantic region primarily represents a supplemental winter feeding ground used by humpbacks.

In New England waters, feeding is the principal activity of humpback whales, and their distribution in this region has been largely correlated to abundance of prey species, although behavior and bathymetry are factors influencing foraging strategy (Payne *et al.* 1986, 1990). Humpback whales are frequently piscivorous when in New England waters, feeding on herring (*Clupea harengus*), sand lance (*Ammodytes* spp.), and other small fishes. In the northern Gulf of Maine, euphausiids are also frequently taken (Paquet *et al.* 1997). Commercial depletion of herring and mackerel led to an increase in sand lance in the southwestern Gulf of Maine in the mid-1970s, with a concurrent decrease in humpback whale abundance in the northern Gulf of Maine. Humpback whales were densest over the sandy shoals in the southwestern Gulf of Maine favored by the sand lance during much of the late 1970s and early 1980s, and humpback distribution appeared to have shifted to this area (Payne *et al.* 1986). An apparent reversal began in the mid-1980s, and herring and mackerel increased as sand lance again decreased (Fogarty *et al.* 1991). Humpback whale abundance in the northern Gulf of Maine increased markedly during 1992–1993, along with a major influx of herring (P. Stevick, pers. comm.). Humpback whales were few in nearshore Massachusetts waters in the 1992–1993 summer seasons. They were more abundant in the offshore waters of Cultivator Shoal and on the Northeast Peak on Georges Bank and on Jeffreys Ledge; these latter areas are traditional locations of herring occurrence. In 1996 and 1997, sand lance and therefore humpback whales were once again abundant in the Stellwagen Bank area. However, unlike previous cycles, when an increase in sand lance corresponded to a decrease in herring, herring remained relatively abundant in the northern Gulf of Maine, and humpbacks correspondingly continued to occupy this portion of the habitat, where they also fed on euphausiids (Wienrich *et al.* 1997). Diel patterns in humpback foraging behavior have been shown to correlate with diel patterns in sand lance behavior (Friedlaender *et al.* 2009).

In early 1992, a major research program known as the Years of the North Atlantic Humpback (YONAH) (Smith *et al.* 1999) was initiated. This was a large-scale, intensive study of humpback whales throughout almost their entire North Atlantic range, from the West Indies to the Arctic. During two primary years of field work, photographs for individual identification and biopsy samples for genetic analysis were collected from summer feeding areas and from the breeding grounds in the West Indies. Additional samples were collected from certain areas in other years. Results pertaining to the estimation of abundance and to genetic population structure are summarized below.

POPULATION SIZE

North Atlantic Population

The overall North Atlantic population (including the Gulf of Maine), derived from genetic tagging data collected by the YONAH project on the breeding grounds, was estimated to be 4,894 males (95% CI=3,374-7,123) and 2,804 females (95% CI=1,776-4,463) (Palsbøll *et al.* 1997). Because the sex ratio in this population is known to be even (Palsbøll *et al.* 1997), the excess of males is presumed a result of sampling bias, lower rates of migration among females, or sex-specific habitat partitioning in the West Indies; whatever the reason, the combined total is an underestimate of overall population size. Photographic mark-recapture analyses from the YONAH project provided an ocean-basin-wide estimate of 11,570 animals during 1992/1993 (CV=0.068, Stevick *et al.* 2003), and an additional genotype-based analysis yielded a similar but less precise estimate of 10,400 whales (CV=0.138, 95% CI=8,000 to 13,600) (Smith *et al.* 1999).

Gulf of Maine stock - earlier estimates

Please see Appendix IV for earlier estimates. As recommended in the GAMMS Workshop Report (Wade and Angliss 1997), estimates older than eight years are deemed unreliable and should not be used for PBR determinations.

Gulf of Maine Stock - Recent surveys and abundance estimates

An abundance of 335 (CV=0.42) humpback whales was estimated from a line-transect survey conducted during June-August 2011 by ship and plane (Palka 2012). The aerial portion that contributed to the abundance estimate covered 5,313 km of tracklines that were over waters north of New Jersey and shallower than the 100-m depth contour through the U.S. and Canadian Gulf of Maine and up to and including the lower Bay of Fundy. The shipboard portion covered 3,107 km of tracklines that were in waters that were deeper than the 100-m depth contour out to beyond the U.S. EEZ. Both sighting platforms used a two-simultaneous-team data collection procedure, which allows estimation of abundance corrected for perception bias (Laake and Borchers, 2004). Estimation of abundance was based on the independent observer approach assuming point independence (Laake and Borchers 2004) and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009). This estimate did not include the portion of the Scotian Shelf that is known to be part of the range used by Gulf of Maine humpback whales. These various line-transect surveys lack consistency in geographic coverage, and because of the mobility of humpback whales, pooling stratum estimates across years to produce a single estimate is not advisable. However, similar to an estimate that appeared in Clapham *et al.* (2003), J. Robbins (Center for Coastal Studies, pers. comm.) used photo-id evidence of presence (see Robbins 2009, 2010, 2011 for data description) to calculate the minimum number alive of catalogued individuals seen during the 2008 feeding season within the Gulf of Maine, or seen both before and after 2008, plus whales seen for the first time as non-calves in 2009. That procedure placed the minimum number alive in 2008 at 823 animals.

Minimum Population Estimate

For statistically-based estimates, the minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally distributed best abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by Wade and Angliss (1997). The most recent line-transect survey, which did not include the Scotian Shelf portion of the stock, produced an estimate of abundance for Gulf of Maine humpback whales of 331 animals (CV=0.48) with a resultant minimum population estimate for this stock of 228 animals. The line-transect based Nmin is unrealistic because at least 500 uniquely identifiable individual whales from the GOM stock were seen during the calendar year of that survey and the actual population would have been larger because re-sighting rates of GOM humpbacks have historically been <1 (Robbins 2007). Using the minimum count from at least 2 years prior to the year of a stock assessment report allows time to resight whales known to be alive prior to and after the focal year. Thus, the minimum population estimate is set to the 2008 mark-recapture based count of 823.

Table 1. Summary of abundance estimates for Gulf of Maine humpback whales with month, year, and area covered during each abundance survey, and resulting abundance estimate (N_{best}) and coefficient of variation (CV). Note that the second row represents the results from an analysis of resights of individually identified animals.

Month/Year	Type	N_{best}	CV
Jun-Oct 2008	Gulf of Maine and Bay of Fundy	823	0
Jun-Aug 2011	Virginia to lower Bay of Fundy	335	0.42

Current Population Trend

As detailed below, the most recent available data suggest that the Gulf of Maine humpback whale stock is characterized by a positive trend in size. This is consistent with an estimated average trend of 3.1% (SE=0.005) in the North Atlantic population overall for the period 1979–1993 (Stevick *et al.* 2003), although there are no feeding-area-specific estimates. The best available estimate of the average rate of increase for the West Indies breeding population [which includes the Gulf of Maine feeding stock] is 3.1% per year (SE= 0.005) for the period 1979–1993 (Stevick et al. 2003), although this estimate is now over 20 years old. An analysis of demographic parameters for the Gulf of Maine (Clapham *et al.* 2003) suggested a lower rate of increase than the 6.5% reported by Barlow and Clapham (1997), but results may have been confounded by distribution shifts.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Zerbini *et al.* (2010) reviewed various estimates of maximum productivity rates for humpback whale populations, and, based on simulation studies, they proposed that 11.8% be considered as the maximum rate at which the species could grow. Barlow and Clapham (1997), applying an interbirth interval model to photographic mark-recapture data, estimated the population growth rate of the Gulf of Maine humpback whale stock at 6.5% (CV=0.012). Maximum net productivity is unknown for this population, although a theoretical maximum for any humpback population can be calculated using known values for biological parameters (Brandão *et al.* 2000; Clapham *et al.* 2001). For the Gulf of Maine stock, data supplied by Barlow and Clapham (1997) and Clapham *et al.* (1995) give values of 0.96 for survival rate, 6 years as mean age at first parturition, 0.5 as the proportion of females, and 0.42 for annual pregnancy rate. From this, a maximum population growth rate of 0.072 is obtained according to the method described by Brandão *et al.* (2000). This suggests that the observed rate of 6.5% (Barlow and Clapham 1997) is close to the maximum for this stock.

Clapham *et al.* (2003) updated the Barlow and Clapham (1997) analysis using data from the period 1992 to 2000. The population growth estimate was either 0% (for a calf survival rate of 0.51) or 4.0% (for a calf survival rate of 0.875). Although uncertainty was not strictly characterized by Clapham *et al.* (2003), their work might reflect a decline in population growth rates from the earlier study period. More recent work by Robbins (2007) places apparent survival of calves at 0.664 (95% CI: 0.517-0.784), a value between those used by Barlow and Clapham (1997) and in addition found productivity to be highly variable and well less than maximum.

Despite the uncertainty accompanying the more recent estimates of observed population growth rate for the Gulf of Maine stock, the maximum net productivity rate was assumed to be 6.5% calculated by Barlow and

Clapham (1997) because it represents an observation greater than the default of 0.04 for cetaceans (Barlow *et al.* 1995) but is conservative in that it is well below the results of Zerbini *et al.* (2010).

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of minimum population size, one-half the maximum productivity rate, and a recovery factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size for the Gulf of Maine stock is 823 whales. The maximum productivity rate is 0.065. In the previous SAR, the recovery factor was 0.10 because this stock was listed as an endangered species under the Endangered Species Act. Due to the 2016 revision to the ESA listing of humpback whales, in which the West Indies Distinct Population Segment (of which the Gulf of Maine stock is a part) was identified as not warranting listing (81 FR 62259, September 8, 2016), the recovery factor is revised to 0.5, the default value for stocks of unknown status relative to OSP (Wade and Angliss 1997). Values other than the defaults for any stock should usually not be used without the approval of the regional Scientific Review Group, and scientific justification for the change should be provided in the Report (NMFS 2016). As the revision to the species' ESA listing occurred after the February 2016 Scientific Review Group meeting, the default recovery factor is applied here. The Atlantic SRG will review the recovery factor for this stock at its February 2017 meeting. PBR for the Gulf of Maine humpback whale stock is 13 whales.

ANNUAL HUMAN-CAUSED SERIOUS INJURY AND MORTALITY

For the period 2010 through 2014, the minimum annual rate of human-caused mortality and serious injury to the Gulf of Maine humpback whale stock averaged 9.05 animals per year. This value includes incidental fishery interaction records, 7.25; and records of vessel collisions, 1.8 (Table 2; Henry *et al.* 2016).

In contrast to stock assessment reports before 2007, these averages include humpback mortalities and serious injuries that occurred in the southeastern and mid-Atlantic states that could not be confirmed as involving members of the Gulf of Maine stock. In past reports, only events involving whales confirmed to be members of the Gulf of Maine stock were counted against the PBR. Starting in the 2007 report, we assumed whales were from the Gulf of Maine unless they were identified as members of another stock. At the time of this writing, no whale was identified as a member of another stock. These determinations may change with the availability of new information. Canadian records from the southern side of Nova Scotia were incorporated into the mortality and serious injury rates, to reflect the effective range of this stock as described above. For the purposes of this report, discussion is primarily limited to those records considered to be confirmed human-caused mortalities or serious injuries.

To better assess human impacts (both vessel collision and commercial fishery mortality and serious injury) there needs to be greater emphasis on the timely recovery of carcasses and complete necropsies. The literature and review of records described here suggest that there are significant human impacts beyond those recorded in the data assessed for serious injury and mortality. For example, a study of entanglement-related scarring on the caudal peduncle of 134 individual humpback whales in the Gulf of Maine suggested that between 48% and 65% had experienced entanglements (Robbins and Mattila 2001). Decomposed and/or unexamined animals (e.g., carcasses reported but not retrieved or no necropsy performed) represent 'lost data', some of which may relate to human impacts.

Background

As with right whales, human impacts (vessel collisions and entanglements) may be slowing recovery of the humpback whale population. Van der Hoop *et al.* (2013) reviewed 1762 mortalities and serious injuries recorded for 8 species of large whales in the Northwest Atlantic for the 40 years 1970–2009. Of 473 records of humpback whales, cause of death could be attributed for 203. Of the 203, 116 (57%) mortalities were caused by entanglements in fishing gear, and 31 (15%) were attributable to vessel strikes.

Robbins and Mattila (2001) reported that males were more likely to be entangled than females. Annually updated inferences made from scar prevalence and multistate models of GOM humpback whales that (1) younger animals are more likely to become entangled than adults, (2) juvenile scarring rates may be trending up, (3) maybe less than 10% of humpback entanglements are ever reported, and (4) 3 % of the population maybe dying annually as the result of entanglements (Robbins 2009, 2010, 2011, 2012). Humpback whale entanglements also occur in relatively high numbers in Canadian waters. Reports of interactions with fixed fishing gear set for groundfish around Newfoundland averaged 365 annually from 1979 to 1987 (range 174-813). An average of 50 humpback whale entanglements (range 26-66) was reported annually between 1979 and 1988, and 12 of 66 humpback whales entangled in 1988 died (Lien *et al.* 1988). A total of 965 humpbacks was reported entangled in fishing gear in Newfoundland and Labrador from 1979 to 2008 (Benjamins *et al.* 2012). Volgenau *et al.* (1995) reported that in

Newfoundland and Labrador, cod traps caused the most entanglements and entanglement mortalities (21%) of humpbacks between 1979 and 1992. They also reported that gillnets were the primary cause of entanglements and entanglement mortalities (20%) of humpbacks in the Gulf of Maine between 1975 and 1990. In more recent times, following the collapse of the cod fishery, groundfish gillnets for other fish species and crab pot lines have been the most common sources of humpback entanglement in Newfoundland. Since the crab pot fishery is primarily an offshore activity on the Grand Banks, these entanglements are hard to respond to and are likely underreported. One humpback whale was reported released alive (status unknown) from a herring weir off Grand Manan in 2009 (H. Koopman, UNC Wilmington, pers. comm.). In U.S. waters, Johnson *et al*. (2005) found 40% of humpback entanglements were in trap/ pot gear and 50% were in gillnet, but sample sizes were small and much uncertainty still exists about the frequency of certain gear types involved in entanglement.

Wiley *et al.* (1995) reported that serious injuries attributable to ship strikes are more common and probably more serious than those from entanglements, but this claim is not supported by more recent analysis. Non-lethal interactions with gear are extremely common (see Robbins 2010, 2011, 2012) and recent analysis suggests entanglement serious injuries and mortalities are more common than ship strikes (van der Hoop *et al.* 2013). Furthermore, in the NMFS records for 2010 through 2014, there are only 9 reports of serious injuries and mortalities as a result of collision with a vessel and 40 records of injuries (prorated or serious) and mortalities attributed to entanglement. Because it has never been shown that serious injuries and mortalities related to ships or to fisheries interactions are equally detectable, it is unclear as to which human source of mortality is more prevalent. A major aspect of vessel collision that will be cryptic as a serious injury is blunt trauma, where when lethal it is usually undetectable from an external exam (Moore *et al.* 2013). No whale involved in the recorded vessel collisions had been identified as a member of a stock other than the Gulf of Maine stock at the time of this writing (Henry *et al.* 2016).

Fishery-Related Serious Injuries and Mortalities

A description of fisheries is provided in Appendix III. Two mortalities were observed in the pelagic drift gillnet fishery, one in 1993 and the other in 1995. In winter 1993, a juvenile humpback was observed entangled and dead in a pelagic drift gillnet along the 200-m isobath northeast of Cape Hatteras. In early summer 1995, a humpback was entangled and found dead in a pelagic drift gillnet on southwestern Georges Bank. Additional reports of mortality and serious injury, as well as description of total human impacts, are contained in records maintained by NMFS. A number of these records (11 entanglements involving lobster pot/trap gear) from the 1990–1994 period were the basis used to reclassify the lobster fishery (62 FR 33, Jan. 2, 1997). Large whale entanglements are rarely observed during fisheries sampling operations. However, during 2008, 3 humpback whales were observed as incidental bycatch: 2 in gillnet gear (1 no serious injury; 1 undetermined) and 1 in a purse seine (released alive), in 2011 a humpback was caught on an observed gillnet trip (disentangled and released free of gear; Henry *et al.* 2016), and in 2012 there was an observed interaction with a humpback whale in mid-Atlantic gillnet gear (non-serious injury). A recent review (Cassoff *et al*. 2011) describes in detail the types of injuries that baleen whales, including humpbacks, suffer as a result of entanglement in fishing gear.

For this report, the records of dead, injured, and/or entangled humpbacks (found either stranded or at sea) for the period 2010 through 2014 were reviewed. When there was no evidence to the contrary, events were assumed to involve members of the Gulf of Maine stock. While these records are not statistically quantifiable in the same way as observer fishery records, they provide some indication of the minimum frequency of entanglements. Specifically to this stock, if the calculations of Robbins (2011, 2012) are reasonable then the 3% mortality due to entanglement that she calculates equates to a minimum average rate of 25, which is nearly 10 times PBR.

Table 2. Confirmed human-caused mortality and serious injury records of Humpback Whales (*Megaptera novaeangliae*) where the cause was assigned as either an entanglement (EN) or a vessel strike (VS): 2010–2014 [a]

Date[b]	Injury Determination	ID	Location[b]	Assigned Cause	Value against PBR[c]	Country[d]	Gear Type[e]	Description
3/7/2010	Serious Injury	-	off Ponte Vedra Beach, FL	EN	1	XU	NR	Constricting body & flipper wraps. May have

								shed some or all of gear, but severe health decline: emaciated, heavy cyamid load.
3/13/2010	Mortality	-	Ocean City Inlet, MD	VS	1	US	-	Skull fractures w/ associated hemorrhaging
5/5/2010	Serious Injury	-	off Northampton, VA	EN	1	XU	NR	Wrap around fluke blades near insertion & trailing gear. Gear likely to become constricting as animal grows.
5/8/2010	Mortality	-	off Point Judith, RI	EN	1	US	GN	Evidence of constricting gear w/ associated hemorrhaging. Fluid filled lungs.
5/15/2010	Mortality	-	Hatteras Inlet, NC	EN	1	XU	NP	Live stranding - euthanized. Necrotic infected wounds at base of flukes & chronic abrasions on head.
5/28/2010	Mortality	-	off Martha's Vineyard, MA	EN	1	XU	GU	Evidence of entanglement w/ associated bruising & edema.
6/10/2010	Mortality	-	Jones Beach State Park, NY	VS	1	US	-	Extensive hemorrhage & edema on right dorsal lateral surface.
7/4/2010	Mortality	-	off Ocean City Inlet, MD	VS	1	US	-	Extensive hemorrhage & edema to left lateral area.

7/26/2010	Prorated Injury	-	off Chatham, MA	EN	0.75	XU	NR	Full configuration unknown.
8/13/2010	Serious Injury	-	off Orleans, MA	EN	1	US	PT	Partial disentanglement, but remaining head wrap likely to become constricting.
8/20/2010	Serious Injury	Chili	off Provincetown, MA	EN	1	XU	NR	Embedded wraps;health decline: thin, moderate cyamids, sloughing skin, fluke discoloration
9/10/2010	Prorated Injury	-	off White Head Island, New Brunswick	EN	0.75	XC	NR	Full configuration unknown.
10/2/2010	Prorated Injury	-	off Provincetown, MA	EN	0.75	XU	NR	Full configuration unknown. Unable to confirm if a resight of 8/20/10 event.
11/27/2010	Mortality	-	off Grand Manan Island, New Brunswick	EN	1	XC	NR	Evidence of constricting wraps on fluke, peduncle, & pectoral
12/23/2010	Serious Injury	-	off Port Everglades Inlet, FL	EN	1	XU	NP	Evidence of recent constricting entanglement & severe health decline.
1/7/2011	Serious Injury	-	off Oregon Inlet, NC	EN	1	US	GN	Extensive entanglement w/ netting covering majority of body including head, blowholes, & flukes. Immobile & drifting.

2/1/2011	Serious Injury	EKG	off Bar Harbor, ME	EN	1	US	NR	Anchored. Cuts were made to gear but whale remained anchored.
3/7/2011	Mortality	-	Thorofare Bay, NC	VS	1	US	-	Live stranded w/ 8 deep lacerations across back. Euthanized.
4/11/2011	Prorated Injury	-	off Rockport, MA	EN	0.75	XU	NR	Full configuration unknown.
5/5/2011	Mortality	-	Little Compton, RI	VS	1	US	-	Hemorrhaging at left jaw associated w/ blunt trauma.
5/27/2011	Mortality	-	Island Beach State Park, NJ	VS	1	US	-	5 broken vertebral processes along left side w/ associated hemorrhaging.
5/30/2011	Prorated Injury	-	off Orleans, MA	EN	0.75	XU	NR	Full configuration unknown.
7/2/2011	Serious Injury	-	off Provincetown, MA	EN	1	XU	NP	Young whale. Missing flukes attributed to chronic entanglement. Laceration due to VS appears minor. Significant health decline: emaciated, swimming by use of pectorals only
7/9/2011	Prorated Injury	-	off Monomoy Island, MA	EN	0.75	XU	NR	Full configuration unknown.
7/10/2011	Prorated Injury	-	off Monomoy Island, MA	EN	0.75	XU	NR	Report of two entangled whales but could not confirm that both were entangled.

								Full configuration unknown.
7/21/2011	Prorated Injury	-	off Oregon Inlet, NC	EN	0.75	XU	NR	Full configuration unknown.
10/10/2011	Serious Injury	Clutter	off Grand Manan Island, New Brunswick	EN	1	XC	NR	Embedded wraps at fluke insertion.
4/29/2012	Serious Injury	-	off Chatham, MA	EN	1	US	NR	SI based on description of body position which indicates anchored
7/29/2012	Serious Injury	-	off Gloucester, MA	EN	1	XU	NR	Calf w/ line cutting into peduncle
8/4/2012	Serious Injury	Aphid	off Provincetow n, MA	EN	1	XU	NR	Line exiting both sides of mouth, under flippers, twisting together aft of the dorsal fin & trailing 75 ft past flukes; no wraps. Health decline: thin w/ graying skin.
8/21/2012	Prorated Injury	2011 Calf of Wizard	off Provincetow n, MA	EN	0.75	XU	MF	Full configuration unknown
8/24/2012	Serious Injury	Forceps	off Provincetow n, MA	EN	1	US	NR	Closed, possibly weighted, bridle w/ large tangle of line just above left eye. SI due to odd behavior & apparent difficulty staying at the surface.
04/03/2013	Mortality	-	off Ft Story, VA	VS	1	US	-	Fractured orbitals & ribs w/

								associated bruising
09/13/2013	Mortality	-	York River, VA	VS	1	US	-	6 lacerations penetrate into muscle w/ associated hemorrhaging
09/16/2013	Prorated Injury	-	off Chatham, MA	EN	0.75	XU	NR	Partial disentanglem ent; original & final configuration s unknown
09/28/2013	Mortality	-	off Saltaire, NY	EN	1	XU	GU	Embedded line in mouth w/ associated hemorrhaging & necrosis; evidence of constriction at pectorals, peduncle & fluke w/ associated hemorrhaging ; emaciated
10/01/2013	Mortality	-	Buzzards Bay, MA	EN	1	US	NP	Evidence of underwater entrapment & subsequent drowning.
10/04/2013	Serious Injury	-	off Chatham, MA	EN	1	XU	NR	Full configuration unknown, but evidence of health decline: emaciation & pale skin
06/02/14	Prorated Injury	-	15 mi E of Monomoy Island, MA	EN	0.75	XU		Free-swimming with buoy and highflier trailing 100ft aft of flukes. Attachment point(s) unknown. Unable to confirm if resighted on 21Jun2014.

06/21/14	Prorated Injury		5 mi E of Gloucester, MA	EN	0.75	XU		Free-swimming trailing a buoy and possibly another buoy/highflier aft. Attachment point(s) unknown. Unable to confirm if this is a resight of 02Jun2014.
07/18/14	Serious Injury		Provincetown Harbor, MA	EN	1	XU		Free-swimming, trailing short amount of line from left side of mouth. No other gear noted, but evidence of previously more complicated, constricting entanglement. Current configuration deemed non-life threatening. Unsuccessful disentanglement attempt. In poor condition - emaciated with some cyamids. No resights
09/04/14	Serious Injury	4001	8 mi SE of Grand Manan, NB	EN	1	XC		Free-swimming with constricting rostrum wrap. Remaining configuration unknown. No resights post Oct 2014.

09/11/14	Mortality	Spinnaker	10 nm SE of Frenchboro, ME	EN	1	XU		Free-swimming with gillnet gear. Found anchored on 12Sep2014. Gillnet panel lodged in mouth and tightly wrapping forward part of body. Panel entangled in pots with 20+ wraps of pot lines around flukes and peduncle. Mostly disentangled--left with short section of gillnet in mouth expecting to shed. Animal entangled again (14May2015 - anchored and disentangled). Carcass found 11Jun2015. Necropsy revealed gillnet from 2014 entanglement embedded deep into the maxilla and through the vomer. Bone had started to grow around the line. Gillnet is unknown origin. Pot/trap is US gear.

09/17/14	Serious Injury	3279	10 mi SE of Grand Manan, NB	EN	1	XC	Unknown	Free-swimming with heavy, green line over head cutting into nares. Remaining configuration unknown. In poor overall condition: heavy cyamids on head and blowholes. Left blowhole appears compromised. No resights.
09/20/14	Prorated Injury	NYC0010	off Rockaway Beach, Long Island, NY	EN	.75	US		Free-swimming with netting and rope with floats wrapping flukes. Entanglement noticed during photo processing. Full configuration unknown. No resights.
10/01/14	Prorated Injury		15 mi E of Metompkin Inlet, VA	EN	.75	US		Free-swimming whale with line & netting on left fluke blade. Gear appeared heavy. Full configuration unknown. No resights.
11/25/14	Mortality		Miacomet Beach, Nantucket, MA	VS	1	XU		Emaciated carcass. Bruising & edema associated with skull fractures. Proximate COD=renal parasitism

								and consequent failure. Ultimate COD=blunt trauma from vessel strike.
12/15/14	Prorated Injury		8.5 nm S of Grand Manan, NB	EN	.75	XC	PT	Fisherman found animal entangled in trawl. Grappled line, animal dove. Upon surfacing, appeared free of gear, but unable to confirm gear free. Original and final configuration unknown.
12/25/14	Mortality	Triomphe	Little Cranberry Island, ME	EN	1	XU		Fresh carcass with evidence of extensive constricting entanglement. No necropsy, but robust body condition and histopatholog y results of samples support EN as COD.
Five-year averages		Shipstrike (US/CN/XU/XC)			1. 80 (1.60/ 0.00/ 0.20/ 0.00)			
		Entanglement (US/CN/XU/XC)			7.25 (1.7/ 0.00/ 4.545/ 1.10)			
a. For more details on events please see Henry *et al.* 2016.								
b. The date sighted and location provided in the table are not necessarily when or where the serious injury or mortality occurred; rather, this information indicates when and where the whale was first reported beached, entangled, or injured.								
c. Mortality events are counted as 1 against PBR. Serious injury events have been evaluated using NMFS guidelines (NOAA 2012)								
d. CN=Canada, US=United States, XC=Unassigned 1st sight in CN, XU=Unassigned 1st sight in US								
e. H=hook, GN=gillnet, GU=gear unidentifiable, MF=monofilament, NP=none present, NR=none recovered/received, PT=pot/trap, WE=weir								

Other Mortality

Between November 1987 and January 1988, at least 14 humpback whales died after consuming Atlantic mackerel containing a dinoflagellate saxitoxin (Geraci *et al.* 1989). The whales subsequently stranded or were recovered in the vicinity of Cape Cod Bay and Nantucket Sound, and it is highly likely that other unrecorded mortalities occurred during this event. During the first six months of 1990, seven dead juvenile (7.6 to 9.1 m long) humpback whales stranded between North Carolina and New Jersey. The significance of these strandings is unknown.

Between July and September 2003, an Unusual Mortality Event (UME) that included 16 humpback whales was invoked in offshore waters of coastal New England and the Gulf of Maine. Biotoxin analyses of samples taken from some of these whales found saxitoxin at very low/questionable levels and domoic acid at low levels, but neither were adequately documented and therefore no definitive conclusions could be drawn. Seven humpback whales were considered part of a large whale UME in New England in 2005. Twenty-one dead humpback whales found between 10 July and 31 December 2006 triggered a humpback whale UME declaration. Causes of these UME events have not been determined.

STATUS OF STOCK

NMFS conducted a global status review of humpback whales (Bettridge *et al*. 2015) and recently revised the ESA listing of the species (81 FR 62259, September 8, 2016). The distinct population segments (DPSs) established in the final rule that occur in waters under the jurisdiction of the United States do not necessarily equate to the existing MMPA stocks. NMFS is evaluating the stock structure of humpback whales under the MMPA, but no changes to current stock structure are presented at this time. As noted within the humpback whale ESA-listing final rule, in the case of a species or stock that achieved its depleted status solely on the basis of its ESA status, such as the humpback whale, the species or stock would cease to qualify as depleted under the terms of the definition set forth in MMPA Section 3(1) if the species or stock is no longer listed as threatened or endangered. The final rule indicated that until the stock delineations are reviewed in light of the DPS designations, NMFS would consider stocks that do not fully or partially coincide with a listed DPS as not depleted for management purposes. Therefore, the Gulf of Maine stock is considered not depleted because it does not coincide with any ESA-listed DPS. The detected level of U.S. fishery-caused mortality and serious injury derived from the available records, which is likely biased low, is more than 10% of the calculated PBR and, therefore, cannot be considered to be insignificant or approaching a zero mortality and serious injury rate. This is not a strategic stock because the average annual human-related mortality and serious injury does not exceed PBR.

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FIN WHALE (*Balaenoptera physalus*): Western North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The Scientific Committee of the International Whaling Commission (IWC) has proposed stock boundaries for North Atlantic fin whales. Fin whales off the eastern United States, Nova Scotia, and the southeastern coast of Newfoundland are believed to constitute a single stock under the present IWC scheme (Donovan 1991). Although the stock identity of North Atlantic fin whales has received much recent attention from the IWC, current understanding of stock boundaries remains uncertain. The existence of a subpopulation structure was suggested by local depletions that resulted from commercial overharvesting (Mizroch *et al.* 1984).

A genetic study conducted by Bérubé *et al.* (1998) using both mitochondrial and nuclear DNA provided strong support for an earlier population model proposed by Kellogg (1929) and others. This postulates the existence of several subpopulations of fin whales in the North Atlantic and Mediterranean with limited gene flow among them. Bérubé *et al.* (1998) also proposed that the North Atlantic population showed recent divergence due to climatic changes (i.e., postglacial expansion), as well as substructuring over even relatively short distances. The genetic data are consistent with the idea that different subpopulations use the same feeding ground, a hypothesis that was also originally proposed by Kellogg (1929). More recent genetic studies have called into question conclusions drawn from early allozyme work (Olsen *et al.* 2014) and North Atlantic fin whales show a very low rate of genetic diversity throughout their range excluding the Mediterranean (Pampoulie *et al*. 2008).

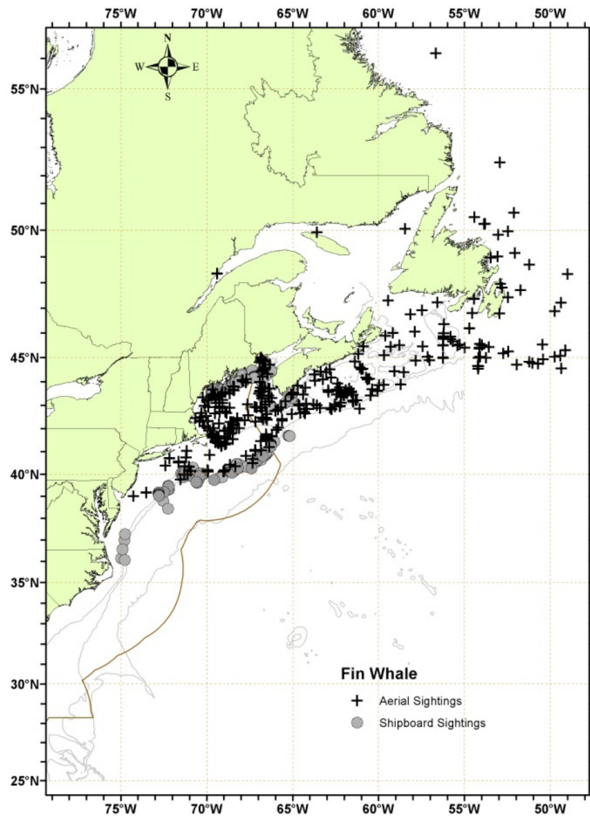

Figure 1.*Distribution of fin whale sightings from NEFSC and SEFSC shipboard and aerial surveys during the summers of 1995, 1998, 1999, 2002, 2004, 2006, 2007, 2008, 2010 and 2011 and DFO's 2007 TNASS survey. Isobaths are the 100-m, 1000-m and 4000-m depth contours.*

Fin whales are common in waters of the U. S. Atlantic Exclusive Economic Zone (EEZ), principally from Cape Hatteras northward (Figure 1). In a recent globally-scaled review of sightings data, Edwards *et al.* (2015) found evidence to confirm the presence of fin whales in every season throughout much of the US EEZ north of 35º. Fin whales accounted for 46% of the large whales and 24% of all cetaceans sighted over the continental shelf during aerial surveys (CETAP 1982) between Cape Hatteras and Nova Scotia during 1978–1982. While much remains unknown, the magnitude of the ecological role of the fin whale is impressive. In this region fin whales are the dominant large cetacean species during all seasons, having the largest standing stock, the largest food requirements, and therefore the largest influence on ecosystem processes of any cetacean species (Hain *et al.* 1992; Kenney *et al.* 1997). Acoustic detections of fin whale singers augment and confirm these visual sighting conclusions for males. Recordings from Massachusetts Bay, New York bight, and deep-ocean areas detected some level of fin whale singing from September through June (Watkins et al. 1987, Clark and Gagnon 2002, Morano et al. 2012). These acoustic observations from both coastal and deep-ocean regions support the conclusion that male fin whales are broadly distributed throughout the western North Atlantic for most of the year.

New England waters represent a major feeding ground for fin whales. There is evidence of site fidelity by females, and perhaps some segregation by sexual, maturational, or reproductive class in the feeding area (Agler *et* *al.* 1993). Seipt *et al.* (1990) reported that 49% of identified fin whales sighted on the Massachusetts Bay area feeding grounds were resighted within the same year, and 45% were resighted in multiple years. The authors suggested that fin whales on these grounds exhibited patterns of seasonal occurrence and annual return that in some respects were similar to those shown for humpback whales. This was reinforced by Clapham and Seipt (1991), who showed maternally-directed site fidelity for fin whales in the Gulf of Maine.

Hain *et al.* (1992), based on an analysis of neonate stranding data, suggested that calving takes place during October to January in latitudes of the U.S. mid-Atlantic region; however, it is unknown where calving, mating, and wintering occur for most of the population. Results from the Navy's SOSUS program (Clark 1995) indicated a substantial deep-ocean distribution of fin whales. It is likely that fin whales occurring in the U.S. Atlantic EEZ undergo migrations into Canadian waters, open-ocean areas, and perhaps even subtropical or tropical regions. However, the popular notion that entire fin whale populations make distinct annual migrations like some other mysticetes has questionable support in the data; in the North Pacific, year-round monitoring of fin whale calls found no evidence for large-scale migratory movements (Watkins *et al.* 2000).

POPULATION SIZE

The best abundance estimate available for the western North Atlantic fin whale stock is 1,618 (CV=0.33). This is the estimate derived from the 2011 NOAA shipboard surveys and is considered best because it represents the only current data. It is likely that the available estimate underestimates this stock’s abundance because much of the stock’s range was not included in the surveys upon which the estimate is based.

Earlier abundance estimates

Please see Appendix IV for earlier abundance estimates. As recommended in the GAMMS II Workshop Report (Wade and Angliss 1997), estimates older than eight years are deemed unreliable for the determination of a current PBR.

Recent surveys and abundance estimates

An abundance estimate of 1,595 (CV=0.33) fin whales was generated from a shipboard and aerial survey conducted during June–August 2011 (Palka 2012). The aerial portion that contributed to the abundance estimate covered 5,313 km of tracklines that were over waters north of New Jersey from the coastline to the 100-m depth contour, through the U.S. and Canadian Gulf of Maine and up to and including the lower Bay of Fundy. The shipboard portion covered 3,107 km of tracklines that were in waters offshore of North Carolina to Massachusetts (waters that were deeper than the 100-m depth contour out to beyond the U.S. EEZ). Both sighting platforms used a double-platform data collection procedure, which allows estimation of abundance corrected for perception bias of the detected species (Laake and Borchers 2004). Estimation of the abundance was based on the independent observer approach assuming point independence (Laake and Borchers 2004) and calculated using the multiple-covariate distance sampling (MCDS) option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009).The abundance estimates of fin whales include a percentage of the estimate of animals identified as fin/sei whales (the two species being sometimes hard to distinguish).The percentage used is the ratio of positively identified fin whales to the total number of positively identified fin whales and positively identified sei whales; the CV of the abundance estimate includes the variance of the estimated fraction.

An abundance estimate of 23 (CV=0.87) fin whales was generated from a shipboard survey conducted concurrently (June–August 2011) in waters between central Virginia and central Florida. This shipboard survey included shelf-break and inner continental slope waters deeper than the 50-m depth contour within the U.S. EEZ. The survey employed two independent visual teams searching with 25× bigeye binoculars. A total of 4,445 km of tracklines was surveyed, yielding 290 cetacean sightings. The majority of sightings occurred along the continental shelf break with generally lower sighting rates over the continental slope. Estimation of the abundance was based on the independent observer approach assuming point independence (Laake and Borchers 2004) and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009).

Table 1. Summary of recent abundance estimates for western North Atlantic fin whales with month, year, and area covered during each abundance survey, and resulting abundance estimate (N_{best}) and coefficient of variation (CV).

Month/Year	Area	N_{best}	CV
Jun-Aug 2011	Central Virginia to lower Bay of Fundy	1,595	0.33

Jun-Aug 2011	Central Florida to Central Virginia	23	0.76
Jun-Aug 2011	Central Florida to lower Bay of Fundy (COMBINED)	1,618	0.33

Minimum Population Estimate

The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally distributed best abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by Wade and Angliss (1997). The best estimate of abundance for fin whales is 1,618 (CV=0.33). The minimum population estimate for the western North Atlantic fin whale is 1,234.

Current Population Trend

A trend analysis has not been conducted for this stock. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval. For example, the power to detect a precipitous decline in abundance (i.e., 50% decrease in 15 years) with estimates of low precision (e.g., CV > 0.30) remains below 80% (alpha = 0.30) unless surveys are conducted on an annual basis (Taylor *et al.* 2007).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. Based on photographically identified fin whales, Agler *et al.* (1993) estimated that the gross annual reproduction rate was 8%, with a mean calving interval of 2.7 years.

For purposes of this assessment, the maximum net productivity rate was assumed to be 0.04. This value is based on theoretical modeling showing that cetacean populations may not grow at rates much greater than 4% given the constraints of their reproductive life history (Barlow *et al.* 1995).

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of minimum population size, one-half the maximum productivity rate, and a recovery factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size is 1,234. The maximum productivity rate is 0.04, the default value for cetaceans. The recovery factor is 0.10 because the fin whale is listed as endangered under the Endangered Species Act (ESA). PBR for the western North Atlantic fin whale is 2.5. Because there is a strong likelihood the abundance estimate used to calculate PBR was biased low due to incomplete coverage of the stock's range, it is therefore likely that this PBR calculation is low.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

For the period 2010 through 2014, the minimum annual rate of human-caused mortality and serious injury to fin whales was 3.8 per year. This value includes incidental fishery interaction records, 1.8 (0.2 U.S./0.8 Canadian/0.8 unknown but first reported in U.S. waters); and records of vessel collisions, 2.0 (all U.S.) (Table 2; Henry *et al.* 2016). Annual rates calculated from detected mortalities should not be considered an unbiased representation of human-caused mortality, but they represent a definitive lower bound. Detections are haphazard and not the result of a designed sampling scheme. As such they represent a minimum estimate of human-caused mortality which is almost certainly biased low.

Fishery-Related Serious Injury and Mortality

No confirmed fishery-related mortalities or serious injuries of fin whales have been reported in the NMFS Sea Sampling bycatch database. A review of the records of stranded, floating, or injured fin whales for the period 2010 through 2014 on file at NMFS found 4 records with substantial evidence of fishery interactions causing mortality (Henry *et al.* 2016). Serious injury determinations from non-fatal fishery interaction records yielded a value of 5.0 over five years, for an annual average of 1.0 (Henry *et al.* 2016). The resultant estimated minimum annual rate of serious injury and mortality from fishery interactions for this fin whale stock is 1.8. These records are not statistically quantifiable in the same way as the observer fishery records, and they almost surely undercount entanglements for the stock.

Table 2a. Confirmed human-caused mortality and serious injury records of fin whales (*Balaenoptera physalus*) first reported in U.S. waters or attributed to U.S. where the cause was assigned as either an entanglement (EN) or a vessel strike (VS): 2010–2014[a]

Date[b]	Injury Determination	ID	Location[b]	Assigned Cause	Value against PBR[c]	Country[d]	Gear Type[e]	Description
3/18/10	Mortality	-	South Delaware Bay Beach, DE	VS	1	US	-	Fractured skull w/ associated hemorrhaging.Abrasion mid-dorsal consistent w/ being folded over the bow of a ship.
9/3/10	Mortality	-	Cape Henlopen State Park, DE	VS	1	US	-	Large laceration & vertebral fractures w/ associated hemorrhaging.
1/1/11	Mortality	-	off Portland, ME	EN	1	XU	NP	Fresh carcass w/ evidence of constricting gear.
6/5/11	Mortality	-	off Long Branch, NJ	VS	1	US	-	Extensive hemorrhage & soft tissue damage to the dorsal & right lateral thoracic region.
9/21/11	Mortality	-	off Atlantic City, NJ	EN	1	US	NP	Fresh carcass w/ evidence of extensive entanglement.
1/23/12	Mortality	-	Ocean City, NJ	VS	1	US	-	Hemorrhaging along right, midlateral surface.
2/19/12	Mortality	-	Norfolk, VA	VS	1	US	-	Deep laceration on head. Skeletal fractures of rostrum and vertebrae. Extensive hemorrhaging.
7/16/12	Prorated Injury	-	off Portland, ME	EN	0.75	XU	NR	Full configuration unknown.
7/30/12	Prorated Injury	0631	off Portsmouth, NH	EN	0.75	XU	NR	Full configuration unknown.
8/10/12	Mortality	-	Hampton Bays, NY	VS	1	US	-	Extensive bruising along right lateral and ventral aspects.
10/7/12	Mortality	-	Boston Harbor, MA	VS	1	US	-	Deep mid-line impression with associated hemorrhaging consistent with being folded across bow of ship.

1/13/13	Mortality	-	East Hampton, NJ	VS	1	US	-	Fracturing of left cranium with associated hematoma
4/12/14	Mortality	-	Port Elizabeth, NJ	VS	1	US	-	Fresh carcass on bow of vessel. Large external abrasions w/ associated hemorrhage and skeletal fractures along right side.
6/23/14	Prorated Injury		off Chatham, MA	EN	0.75	XU	NR	Free-swimming, trailing 200ft of line. Attachment point(s) unknown. No resights.
8/20/14	Prorated Injury		off Provincetown , MA	EN	0.75	XU	NR	Free-swimming, trailing buoy & 200ft of line aft of flukes. Attachment point(s) unknown. No resights.
10/5/14	Mortality	-	off Manasquan, NJ	VS	1	US	-	Large area of hemorrhage along dorsal, ventral, and right lateral surfaces consistent with blunt force trauma.
Five-year averages			Shipstrike (US/ XU)		2.0 (2.0/ 0.0)			
			Entanglement (US/ XU)		1.0 (0.2/ 0.8)			
a. For more details on events please see Henry *et al.* 2016.								
b. The date sighted and location provided in the table are not necessarily when or where the serious injury or mortality occurred; rather, this information indicates when and where the whale was first reported beached, entangled, or injured.								
c. Mortality events are counted as 1 against PBR. Serious injury events have been evaluated using NMFS guidelines (NOAA 2012)								
d. US=United States, XU=Unassigned 1st sight in U.S.								
e. H=hook, GN=gillnet, GU=gear unidentifiable, MF=monofilament, NP=none present, NR=none recovered/received, PT=pot/trap, WE=weir								

Table 2b. Confirmed human-caused mortality and serious injury records of fin whales (*Balaenoptera physalus*) first reported in Canadian waters or attributed to Canada where the cause was assigned as either an entanglement (EN) or a vessel strike (VS): 2010–2014[a]

Date[b]	Injury Determination	ID	Location[b]	Assigned Cause	Value against PBR[c]	Country[d]	Gear Type[e]	Description
7/2/11	Serious Injury	F100	Gulf of St. Lawrence	EN	1	CN	PT	Deep lacerations at peduncle. Unconfirmed if gear free.
7/24/11	Mortality	-	Cheticamp, Nova Scotia	EN	1	CN	NP	Fresh carcass w/ evidence of extensive entanglement.

6/6/13	Serious Injury	Capitaine Crochet	St. Lawrence Marine Park, Quebec	EN	1	CN	PT	Pot resting on upper jaw w/ bridle lines embedding in mouth; health decline: emaciation
5/13/14	Mortality	-	Rocky Harbour, NL	EN	1	CN	PT	Fresh carcass hog-tied in gear.
Five-year averages		Shipstrike (CN/XC)			0			
		Entanglement (CN/XC)			0.8 (0.8/ 0.0)			
a. For more details on events please see Henry *et al.* 2016.								
b. The date sighted and location provided in the table are not necessarily when or where the serious injury or mortality occurred; rather, this information indicates when and where the whale was first reported beached, entangled, or injured.								
c. Mortality events are counted as 1 against PBR. Serious injury events have been evaluated using NMFS guidelines (NOAA 2012)								
d. CN=Canada, XC=Unassigned 1st sight in CN								
e. H=hook, GN=gillnet, GU=gear unidentifiable, MF=monofilament, NP=none present, NR=none recovered/received, PT=pot/trap, WE=weir								

Other Mortality

After reviewing NMFS records for 2010 through 2014, 10 were found that had sufficient information to confirm the cause of death as collisions with vessels (Table 2; Henry *et al.* 2016). These records constitute an annual rate of serious injury or mortality of 2.0 fin whales from vessel collisions.

STATUS OF STOCK

This is a strategic stock because the fin whale is listed as an endangered species under the ESA. The total level of human-caused mortality and serious injury is unknown. NMFS records represent coverage of only a portion of the area surveyed for the population estimate for the stock. The total U.S. fishery-related mortality and serious injury for this stock derived from the available records is likely biased low and is not less than 10% of the calculated PBR. Therefore entanglement rates cannot be considered insignificant and approaching a zero mortality and serious injury rate. The status of this stock relative to OSP in the U.S. Atlantic EEZ is unknown. There are insufficient data to determine the population trend for fin whales.

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SEI WHALE (*Balaenoptera borealis borealis*): Nova Scotia Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Mitchell and Chapman (1977) reviewed the sparse evidence on stock identity of northwestern Atlantic sei whales, and suggested two stocks—a Nova Scotia stock and a Labrador Sea stock. The range of the Nova Scotia stock includes the continental shelf waters of the northeastern U.S., and extends northeastward to south of Newfoundland. The Scientific Committee of the International Whaling Commission (IWC), while adopting these general boundaries, noted that the stock identity of sei whales (and indeed all North Atlantic whales) was a major research problem (Donovan 1991). In the absence of evidence to the contrary, the proposed IWC stock definition is provisionally adopted, and the "Nova Scotia stock" is used here as the management unit for this stock assessment. The IWC boundaries for this stock are from the U.S. east coast to Cape Breton, Nova Scotia, thence east to longitude 42^{o} W. Recent telemetry evidence offers some support that sei whales foraging in the Labrador Sea winter in the Azores and constitute a separate stock (Prieto *et al*. 2014).

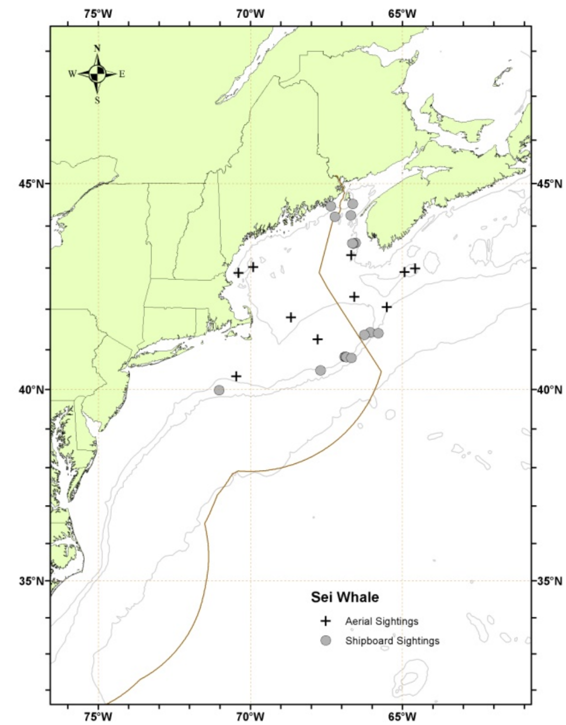

Figure 1. *Distribution of sei whale sightings from NEFSC and SEFSC shipboard and aerial surveys during the summers of 1995, 1998, 1999, 2002, 2004, 2006, 2007, 2008, 2010 and 2011. Isobaths are the 100-m, 1000-m and 4000-m depth contours.*

Indications are that, at least during the feeding season, a major portion of the Nova Scotia sei whale stock is centered in northerly waters, perhaps on the Scotian Shelf (Mitchell and Chapman 1977). The southern portion of the species' range during spring and summer includes the northern portions of the U.S. Atlantic Exclusive Economic Zone (EEZ)—the Gulf of Maine and Georges Bank. Spring is the period of greatest abundance in U.S. waters, with sightings concentrated along the eastern margin of Georges Bank and into the Northeast Channel area, and along the southwestern edge of Georges Bank in the area of Hydrographer Canyon (CETAP 1982). NMFS aerial surveys since 1999 have found concentrations of sei and right whales along the northern edge of Georges Bank in the spring. The sei whale is often found in the deeper waters characteristic of the continental shelf edge region (Hain *et al.* 1985), and NMFS aerial surveys found substantial numbers of sei whales in this region, in particular south of Nantucket, in the spring of 2001. Similarly, Mitchell (1975) reported that sei whales off Nova Scotia were often distributed closer to the 2,000-m depth contour than were fin whales.

This general offshore pattern of sei whale distribution is disrupted during episodic incursions into shallower, more inshore waters. Although known to eat fish in other oceans, sei whales (like right whales) are largely planktivorous, feeding primarily on euphausiids and copepods (Flinn *et al.* 2002). A review of prey preferences by Horwood (1987) showed that, in the North Atlantic, sei whales seem to prefer copepods over all other prey species. In Nova Scotia sampled stomachs from captured sei whales showed a clear preference for copepods between June and October, and euphausiids were taken only in May and November (Mitchell 1975). Sei whales are reported in some years in more inshore locations, such as the Great South Channel (in 1987 and 1989) and Stellwagen Bank (in 1986) areas (R.D. Kenney, pers. comm.; Payne *et al.* 1990). An influx of sei whales into the southern Gulf of Maine occurred in the summer of 1986 (Schilling *et al.* 1993). Such episodes, often punctuated by years or even decades of absence from an area, have been reported for sei whales from various places worldwide (Jonsgård and Darling 1977).

Based on analysis of records from the Blandford, Nova Scotia, whaling station, where 825 sei whales were taken between 1965 and 1972, Mitchell (1975) described two "runs" of sei whales, in June–July and in September–October. He speculated that the sei whale stock migrates from south of Cape Cod and along the coast of eastern Canada in June and July, and returns on a southward migration again in September and October; however, such a migration remains unverified.

POPULATION SIZE

The summer 2011 abundance estimate of 357 (CV=0.52) is considered the best available for the Nova Scotia stock of sei whales. However, this estimate must be considered conservative because all of the known range of this stock was not surveyed, because it did not include an availability-bias correction for animals missed while submerged, and because of uncertainties regarding population structure and whale movements between surveyed and unsurveyed areas.

Earlier abundance estimates

Please see appendix IV for earlier abundance estimates. As recommended in the GAMMS Workshop Report (Wade and Angliss 1997), estimates older than eight years are deemed unreliable for determination of the current PBR.

Recent surveys and abundance estimates

An abundance estimate of 357 (CV=0.52) sei whales was generated from a shipboard and aerial survey conducted during June–August 2011 (Palka 2012). The aerial portion that contributed to the abundance estimate covered 5,313 km of tracklines that were over waters from north of New Jersey from the coastline to the 100-m depth contour, through the U.S. and Canadian Gulf of Maine and up to and including the lower Bay of Fundy. The shipboard portion covered 3,107 km of tracklines that were in waters offshore of Virginia to Massachusetts (waters that were deeper than the 100-m depth contour out to beyond the U.S. EEZ). Both sighting platforms used a double-platform data collection procedure, which allows estimation of abundance corrected for perception bias of the detected species (Laake and Borchers 2004). Estimation of the abundance was based on the independent observer approach assuming point independence (Laake and Borchers 2004) and calculated using the multiple-covariate distance sampling (MCDS) option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009). The abundance estimates of sei whales include a percentage of the estimate of animals identified as fin/sei whales (the two species being sometimes hard to distinguish). The percentage used is the ratio of positively identified sei whales to the total of positively identified fin whales and positively identified sei whales; the CV of the abundance estimate includes the variance of the estimated fraction. Although this is the best estimate available for this stock, it should be noted that the abundance survey from which it was derived excluded waters off the Scotian Shelf, an area encompassing a large portion of the stated range of the stock.

Table 1. Summary of recent abundance estimates for Nova Scotia sei whales with month, year, and area covered during each abundance survey, and resulting abundance estimate (N_{best}) and coefficient of variation (CV).

Month/Year	Area	N_{best}	CV
Jun-Aug 2011	Central Virginia to lower Bay of Fundy	357	0.52

Minimum Population Estimate

The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally distributed best abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by (Wade and Angliss 1997). The best estimate of abundance for the Nova Scotia stock sei whales is 357 (CV=0.52). The minimum population estimate is 236.

Current Population Trend

A trend analysis has not been conducted for this stock. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval. For example, the power to detect a precipitous decline in abundance (i.e., 50% decrease in 15 years) with estimates of low precision (e.g., CV > 0.30) remains below 80% (alpha = 0.30) unless surveys are conducted on an annual basis (Taylor *et al.* 2007).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. For purposes of this assessment, the maximum net productivity rate was assumed to be 0.04. This value is based on theoretical modeling showing that cetacean populations may not grow at rates much greater than 4% given the constraints of their reproductive life history (Barlow *et al.* 1995).

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of minimum population size, one-half the maximum productivity rate, and a recovery factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size is 236. The maximum productivity rate is 0.04, the default value for cetaceans. The recovery factor is 0.10 because the sei whale is listed as endangered under the Endangered Species Act (ESA). PBR for the Nova Scotia stock of the sei whale is 0.5.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

For the period 2010 through 2014, the minimum annual rate of human-caused mortality and serious injury to sei whales was 0.8. This value includes incidental fishery interaction records, 0, and records of vessel collisions, 0.8 (Table 2; Henry *et al*. 2016). Annual rates calculated from detected mortalities should not be considered an unbiased estimate of human-caused mortality, but they represent a definitive lower bound. Detections are haphazard, incomplete, and not the result of a designed sampling scheme. As such they represent a minimum estimate of human-caused mortality which is almost certainly biased low.

Fishery-Related Serious Injury and Mortality

No confirmed fishery-related mortalities or serious injuries of sei whales have been reported in the NMFS Sea Sampling bycatch database. A review of the records of stranded, floating, or injured sei whales for the period 2010 through 2014 on file at NMFS found no records with substantial evidence of fishery interactions causing serious injury or mortality (Table 2), which results in an annual serious injury and mortality rate of 0 sei whales from fishery interactions.

Table 2. Confirmed human-caused mortality and serious injury records of Sei Whales (*Balaenoptera borealis*) where the cause was assigned as either an entanglement (EN) or a vessel strike (VS): 2010–2014 [a]

Date[b]	Injury Determination	ID	Location[b]	Assigned Cause	Value against PBR[c]	Country[d]	Gear Type[e]	Description
3/26/2011	Mortality		Virginia Beach, VA	VS	1	US	-	Jaw, scapula, rib & vertebral fractures along right side w/ associated hemorrhaging.
5/4/2014	Mortality		Hudson River, NY	VS	1	US	-	Fresh carcass on bow of vessel. Extensive skeletal fractures w/ associated hemorrhage along right side.
5/7/2014	Mortality		Delaware River, PA	VS	1	US	-	Fresh carcass on bow of

								vessel.
8/14/2014	Mortality		James River, VA	VS	1	US	-	Live stranded and died. Emaciated. Fragment of plastic DVD case in stomach. Broken bones w/ associated hemorrhaging. Proximate COD – starvation by ingestion of plastic debris. Ultimate COD – blunt trauma from vessel strike
Five-year averages		Shipstrike (US/CN/XU/XC)			0.80 (0.80/ 0.00/ 0.00/ 0.00)			
		Entanglement (US/CN/XU/XC)			00			
a. For more details on events please see Henry *et al.* 2016.								
b. The date sighted and location provided in the table are not necessarily when or where the serious injury or mortality occurred; rather, this information indicates when and where the whale was first reported beached, entangled, or injured.								
c. Mortality events are counted as 1 against PBR. Serious injury events have been evaluated using NMFS guidelines (NOAA 2012)								
d. CN=Canada, US=United States, XC=Unassigned 1st sight in CN, XU=Unassigned 1st sight in US								
e. H=hook, GN=gillnet, GU=gear unidentifiable, MF=monofilament, NP=none present, NR=none recovered/received, PT=pot/trap, WE=weir								

Other Mortality

For the period 2010 through 2014 files at NMFS included four records with substantial evidence of vessel collision causing serious injury or mortality (Table 2), which resulted in an annual rate of serious injury and mortality of 0.8 sei whales from vessel collisions.

STATUS OF STOCK

This is a strategic stock because the sei whale is listed as an endangered species under the ESA. The total U.S. fishery-related mortality and serious injury for this stock derived from the available records was less than 10% of the calculated PBR, and therefore could be considered insignificant and approaching a zero mortality and serious injury rate. However, evidence for fisheries interactions with large whales are subject to imperfect detection, and caution should be used in interpreting these results. The status of this stock relative to OSP in the U.S. Atlantic EEZ is unknown. There are insufficient data to determine population trends for sei whales.

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MINKE WHALE (*Balaenoptera acutorostrata acutorostrata*): Canadian East Coast Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Minke whales have a cosmopolitan distribution in temperate, tropical and high-latitude waters. In the North Atlantic, there are four recognized populations—Canadian East Coast, west Greenland, central North Atlantic, and northeastern North Atlantic (Donovan 1991). These divisions were defined by examining segregation by sex and length, catch distributions, sightings, marking data, and pre-existing ICES boundaries. However, there were very few data from the Canadian East Coast population. Anderwald *et al.* (2011) found no evidence for geographic structure comparing these putative populations but did, using individual genotypes and likelihood assignment methods, identify two cryptic stocks distributed across the North Atlantic. Until better information is available, minke whales off the eastern coast of the United States are considered to be part of the Canadian East Coast stock, which inhabits the area from the western half of the Davis Strait (45ºW) to the Gulf of Mexico. It is also uncertain if there are separate sub-stocks within the Canadian East Coast stock.

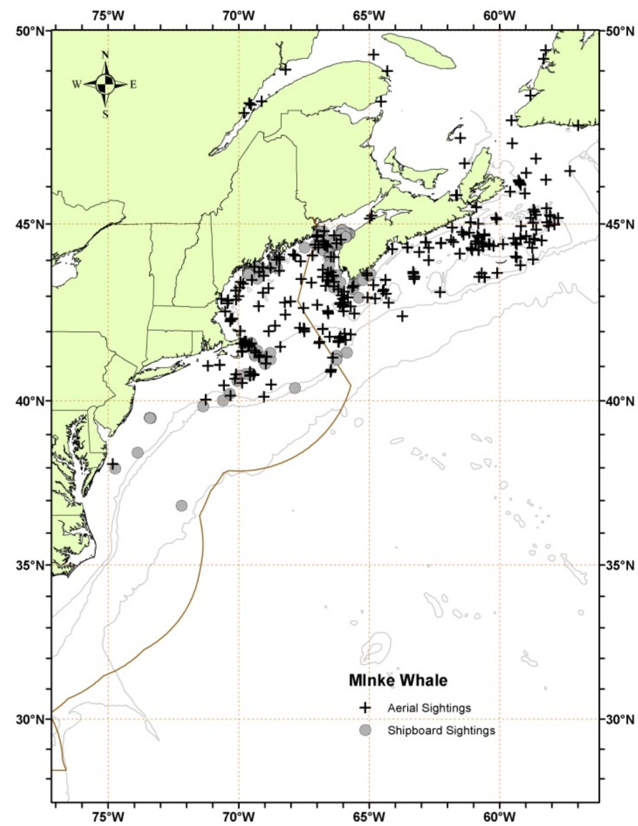

Figure 1. *Distribution of minke whale sightings from NEFSC and SEFSC shipboard and aerial surveys during the summers of 1995, 1998, 1999, 2002, 2004, 2006, 2007, 2008, 2010, and 2011and DFO's 2007 TNASS survey. Isobaths are the 100-m, 1000-m and 4000-m depth contours.*

The minke whale is common and widely distributed within the U.S. Atlantic Exclusive Economic Zone (EEZ) (CETAP 1982). There appears to be a strong seasonal component to minke whale distribution on both the continental shelf and in deeper, off-shelf waters. Spring to fall are times of relatively widespread and common occurrence on the shelf, and when the whales are most abundant in New England waters (e.g., Risch *et al.* 2013; 2014), while during the fall to spring period the species appears to be relatively widespread and common on deep-ocean waters (Clark and Gagnon 2002) . Records based on visual sightings and summarized by Mitchell (1991) hinted at a possible winter distribution in the West Indies, and in the mid-ocean south and east of Bermuda. In contrast, acoustic monitoring for minke whales have revealed minke acoustic occurrence throughout broad, deep-ocean areas of the western North Atlantic from late October through early June (Clark and Gagnon 2002).

POPULATION SIZE

The best recent abundance estimate for this stock is 2,591 (CV=0.81) minke whales. This estimate, derived from 2011 shipboard and aerial surveys, is the only current estimate available. This estimate is substantially lower than the estimate from the previous (2015) SAR. This is because the previous estimate included data from the 2007 TNASS surveys of Canadian waters. For the purposes of this SAR, as recommended in the GAMMS II Workshop Report (Wade and Angliss 1997), estimates older than eight years are deemed unreliable, so this new estimate must not include data from the 2007 TNASS survey. This new estimate should not be interpreted as a decline in abundance of this stock, as previous estimates are not directly comparable.

Earlier estimates

Please see Appendix IV for a summary of abundance estimates, including earlier estimates and survey descriptions. As recommended in the GAMMS II Workshop Report (Wade and Angliss 1997), estimates older than eight years are deemed unreliable for the determination of the current PBR.

Recent surveys and abundance estimates

An abundance estimate of 2,591 (CV=0.81) minke whales was generated from a shipboard and aerial survey conducted during June-August 2011 (Palka 2012). The aerial portion that contributed to the abundance estimate covered 5,313 km of tracklines that were over waters north of New Jersey from the coastline to the 100-m depth contour through the U.S. and Canadian Gulf of Maine, and up to and including the lower Bay of Fundy. The shipboard portion covered 3,107 km of tracklines that were in waters offshore of central Virginia to Massachusetts (waters that were deeper than the 100-m depth contour out to beyond the U.S. EEZ). Both sighting platforms used a double-platform data collection procedure, which allows estimation of abundance corrected for perception bias of the visually detected species (Laake and Borchers, 2004). Estimation of the abundance was based on the independent-observer approach assuming point independence (Laake and Borchers 2004) and calculated using the multiple-covariate distance sampling (MCDS) option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009).

Table 1. Summary of recent abundance estimates for the Canadian East Coast stock of minke whales (*Balaenoptera acutorostrata acutorostrata*) by month, year, and area covered during each abundance survey, and resulting abundance estimate (N_{best}) and coefficient of variation. (CV).

Month/Year	Area	N_{best}	CV
Jul-Aug 2011	Central Virginia to lower Bay of Fundy	2,591	0.81

Minimum Population Estimate

The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally distributed best abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by Wade and Angliss (1997). The best estimate of abundance for the Canadian East Coast stock of minke whales is 2,591animals (CV=0.81). The minimum population estimate is 1,425 animals.

Current Population Trend

A trend analysis has not been conducted for this stock. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval. For example, the power to detect a precipitous decline in abundance (i.e., 50% decrease in 15 years) with estimates of low precision (e.g., CV > 0.30) remains below 80% (alpha = 0.30) unless surveys are conducted on an annual basis (Taylor *et al.* 2007).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. Life history parameters that could be used to estimate net productivity are that females mature between 6 and 8 years of age, and pregnancy rates are approximately 0.86 to 0.93. Based on these parameters, the calving interval is between 1 and 2 years. Calves are probably born during October to March after 10 to 11 months gestation and nursing lasts for less than 6 months. Maximum ages are not known, but for Southern Hemisphere minke whales maximum age appears to be about 50 years (IWC 1991; Katona *et al.* 1993).

For purposes of this assessment, the maximum net productivity rate was assumed to be 0.04. This value is based on theoretical modeling showing that cetacean populations may not grow at rates much greater than 4% given the constraints of their reproductive life history (Barlow *et al.* 1995).

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of minimum population size, one-half the maximum productivity rate, and a recovery factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size is 1,425. The maximum productivity rate is 0.04, the default value for cetaceans. The recovery factor is 0.5, the default value for stocks of unknown status relative to OSP, and the CV of the average mortality estimate is less than 0.3 (Wade and Angliss 1997). PBR for the Canadian east coast minke whale is 14.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

During 2010 to 2014, the average annual minimum detected human-caused mortality and serious injury was 8.25 minke whales per year: 0.2 minke whales per year from observed U.S. fisheries, 6.45 (1.7 U.S/2.5 Canada/2.25 unassigned but first reported in the U.S.) minke whales per year from U.S. and Canadian fisheries using strandings and entanglement data, and 1.6 (1.2 U.S./0.4 Canada) per year from vessel strikes.

Data to estimate the mortality and serious injury of minke whales come from the Northeast Fisheries Science Center Observer Program, the At-Sea Monitor Program, and from records of strandings and entanglements in U.S. and Canadian waters. For the purposes of this report, mortalities and serious injuries from reports of strandings and entanglements considered confirmed human-caused mortalities or serious injuries are shown in Table 2 while those recorded by the Observer or At-Sea Monitor Programs are shown in Table 3.

Detected interactions in the strandings and entanglement data should not be considered an unbiased representation of human-caused mortality. Detections are haphazard and not the result of a designed sampling scheme. As such they represent a minimum estimate, which is almost certainly biased low.

Fishery Information

Detailed fishery information is reported in Appendix III.

Earlier Interactions

For more details on the historical fishery interactions prior to 1999, see Waring *et al.* (2007).

In 2002, one minke whale mortality and one live release were attributed to the lobster trap fishery. A June 2003 mortality, while wrapped in lobster gear, cannot be confirmed to have become entangled in the area, and so is not attributed to the fishery. Annual mortalities due to the northeast/mid-Atlantic Lobster Trap/Pot fishery, as determined from strandings and entanglement records that have been audited, were 1 in 1991, 2 in 1992, 1 in 1994, 1 in 1995, 0 in 1996, 1 in 1997, 0 in 1998 to 2001, 1 in 2002, and 0 in 2003 through 2011. See Appendix V for more information on historical takes.

U.S.

Northeast Mid-water Trawl Fishery (Including Pair Trawl)

During July 2013, one minke whale was observed dead in the mid-water otter trawl on Georges Bank. Due to the small sample size of observed takes, an expanded estimate was not calculated. Annual average estimated minke whale mortality and serious injury from the mid-Atlantic mid-water trawl (including pair trawl) during 2010 to 2014 was 0.2 (Table 3).

Atlantic Large Pelagics Longline Fishery

In 2010, a minke whale was caught but released alive (no serious injury) in the large pelagics longline fishery, South Atlantic Bight fishing area (Garrison and Stokes 2012).

Other Fisheries

The audited NE Regional Office/NMFS entanglement/stranding database contains records of minke whales, of which the confirmed mortalities and serious injuries from the last five years are reported in Table 2. During 2010 to 2014, as determined from stranding and entanglement records confirmed to be of U.S. origin or first sighted in U.S. waters, the minimum detected average annual mortality and serious injury was 3.95 minke whales per year in U.S. fisheries (Table 2a). Most cases where gear was recovered and identified involved gillnet or pot/trap gear.

CANADA

Read (1994) reported interactions between minke whales and gillnets in Newfoundland and Labrador, in cod traps in Newfoundland, and in herring weirs in the Bay of Fundy. Hooker *et al.* (1997) summarized bycatch data from a Canadian fisheries observer program that placed observers on all foreign fishing vessels operating in Canadian waters, on between 25% and 40% of large Canadian fishing vessels (greater than 100 feet long), and on approximately 5% of smaller Canadian fishing vessels. During 1991 through 1996, no minke whales were observed taken.

Herring Weirs

During 1980 to 1990, 15 of 17 minke whales were released alive from herring weirs in the Bay of Fundy. During January 1991 to September 2002, 26 minke whales were trapped in herring weirs in the Bay of Fundy. Of these 26, 1 died (H. Koopman, pers. comm.) and several (number unknown) were released alive and unharmed (A. Westgate, pers. comm.). Weir interactions that may have resulted in serious injury to minke whales are reported in Table 2b.

Other Fisheries

Mortalities and serious injuries that were likely a result of an interaction with an unknown Canadian fishery are detailed in Table 2b. During 2010 to 2014, as determined from stranding and entanglement records confirmed to be of Canadian origin or first sighted in Canadian waters, the minimum detected average annual mortality and serious injury was 2.5 minke whales per year in Canadian fisheries (Table 2b; prorated value).

Table 2a. Confirmed human-caused mortality and serious injury records of minke whales (*Balaenoptera acutorostrata acutorostrata*) first reported in U.S. waters or attributed to U.S.: 2010–2014[a]

Date[b]	Injury determination	ID	Location[b]	Assigned Cause[f]	Value against PBR[c]	Country[d]	Gear Type[e]	Description
7/9/2010	Mortality	-	Fire Island Inlet, NY	VS	1	US	-	3-4 large dorsal lacerations associated w/ fractured ribs
8/21/2010	Serious Injury	-	off Plymouth Harbor, MA	EN	1	XU	NR	Embedded rostrum wrap.
5/6/2011	Mortality	-	off Martha's Vineyard, MA	EN	1	US	PT	Anchored in gear. Embedded line at fluke. Evidence of entanglement w/ associated hemorrhaging at mouth corners & insertion of pectorals
7/17/2011	Prorated Injury	-	off Nahant, MA	EN	0.75	XU	NR	Full configuration unknown.
7/24/2011	Prorated Injury	-	off North Truro, MA	EN	0.75	XU	NR	Full configuration unknown
8/4/2011	Mortality	-	Sandy Hook Bay, NJ	VS	1	US	-	4 propeller lacerations across dorsal surface. Fractured ribs w/associated hemorrhaging
8/26/2011	Mortality	-	Horseshoe Cove, NJ	EN	1	US	NP	Fresh carcass w/ evidence of extensive entanglement
8/29/2011	Mortality	-	Moriches Bay, NY	VS	1	US	-	Extensive hemorrhage & edema along dorsal & both lateral surfaces

10/6/2011	Mortality	-	off Matinicus Island, ME	EN	1	US	PT	Fresh carcass anchored in gear
12/7/2011	Mortality	-	Carolina Beach, NC	VS	1	US	-	Healed deep & superficial propeller lacerations; internal lesions associated w/ deep lacerations indicative of peritonitis & infection
2/4/2012	Prorated Injury	-	off Virginia Beach, VA	EN	0.75	XU	CE	Reported with hook/monofilament gear. Attachment point unknown.
3/16/2012	Mortality	-	Ipswich, MA	EN	1	US	NP	Evidence of extensive, constricting gear w/ associated hemorrhaging
6/21/2012	Serious Injury	-	off Frenchboro, ME	EN	1	XU	NR	Constricting body wrap, flipper pinned, embedded in mouthline; emaciated
6/23/2012	Mortality	-	Newark, NJ	VS	1	US	-	Fresh carcass on bow of ship. Deep laceration across ventral surface; Cause of death - disembowlment & hypovolemic shock
7/1/2012	Prorated Injury	-	off Portsmouth, NH	EN	0.75	XU	NR	Full configuration unknown
7/13/2012	Prorated Injury	-	off Jonesport, ME	EN	0.75	US	NR	Anchored. Partial disentanglement; Final configuration unknown
7/17/2012	Serious Injury	-	off Chatham, MA	EN	1	XU	NR	Tight wrap across back; health decline: emaciated
8/2/2012	Prorated Injury	-	off Provincetown, MA	EN	0.75	XU	NR	Full configuration unknown
8/5/2012	Mortality	-	Chatham, MA	EN	1	US	NR	Multiple constricting wraps through & around mouth and on fluke blades; COD - acute underwater entrapment

10/4/2012	Mortality	-	Cliff Island, ME	EN	1	US	NR	Evidence of constricting gear at mouthline, across ventral pleats, & at peduncle
7/23/2013	Prorated Injury	-	off Newport, RI	EN	0.75	XU	NR	Full configuration unknown
8/17/2013	Serious Injury	-	off Newburyport, MA	EN	1	XU	NR	Constricting rostrum wrap cutting into upper lip
10/04/2013	Prorated Injury	-	off Seal Harbor, ME	EN	0.75	US	NR	Anchored, partially disentangled, final configuration unknown
6/9/2014	Mortality	-	off Truro, MA	EN	1	US	PT	Fresh carcass anchored, hog-tied in gear. COD=peracute underwater entrapment.
7/10/2014	Prorated Injury	-	S of Bristol, ME	EN	0.75	XU	NR	Free-swimming, trailing 2 buoys. Attachment point(s) unknown.
7/12/2014	Serious Injury	-	South Shinnecock Inlet, NY	EN	1	XU	NR	Free-swimming with yellow plastic strapping cutting into top and sides of rostrum. No trailing gear.
7/17/2014	Mortality	-	South Addison, ME	EN	1	XU	NP	Fresh carcass with line impression across ventral surface & evidence of constricting gear around peduncle and fluke insertion. Bruising evident at fluke injuries. No gear present.
12/24/2014	Mortality	-	Dam Neck, VA	VS	1	US	-	Fresh carcass with broken ribs & fractured vertebrae w/ extensive hemorrhage & edema.
Five-year averages		Vessel strike (US/ XU)		1.20 (1.20/ 0.00)				
		Entanglement (US/ XU)		3.95 (1.70/ 2.25)				
a. For more details on events please see Henry *et al.* 2016.								
b. The date sighted and location provided in the table are not necessarily when or where the serious injury or mortality occurred; rather, this information indicates when and where the whale was first reported beached, entangled, or injured.								

c. Mortality events are counted as 1 against PBR. Serious injury events have been evaluated using NMFS guidelines (NOAA 2012)
d. US=United States, XU=Unassigned 1st sight in US
e. H=hook, GN=gillnet, GU=gear unidentifiable, MF=monofilament, MT=midwater trawl, NP=none present, NR=none recovered/received, PT=pot/trap, WE=weir
f. Assigned cause: EN=entanglement, VS=vessel strike, ET=entrapment (summed with entanglement).

Table 2b. Confirmed human-caused mortality and serious injury records of minke whales (*Balaenoptera acutorostrata acutorostrata*) first reported in Canadian waters or attributed to Canada: 2010–2014[a]

Date[b]	Injury determination	ID	Location[b]	Assigned Cause[f]	Value against PBR[c]	Country[d]	Gear Type[e]	Description
6/16/2010	Mortality	-	Goose River, Prince Edward Island	EN	1	CN	NP	Deep laceration consistent w/ entanglement at base of fluke w/ associated hemorrhage
7/2/2010	Mortality	-	Naufrage, Prince Edward Island	EN	1	CN	NP	Evidence of body entanglement & constriction at mouthline
7/27/2010	Prorated Injury	-	off Bliss Island, New Brunswick	ET	0.75	CN	WE	Live in weir. Not present next day. Unclear if whale swam out or drowned.
6/3/2011	Serious Injury	-	Tadoussac, Quebec	EN	1	CN	NR	Tight rostrum wrap.
9/7/2011	Prorated Injury	-	Greenspond, Newfoundland	EN	0.75	CN	GN	Partially disentangled from anchoring gear. Final configuration unknown.
9/19/2011	Prorated Injury	-	Northumberland Strait, Prince Edward Island	EN	0.75	CN	NR	Partially disentangled from anchoring gear. Final configuration unknown.
12/19/2011	Mortality	-	off Grand Manan Island, New Brunswick	EN	1	CN	PT	Live entanglement; recovered dead in gear the following day. Constricting peduncle wraps
5/15/2012	Serious Injury	-	Sable Island Bank, Canada	EN	1	CN	PT	Disentangled from gear embedded down to bone of

								peduncle.
6/26/2012	Mortality	-	Renews Rock, Newfoundland	EN	1	CN	PT	Fresh carcass w/ constricting gear around peduncle
6/30/2012	Mortality	-	off Naufrage, Prince Edward Island	EN	1	CN	PT	Fresh carcass anchored in gear
7/1/2012	Mortality	-	Northern Lake Harbor, Prince Edward Island	EN	1	CN	PT	Constricting gear w/ associated hemorrhaging; COD - drowning
8/31/2013	Mortality	-	Miminegash, Prince Edward Island	EN	1	CN	NP	Fresh carcass w/ evidence of extensive, constricting gear
7/2/2014	Mortality	-	Northumberland Strait, NB	EN	1	CN	NR	Carcass with constricting gear around lower jaw. Large open injury at attachment point on the left side.
7/10/2014	Mortality	-	Cape George, Antigonish, NS	VS	1	CN	-	Fresh carcass with jaw fractures.
7/29/2014	Mortality	-	5 nm E of Herring Cove, NS	VS	1	CN	-	Live animal w/ tongue completely ballooned out, forcing its jaws 90 degrees apart. Found dead at same location the next day. Carcass recovered with two traps & constricting line around the peduncle. Necropsy found indication of blunt trauma to right jaw. Animal anchored in gear was subsequently struck by a vessel (primary cause of death)
Five-year averages		Vessel strike (CN/ XC)			0.40 (0.40/ 0.00)			
		Entanglement (CN/ XC)			2.50 (2.50/ 0.00)			
a. For more details on events please see Henry *et al.* 2016.								

b. The date sighted and location provided in the table are not necessarily when or where the serious injury or mortality occurred; rather, this information indicates when and where the whale was first reported beached, entangled, or injured.
c. Mortality events are counted as 1 against PBR. Serious injury events have been evaluated using NMFS guidelines (NOAA 2012)
d. CN=Canada, US=United States, XC=Unassigned 1st sight in CN, XU=Unassigned 1st sight in US
e. H=hook, GN=gillnet, GU=gear unidentifiable, MF=monofilament, MT=midwater trawl, NP=none present, NR=none recovered/received, PT=pot/trap, WE=weir
f. Assigned cause: EN=entanglement, VS=vessel strike, ET=entrapment (summed with entanglement).

Table 3. Summary of the incidental mortality and serious injury of Canadian East Coast stock of minke whales (*Balaenoptera acutorostrata acutorostrata*) by commercial fishery including the years sampled, the type of data used, the annual observer coverage, the serious injuries and mortalities recorded by on-board observers, the estimated annual serious injury and mortality, the estimated CV of the combined annual mortality and the mean annual mortality (CV in parentheses).

Fishery	Years	Data Type[a]	Observer Coverage[b]	Observed Serious Injury	Observed Mortality	Estimated Serious Injury	Estimated Mortality	Estimated Combined Mortality	Estimated CVs	Mean Combined Annual Mortality
Northeast Mid-water Trawl - Including Pair Trawl	10-14	Obs. Data Weighout Trip Logbook	.41, .17, .45, .37,	0, 0, 0, 0, 0	0, 0, 0, 1, 0	0, 0, 0, 0, 0	0, 0, 0, 1, 0	0, 0, 0, 1, 0	0, 0, 0, 0, 0	0.2 (0)
TOTAL										0.2 (0)

[a] Observer data (Obs. Data), used to measure bycatch rates, are collected within the Northeast Fisheries Observer Program and mandatory Vessel Trip Reports (VTR) (Trip Logbook) are used to determine the spatial distribution of landings and fishing effort.

[b] Northeast mid-water trawl (including pair trawl) fisheries coverage is ratios based on trips.

Other Mortality

North Atlantic minke whales have been and continue to be hunted. From the Canadian East Coast population, documented whaling occurred from 1948 to 1972 with a total kill of 1,103 animals (IWC 1992). Animals from other North Atlantic minke populations (e.g. Iceland) are being harvested presently.

U.S.

Minke whales inhabit coastal waters during much of the year and are thus susceptible to collision with vessels. In 2010 a juvenile male minke was discovered killed by vessel strike off Fire Island, New York. In 2011, three juvenile minkes were confirmed dead due to vessel strikes: a female off Sandy Hook, New Jersey, a female off Moriches, New York, and a male off Carolina Beach, North Carolina. In 2012, a confirmed vessel strike resulted in a mortality off Newark, New Jersey. In 2014, a confirmed vessel strike resulted in a mortality off Dam Neck, Virginia. Thus, during 2010–2014, as determined from stranding and entanglement records, the minimum detected annual average was 1.2 minke whales per year struck by vessels in U.S. waters or first seen in U.S. waters (Table 2a;

Henry *et al.* 2016).

CANADA

The Nova Scotia Stranding Network documented whales and dolphins stranded on the coast of Nova Scotia between 1991 and 1996 (Hooker *et al.* 1997). Researchers with the Department of Fisheries and Oceans, Canada documented strandings on the beaches of Sable Island (Lucas and Hooker 2000). Starting in 1997, minke whales stranded on the coast of Nova Scotia were recorded by the Marine Animal Response Society (MARS) and the Nova Scotia Stranding Network. The events that are determined to be human-caused serious injury or mortality are included in Table 2b.

The Whale Release and Strandings program has reported the following minke whale stranding mortalities in Newfoundland and Labrador for the time period of this report: 1 in 2010, 0 in 2011, 3 in 2012, and 0 in 2013 and 1 in 2014. Those that have been determined to be human-caused serious injury or mortality are included in Table 2b (Ledwell and Huntington 2011, 2012, 2012b, 2013, 2014).

During 2010–2014, as determined from stranding and entanglement records, the minimum detected annual average was 0.4 minke whales per year struck by vessels in Canadian waters or first seen in Canadian waters (Table 2b; Henry *et al.* 2016).

STATUS OF STOCK

Minke whales are not listed as threatened or endangered under the Endangered Species Act, and the Canadian East Coast stock is not considered strategic under the Marine Mammal Protection Act. The total U.S. fishery-related mortality and serious injury for this stock is not less than 10% of the calculated PBR and, therefore, cannot be considered to be insignificant and approaching zero mortality and serious injury rate. The status of minke whales relative to OSP in the U.S. Atlantic EEZ is unknown.

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DWARF SPERM WHALE (*Kogia sima*): Western North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The dwarf sperm whale (*Kogia sima*) is distributed worldwide in temperate to tropical waters (Caldwell and Caldwell 1989; McAlpine 2009). Sightings of *Kogia* whales in the western North Atlantic occur in oceanic waters (Figure 1; Mullin and Fulling 2003; Roberts *et al.* 2015). Stranding records exist from Florida to Maine, but there are no stranding records for the eastern Canadian coast (Willis and Baird 1998).

Dwarf sperm whales and pygmy sperm whales (*K. breviceps*) are difficult to differentiate at sea due to similarities in appearance (Caldwell and Caldwell 1989; Bloodworth and Odell 2008; McAlpine 2009), and sightings of either species are often categorized as *Kogia* sp. When measurements can be obtained, diagnostic morphological characters have been useful in distinguishing the two *Kogia* species (Handley 1966; Barros and Duffield 2003), thus enabling researchers to use stranding data in distributional and ecological studies. Specifically, the distance from the snout to the center of the blowhole in proportion to the animal's total length, as well as the height of the dorsal fin in proportion to the animal's total length, can be used to differentiate between the two *Kogia* species (Handley 1966; Barros and Duffield 2003).

In addition to similarities in appearance, dwarf sperm whales and pygmy sperm whales demonstrate similarities in their foraging ecology. Staudinger *et al.* (2014) conducted diet and stable isotope analyses on stranded pygmy and dwarf sperm whales from the mid-Atlantic coast and found that the 2 species shared the same primary prey and fed in similar habitats.

Across its geographic range, including the western North Atlantic, the population biology of dwarf sperm whales is inadequately known (Staudinger *et al.* 2014). The western North Atlantic dwarf sperm whale population is being considered a separate stock for management purposes, although there is currently no information to differentiate this stock from the northern Gulf of Mexico stock(s). Additional morphological, genetic and/or behavioral data are needed to provide further information on stock delineation.

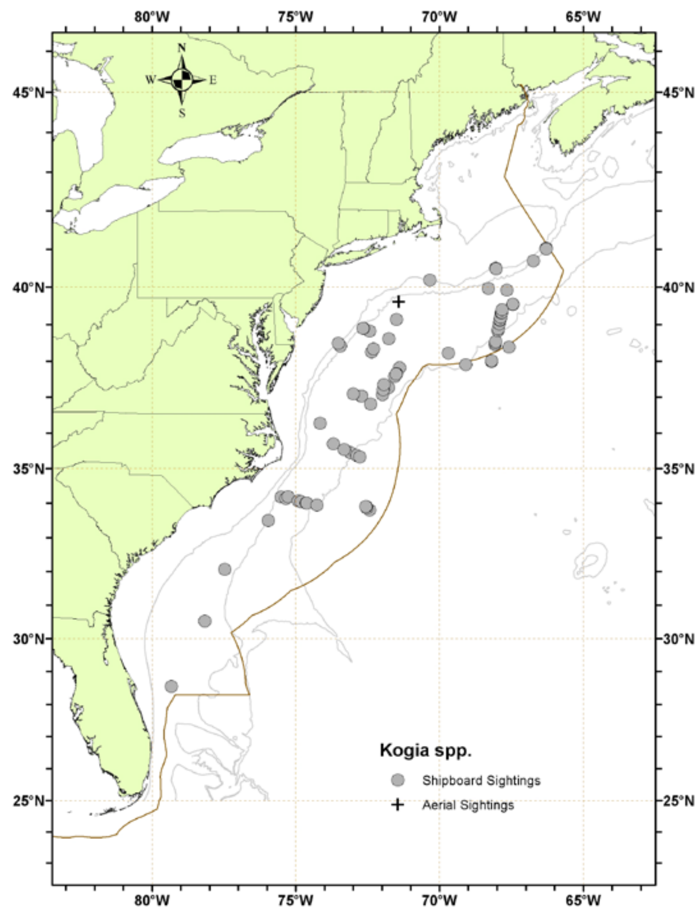

Figure 1. *Distribution of* Kogia *spp. sightings from NEFSC and SEFSC shipboard and aerial surveys during the summers in 2004 and 2011. Isobaths are the 100-m, 1,000-m and 4,000- m depth contours.*

POPULATION SIZE

Total numbers of dwarf sperm whales off the U.S. Atlantic coast are unknown, although abundance estimates from selected regions of dwarf sperm whale habitat exist for select time periods. Because *K. sima* and *K. breviceps* are difficult to differentiate at sea, the reported abundance estimates are for both species of *Kogia* combined. The best estimate for *Kogia* spp. in the western North Atlantic is 3,785 (CV=0.47; Table 1; Palka 2012; Garrison 2016). This estimate is from summer 2011 surveys covering waters from central Florida to the lower Bay of Fundy. This estimate is almost certainly negatively biased. One component of line transect estimates is *g(0)*, the probability of seeing an animal on the transect line. Estimating *g(0)* is difficult because it consists of accounting for both perception bias (i.e., at the surface but missed) and availability bias (i.e., below the surface while in range of the observers), and many uncertainties (e.g., group size and diving behavior) can confound both (Marsh and Sinclair 1989; Barlow 1999). The best estimate was corrected for perception bias (see below) but not availability bias and is therefore an underestimate.

Earlier abundance estimates

Please see Appendix IV for a summary of abundance estimates, including earlier estimates and survey descriptions.

Recent surveys and abundance estimates

An abundance estimate of 1,783 (CV=0.62) *Kogia* spp. was generated from aerial and shipboard surveys conducted during June–August 2011 between central Virginia and the lower Bay of Fundy (Palka 2012). The aerial portion covered 6,850 km of tracklines over waters north of New Jersey between the coastline and the 100-m depth contour through the U.S. and Canadian Gulf of Maine, and up to and including the lower Bay of Fundy. The shipboard portion covered 3,811 km of trackline between central Virginia and Massachusetts in waters deeper than the 100-m depth contour out to beyond the U.S. EEZ. Both sighting platforms used a double-platform data collection procedure, which allowed estimation of abundance corrected for perception bias of the detected species (Laake and Borchers 2004). Estimation of the abundance was based on the independent observer approach assuming point independence (Laake and Borchers 2004) and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009).

An abundance estimate of 2,002 (CV=0.69) *Kogia* spp. was generated from a shipboard survey conducted concurrently (June–August 2011) in waters between central Virginia and central Florida (Garrison 2016). This shipboard survey included shelf-break and inner continental slope waters deeper than the 50-m depth contour within the U.S. EEZ. The survey employed two independent visual teams searching with 25x bigeye binoculars. A total of 4,445 km of trackline were surveyed, yielding 290 cetacean sightings. The majority of sightings occurred along the continental shelf break with generally lower sighting rates over the continental slope. Estimation of the abundance was based on the independent observer approach assuming point independence (Laake and Borchers 2004) and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009).

Table 1. Summary of abundance estimates for the western North Atlantic *Kogia* spp. with month, year, and area covered during each abundance survey, and resulting abundance estimate (N_{best}) and coefficient of variation (CV).

Month/Year	Area	N_{best}	CV
Jun–Aug 2011	central Virginia to lower Bay of Fundy	1,783	0.62
Jun–Aug 2011	central Florida to central Virginia	2,002	0.69
Jun–Aug 2011	central Florida to lower Bay of Fundy (COMBINED)	3,785	0.47

Minimum Population Estimate

The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally distributed best abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by Wade and Angliss (1997). The best estimate of abundance for *Kogia* spp. is 3,785 (CV=0.47). The minimum population estimate for *Kogia* spp. is 2,598 animals.

Current Population Trend

A trend analysis has not been conducted for this stock. There are 3 abundance estimates for *Kogia* spp. from: 1) summer 1998 surveys (536; CV=0.45); 2) summer 2004 surveys (395; CV=0.4); and 3) summer 2011 surveys (3,785; CV=0.47). Methodological differences between the estimates need to be evaluated to quantify trends.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. For purposes of this assessment, the maximum net productivity rate was assumed to be 0.04. This value is based on theoretical modeling showing that cetacean populations may not grow at rates much greater than 4% given the constraints of their reproductive life history (Barlow *et al.* 1995).

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of minimum population size, one-half the maximum productivity rate, and a recovery factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size for *Kogia* spp. is 2,598. The maximum productivity rate is 0.04, the default value for cetaceans. The recovery factor is 0.40 because the CV of the average mortality estimate is greater than 0.8 (Wade and Angliss 1997). PBR for western North Atlantic *Kogia* spp. is 21.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

The estimated annual average fishery-related mortality or serious injury for *Kogia* sp. during 2010–2014 was 3.5 (CV=1.0; Table 2).

Fishery Information

The commercial fisheries that interact, or that could potentially interact, with this stock in the Atlantic Ocean are the Category I Atlantic Highly Migratory Species longline and Atlantic Ocean, Caribbean, Gulf of Mexico large pelagics longline fisheries (Appendix III).

The large pelagics longline fishery operates in the U.S. Atlantic (including Caribbean) and Gulf of Mexico EEZ. Pelagic swordfish, tunas and billfish are the targets of the large pelagics longline fishery. Total estimated annual average fishery-related mortality and serious injury during 2010–2014 was unknown for Atlantic dwarf sperm whales because species-specific mortality estimates could not be made. However, there was 1 report of a *Kogia* sp. seriously injured by the pelagic longline fishery during quarter 4 of 2011 in the mid-Atlantic Bight region. Estimated total serious injury of *Kogia* sp. attributable to the pelagic longline fishery during 2011 was 17.4 (CV=1.0; Garrison and Stokes 2012b). The annual average serious injury and mortality attributable to the Atlantic large pelagics longline fishery for the 5-year period from 2010 to 2014 was 3.5 animals (CV=1.0; Table 2) (Garrison and Stokes 2012a,b; 2013; 2014; 2016).

The Atlantic Highly Migratory Species longline fishery operates outside the U.S. EEZ. No takes of dwarf sperm whales or *Kogia* sp. within high seas waters of the Atlantic Ocean have been observed or reported thus far.

See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and AppendixV for historical estimates of annual mortality and serious injury.

Table 2. Summary of the incidental mortality and serious injury of Atlantic Ocean *Kogia* sp. in the pelagic longline commercial fishery including the years sampled (Years), the number of vessels active within the fishery (Vessels), the type of data used (Data Type), the annual observer coverage (Observer Coverage), the annual observed serious injury and mortality recorded by on-board observers, the annual estimated serious injury and mortality, the combined annual estimates of serious injury and mortality (Estimated Combined Mortality), the estimated CV of the combined annual mortality estimates (Est. CVs) and the mean of the combined mortality estimates (CV in parentheses).

Fishery	Years	Vessels [a]	Data Type [b]	Observer Coverage [c]	Observed Serious Injury	Observed Mortality	Estimated Serious Injury	Estimated Mortality	Estimated Combined Mortality	Est. CVs	Mean Annual Mortality
Pelagic Longline	2010 – 2014	80, 83, 82, 79, 78	Obs. Data Logbook	.08, .09, .07, .09, .10	0,1,0,0,0	0,0,0,0,0	0,17,0,0,0	0,0,0,0,0	0,17,0,0,0	NA, 1.00, NA, NA, NA	3.5 (1.0)
TOTAL											3.5 (1.0)

[a] Number of vessels in the fishery is based on vessels reporting effort to the pelagic longline logbook.
[b] Observer data (Obs. Data) are used to measure bycatch rates, and the data are collected within the Northeast Fisheries Observer Program. Mandatory logbook data were used to measure total effort for the longline fishery. These data are collected at the Southeast Fisheries Science Center (SEFSC).
[c] Proportion of sets observed.

Earlier Interactions

Between 1992 and 2009, 1 *Kogia* sp. was hooked, released alive and considered seriously injured in 2000 (in the Florida East coast fishing area) (Yeung 2001).

Other Mortality

During 2010–2014, 34 dwarf sperm whales were reported stranded along the U.S. Atlantic coast and Puerto Rico (Table 3; Northeast Regional Marine Mammal Stranding Network, Southeast Regional Marine Mammal Stranding Network; NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 15 June 2015 (SER) and 9 June 2015 (NER)). In addition, there were 11 records of unidentified stranded *Kogia*.

Table 3. Dwarf and pygmy sperm whale (*Kogia sima* (Ks), *Kogia breviceps* (Kb) and *Kogia* sp. (Sp)) strandings along the Atlantic coast, 2010–2014. Strandings that were not reported to species have been reported as *Kogia* sp. The level of technical expertise among stranding network personnel varies, and given the potential difficulty in correctly identifying stranded *Kogia* whales to species, reports to specific species should be viewed with caution.

STATE	2010			2011			2012			2013			2014			TOTALS		
	Ks	Kb	Sp	Ks	Kb	Sp	Ks	Kb	Sp	Ks	Kb	Sp	Ks	Kb	Sp	Ks	Kb	Sp
Maine	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
Massachusetts	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0
New York	0	2	0	0	1	0	0	1	0	0	2	0	0	1	0	0	7	0
New Jersey	0	3	0	1	1	0	0	1	0	1	1	0	0	1	0	2	7	0
Delaware	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	2	0
Maryland	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	2	0
Virginia	0	2	0	1	1	0	1	0	0	1	2	0	1	2	0	4	7	0
North Carolina	3	5	0	2	10	0	0	4	0	3	3	1	3	4	1	11	26	2
South Carolina	1	6	0	1	2	0	1	0	0	2	2	0	0	3	0	5	13	0
Georgia	0	2	1	0	4	0	0	4	0	0	5	1	5	1	0	5	16	2
Florida	3	17	0	2	14	1	0	10	0	0	9	6	0	9	0	5	59	7
Puerto Rico	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0
TOTALS	8	38	1	8	34	1	2	21	0	7	26	8	9	23	1	34	142	11

There were two documented strandings of dwarf sperm whales along the U.S. Atlantic coast during 2010–2014 with evidence of human interactions. The first was a whale stranded in Florida during 2010 whose flukes were cut off by a public person on the beach. For the second, plastic was found in the stomach of an animal that stranded in New Jersey during 2011.

Stranding data probably underestimate the extent of human and fishery-related mortality and serious injury because not all of the dolphins that die or are seriously injured in human interactions wash ashore, or, if they do, they are not all recovered (Peltier *et al*. 2012; Wells *et al*. 2015). Additionally, not all carcasses will show evidence of human interaction, entanglement or other fishery-related interaction due to decomposition, scavenger damage, etc. (Byrd *et al*. 2014). Finally, the level of technical expertise among stranding network personnel varies widely as does the ability to recognize signs of human interaction.

STATUS OF STOCK

Dwarf sperm whales are not listed as threatened or endangered under the Endangered Species Act, and the western North Atlantic stock is not considered strategic under the Marine Mammal Protection Act. Total U.S. fishery-related mortality and serious injury for *Kogia* sp. is not less than 10% of the calculated PBR and, therefore, cannot be considered to be insignificant and approaching zero mortality and serious injury rate. The status of dwarf sperm whales in the U.S. Atlantic EEZ relative to OSP is unknown. There are insufficient data to determine population trends for this species.

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PYGMY SPERM WHALE (*Kogia breviceps*): Western North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The pygmy sperm whale (*Kogia breviceps*) is distributed worldwide in temperate to tropical waters (Caldwell and Caldwell 1989; McAlpine 2009). Sightings of *Kogia* whales in the western North Atlantic occur in oceanic waters (Figure 1; Mullin and Fulling 2003; Roberts *et al.* 2015). Stranding records exist from Florida to Maine, but there are no stranding records for the east Canadian coast (Willis and Baird 1998).

Pygmy sperm whales and dwarf sperm whales (*K. sima*) are difficult to differentiate at sea (Caldwell and Caldwell 1989; Bloodworth and Odell 2008; McAlpine 2009), and sightings of either species are often categorized as *Kogia* sp. When measurements can be obtained, diagnostic morphological characters have been useful in distinguishing the two *Kogia* species (Handley 1966; Barros and Duffield 2003), thus enabling researchers to use stranding data in distributional and ecological studies. Specifically, the distance from the snout to the center of the blowhole in proportion to the animal's total length, as well as the height of the dorsal fin in proportion to the animal's total length, can be used to differentiate between the two *Kogia* species (Handley 1966; Barros and Duffield 2003).

In addition to similarities in appearance, dwarf sperm whales and pygmy sperm whales demonstrate similarities in their foraging ecology. Staudinger *et al.* (2014) conducted diet and stable isotope analyses on stranded pygmy and dwarf sperm whales from the mid-Atlantic coast and found that the two species shared the same primary prey and fed in similar habitats.

Across its geographic range, including the western North Atlantic, the population biology of dwarf sperm whales is inadequately known (Staudinger *et al.* 2014). The western North Atlantic pygmy sperm whale population is being considered a separate stock for management purposes, although there is currently no information to differentiate this stock from the northern Gulf of Mexico stock(s). Additional morphological, genetic and/or behavioral data are needed to provide further information on stock delineation.

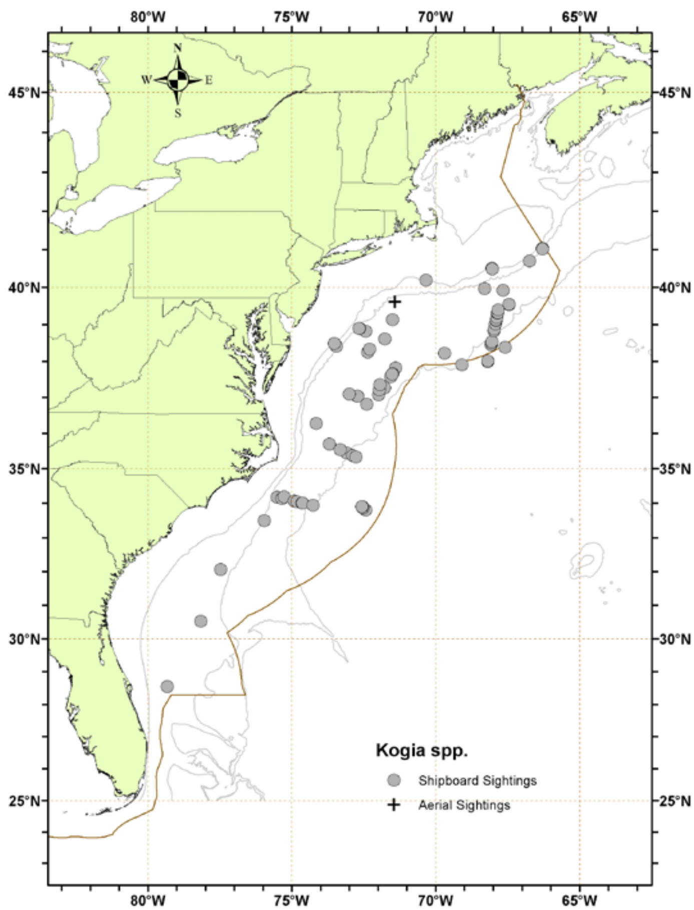

Figure 1. *Distribution of* Kogia *spp. sightings from NEFSC and SEFSC shipboard and aerial surveys during the summers in 2004 and 2011. Isobaths are the 100-m, 1,000-m and 4,000-m depth contours.*

POPULATION SIZE

Total numbers of pygmy sperm whales off the U.S. Atlantic coast are unknown, although abundance estimates from selected regions of pygmy sperm whale habitat do exist for select time periods. Because *K. breviceps* and *K. sima* are difficult to differentiate at sea, the reported abundance estimates are for both species of *Kogia* combined. The best abundance estimate for *Kogia* spp. in the western North Atlantic is 3,785 (CV=0.47; Table 1; Palka 2012; Garrison 2016). This estimate is from summer 2011 surveys covering waters from central Florida to the lower Bay of Fundy. This estimate is almost certainly negatively biased. One component of line transect estimates is *g(0)*, the probability of seeing an animal on the transect line. Estimating *g(0)* is difficult because it consists of accounting for both perception bias (i.e., at the surface but missed) and availability bias (i.e., below the surface while in range of the observers), and many uncertainties (e.g., group size and diving behavior) can confound both (Marsh and Sinclair 1989; Barlow 1999). The best estimate was corrected for perception bias (see below) but not availability bias and is therefore an underestimate.

Earlier abundance estimates

Please see Appendix IV for a summary of abundance estimates, including earlier estimates and survey descriptions.

Recent surveys and abundance estimates

An abundance estimate of 1,783 (CV=0.62) *Kogia* spp. was generated from aerial and shipboard surveys conducted during June–August 2011 between central Virginia and the lower Bay of Fundy (Palka 2012). The aerial portion covered 6,850 km of trackline over waters north of New Jersey between the coastline and the 100-m depth contour through the U.S. and Canadian Gulf of Maine, and up to and including the lower Bay of Fundy. The shipboard portion covered 3,811 km of trackline between central Virginia and Massachusetts in waters deeper than the 100-m depth contour out to beyond the U.S. EEZ. Both sighting platforms used a double-platform data collection procedure, which allowed estimation of abundance corrected for perception bias of the detected species (Laake and Borchers 2004). Estimation of the abundance was based on the independent observer approach assuming point independence (Laake and Borchers 2004) and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009).

An abundance estimate of 2,002 (CV=0.69) *Kogia* spp. was generated from a shipboard survey conducted concurrently (June–August 2011) in waters between central Virginia and central Florida (Garrison 2016). This shipboard survey included shelf-break and inner continental slope waters deeper than the 50-m depth contour within the U.S. EEZ. The survey employed two independent visual teams searching with 25x bigeye binoculars. A total of 4,445 km of trackline were surveyed, yielding 290 cetacean sightings. The majority of sightings occurred along the continental shelf break with generally lower sighting rates over the continental slope. Estimation of the abundance was based on the independent observer approach assuming point independence (Laake and Borchers 2004) and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009).

Table 1. Summary of abundance estimates for the western North Atlantic *Kogia* spp. with month, year, and area covered during each abundance survey, and resulting abundance estimate (N_{best}) and coefficient of variation (CV).

Month/Year	Area	N_{best}	CV
Jun–Aug 2011	central Virginia to lower Bay of Fundy	1,783	0.62
Jun–Aug 2011	central Florida to central Virginia	2,002	0.69
Jun–Aug 2011	central Florida to lower Bay of Fundy (COMBINED)	3,785	0.47

Minimum Population Estimate

The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally distributed best abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by Wade and Angliss (1997). The best estimate of abundance for *Kogia* spp. is 3,785 (CV=0.47). The minimum population estimate for *Kogia* spp. is 2,598 animals.

Current Population Trend

A trend analysis has not been conducted for this stock. There are 3 abundance estimates for *Kogia* spp. from: 1) summer 1998 surveys (536; CV=0.45); 2) summer 2004 surveys (395; CV=0.4); and 3) summer 2011 surveys (3,785; CV=0.47). Methodological differences between the estimates need to be evaluated to quantify trends.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. For purposes of this assessment, the maximum net productivity rate was assumed to be 0.04. This value is based on theoretical modeling showing that cetacean populations may not grow at rates much greater than 4% given the constraints of their reproductive life history (Barlow *et al.* 1995).

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of minimum population size, one-half the maximum productivity rate, and a recovery factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size for *Kogia* spp. is 2,598. The maximum productivity rate is 0.04, the default value for cetaceans. The recovery factor is 0.40 because the CV of the average mortality estimate is greater than 0.8 (Wade and Angliss 1997). PBR for western North Atlantic *Kogia* spp. is 21.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

The estimated annual average fishery-related mortality or serious injury for *Kogia* sp. during 2010–2014 was 3.5 (CV=1.0; Table 2).

Fishery Information

The commercial fisheries that interact, or that could potentially interact, with this stock in the Atlantic Ocean are the Category I Atlantic Highly Migratory Species longline and Atlantic Ocean, Caribbean, Gulf of Mexico large pelagics longline fisheries (Appendix III).

The large pelagics longline fishery operates in the U.S. Atlantic (including Caribbean) and Gulf of Mexico EEZ. Pelagic swordfish, tunas and billfish are the targets of the large pelagics longline fishery. Total estimated annual average fishery-related mortality and serious injury during 2010–2014 was unknown for Atlantic pygmy sperm whales because species-specific mortality estimates could not be made. However, there was 1 report of a *Kogia* sp. seriously injured by the pelagic longline fishery during quarter 4 of 2011 in the mid-Atlantic Bight region. Estimated total serious injury of *Kogia* attributable to the pelagic longline fishery during 2011 was 17.4 (CV=1.0; Garrison and Stokes 2012b). The annual average serious injury and mortality for *Kogia* sp. attributable to the Atlantic large pelagics longline fishery for the 5-year period from 2010 to 2014 was 3.5 animals (CV=1.0; Table 2) (Garrison and Stokes 2012a,b; 2013; 2014; 2016).

The Atlantic Highly Migratory Species longline fishery operates outside the U.S. EEZ. No takes of pygmy sperm whales or *Kogia* sp. within high seas waters of the Atlantic Ocean have been observed or reported thus far.

See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical estimates of annual mortality and serious injury.

Table 2. Summary of the incidental mortality and serious injury of Atlantic Ocean *Kogia* sp. in the pelagic longline commercial fishery including the years sampled (Years), the number of vessels active within the fishery (Vessels), the type of data used (Data Type), the annual observer coverage (Observer Coverage), the annual observed serious injury and mortality recorded by on-board observers, the annual estimated serious injury and mortality, the combined annual estimates of serious injury and mortality (Estimated Combined Mortality), the estimated CV of the combined annual mortality estimates (Est. CVs) and the mean of the combined mortality estimates (CV in parentheses).

Fishery	Years	Vessels[a]	Data Type[b]	Observer Coverage[c]	Observed Serious Injury	Observed Mortality	Estimated Serious Injury	Estimated Mortality	Estimated Combined Mortality	Est. CVs	Mean Annual Mortality
Pelagic Longline	2010–2014	80, 83, 82, 79, 78	Obs. Data Logbook	.08, .09, .07, .09, .10	0,1,0,0,0	0,0,0,0,0	0,17,0,0,0	0,0,0,0,0	0,17,0,0,0	NA, 1.00, NA, NA, NA	3.5 (1.0)
TOTAL											3.5 (1.0)

[a] Number of vessels in the fishery is based on vessels reporting effort to the pelagic longline logbook.
[b] Observer data (Obs. Data) are used to measure bycatch rates, and the data are collected within the Northeast Fisheries Observer Program. Mandatory logbook data were used to measure total effort for the longline fishery. These data are collected at the Southeast Fisheries Science Center (SEFSC).
[c] Proportion of sets observed.

Earlier Interactions

Between 1992 and 2009, 1 *Kogia* sp. was hooked, released alive and considered seriously injured in the pelagic longline fishery in the Atlantic in 2000 (Yeung 2001).

Other Mortality

During 2010–2014, 142 pygmy sperm whales were reported stranded along the U.S. Atlantic coast and Puerto Rico (Table 3; Northeast Regional Marine Mammal Stranding Network, Southeast Regional Marine Mammal Stranding Network; NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 15 June 2015 (SER) and 9 June 2015 (NER)). In addition, there were 11 records of unidentified *Kogia*.

Table 3. Dwarf and pygmy sperm whale (*Kogia sima* (Ks), *Kogia breviceps* (Kb) and *Kogia* sp. (Sp)) strandings along the Atlantic coast, 2010–2014. Strandings that were not reported to species have been reported as *Kogia* sp. The level of technical expertise among stranding network personnel varies, and given the potential difficulty in correctly identifying stranded *Kogia* whales to species, reports to specific species should be viewed with caution.

STATE	2010			2011			2012			2013			2014			TOTALS		
	Ks	Kb	Sp	Ks	Kb	Sp	Ks	Kb	Sp	Ks	Kb	Sp	Ks	Kb	Sp	Ks	Kb	Sp
Maine	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
Massachusetts	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0
New York	0	2	0	0	1	0	0	1	0	0	2	0	0	1	0	0	7	0
New Jersey	0	3	0	1	1	0	0	1	0	1	1	0	0	1	0	2	7	0
Delaware	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	2	0
Maryland	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	2	0
Virginia	0	2	0	1	1	0	1	0	0	1	2	0	1	2	0	4	7	0
North Carolina	3	5	0	2	10	0	0	4	0	3	3	1	3	4	1	11	26	2
South Carolina	1	6	0	1	2	0	1	0	0	2	2	0	0	3	0	5	13	0
Georgia	0	2	1	0	4	0	0	4	0	0	5	1	5	1	0	5	16	2
Florida	3	17	0	2	14	1	0	10	0	0	9	6	0	9	0	5	59	7
Puerto Rico	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0
TOTALS	8	38	1	8	34	1	2	21	0	7	26	8	9	23	1	34	142	11

There were 14 documented strandings of pygmy sperm whales along the U.S. Atlantic coast during 2010–2014 with evidence of human interactions. There were 7 strandings with evidence of human interactions in 2010—3 in Florida, 2 in New Jersey and 2 in South Carolina (1 of them classified as a fishery interaction due to ingested fishing gear, 5 animals ingested plastic, and 1 carcass had some teeth removed by public). In 2011, there were 4 strandings with evidence of human interactions—1 in Virginia (public attempted to move the animal), 1 in Florida (pushed out to sea by public) and 2 in Georgia (plastic ingestion). In 2012 there was 1 stranding in Florida with evidence of human interaction (ingested debris). In 2013 in Georgia there was 1 stranding with evidence of human interaction, and in 2014 in North Carolina there was also 1 stranding with evidence of human interaction (both animals ingested plastic).

Stranding data probably underestimate the extent of human and fishery-related mortality and serious injury because not all of the dolphins that die or are seriously injured in human interactions wash ashore, or, if they do, they are not all recovered (Peltier *et al*. 2012; Wells *et al*. 2015). Additionally, not all carcasses will show evidence of human interaction, entanglement or other fishery-related interaction due to decomposition, scavenger damage, etc. (Byrd *et al*. 2014). Finally, the level of technical expertise among stranding network personnel varies widely as does the ability to recognize signs of human interaction.

STATUS OF STOCK

Pygmy sperm whales are not listed as threatened or endangered under the Endangered Species Act, and the western North Atlantic stock is not considered strategic under the Marine Mammal Protection Act. Total U.S. fishery-related mortality and serious injury for *Kogia* sp. is not less than 10% of the calculated PBR and, therefore, cannot be considered to be insignificant and approaching zero mortality and serious injury rate. The status of pygmy sperm whales in the U.S. Atlantic EEZ relative to OSP is unknown. There are insufficient data to determine population trends for this species.

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RISSO'S DOLPHIN (*Grampus griseus*): Western North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Risso's dolphins are distributed worldwide in tropical and temperate seas (Jefferson *et al*. 2008, 2014), and in the Northwest Atlantic occur from Florida to eastern Newfoundland (Leatherwood *et al*. 1976; Baird and Stacey 1991). Off the northeastern U.S. coast, Risso's dolphins are distributed along the continental shelf edge from Cape Hatteras northward to Georges Bank during spring, summer, and autumn (CETAP 1982; Payne *et al*. 1984) (Figure 1). In winter, the range is in the mid-Atlantic Bight and extends outward into oceanic waters (Payne *et al*. 1984). In general, the population occupies the mid-Atlantic continental shelf edge year round, and is rarely seen in the Gulf of Maine (Payne *et al*. 1984). During 1990, 1991 and 1993, spring/summer surveys conducted along the continental shelf edge and in deeper oceanic waters sighted Risso's dolphins associated with strong bathymetric features, Gulf Stream warm-core rings, and the Gulf Stream north wall (Waring *et al*. 1992, 1993; Hamazaki 2002). There is no information on stock structure of Risso's dolphin in the western North Atlantic, or to determine if separate stocks exist in the Gulf of Mexico and Atlantic. Thus, it is plausible that the stock could actually contain multiple demographically independent populations that should themselves be stocks, because the current stock spans multiple eco-regions (Longhurst 1998; Spalding *et al*. 2007). In 2006, a rehabilitated adult male Risso's dolphin stranded and released in the Gulf of Mexico off Florida was tracked via satellite-linked tag to waters off Delaware (Wells *et al*. 2009). The Gulf of Mexico and Atlantic stocks are currently being treated as two separate stocks.

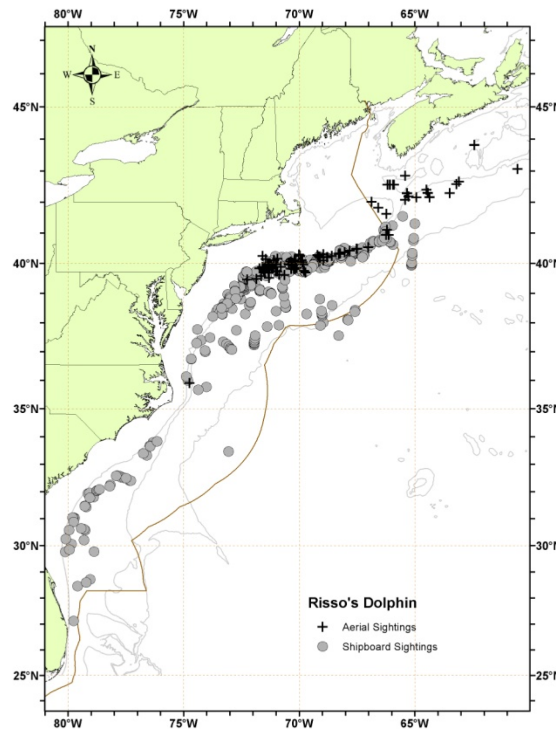

Figure 1. *Distribution of Risso's dolphin sightings from NEFSC and SEFSC shipboard and aerial surveys during the summers of 1995, 1998, 1999, 2002, 2004, 2006, 2007, 2008 2010 and 2011. Isobaths are the 100-m, 1,000-m, and 4,000-m depth contours.*

POPULATION SIZE

The best abundance estimate for Risso's dolphins is the sum of the estimates from the 2011 surveys—18,250 (CV = 0.46).

Earlier abundance estimates

Please see Appendix IV for a summary of abundance estimates, including earlier estimates and survey descriptions. As recommended in the GAMMS II Workshop Report (Wade and Angliss 1997), estimates older than eight years are deemed unreliable for the determination of the current PBR.

Recent surveys and abundance estimates

An abundance estimate of 15,197 (CV = 0.55) Risso's dolphins was generated from a shipboard and aerial survey conducted during June–August 2011 (Palka 2012). The aerial portion that contributed to the abundance estimate covered 5,313 km of tracklines that were over waters north of New Jersey from the coastline to the 100-m depth contour, through the U.S. and Canadian Gulf of Maine and up to and including the lower Bay of Fundy. The shipboard portion covered 3,107 km of tracklines that were in waters offshore of central Virginia to Massachusetts (waters that were deeper than the 100-m depth contour out to beyond the U.S. EEZ). Both sighting platforms used a double-platform data-collection procedure, which allows estimation of abundance corrected for perception bias of the detected species (Laake and Borchers, 2004). Shipboard data were inspected to determine if there was significant responsive movement to the ship (Palka and Hammond 2001). Because there was evidence of responsive (evasive) movement of this species to the ship, estimation of the abundance was based on Palka and Hammond (2001) and the independent-observer approach assuming full independence (Laake and Borchers 2004), and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009).

An abundance estimate of 3,053 (CV = 0.44) Risso's dolphins was generated from a shipboard survey conducted concurrently (June–August 2011) in waters between central Virginia and central Florida. This shipboard survey included shelf-break and inner continental slope waters deeper than the 50-m depth contour within the U.S. EEZ. The survey employed the double-platform methodology searching with 25×150 "bigeye" binoculars. A total of 4,445 km of tracklines was surveyed, yielding 290 cetacean sightings. The majority of sightings occurred along the continental shelf break with generally lower sighting rates over the continental slope. Estimation of the abundance was based on the independent-observer approach assuming point independence (Laake and Borchers 2004) and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009).

Table 1. Summary of recent abundance estimates for the western North Atlantic Risso's dolphin (*Grampus griseus*), by month, year, and area covered during each abundance survey, resulting abundance estimate (N_{best}) and coefficient of variation (CV).

Month/Year	Area	N_{best}	CV
Jun-Aug 2011	Central Virginia to lower Bay of Fundy	15,197	0.55
Jun-Aug 2011	Central Florida to Central Virginia	3,053	0.44
Jun-Aug 2011	Central Florida to lower Bay of Fundy (COMBINED)	18,250	0.46

Minimum Population Estimate

The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally distributed best abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by Wade and Angliss (1997). The best estimate of abundance for Risso's dolphins is 18,250 (CV = 0.46), obtained from the 2011 surveys. The minimum population estimate for the western North Atlantic Risso's dolphin is 12,619.

Current Population Trend

A trend analysis has not been conducted for this stock. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval. For example, the power to detect a precipitous decline in abundance (i.e., 50% decrease in 15 years) with estimates of low precision (e.g., CV > 0.30) remains below 80% (alpha = 0.30) unless surveys are conducted on an annual basis (Taylor *et al.* 2007).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. For purposes of this assessment, the maximum net productivity rate was assumed to be 0.04. This value is based on theoretical modeling showing that cetacean populations may not grow at rates much greater than 4% given the constraints of their reproductive life history (Barlow *et al*. 1995).

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of minimum population size, one-half the maximum productivity rate, and a recovery factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size is 12,619. The maximum productivity rate is 0.04, the default value for cetaceans (Barlow *et al.* 1995). The recovery factor is 0.5, the default value for stocks of unknown status relative to OSP, and the CV of the average mortality estimate is less than 0.3 (Wade and Angliss 1997). PBR for the western North Atlantic stock of

Risso's dolphin is 126.

ANNUAL HUMAN-CAUSED MORTALITY

Total annual estimated average fishery-related mortality or serious injury to this stock during 2010–2014 was 53.6 Risso's dolphins, derived from 2 components: 1) 53 estimated mortalities in observed fisheries (CV = 0.28; Table 2) and 2) 0.6 from average 2010–2014 non-fishery related, human interaction stranding mortalities (NOAA National Marine Mammal Health and Stranding Response Database, accessed 08 October 2015)

Fishery Information

Detailed fishery information is reported in Appendix III.

Earlier Interactions

One Risso's dolphin mortality was observed in the mid-Atlantic midwater trawl fishery in 2008. No bycatch estimate was developed, so the 2008 average annual serious injury and mortality attributed to the mid-Atlantic midwater trawl was calculated as a minimum value of 1 animal.

Historically, fishery interactions have been documented with Risso's dolphins in squid and mackerel trawl activities (1977–1991), the pelagic drift gillnet fishery (1989–1998), the pelagic pair trawl fishery (1992), and the mid-Atlantic gillnet fishery (2007). See Appendix V for more information on historical takes.

Pelagic Longline

Pelagic longline bycatch estimates of Risso's dolphins for 2010–2014 are documented in Garrison and Stokes (2012a, 2012b, 2013, 2014, 2016). Most of the estimated marine mammal bycatch was from U.S. Atlantic EEZ waters between South Carolina and Cape Cod. There is a high likelihood that dolphins released alive with ingested gear or gear wrapped around appendages will not survive (Wells *et al.* 2008). See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Northeast Bottom Trawl

One Risso's dolphin was observed taken in northeast bottom trawl fisheries in 2010 and one in 2014 (Table 2). Annual Risso's dolphin mortalities were estimated using annual stratified ratio-estimator methods (Lyssikatos 2015).See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Mid-Atlantic Bottom Trawl

Risso's dolphinss have been observed taken in mid-Atlantic bottom trawl fisheries (Table 2). No seriously injured Risso's dolphins have been observed in this fishery. It was discovered in 2010 that a small segment of the mid-Atlantic bottom trawl fleet was equipping fishing nets with acoustic deterrent devices (i.e., pingers). To the extent possible, the use of pingers on bottom trawl gear has been taken into account when estimating bycatch mortality of Risso's dolphins (methodology is detailed in Lyssikatos 2015). Annual Risso's dolphin mortalities were estimated using annual stratified ratio-estimator methods (Lyssikatos 2015). See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Northeast Sink Gillnet

In the northeast sink gillnet fishery, Risso's dolphin interactions have historically been rare, but in 2012 and 2013 one animal was observed each year in the waters south of Massachusetts (Hatch and Orphanides 2014, 2015, 2016*)*. See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Table 2. Summary of the incidental serious injury and mortality of Risso's dolphin (*Grampus griseus*) by commercial fishery including the years sampled, the type of data used, the annual observer coverage, the observed mortalities and serious injuries recorded by on-board observers, the estimated annual mortality and serious injury, the combined annual estimates of mortality and serious injury, the estimated CV of the combined estimates and the mean of the combined estimates (CV in parentheses).

Fishery	Years	Data Type [a]	Observer Coverage [b]	Observed Serious Injury	Observed Mortality	Estimated Serious Injury[e]	Estimated Mortality	Estimated Combined Mortality	Estimated CVs	Mean Combined Annual Mortality
Pelagic Longline [c]	10-14	Obs. Data Logbook	.08, .09, .07, .09	0, 2, 1, 1, 1	0, 0, 0, 0, 0	0, 12, 15, 1.9, 7.7	0, 0, 0, 0. 0	0, 12, 15, 1.9, 7.7	0, .63, 1.0, 1.0, 1.0	7.3 (0.52)
Northeast Sink Gillnet	10-14	Obs. Data, Trip Logbook, Allocated Dealer Data	0.17, .19, .15, .11, .18	0, 0, 0, 0, 0	0, 0, 1, 1, 0	0, 0, 0, 0, 0	0, 0, 6, 23, 0	0, 0, 6, 23, 0	0, 0, .87, 1, 0	5.8 (0.79)
Northeast Bottom Trawl[c]	10-14	Obs. Data Dealer Data VTR Data	.16, .26, .17, .15, .17	0, 0, 0, 0, 0	1, 0, 0, 0, 1	0, 0, 0, 0, 0	2, 3, 0, 0, 4.2	2, 3, 0, 0, 4.2	.55, .55, 0, 0, .91	1.8 (0.47)
Mid-Atlantic Bottom Trawl [d]	10-14	Obs. Data Dealer Data	.06, .08, .05, .06, .08	0, 0, 0, 0 , 0	15, 2, 1, 4, 2	0, 0, 0, 0 , 0	54, 62, 7, 46, 21	54, 62, 7, 46, 21	.74, .56, 1.0, .71, .93	38 (.35)
TOTAL										53 (0.28)

[a] Observer data (Obs. Data) are used to measure bycatch rates and the data are collected within the Northeast Fisheries Observer Program. NEFSC collects landings data (unallocated Dealer Data and Allocated Dealer Data) which are used as a measure of total landings and mandatory Vessel Trip Reports (VTR) (Trip Logbook) are used to determine the spatial distribution of landings and fishing effort. Total landings are used as a measure of total effort for the coastal gillnet fishery.

[b] The observer coverages for the northeast and mid-Atlantic sink gillnet fishery are ratios based on tons of fish landed. Northeast bottom trawl, mid-Atlantic bottom trawl, northeast mid-water and mid-Atlantic mid-water trawl fishery coverages are ratios based on trips. Total observer coverage reported for gillnet and bottom trawl gear in the years starting in 2010 include samples collected from traditional fisheries observers in addition to fishery at-sea monitors through the Northeast Fisheries Observer Program (NEFOP). For 2010 only the NEFOP observed data were reported in this table, since the at-sea monitoring program just started in May 2010. Both at-sea monitor and traditional fisheries observer data were used for 2011 and onwards.

[c] Estimates can include data pooled across years, so years without observed SI or Mortality may still have an estimated value.

[d] Fishery related bycatch rates were estimated using an annual stratified ratio-estimator.

e Waring et al. 2014,2015, Wenzel *et al*. 2015, 2016.

Other Mortality

From 2010 to 2014, 30 Risso's dolphin strandings were recorded along the U.S. Atlantic coast (NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 08 October 2015). Five animals had indications of human interaction, 2 of which were fishery interactions. Indications of human interaction are not necessarily the cause of death (Table 3).

Table 3. Risso's dolphin (*Grampus griseus*) reported strandings along the U.S. Atlantic coast and Puerto Rico, 2010-2014.						
STATE	**2010**	**2011**	**2012**	**2013**	**2014**	**TOTALS**
Maine	0	0	0	0	0	0
Massachusetts[a]	0	0	0	3	2	5
New York	0	1	0	2	0	3
New Jersey	0	0	0	0	0	0
Maryland	1	0	0	1	0	2
Virginia[b]	4	1	0	0	1	6
North Carolina[c]	2	1	2	1	1	7
Georgia	0	0	0	0	0	0
Florida	0	2	2	2	0	6
Puerto Rico	0	1	0	0	0	1
TOTAL	**7**	**6**	**4**	**9**	**4**	**30**
a. One animal in 2014 was classified as human interaction due to signs of ear trauma.						
b. One animal in 2014 classified as HI due to plastic injestion.						
c. One animal in 2010 classified as human interaction due to beach mutilation. Two animals in 2012 showed signs of fishery interaction.						

Stranding data probably underestimate the extent of fishery-related mortality and serious injury because all of the marine mammals that die or are seriously injured may not wash ashore, nor will all of those that do wash ashore necessarily show signs of entanglement or other fishery-interaction. Finally, the level of technical expertise among stranding network personnel varies widely as does the ability to recognize signs of fishery interaction.

STATUS OF STOCK

Risso's dolphins are not listed as threatened or endangered under the Endangered Species Act and the Western North Atlantic stock is not considered strategic under the Marine Mammal Protection Act. The 2010–2014 average annual human-related mortality does not exceed PBR. The total U.S. fishery mortality and serious injury for this stock is not less than 10% of the calculated PBR and, therefore, cannot be considered to be insignificant and approaching a zero mortality and serious injury rate. The status of Risso's dolphins relative to OSP in the U.S. Atlantic EEZ is unknown. Population trends for this species have not been investigated.

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LONG-FINNED PILOT WHALE (*Globicephala melas melas*): Western North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

There are two species of pilot whales in the western Atlantic—the long-finned pilot whale, *Globicephala melas melas*, and the short-finned pilot whale, *G. macrorhynchus*. These species are difficult to differentiate at sea and cannot be reliably visually identified during either abundance surveys or observations of fishery mortality without high-quality photographs (Rone and Pace 2012); therefore, the ability to separately assess the two species in U.S. Atlantic waters is complex and requires additional information on seasonal spatial distribution. The long-finned pilot whale is distributed from North Carolina to North Africa (and the Mediterranean) and north to Iceland, Greenland and the Barents Sea (Sergeant 1962; Leatherwood *et al.* 1976; Abend 1993; Bloch *et al.* 1993; Abend and Smith 1999). The stock structure of the North Atlantic population is uncertain (ICES 1993; Fullard *et al.* 2000). Morphometric (Bloch and Lastein 1993) and genetic (Siemann 1994; Fullard *et al.* 2000) studies have provided little support for stock separation across the Atlantic (Fullard *et al.* 2000). However, Fullard *et al.* (2000) have proposed a stock structure that is related to sea-surface temperature: 1) a cold-water population west of the Labrador/North Atlantic current, and 2) a warm-water population that extends across the Atlantic in the Gulf Stream.

In U.S. Atlantic waters, pilot whales (*Globicephala* sp.) are distributed principally along the continental shelf edge off the northeastern U.S. coast in winter and early spring (CETAP 1982; Payne and Heinemann 1993; Abend and Smith 1999; Hamazaki 2002). In late spring, pilot whales move onto Georges Bank and into the Gulf of Maine and more northern waters, and remain in these areas through late autumn (CETAP 1982; Payne and Heinemann 1993). Pilot whales tend to occupy areas of high relief or submerged banks. They are also associated with the Gulf Stream wall and thermal fronts along the continental shelf edge (Waring *et al.* 1992). Long-finned and short-finned pilot whales overlap spatially along the mid-Atlantic shelf break between New Jersey and the southern flank of Georges Bank (Payne and Heinemann 1993; Rone and Pace 2012). Long-finned pilot whales have occasionally been observed stranded as far south as South Carolina, and short-finned pilot whales have occasionally been observed stranded as far north as Massachusetts. The latitudinal ranges of the two species therefore remain uncertain, although south of Cape Hatteras, most pilot whale sightings are expected to be short-finned

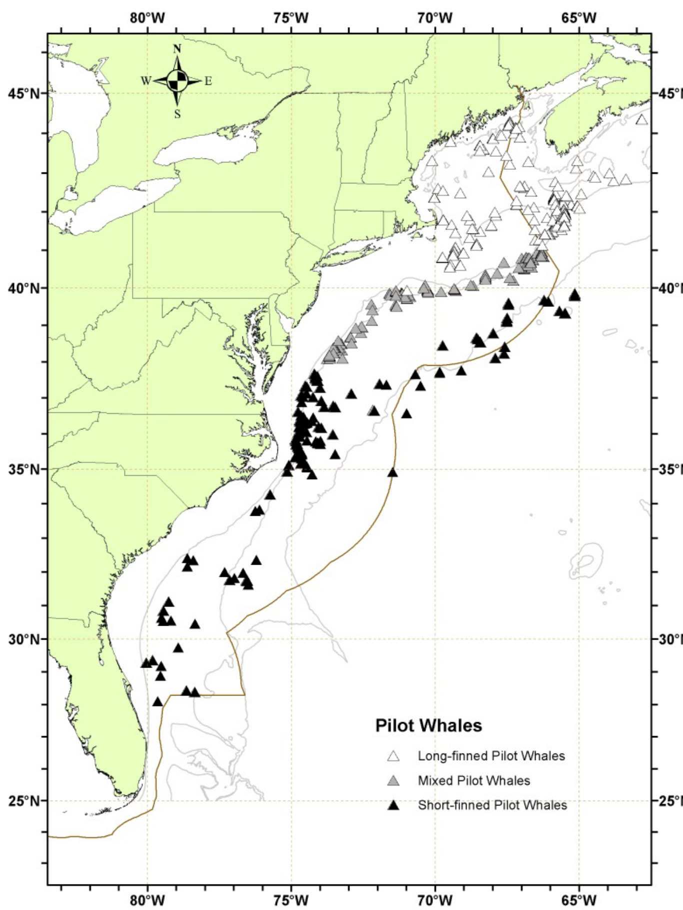

Figure 1. *Distribution of long-finned (open symbols), short-finned (black symbols), and possible mixed (gray symbols; could be either species) pilot whale sightings from NEFSC and SEFSC shipboard and aerial surveys during the summers of 1998, 1999, 2002, 2004, 2006, 2007 and 2011. The inferred distribution of the two species is preliminary and is valid for June-August only. Isobaths are the 100-m, 1,000-m, and 4,000-m depth contours.*

pilot whales, while north of ~42°N most pilot whale sightings are expected to be long-finned pilot whales (Figure 1).

POPULATION SIZE

The best available estimate for long-finned pilot whales in the western North Atlantic is 5,636 (CV=0.63; Table 1; Palka 2012). This estimate is from summer 2011 surveys covering waters from central Virginia to the lower Bay of Fundy. It should be noted, however, that these surveys did not include areas of the Scotian Shelf where the highest densities of pilot whales were observed in the summer of 2006, therefore they represent an underestimate of the overall abundance of this stock. Because long-finned and short-finned pilot whales are difficult to distinguish at sea, sightings data are reported as *Globicephala sp*. These survey data have been combined with an analysis of the spatial distribution of the 2 species based on genetic analyses of biopsy samples to derive separate abundance estimates (Garrison and Rosel 2017).

Earlier estimates

Please see appendix IV for a summary of abundance estimates including earlier estimates and survey descriptions. As recommended in the GAMMS II Workshop Report (Wade and Angliss 1997), estimates older than eight years are deemed unreliable for the determination of the current PBR. Due to changes in survey methodology, these historical data should not be used to make comparisons with more current estimates.

Recent surveys and abundance estimates for *Globicephala* sp.

An abundance estimate of 11,865 (CV=0.57) *Globicephala* sp. was generated from aerial and shipboard surveys conducted during June–August 2011 between central Virginia and the lower Bay of Fundy (Palka 2012). The aerial portion covered 6,850 km of tracklines over waters north of New Jersey between the coastline and the 100-m depth contour through the U.S. and Canadian Gulf of Maine, and up to and including the lower Bay of Fundy. Pilot whales were not observed during the aerial portion of the survey. The shipboard portion covered 3,811 km of tracklines between central Virginia and Massachusetts in waters deeper than the 100-m depth contour out to beyond the U.S. Exclusive Economic Zone (EEZ). Both sighting platforms used a double-platform data-collection procedure, which allows estimation of abundance corrected for perception bias of the detected species (Laake and Borchers 2004). Estimation of the abundance was based on the independent-observer approach assuming point independence (Laake and Borchers 2004) and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009). The vessel portion of this survey included habitats where both short-finned and long-finned pilot whales occur. A logistic regression (see next section) was used to estimate the abundance of long-finned pilot whales from this survey as 5,636 (CV=0.63).

An abundance estimate of 16,946 (CV=0.43) *Globicephala* sp. was generated from a shipboard survey conducted concurrently (June–August 2011) in waters between central Virginia and central Florida (Garrison 2016). This shipboard survey included shelf-break and inner continental slope waters deeper than the 50-m depth contour within the U.S. EEZ. The survey employed two independent visual teams searching with 25× bigeye binoculars. A total of 4,445 km of tracklines was surveyed, yielding 290 cetacean sightings. The majority of sightings occurred along the continental shelf break north of Cape Hatteras, North Carolina, with a lower number of sightings over the continental slope in the southern portion of the survey. Estimation of pilot whale abundance was based on the independent-observer approach assuming point independence (Laake and Borchers 2004) and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009). This survey included habitats where only short-finned pilot whales are expected to occur.

Spatial Distribution and Abundance Estimates for *Globicephala melas*

Biopsy samples from pilot whales were collected during summer months (June–August) from South Carolina to the southern flank of Georges Bank between 1998 and 2007. These samples were identified to species using genetic analysis of mitochondrial DNA sequences. A portion of the mtDNA genome was sequenced from each biopsy sample collected in the field, and genetic species identification was performed through phylogenetic reconstruction of the haplotypes. Stranded specimens that were morphologically identified to species were used to assign clades in the phylogeny to species and thereby identify all samples. The probability of a sample being from a long-finned (or short-finned) pilot whale was evaluated as a function of sea-surface temperature and water depth using logistic regression. This analysis indicated that the probability of a sample coming from a long-finned pilot whale was near 1 at water temperatures <22°C, and near 0 at temperatures >25°C. The probability of a long-finned pilot whale also decreased with increasing water depth. Spatially, during summer months, this regression model predicts that all pilot whales observed in offshore waters near the Gulf Stream are most likely short-finned pilot whales. The area of overlap between the 2 species occurs primarily along the shelf break off the coast of New Jersey between 38°N and

40°N latitude (Garrison and Rosel 2017). This model was used to partition the abundance estimates from surveys conducted during the summer of 2011. The sightings from the southeast shipboard survey covering waters from Florida to central Virginia were predicted to consist entirely of short-finned pilot whales. The aerial portion of the northeast surveys covered the Gulf of Maine and the Bay of Fundy and surveys where the model predicted that only long-finned pilot whales would occur, but no pilot whales were observed. The vessel portion of the northeast survey recorded a mix of both species along the shelf break, and the sightings in offshore waters near the Gulf Stream were predicted to consist predominantly of short-finned pilot whales (Garrison and Rosel 2017). The abundance estimate for long-finned pilot whales from the northeast summer 2011 vessel survey was 5,636 (CV=0.63; Palka 2012). The summer 2011 aerial survey of the Gulf of Maine to the Bay of Fundy did not include areas of the Scotian Shelf where the highest densities of pilot whales were observed in the summer of 2006, therefore the 2011 summer surveys are an underestimate of the overall abundance of this stock.

Table 1. Summary of recent abundance estimates for the western North Atlantic long-finned pilot whale (*Globicephala melas melas*) by month, year, and area covered during each abundance survey, and resulting abundance estimate (N_{best}) and coefficient of variation (CV).

Month/Year	Area	N_{best}	CV
Jun-Aug 2011	central Virginia to Lower Bay of Fundy	5,636	0.63

Minimum Population Estimate

The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally distributed best abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by Wade and Angliss (1997). The best estimate of abundance for western North Atlantic long-finned pilot whales is 5,636 animals (CV=0.63). The minimum population estimate for long-finned pilot whales is 3,464.

Current Population Trend

A trend analysis has not been conducted for this stock. There are 2 abundance estimates for *Globicephala* spp. from summer 1998 (14,909; CV=0.26) and summer 2004 surveys (31,139; CV=0.27), and 1 abundance estimate of *G. melas* from summer 2011 surveys (5,636; CV=0.63). Because the 1998 and 2004 surveys did not derive separate abundance estimates for each pilot whale species, comparisons to the 2011 estimate are inappropriate.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. For purposes of this assessment, the maximum net productivity rate was assumed to be 0.04. This value is based on theoretical modeling showing that cetacean populations may not grow at rates much greater than 4% given the constraints of their reproductive life history (Barlow *et al.* 1995).

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of minimum population size, one-half the maximum productivity rate, and a "recovery" factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size for long-finned pilot whales is 3,464. The maximum productivity rate is 0.04, the default value for cetaceans. The "recovery" factor is 0.5 because this stock is of unknown status relative to optimum sustainable population (OSP) and the CV of the average mortality estimate is less than 0.3 (Wade and Angliss 1997). PBR for the western North Atlantic long-finned pilot whale is 35.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Total annual observed average fishery-related mortality or serious injury during 2010–2014 was 38 for long-finned pilot whales (CV=0.15; see Table 2). In bottom trawls and mid-water trawls and in the gillnet fisheries, mortalities were more generally observed north of 40°N latitude and in areas expected to have only long-finned pilot whales. Takes in these fisheries were therefore attributed to the long-finned pilot whales. Takes in the pelagic longline fishery were partitioned according to a logistic regression model (Garrison and Rosel 2017).

Fishery Information

The commercial fisheries that could potentially interact with this stock in the Atlantic Ocean are the Category I northeast sink gillnet and the Atlantic Ocean, Caribbean, Gulf of Mexico large pelagics longline fisheries; and the

Category II northeast bottom trawl and northeast mid-water trawl (including pair trawl) fisheries. Detailed fishery information is reported in Appendix III.

Earlier Interactions

Historically, fishery interactions have been documented with pilot whales in the Atlantic pelagic drift gillnet fishery, Atlantic tuna pair trawl and tuna purse seine fisheries, northeast and mid-Atlantic gillnet fisheries, northeast and mid-Atlantic bottom trawl fisheries, northeast midwater trawl fishery, and the pelagic longline fishery. See Appendix V for more information on historical takes.

Northeast Sink Gillnet

One pilot whale was caught in this fishery in 2010. According to modeled species distribution, this whale was a long-finned pilot whale. See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Longline

Most of the estimated marine mammal bycatch in the U.S. pelagic longline fishery was recorded in U.S. Atlantic EEZ waters between South Carolina and Cape Cod (Garrison 2007). During 2010–2013, all observed interactions and estimated bycatch in the pelagic longline fishery was assigned to the short-finned pilot whale stock because the observed interactions all occurred at times and locations where available data indicated that long-finned pilot whales were very unlikely to occur. Specifically, the highest bycatch rates of undifferentiated pilot whales were observed during September–November along the mid-Atlantic coast (south of 40°N; Garrison 2007), and biopsy data collected in this area during October–November 2011 indicated that only short-finned pilot whales occurred in this region (Garrison and Rosel 2017). Similarly, all genetic data collected from interactions in the pelagic longline fishery have indicated interactions with short-finned pilot whales. However, during 2014, 4 pilot whale interactions (all serious injuries) occurred along the southern flank of Georges Bank. No samples were collected from these animals. Therefore, the logistic regression model (described above in 'Spatial Distribution and Abundance Estimates for *Globicephala melas*') was applied to estimate the probability that these 2014 interactions were from short-finned vs. long-finned pilot whales (Garrison and Rosel 2017). Due to high water temperatures (approximately 25ºC) along the southern flank of Georges Bank at the time of the observed takes, these interactions were estimated to have a >80% probability of coming from short-finned pilot whales. The estimated probability was used to apportion the estimated serious injury and mortality from 2014 in the pelagic longline fishery between the short-finned and long-finned pilot whale stocks. The estimated serious injury and mortality for the short-finned pilot whale was 233 (CV=0.24), and that for long-finned pilot whales was 9.6 (CV=0.43; Garrison and Stokes 2016). See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Northeast Bottom Trawl

In addition to takes observed by fisheries observers, the Marine Mammal Authorization Program (MMAP) (http://www.nmfs.noaa.gov/pr/interactions/mmap/) included 2 self-reported incidental takes (mortalities) in trawl gear off Maine and Rhode Island during 2011. Self-reported takes were not used in the estimation process and are not reported in Table 2. Fishery-related bycatch rates for years 2010–2014 were estimated using an annual stratified ratio-estimator (Lyssikatos 2015). These mortality estimates replace the 2008–2011 annual estimates reported in the 2013 stock assessment report that were generated using a different method described in Rossman (2010). See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Northeast Mid-Water Trawl (Including Pair Trawl)

In September 2011, one pilot whale was taken in the northeast mid-water trawl fishery on the northern flank of Georges Bank. Another pilot whale was taken in a mid-water trawl in 2012. Three were taken in 2013 near the western edge of Georges Bank. Four were taken in 2014. Using model-based predictions and at-sea identification, these takes have all been assigned as long-finned pilot whales. Due to small sample sizes, the ratio method was used to estimate the bycatch rate (observed takes per observed hours the gear was in the water) for each year, where the paired and single northeast mid-water trawls were pooled and only hauls that targeted herring or mackerel were used. The VTR herring and mackerel data were used to estimate the total effort (NMFS unpublished data). Estimated annual fishery-related mortalities were 0 in 2010 (Table 2). Expanded estimates of fishery mortality for 2011- 2014 are not available, and so for those years the raw number is provided. See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

CANADA

Unknown numbers of long-finned pilot whales have been taken in Newfoundland, Labrador, and Bay of Fundy groundfish gillnets; Atlantic Canada and Greenland salmon gillnets; and Atlantic Canada cod traps (Read 1994).

Table 2. Summary of the incidental mortality and serious injury of long-finned pilot whales (*Globicephala melas melas.*) by commercial fishery including the years sampled (Years), the type of data used (Data Type), the annual observer coverage (Observer Coverage), the observed mortalities and serious injuries recorded by on-board observers, the estimated annual mortality and serious injury, the combined annual estimates of mortality and serious injury (Estimated Combined Mortality), the estimated CV of the combined estimates (Est. CVs) and the mean of the combined estimates (CV in parentheses). These are minimum observed counts as expanded estimates are not available.

Fishery	Years	Data Type[a]	Observer Coverage[b]	Observed Serious Injury [d]	Observed Mortality	Estimated Serious Injury	Estimated Mortality	Estimated Combined Mortality	Est. CVs	Mean Annual Mortality
Northeast Sink Gillnet	10-14	Obs. Data, Logbook , Dealer Data	.17, .19, .15, .11, .18	0, 0, 0, 0, 0	1, 0, 0, 0, 0	0, 0, 0, 0, 0	3, 0, 0, 0, 0	3, 0, 0, 0, 0	82, 0, 0, 0, 0	0.6 (0.82)
Northeast Bottom Trawl [b]	10-14	Obs. Data, Logbook	.16, .26, .17. .15	1,3,3,0, 1	9,9,7,4, 4	6, 12, 10, 0, 6	24, 43, 23, 16, 25	30, 55, 33, 16, 32	.43, .18, .32, .42, .44	33.2 (0.15)
Northeast Mid-Water Trawl - Including Pair Trawl [c]	10-14	Obs. Data, Dealer Data, VTR Data	.41, .17, .45, .37, .42	0, 0, 0, 0, 0	0,1, 1, 3, 4	0, 0, 0, 0, 0	,0, 1, 1, 3, 4	0, 1, 1, 3, 4	na, na, na, na, na	1.8 (na)
Pelagic Longline Fishery	10-14	Obs. Data, Logbook Data	.08, .09, . 07, .09, .1 0	0,0,0,0,1	0,0,0,0,0	0,0,0,0,9.6	0,0,0,0,0	0,0,0,0,0,9.6	na, na, na, na, .43	1.9 (0.43)
TOTAL										38 (0.15)

[a] Observer data (Obs. Data) are used to measure bycatch rates and the data are collected within the Northeast Fisheries Observer Program (NEFOP). NEFSC collects landings data (unallocated Dealer Data and Allocated Dealer Data) which are used as a measure of total landings and mandatory Vessel Trip Reports (VTR) (Trip Logbook) are used to determine the spatial distribution of landings and fishing effort. Total landings are used as a measure of total effort for the coastal gillnet fishery.

[b] The observer coverages for the northeast sink gillnet fishery are ratios based on tons of fish landed. Northeast bottom trawl and northeast mid-water trawl fishery coverages are ratios based on trips. Total observer coverage reported for gillnet and bottom trawl gear in the years starting in 2010 include samples collected from traditional fisheries observers in addition to fishery at-sea monitors through the Northeast Fisheries Observer Program (NEFOP). For 2010 only the NEFOP observed data were reported in this table, since the at-sea monitoring program just started in May 2010. Both at-sea monitor and traditional fisheries observer data were used for 2011 and onwards

[c] Expanded estimates for 2010–2014 are not available for this fishery.

[d] Waring et al. 2014,2015, Wenzel *et al*. 2015, 2016.

Other Mortality

Pilot whales have a propensity to mass strand throughout their range, but the role of human activity in these events is unknown. From 2010 to 2014, 27 long-finned pilot whales (*Globicephala melas melas*), and 5 pilot whales not specified to the species level (*Globicephala* sp.) were reported stranded between Maine and Florida, including the EEZ (Table 3).

Long-finned pilot whales have been reported stranded as far south as Florida, where 2 long-finned pilot whales were reported stranded in November 1998, though their flukes had been apparently cut off, so it is unclear where these animals actually may have died. One additional long-finned pilot whale stranded in South Carolina in 2003, though the confidence in the species identification at the time was only moderate. A genetic sample from this animal has subsequently been sequenced and mitochondrial DNA analysis supports the long-finned pilot whale identification.

During 2010–2014, several human and/or fishery interactions were documented in stranded pilot whales within the U.S. EEZ. Two long-finned pilot whale stranding mortalities in 2011 in Massachusetts were classified as human interaction cases, one due to onlookers trying to refloat the animal, and another with tow rope around the tail most likely tied on postmortem.

Table 3. Pilot whale *Globicephala melas melas* [LF] *and Globicephala* sp. [Sp]) strandings along the Atlantic coast, 2010-2014. Strandings which were not reported to species have been reported as *Globicephala* sp. The level of technical expertise among stranding network personnel varies, and given the potential difficulty in correctly identifying stranded pilot whales to species, reports to specific species should be viewed with caution.

STATE	2010		2011		2012		2013		2014		TOTALS	
	LF	Sp	LF	Sp	LF	Sp	LF	Sp	LF	Sp	LF	Sp
Nova Scotia[a]	0	11	0	19	0	3	15	0	0	0	15	33
Newfoundland and Labrador[b]	0	1	0	8	0	6	1	1	0	1	1	17
Maine	0	0	1	0	1	0	0	0	2	0	4	0
Massachusetts[c]	2	0	4		3		3		1		13	0
Rhode Island	0	0	2	0	0	0	0	0	0	0	2	0
New York	0	0	1	0	1	0	2	0	1	0	5	0
New Jersey	0	0	0	1	0	0	1	0	0	0	1	1
Maryland	0	0	0	0	0	0	1	0	0	0	1	0
Virginia	0	2	0	0	1	0	0	0	0	0	1	2
South Carolina	0	1	0	0	0	1	0	0	0	0	0	2
TOTALS - U.S. & EEZ	2	3	8	1	6	1	7	0	4	0	27	5

[a] Data supplied by Nova Scotia Marine Animal Response Society (pers. comm.). Strandings in 2011 include one mass stranding of 6-8 whales (one of which died) and 2 animals with ropes tied around their tail stocks. Strandings in 2013 include one fishery entanglement (bait net) and one mass stranding of 4 animals.

[b] (Ledwell and Huntington 2010, 2011, 2012, 2013, 2014). 2011 included 2 mom/calf pairs. Not included in 2011 total was group of 6 pilot whales shepherded out of a narrow channel.

[c] One of the 2010 animals released alive.

Stranding data probably underestimate the extent of human and fishery-related mortality and serious injury, particularly for offshore species such as pilot whales, because not all of the whales that die or are seriously injured in human interactions wash ashore, or, if they do, they are not all recovered (Peltier *et al*. 2012; Wells *et al*. 2015). Additionally, not all carcasses will show evidence of human interaction, entanglement or other fishery-related interaction due to decomposition, scavenger damage, etc. (Byrd *et al*. 2014). Finally, the level of technical expertise among stranding network personnel varies widely as does the ability to recognize signs of human interaction.

HABITAT ISSUES

A potential human-caused source of mortality is from polychlorinated biphenyls (PCBs) and chlorinated pesticides (DDT, DDE, dieldrin, etc.), moderate levels of which have been found in pilot whale blubber (Taruski *et al.* 1975; Muir *et al.* 1988; Weisbrod *et al.* 2000). Weisbrod *et al.* (2000) reported that bioaccumulation levels were more similar in whales from the same stranding group than in animals of the same sex or age. Also, high levels of toxic metals (mercury, lead, cadmium) and selenium were measured in pilot whales harvested in the Faroe Island drive fishery (Nielsen *et al.* 2000). Similarly, Dam and Bloch (2000) found very high PCB levels in pilot whales in the Faroes. The population effect of the observed levels of such contaminants is unknown.

STATUS OF STOCK

The long-finned pilot whale is not listed as threatened or endangered under the Endangered Species Act, but the western North Atlantic stock is considered strategic under the MMPA because the mean annual human-caused mortality and serious injury exceeds PBR. Total U.S. fishery-related mortality and serious injury for long-finned pilot whales is not less than 10% of the calculated PBR and, therefore, cannot be considered to be insignificant and approaching zero mortality and serious injury rate. The status of this stock relative to OSP in the U.S. Atlantic EEZ is unknown. There are insufficient data to determine the population trends for this stock.

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SHORT-FINNED PILOT WHALE (*Globicephala macrorhynchus*): Western North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

There are 2 species of pilot whales in the western North Atlantic - the long-finned pilot whale, *Globicephala melas melas*, and the short-finned pilot whale, *G. macrorhynchus*. These species are difficult to differentiate at sea and cannot be reliably visually identified during either abundance surveys or observations of fishery mortality without high-quality photographs (Rone and Pace 2012); therefore, the ability to separately assess the 2 species in U.S. Atlantic waters is complex and requires additional information on seasonal spatial distribution. Undifferentiated pilot whales (*Globicephala* sp.) in the western North Atlantic occur primarily near the continental shelf break ranging from Florida to the Nova Scotia Shelf (Mullin and Fulling 2003). Long-finned and short-finned pilot whales overlap spatially along the mid-Atlantic shelf break between New Jersey and the southern flank of Georges Bank (Payne and Heinemann 1993; Rone and Pace 2012). Long-finned pilot whales have occasionally been observed stranded as far south as South Carolina, and short-finned pilot whales have occasionally been observed stranded as far north as Massachusetts. The latitudinal ranges of the two species therefore remain uncertain, although south of Cape Hatteras, most pilot whale sightings are expected to be short-finned pilot whales, while north of ~42°N most pilot whale sightings are expected to be long-finned pilot whales (Figure 1). In addition, short-finned pilot whales are documented along the continental shelf and continental slope in the northern Gulf of Mexico (Hansen *et al.* 1996; Mullin and Hoggard 2000; Mullin and Fulling 2003), and they are also known from the wider Caribbean. A May 2011 mass stranding of 23 short-finned pilot whales in the Florida Keys has been considered to be Gulf of Mexico stock whales based on stranding location, yet two tagged and released individuals from this stranding travelled directly into the Atlantic (Wells *et al.* 2013). Studies are currently being conducted at the Southeast Fisheries Science Center to evaluate genetic population structure in short-finned pilot whales. Pending these results, the *Globicephala macrorhynchus* population occupying U.S. Atlantic waters is considered separate from both the northern Gulf of Mexico stock and short-finned pilot whales occupying

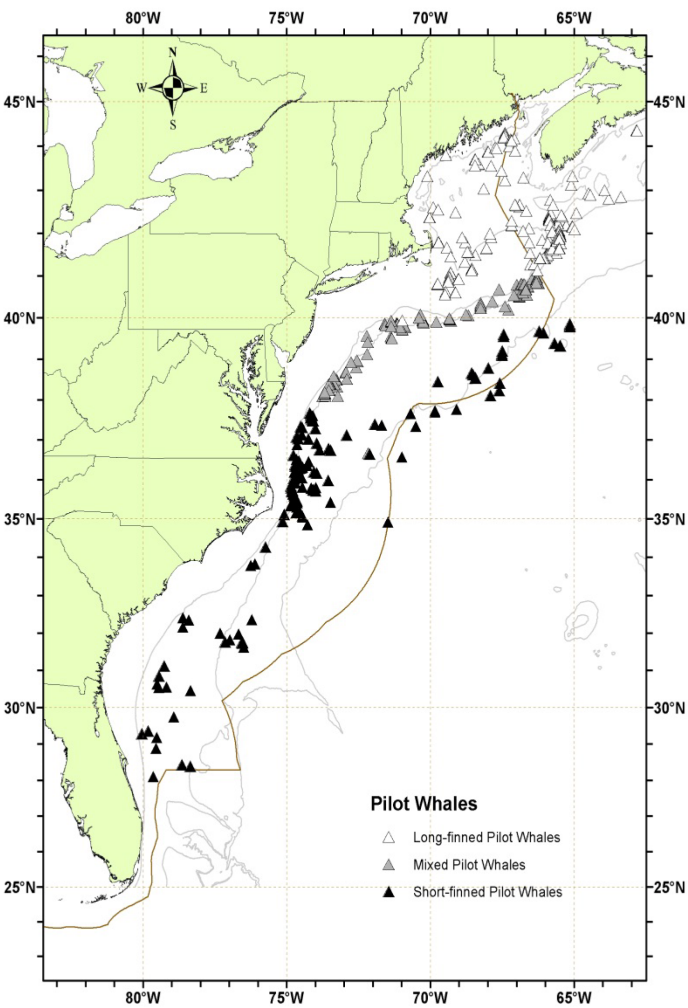

Figure 1. *Distribution of long-finned (open symbols), short-finned (black symbols), and possibly mixed (gray symbols; could be either species) pilot whale sightings from NEFSC and SEFSC shipboard and aerial surveys during the summers of 1998, 1999, 2002, 2004, 2006, 2007 and 2011. The inferred distribution of the two species is preliminary and is valid for June-August only. Isobaths are the 100-m, 1,000-m, and 4,000-m depth contours.*

Caribbean waters.

POPULATION SIZE

The best available estimate for short-finned pilot whales in the western North Atlantic is 21,515 (CV=0.37; Table 1; Palka 2012; Garrison 2016). This estimate is from summer 2011 surveys covering waters from central Florida to the lower Bay of Fundy. Sightings from vessel and aerial surveys were strongly concentrated along the continental shelf break; however, pilot whales were also observed over the continental slope in waters associated with the Gulf Stream (Figure 1). The best available abundance estimates are from aerial and shipboard surveys conducted during the summer of 2011 because these are the most recent surveys covering the full range of pilot whales in U.S. Atlantic waters. Because long-finned and short-finned pilot whales are difficult to distinguish at sea, sightings data are reported as *Globicephala sp*. These survey data have been combined with an analysis of the spatial distribution of the 2 species based on genetic analyses of biopsy samples to derive separate abundance estimates (Garrison and Rosel 2017).

Earlier Estimates

Please see Appendix IV for a summary of abundance estimates including earlier estimates and survey descriptions. Due to changes in survey methodology, these historical data should not be used to make comparisons with more current estimates. In addition, as recommended in the GAMMS II Workshop Report (Wade and Angliss 1997), estimates older than 8 years are deemed unreliable for the determination of a current PBR.

Recent surveys and abundance estimates for *Globicephala* sp.

An abundance estimate of 11,865 (CV=0.57) *Globicephala* sp. was generated from aerial and shipboard surveys conducted during June–August 2011 between central Virginia and the lower Bay of Fundy (Palka 2012). The aerial portion covered 6,850 km of trackline over waters north of New Jersey between the coastline and the 100-m depth contour through the U.S. and Canadian Gulf of Maine, and up to and including the lower Bay of Fundy. Pilot whales were not observed during the aerial portion of the survey. The shipboard portion covered 3,811 km of trackline between central Virginia and Massachusetts in waters deeper than the 100-m depth contour out to beyond the U.S. Exclusive Economic Zone (EEZ). Both sighting platforms used a double-platform data collection procedure, which allows estimation of abundance corrected for perception bias of the detected species (Laake and Borchers 2004). Estimation of the abundance was based on the independent observer approach assuming point independence (Laake and Borchers 2004) and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009). The vessel portion of this survey included habitats where both short-finned and long-finned pilot whales occur. A logistic regression (see next section) was used to estimate the abundance of short-finned pilot whales from this survey as 4,569 (CV=0.57).

An abundance estimate of 16,946 (CV=0.43) *Globicephala* sp. was generated from a shipboard survey conducted concurrently (June–August 2011) in waters between central Virginia and central Florida (Garrison 2016). This shipboard survey included shelf-break and inner continental slope waters deeper than the 50-m depth contour within the U.S. EEZ. The survey employed two independent visual teams searching with 25x150 “bigeye” binoculars. A total of 4,445 km of trackline was surveyed, yielding 290 cetacean sightings. The majority of sightings occurred along the continental shelf break north of Cape Hatteras, North Carolina, with a lower number of sightings over the continental slope in the southern portion of the survey. Estimation of pilot whale abundance was based on the independent observer approach assuming point independence (Laake and Borchers 2004) and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009). This survey included habitats that are expected to exclusively contain short-finned pilot whales.

Spatial Distribution and Abundance Estimates for *Globicephala macrorhynchus*

Pilot whale biopsy samples were collected during summer months (June–August) from South Carolina to the southern flank of Georges Bank between 1998 and 2007. These samples were identified to species using genetic analysis of mitochondrial DNA sequences. A portion of the mtDNA genome was sequenced from each biopsy sample collected in the field, and genetic species identification was performed through phylogenetic reconstruction of the haplotypes. Samples from stranded specimens that were morphologically identified to species were used to assign clades in the phylogeny to species and thereby identify all survey samples. The probability of a sample being from a short-finned (or long-finned) pilot whale was evaluated as a function of sea surface temperature and water depth using logistic regression. This analysis indicated that the probability of a sample coming from a short-finned pilot whale was near 0 at water temperatures <22°C, and near 1 at temperatures >25°C. The probability of a short-finned pilot whale also increased with increasing water depth. Spatially, during summer months, this regression model predicts that all pilot whales observed in offshore waters near the Gulf Stream are most likely short-finned pilot whales. The area of overlap between the 2 species occurs primarily along the shelf break off the coast of New Jersey between 38°N and 40°N latitude (Garrison and Rosel 2017). This model was used to partition the abundance estimates from surveys conducted during the summer of 2011. The sightings from the southeast shipboard survey covering waters from Florida to central Virginia were predicted to consist entirely of short-finned pilot whales. The aerial portion of the northeast surveys covered the Gulf of Maine and the Bay of Fundy where the model predicted that only long-finned pilot whales would occur, but no pilot whales were observed. The vessel portion of the northeast survey included waters along the shelf break and waters further offshore extending to the U.S. EEZ. Pilot whales were observed in both areas during the survey. Along the shelf break, the model predicted a mixture of both species, but the sightings in offshore waters near the Gulf Stream were predicted to consist predominantly of short-finned pilot whales (Garrison and Rosel 2017). The best abundance estimate for short-finned pilot whales is thus the sum of the southeast survey estimate (16,946; CV=0.43) and the estimated number of short-finned pilot whales from the northeast vessel survey (4,569; CV=0.57). The best available abundance estimate is thus 21,515 (CV=0.37).

Table 1. Summary of recent abundance estimates for the western North Atlantic short-finned pilot whale (*Globicephala macrorhynchus*) by month, year, and area covered during each abundance survey, and resulting abundance estimate (N_{best}) and coefficient of variation (CV).

Month/Year	Area	N_{best}	CV
Jun–Aug 2011	central Virginia to Lower Bay of Fundy	4,569	0.57
Jun–Aug 2011	central Florida to central Virginia	16,946	0.43
Jun–Aug 2011	central Florida to lower Bay of Fundy (COMBINED)	21,515	0.37

Minimum Population Estimate

The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally distributed best abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by Wade and Angliss (1997). The best estimate of abundance for western North Atlantic *Globicephala macrorhnychus* is 21,515 animals (CV=0.37). The minimum population estimate is 15,913.

Current Population Trend

A trend analysis has not been conducted for this stock. There are 2 abundance estimates for *Globicephala* spp. from summer 1998 (14,909; CV=0.26) and summer 2004 surveys (31,139; CV=0.27), and 1 abundance estimate of *G. macrorhynchus* from summer 2011 surveys (21,515; CV=0.37). Because the 1998 and 2004 surveys did not derive separate abundance estimates for each pilot whale species, comparisons to the 2011 estimate are inappropriate.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. For purposes of this assessment, the maximum net productivity rate was assumed to be 0.04. This value is based on theoretical modeling showing that cetacean populations may not grow at rates much greater than 4% given the constraints of their reproductive life history (Barlow *et al.* 1995).

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of minimum population size, one-half the maximum productivity rate, and a “recovery” factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size for short-finned pilot whales is 15,913. The maximum productivity rate is 0.04, the default value for cetaceans. The “recovery” factor is 0.5 because the stock's status relative to optimum sustainable population (OSP) is unknown and the CV of the average mortality estimate is less than 0.3 (Wade and Angliss 1997). PBR for the western North Atlantic short-finned pilot whale is 159.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

The estimated mean annual fishery-related mortality and serious injury during 2010–2014 due to the pelagic longline fishery was 192 short-finned pilot whales (CV=0.17; Table 2). The total annual fishery-related mortality and serious injury for this stock during 2010–2014 is unknown because in addition to observed takes in the pelagic longline fishery, there was a self-reported take in the unobserved hook and line fishery in 2013.

During 2010–2013, all observed interactions and estimated bycatch was assigned to the short-finned pilot whale stock because the observed interactions all occurred at times and locations where available data indicated that long-finned pilot whales were very unlikely to occur. Specifically, the highest bycatch rates of undifferentiated pilot whales were observed during September–November along the mid-Atlantic coast (south of 40°N; Garrison 2007), and biopsy data collected in this area during October–November 2011 indicated that only short-finned pilot whales occurred in this region (Garrison and Rosel 2017). Similarly, all genetic data collected from interactions in the pelagic longline fishery have indicated interactions with short-finned pilot whales. However, during 2014, 4 pilot whale interactions (all serious injuries) occurred along the southern flank of Georges Bank. No samples were collected from these animals. Therefore, the logistic regression model (described above in 'Spatial Distribution and Abundance Estimates for *Globicephala macrorhynchus*') was applied to estimate the probability that these 2014 interactions were from short-finned vs. long-finned pilot whales (Garrison and Rosel 2017). Due to high water temperatures (approximately 25ºC) along the southern flank of Georges Bank at the time of the observed takes, these interactions were estimated to have a >80% probability of coming from short-finned pilot whales. The estimated probability was used to apportion the estimated serious injury and mortality from 2014 in the pelagic longline fishery between the short-finned and long-finned pilot whale stocks. The estimated serious injury and mortality for the short-finned pilot whale was 233 (CV=0.24), and that for long-finned pilot whales was 9.6 (CV=0.43; Garrison and Stokes 2016).

In bottom trawl, mid-water trawl, and gillnet fisheries, mortalities were observed north of 40°N latitude and in areas expected to have only long-finned pilot whales. Takes and bycatch estimates for these fisheries are therefore attributed to the long-finned pilot whale stock.

Fishery Information

The commercial fisheries that interact, or that potentially could interact, with this stock in the Atlantic Ocean are the Category I Atlantic Ocean, Caribbean, Gulf of Mexico large pelagics longline and Atlantic Highly Migratory Species longline fisheries; and the Category III U.S. Atlantic tuna purse seine and Atlantic Ocean, Gulf of Mexico, Caribbean commercial passenger fishing vessel (hook and line) fisheries. All recent gillnet and trawl interactions have been assigned to long-finned pilot whales using model-based predictions. Detailed fishery information is reported in Appendix III.

Earlier Interactions

See Appendix V for information on historical takes.

Longline

The large pelagics longline fishery operates in the U.S. Atlantic (including Caribbean) and Gulf of Mexico EEZ, and pelagic swordfish, tunas and billfish are the target species. The estimated annual average serious injury and mortality attributable to the Atlantic Ocean large pelagics longline fishery for the 5-year period from 2010 to 2014 was 192 short-finned pilot whales (CV=0.17; Table 2). During 2010–2014, 69 serious injuries were observed in the following fishing areas of the North Atlantic: Florida East Coast, Mid-Atlantic Bight, Northeast Coastal, and South Atlantic Bight. During 2010–2014, 1 mortality was observed (in 2011) in the Mid-Atlantic Bight fishing area (Garrison and Stokes 2012a,b; 2013; 2014; 2016).

Most of the estimated marine mammal bycatch in the U.S. pelagic longline fishery was recorded in U.S. Atlantic EEZ waters between South Carolina and Cape Cod (Garrison 2007). January–March observed bycatch was concentrated on the continental shelf edge northeast of Cape Hatteras, North Carolina. During April–June, bycatch was recorded in this area as well as north of Hydrographer Canyon in water over 1,000 fathoms (1830 m) deep. During the July–September period, observed takes occurred on the continental shelf edge east of Cape Charles, Virginia, and on Block Canyon slope in over 1,000 fathoms of water. October–December bycatch occurred between the 20- and 50-fathom (37- and 92-m) isobaths between Barnegat Bay, New Jersey and Cape Hatteras, North Carolina.

The Atlantic Highly Migratory Species longline fishery operates outside the U.S. EEZ. No takes of short-finned pilot whales within high seas waters of the Atlantic Ocean have been observed or reported thus far.

See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical estimates of annual mortality and serious injury.

Table 2. Summary of the incidental mortality and serious injury of short-finned pilot whales (*Globicephala macrorhynchus*) by the pelagic longline commercial fishery including the years sampled (Years), the number of vessels active within the fishery (Vessels), the type of data used (Data Type), the annual observer coverage (Observer Coverage), the annual observed serious injury and mortality recorded by on-board observers, the annual estimated serious injury and mortality, the combined annual estimates of serious injury and mortality (Estimated Combined Mortality), the estimated CV of the combined annual mortality estimates (Est. CVs) and the mean of the combined mortality estimates (CV in parentheses).

Fishery	Years	Vessels[a]	Data Type[b]	Observer Coverage[c]	Observed Serious Injury	Observed Mortality	Estimated Serious Injury	Estimated Mortality	Estimated Combined Mortality	Est. CVs	Mean Annual Mortality
Pelagic Longline	2010 – 2014	80, 83,82, 79,78	Obs. Data, Logbook	.08, .09, .07, .09, .10	5, 18, 14, 13, 19	0, 1, 0, 0, 0	127, 286, 170, 124, 233	0, 19, 0, 0, 0	127, 305, 170, 124, 233	.78, .29, .33, .32, .24	192 (.17)

[a] Number of vessels in the fishery is based on vessels reporting effort to the pelagic longline logbook.
[b] Observer data (Obs. Data) are used to measure bycatch rates and the data are collected within the Northeast Fisheries Observer Program (NEFOP) and the Southeast Pelagic Longline Observer Program.
[c] Proportion of sets observed

Hook and Line

During 2010–2014, there was 1 self-reported take (in 2013) in which a short-finned pilot whale was hooked and entangled by a charterboat fisherman. The animal was released alive but considered seriously injured (Maze-Foley and Garrison 2016).

Other Mortality

Pilot whales have a propensity to mass strand throughout their range, but the role of human activity in these events is unknown. Between 2 and 168 pilot whales have stranded annually, either individually or in groups, along the eastern U.S. seaboard since 1980 (NMFS 1993, stranding databases maintained by NMFS NER, NEFSC and SEFSC). From 2010–2014, 45 short-finned pilot whales (*Globicephala macrorhynchus*) and 6 pilot whales not specified to the species level (*Globicephala* sp.) were reported stranded between Massachusetts and Florida, including the EEZ (Table 3).

Table 3. Short-finned pilot whale (*Globicephala macrorhynchus* [SF] *and Globicephala* sp. [Sp]) strandings along the Atlantic coast, 2010–2014. Strandings which were not reported to species have been reported as *Globicephala* sp. The level of technical expertise among stranding network personnel varies, and given the potential difficulty in correctly identifying stranded pilot whales to species, reports to specific species should be viewed with caution.

STATE	2010		2011		2012		2013		2014		TOTALS	
	SF	Sp	SF	Sp	SF	Sp	SF	Sp	SF	Sp	SF	Sp
Massachusetts	0	0	3	0	0	0	0	0	0	0	3	0
New Jersey	0	0	1[a]	1	0	0	0	0	0	0	1	1
Virginia	0	2	0	0	0	0	0	0	0	0	0	2
North Carolina	1[b]	0	1[b]	0	1[b]	0	0	0	3	0	6	0
South Carolina	0	1	0	0	3[c]	1	1	0	2	0	6	2
Florida	4	0	2	0	23	0	0	0	0	0	29	0

TOTALS	5	3	7	1	27	1	1	0	5	0	45	5
[a] Signs of human interaction were observed for this short-finned pilot whale stranding. [b] Signs of fishery interaction were observed for these short-finned pilot whale strandings. [c] Signs of fishery interaction were observed for 2 of these short-finned pilot whale strandings.												

Short-finned pilot whales strandings (*Globicephala macrorhynchus*) have been reported as far north as Block Island, Rhode Island (2001), and Cape Cod, Massachusetts (2011), although the majority of the strandings occurred from North Carolina southward (Table 3).

During 2010–2014, several human interactions, including some that were fishery interactions, were documented in stranded pilot whales along the U.S. Atlantic coast. A short-finned pilot whale stranded in North Carolina in 2010 had evidence of longline interaction. In 2011, a short-finned pilot whale in North Carolina was classified as a fishery interaction and a short-finned pilot whale in New Jersey was found with a healed but abscessed bullet wound. In 2012, 3 short-finned pilot whales had evidence of fishery interactions, 2 of them in South Carolina and 1 in North Carolina. During 2013–2014, no evidence of human interactions was documented for stranded pilot whales.

Stranding data probably underestimate the extent of human and fishery-related mortality and serious injury, particularly for offshore species such as pilot whales, because not all of the whales that die or are seriously injured in human interactions wash ashore, or, if they do, they are not all recovered (Peltier *et al*. 2012; Wells *et al*. 2015). Additionally, not all carcasses will show evidence of human interaction, entanglement or other fishery-related interaction due to decomposition, scavenger damage, etc. (Byrd *et al*. 2014). Finally, the level of technical expertise among stranding network personnel varies widely as does the ability to recognize signs of human interaction.

HABITAT ISSUES

A potential human-caused source of mortality is from polychlorinated biphenyls (PCBs) and chlorinated pesticides (DDT, DDE, dieldrin, etc.), moderate levels of which have been found in pilot whale blubber (Taruski *et al.* 1975; Muir *et al.* 1988; Weisbrod *et al.* 2000). Weisbrod *et al.* (2000) reported that bioaccumulation levels were more similar in whales from the same stranding group than in animals of the same sex or age. Also, high levels of toxic metals (mercury, lead, cadmium) and selenium were measured in pilot whales harvested in the Faroe Island drive fishery (Nielsen *et al.* 2000). Similarly, Dam and Bloch (2000) found very high PCB levels in pilot whales in the Faroes. The population effect of the observed levels of such contaminants is unknown.

STATUS OF STOCK

The short-finned pilot whale is not listed as threatened or endangered under the Endangered Species Act, but the western North Atlantic stock is considered strategic under the MMPA because the mean annual human-caused mortality and serious injury exceeds PBR. Total U.S. fishery-related mortality and serious injury attributed to short-finned pilot whales exceeds 10% of the calculated PBR and therefore cannot be considered to be insignificant and approaching zero mortality and serious injury rate. The status of this stock relative to OSP in the U.S. Atlantic EEZ is unknown. There are insufficient data to determine the population trends for this stock.

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ATLANTIC WHITE-SIDED DOLPHIN (*Lagenorhynchus acutus*): Western North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

White-sided dolphins are found in temperate and sub-polar waters of the North Atlantic, primarily in continental shelf waters to the 100-m depth contour. In the western North Atlantic the species inhabits waters from central West Greenland to North Carolina (about 35˚N) and perhaps as far east as 29˚W in the vicinity of the mid-Atlantic Ridge (Evans 1987; Hamazaki 2002; Doksaeter *et al.* 2008; Waring *et al.* 2008). Distribution of sightings, strandings and incidental takes suggest the possible existence of three stock units: Gulf of Maine, Gulf of St. Lawrence and Labrador Sea stocks (Palka *et al.* 1997). Evidence for a separation between the population in the southern Gulf of Maine and the Gulf of St. Lawrence population comes from the reduced density of summer sightings along the Atlantic side of Nova Scotia. This was reported in Gaskin (1992), is evident in Smithsonian stranding records and in Canadian/west Greenland bycatch data (Stenson *et al.* 2011) and was obvious during summer abundance surveys that covered waters from Virginia to the Gulf of St. Lawrence and during the Canadian component of the Trans-North Atlantic Sighting Survey in the summer of 2007 (Lawson and Gosselin 2009, 2011). White-sided dolphins were seen frequently in Gulf of Maine waters and in waters at the mouth of the Gulf of St. Lawrence, but only a relatively few sightings were recorded between these two regions. This trend is less obvious since 2007.

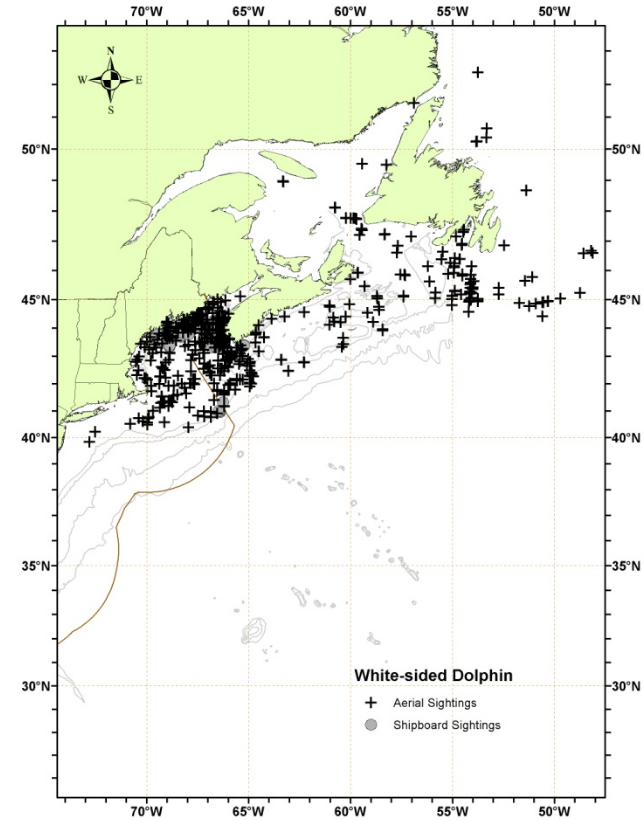

Figure 1. *Distribution of white-sided dolphin sightings from NEFSC and SEFSC shipboard and aerial surveys during the summers of 1995, 1998, 1999, 2002, 2004, 2006, 2007, 2008, 2010, and 2011, and DFO's 2007 TNASS survey. Isobaths are the 100-m, 1000-m and 4000-m depth contours.*

The Gulf of Maine population of white-sided dolphins is most common in continental shelf waters from Hudson Canyon (approximately 39˚N) to Georges Bank, and in the Gulf of Maine and lower Bay of Fundy. Sighting data indicate seasonal shifts in distribution (Northridge *et al.* 1997). During January to May, low numbers of white-sided dolphins are found from Georges Bank to Jeffreys Ledge (off New Hampshire), with even lower numbers south of Georges Bank, as documented by a few strandings collected on beaches of Virginia to South Carolina. From June through September, large numbers of white-sided dolphins are found from Georges Bank to the lower Bay of Fundy. From October to December, white-sided dolphins occur at intermediate densities from southern Georges Bank to southern Gulf of Maine (Payne and Heinemann 1990). Sightings south of Georges Bank, particularly around Hudson Canyon, occur year round but at low densities. The Virginia and North Carolina observations appear to represent the southern extent of the species' range during the winter months. On 4 May 2008 a stranded 17-year old male white-sided dolphin with severe pulmonary distress and reactive lymphadenopathy stranded in South Carolina (Powell *et al.* 2012). In the absence of additional strandings or sightings, this stranding seems to be an out-of-range anomaly. The seasonal spatial distribution of this species appears to be changing during the last few years. There is evidence for an earlier distributional shift during the 1970s, from primarily offshore waters into the Gulf of Maine, hypothesized to be related to shifts in abundance of pelagic fish stocks resulting from depletion of herring by foreign distant-water fleets (Kenney *et al*. 1986).

Recent stomach-content analysis of both stranded and incidentally caught white-sided dolphins in U.S. waters determined that the predominant prey were silver hake (*Merluccius bilinearis*), spoonarm octopus (*Bathypolypus* *bairdii*) and haddock (*Melanogrammus aeglefinus*). Sand lances (*Ammodytes* spp.) were only found in the stomach of one stranded white-sided dolphin. Seasonal variation in diet was indicated; pelagic Atlantic herring (*Clupea harengus*) was the most important prey in summer, but was rare in winter (Craddock *et al.* 2009).

POPULATION SIZE

The best available current abundance estimate for white-sided dolphins in the western North Atlantic stock is 48,819 (CV= 0.61), resulting from a June–August 2011survey.

Earlier abundance estimates

Please see Appendix IV for earlier abundance estimates. As recommended in the GAMMS Workshop Report (Wade and Angliss 1997), estimates older than eight years are deemed unreliable to determine the current PBR.

Recent surveys and abundance estimates

An abundance estimate of 48,819 (CV=0.61) white-sided dolphins was generated from a shipboard and aerial survey conducted during June–August 2011 (Palka 2012). The aerial portion that contributed to the abundance estimate covered 5,313 km of tracklines that were over waters north of New Jersey from the coastline to the 100-m depth contour through the U.S. and Canadian Gulf of Maine and up to and including the lower Bay of Fundy. The shipboard portion covered 3,107 km of tracklines that were in waters offshore of central Virginia to Massachusetts (waters that were deeper than the 100-m depth contour out to beyond the U.S. EEZ). Both sighting platforms used a double-platform data-collection procedure, which allows estimation of abundance corrected for perception bias of the detected species (Laake and Borchers, 2004). Estimation of the abundance was based on the independent-observer approach assuming point independence (Laake and Borchers 2004) and calculated using the MRDS option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009).

No white-sided dolphins were detected in the aerial and ship abundance surveys that were conducted concurrently (June-August 2011) in waters between central Virginia and central Florida. This shipboard survey included shelf-break and inner continental slope waters deeper than the 50-m depth contour within the U.S. EEZ. The survey employed the double-platform methodology searching with 25x150 “bigeye” binoculars. A total of 4,445 km of tracklines was surveyed, yielding 290 cetacean sightings.

Table 1. Summary of recent abundance estimates for western North Atlantic stock of white-sided dolphins (*Lagenorhynchus acutus*) , by month, year, and area covered during each abundance survey, and resulting abundance estimate (N_{best}) and coefficient of variation (CV).

Month/Year	Area	N_{best}	CV
Jun-Aug 2011	Central Virginia to lower Bay of Fundy	48,819	0.61

Minimum Population Estimate

The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally distributed best abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by (Wade and Angliss 1997). The best estimate of abundance for the western North Atlantic stock of white-sided dolphins is 48,819 (CV=0.61). The minimum population estimate for these white-sided dolphins is 30,403.

Current Population Trend

A trend analysis has not been conducted for this stock. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval. For example, the power to detect a precipitous decline in abundance (i.e., 50% decrease in 15 years) with estimates of low precision (e.g., CV > 0.30) remains below 80% (alpha = 0.30) unless surveys are conducted on an annual basis (Taylor *et al.* 2007).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. Life history parameters that could be used to estimate net productivity include: calving interval is 2-3 years; lactation period is 18 months; gestation period is 10–12 months and births occur from May to early August, mainly in June and July; length at birth is 110 cm; length at sexual maturity is 230–240 cm for males, and 201–222 cm for females; age at sexual maturity is 8–9 years for males and 6–8 years for females; mean adult length is 250 cm for males and 224 cm for females (Evans 1987); and maximum reported age for males is 22 years and for females, 27 years (Sergeant *et al.* 1980).

For purposes of this assessment, the maximum net productivity rate was assumed to be 0.04. This value is based on theoretical modeling showing that cetacean populations may not grow at rates much greater than 4% given the constraints of their reproductive life history (Barlow *et al.* 1995).

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of minimum population size, one-half the maximum productivity rate, and a recovery factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size is 30,403. The maximum productivity rate is 0.04, the default value for cetaceans. The recovery factor is 0.5 , the default value for stocks of unknown status relative to OSP, and the CV of the average mortality estimate is less than 0.3 (Wade and Angliss 1997). PBR for the western North Atlantic stock of white-sided dolphin is 304.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Total annual estimated average fishery-related mortality or serious injury to this stock during 2010–2014 was 77 (CV=0.2) white-sided dolphins (Table 2).

Fishery Information

Detailed fishery information is reported in Appendix III.

Earlier Interactions

Historically, fishery interactions have been documented with white-sided dolphins in the Joint Venture and Foreign Atlantic mackerel fishery (1977–1991), the Atlantic pelagic drift gillnet fishery (1991–1998), the U.S. J.V midwater (pelagic) trawl fishery (2001), the mid-Atlantic gillnet fishery (1997), Northeast midwater pair trawls (2002, 2005), and the mid-Atlantic bottom trawl (1997, 2005, 2007). See Appendix V for more information on historical takes.

U.S.

Northeast Sink Gillnet

Annual white-sided dolphin mortalities were estimated using annual ratio-estimator methods (Table 2; Orphanides 2013; Hatch and Orphanides 2014, 2015, 2016). Recently white-sided dolphin bycatch has occurred mostly in the Gulf of Maine, with a few south of Cape Cod. Bycatch occurred nearly year round, though mostly in the winter and summer. There are large inter-annual differences in the magnitude of the level of bycatch, which may be due to inter-annual differences in the number of white-sided dolphins using the Gulf of Maine, as has been seen in the series of past abundance estimates for this species. See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for long-term bycatch information.

Northeast Bottom Trawl

Fishery-related bycatch rates for years 2009–2013 were estimated using an annual stratified ratio-estimator (Lyssikatos 2015). Between 2008 and 2013, all white-sided dolphin bycatch occurred in the Gulf of Maine and Georges Bank eco-regions, primarily during the winter (January–April) season when sea surface temperatures are less than 10° C. See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for long-term bycatch information.

Mid-Atlantic Bottom Trawl

Fishery-related bycatch rates were estimated using an annual stratified ratio-estimator (Lyssikatos 2015). See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for long-term bycatch information.

Table 2. Summary of the incidental mortality of North Atlantic stock of white-sided dolphins (*Lagenorhynchus acutus*) by commercial fishery including the years sampled, the type of data used, the annual observer coverage, the serious injuries and mortalities recorded by on-board observers, the estimated annual serious injury and mortality, the estimated CV of the combined annual mortality and the mean annual mortality (CV in parentheses).

Fishery	Years	Data Type [a]	Observer Coverage [b]	Observed Serious Injury	Observed Mortality	Estimated Serious Injury[d]	Estimated Mortality	Estimated Combined Mortality	Estimated CVs	Mean Combined Annual Mortality
Northeast Sink Gillnet[c]	10-14	Obs. Data Weighout Trip Logbook	.17, .19, .15, .11, .18	1, 0, 0, 0, 0	6, 5, 1, 1, 2	4, 1, 0, 0, 0	62, 17, 9, 4, 10	66,18, 9, 4, 10	.90, .43, .92, 1.03, .66	21 (0.57)
Northeast Bottom Trawl	10-14	Obs. Data Trip Logbook	.16, .26, 0.17, .15, 17	0, 2, 0, 0, 0	10, 47, 9, 8, 3	1, 3, 0, 0, 0	36, 138, 27, 33, 16	37, 140, 27, 33, 16	.32, .24, .47, .31, .5	51 (0.16)
Mid-Atlantic Bottom Trawl	10-14	Obs. Data Trip Logbook	.06, .08, .05, .06, .08	0, 0, 0, 0, 0	0, 0, 0, 0,1	0, 0, 0, 0, 0	0, 0, 0, 0, 9.67	0, 0, 0, 0, 9.67	0, 0, 0, 0, .94	1.9 (.94)
Total										74 (0.2)

a Observer data (Obs. Data), used to measure bycatch rates, are collected within the Northeast Observer Program and At-sea Monitoring Program. NEFSC collects landings data (unallocated Dealer Data or Allocated Dealer Data) which are used as a measure of total landings and mandatory Vessel Trip Reports (VTR) (Trip Logbook) are used to determine the spatial distribution of landings and fishing effort in the sink gillnet, bottom trawl and mid-water trawl fisheries. In addition, the Trip Logbooks are the primary source of the measure of total effort (tow duration) in the mid-water and bottom trawl fisheries.

b Observer coverage is defined as the ratio of observed to total metric tons of fish landed for the gillnet fisheries ,.and the ratio of observed to total trips for bottom trawl and Mid-Atlantic mid-water trawl (including pair trawl) fisheries. Beginning in May 2010 total observer coverage reported for bottom trawl and gillnet gear includes samples collected from the at-sea monitoring program in addition to traditional observer coverage through the Northeast Fisheries Observer Program (NEFOP).

c After 1998, a weighted bycatch rate was applied to effort from both pingered and non-pingered hauls within the stratum where white-sided dolphins were observed taken. During the years 1997, 1999, 2001, 2002, and 2004, respectively, there were 2, 1, 1, 1, and 1 observed white-sided dolphins taken on pingered trips. No takes were observed on pinger trips during 1995, 1996, 1998, 2000, 2005 through 2007. Three of the 2008 takes were on non-pingered hauls and the fourth take was recorded as pinger condition unknown. Of the six 2010 observed takes, 4 were in pingered nets and 2 in non-pingered nets. Four of the 2011 takes were in pingered nets. The 2012 take was in a non-pingered net. The 2013 take was in a pingered net. In 2010, both observed mortalities were in pingered nets.

d Waring *et al.* 2014,2015, Wenzel *et al*. 2015, 2016.

CANADA

There is little information available that quantifies fishery interactions involving white-sided dolphins in Canadian waters. Two white-sided dolphins were reported caught in groundfish gillnet sets in the Bay of Fundy during 1985 to 1989, and 9 were reported taken in West Greenland between 1964 and 1966 in the now non-operational salmon drift nets (Gaskin 1992). Several (number not specified) were also taken during the 1960s in the now non-operational Newfoundland and Labrador groundfish gillnets. A few (number not specified) were taken in an experimental drift gillnet fishery for salmon off West Greenland which took place from 1965 to 1982 (Read 1994).

Hooker *et al.* (1997) summarized bycatch data from a Canadian fisheries observer program that placed observers on all foreign fishing vessels operating in Canadian waters, on 25-40% of large Canadian fishing vessels (greater than 100 feet long), and on approximately 5% of smaller Canadian fishing vessels. Bycaught marine mammals were noted as weight in kilos rather than by the numbers of animals caught. Thus the number of individuals was estimated by dividing the total weight per species per trip by the maximum recorded weight of each species. During 1991 through 1996, an estimated 6 white-sided dolphins were observed taken. One animal was from a longline trip south of the Grand Banks (43º 10'N 53º 08'W) in November 1996 and the other 5 were taken in the bottom trawl fishery off Nova Scotia in the Atlantic Ocean; 1 in July 1991, 1 in April 1992, 1 in May 1992, 1 in April 1993, 1 in June 1993 and 0 in 1994 to 1996.

Estimation of small cetacean bycatch for Newfoundland fisheries using data collected during 2001 to 2003 (Benjamins *et al.* 2007) indicated that, while most of the estimated 862 to 2,228 animals caught were harbor porpoises, a few were white-sided dolphins caught in the Newfoundland nearshore gillnet fishery and offshore monkfish/skate gillnet fisheries.

Herring Weirs

Previously only one white-sided dolphin was released alive and unharmed from a herring weir in the Bay of Fundy (A. Westgate, pers. comm.). Due to the formation of a cooperative program between Canadian fishermen and biologists, it is expected that most dolphins and whales will be able to be released alive. Fishery information is available in Appendix III.

Other Mortality

U.S.

During 2010–2014 there were 130 documented Atlantic white-sided dolphin strandings on the U.S. Atlantic coast (Table 3; NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 08 October 2015). Thirty of these animals were released alive. Human interaction was indicated in 5 records during this period. Of these, one was classified as a fishery interaction.

Mass strandings involving up to a hundred or more animals at one time are common for this species. The causes of these strandings are not known. Because such strandings have been known since antiquity, it could be presumed that recent strandings are a normal condition (Gaskin 1992). It is unknown whether human causes, such as fishery interactions and pollution, have increased the number of strandings. In an analysis of mortality causes of stranded marine mammals on Cape Cod and southeastern Massachusetts between 2000 and 2006, Bogomolni *et al.* (2010) found 69% (46 of 67) of stranded white-sided dolphins were involved in mass-stranding events with no significant cause determined, and 21% (14 of 67) were classified as disease-related.

Stranding data probably underestimate the extent of fishery-related mortality and serious injury because all of the marine mammals that die or are seriously injured may not wash ashore, nor will all of those that do wash ashore necessarily show signs of entanglement or other fishery-interaction. Finally, the level of technical expertise among stranding network personnel varies widely as does the ability to recognize signs of fishery interaction.

CANADA

The Nova Scotia Stranding Network documented whales and dolphins stranded on the coast of Nova Scotia during 1991 to 1996 (Hooker *et al.* 1997). Researchers with Dept. of Fisheries and Oceans, Canada documented strandings on the beaches of Sable Island during 1970 to 1998 (Lucas and Hooker 2000). More recently whales and dolphins stranded on the coast of Nova Scotia have been recorded by the Marine Animal Response Society and the Nova Scotia Stranding Network (Table 3; Marine Animal Response Society, pers. comm.). In addition, stranded white-sided dolphins in Newfoundland and Labrador are being recorded by the Whale Release and Strandings Program (Table 3; Ledwell and Huntington 2010, 2011, 2012a, 2012b, 2013, 2014).

Table 3. White-sided dolphin (*Lagenorhynchus acutus*) reported strandings along the U.S. and Canadian Atlantic coast, 2010-2014.

Area	**Year**					**Total**
	2010	**2011**	**2012**	**2013**	**2014**	
Maine	1	2	1	1	2	7
New Hampshire	0	0	2	0	0	2
Massachusetts[a,b]	50	42	3	10	2	107
Rhode Island	0	1	1	1	0	3
Connecticut	0	0	0	0	0	0
New York	1	0	3	2	0	6
New Jersey	0	1	0	0	0	1
Delaware	0	1	0	0	0	1
Maryland	0	1	0	0	0	1
Virginia	0	0	0	0	0	0
North Carolina	0	1	0	0	0	1
South Carolina	0	0	0	0	0	0
Georgia	0	1	0	0	0	1
TOTAL US	**52**	**50**	**10**	**14**	**4**	**130**
Nova Scotia[c]	2	6	5	7	12	32
Newfoundland and Labrador[d]	2	0	3	0	5	10
GRAND TOTAL	**56**	**56**	**18**	**21**	**21**	**172**

[a] Records of mass strandings in Massachusetts during this period are: March 2010 - 7 animals (one dead calf, 6 adults released alive), 16 animals (5 dead, 11 released alive) and 3 animals (one released alive); April 2010 - 2 animals (released alive); July 2010 - 2 animals (released alive); March 2011 - 4 animals (2 released alive), 2 animals (released alive); April 2013 - 2 animals (one released alive); December 2013 - 3 animals (all released alive).

[b] In 2010, 2 animals in Massachusetts were classified as human interactions, 1 of them a fishery interaction. In 2011, 1 animal in Massachusetts was classified as human interaction due to post-mortem mutilation. In 2014, 1 animal in Massachusetts was classified as human interaction due to attempts by public to return animal to sea. In 2014, 1 animal in Maine was classified as human interaction due to plastics injestion.

[c] Data supplied by Nova Scotia Marine Animal Response Society (pers. comm.). 2014 data include a mass stranding of 7 animals all released alive and a single animal released alive.

[d] (Ledwell and Huntington 2010,2011, 2012a, 2012b, 2013, 2014, 2015).

STATUS OF STOCK

White-sided dolphins are not listed as threatened or endangered under the Endangered Species Act. The Western North Atlantic stock of white-sided dolphins is not considered strategic under the Marine Mammal Protection Act. The estimated average annual human-related mortality does not exceed PBR but is not less than 10% of the calculated PBR; therefore, it cannot be considered to be insignificant and approaching zero mortality and serious injury rate. The status of white-sided dolphins, relative to OSP, in the U.S. Atlantic EEZ is unknown. A trend analysis has not been conducted for this species.

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COMMON DOLPHIN (*Delphinus delphis delphis*): Western North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The common dolphin (*Delphinus delphis delphis*) may be one of the most widely distributed species of cetaceans, as it is found world-wide in temperate and subtropical seas. In the North Atlantic, common dolphins are commonly found along the shoreline of Massachusetts in mass-stranding events (Bogomolni et al. 2010; Sharp et al. 2014), as well as found over the continental shelf between the 100-m and 2000-m isobaths and over prominent underwater topography and east to the mid-Atlantic Ridge (29˚W) (Doksaeter *et al.* 2008; Waring *et al*. 2008) and are associated with Gulf Stream features (CETAP 1982; Selzer and Payne 1988; Waring *et al.* 1992; Hamazaki 2002). The species is less common south of Cape Hatteras, although schools have been reported as far south as the Georgia/South Carolina border (32º N) (Jefferson *et al*. 2009). They have seasonal movements where they are found from Cape Hatteras northeast to Georges Bank (35˚ to 42˚N) during mid-January to May (Hain *et al.* 1981; CETAP 1982; Payne *et al.* 1984) though some animals tagged and released after stranding in winters of 2010-2012 used habitat in the Gulf of Maine north to almost 44˚ (Sharp *et al*. 2016). Common dolphins move onto Georges Bank, Gulf of Maine, and the Scotian Shelf from mid-summer to autumn. Selzer and Payne (1988) reported very large aggregations (greater than 3,000 animals) on Georges Bank in autumn. Common dolphins were occasionally found in the Gulf of Maine (Selzer and Payne 1988), more often in the last few years (Figure 1). Migration onto the Scotian Shelf and continental shelf off Newfoundland occurs during summer and autumn when water temperatures exceed 11ºC (Sergeant *et al.* 1970; Gowans and Whitehead 1995).

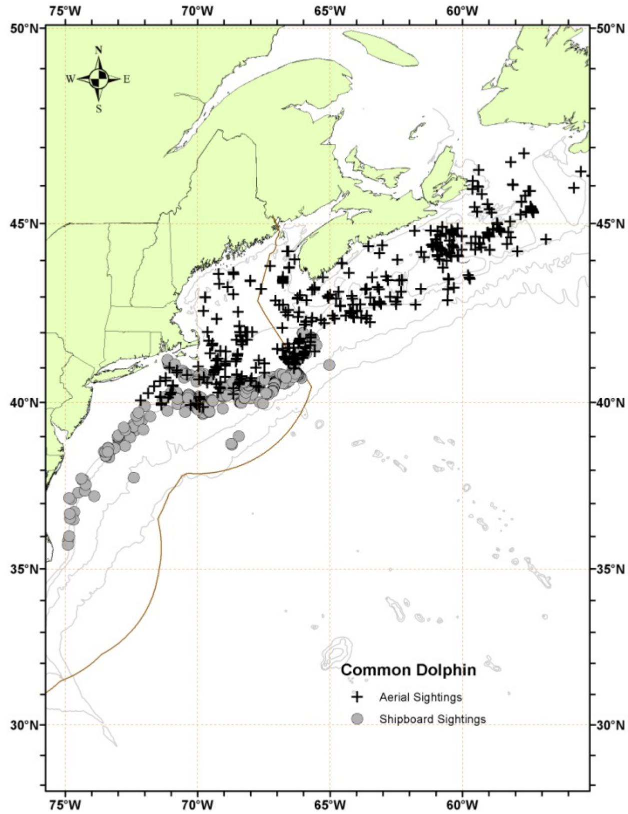

Figure 1. *Distribution of common dolphin sightings from NEFSC and SEFSC shipboard and aerial surveys during the summers of 1998, 1999, 2002, 2004, 2006, 2007, 2010 and 2011 and DFO's 2007 TNASS survey. Isobaths are the 100-m, 1000-m and 4000-m depth contours.*

Westgate (2005) tested the proposed one-population-stock model using a molecular analysis of mitochondrial DNA (mtDNA), as well as a morphometric analysis of cranial specimens. Both genetic analysis and skull morphometrics failed to provide evidence (p>0.05) of more than a single population in the western North Atlantic, supporting the proposed one-stock model. However, when western and eastern North Atlantic common dolphin mtDNA and skull morphology were compared, both the cranial and mtDNA results showed evidence of restricted gene flow (p<0.05) indicating that these two areas are not panmictic. Cranial specimens from the two sides of the North Atlantic differed primarily in elements associated with the rostrum. These results suggest that common dolphins in the western North Atlantic are composed of a single panmictic group whereas gene flow between the western and eastern North Atlantic is limited (Westgate 2005, 2007).

POPULATION SIZE

The current best abundance estimate for common dolphins off the U.S. Atlantic coast is 70,184 (CV=0.28). This estimate, derived from 2011 shipboard and aerial surveys, is the only current estimate available. This estimate is substantially lower than the estimate from the previous (2015) SAR. This is because the previous estimate included data from the 2007 TNASS surveys of Canadian waters. For the purposes of this SAR, as recommended in the GAMMS II Workshop Report (Wade and Angliss 1997), estimates older than eight years are deemed unreliable, so this new estimate must not include data from the 2007 TNASS survey. This new estimate should not be interpreted as a decline in abundance of this stock, as previous estimates are not directly comparable.

Earlier estimates

Please see Appendix IV for a summary of abundance estimates, including earlier estimates and survey descriptions. As recommended in the GAMMS II Workshop Report (Wade and Angliss 1997), estimates older than eight years are deemed unreliable to determine a current PBR.

Recent surveys and abundance estimates

An abundance estimate of 67,191 (CV=0.29) common dolphins was generated from a shipboard and aerial survey conducted during June–August 2011 (Palka 2012). The aerial portion that contributed to the estimate covered 5,313 km of tracklines that were over waters north of New Jersey from the coastline to the 100-m depth contour through the U.S. and Canadian Gulf of Maine and up to and including the lower Bay of Fundy. The shipboard portion covered 3,107 km of tracklines between central Virginia and Massachusetts in waters deeper than the 100-m depth contour out to beyond the U.S. EEZ. Both sighting platforms used a double-platform data-collection procedure, which allows estimation of abundance corrected for perception bias of the detected species (Laake and Borchers 2004). Estimation of the abundance was based on the independent-observer approach assuming point independence (Laake and Borchers 2004) and calculated using the MRDS option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009).

An abundance estimate of 2,993 (CV=0.87) common dolphins was generated from a shipboard survey conducted concurrently (June–August 2011) in waters between central Virginia and central Florida. This shipboard survey included shelf-break and inner continental slope waters deeper than the 50-m depth contour within the U.S. EEZ. The survey employed a double-platform visual team procedure searching with 25×150 “bigeye” binoculars. A total of 4,445 km of tracklines was surveyed, yielding 290 cetacean sightings. The majority of sightings occurred along the continental shelf break with generally lower sighting rates over the continental slope. Estimation of the abundance was based on the independent-observer approach assuming point independence (Laake and Borchers 2004) and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009).

Table 1. Summary of recent abundance estimates for western North Atlantic common dolphin (*Delphinus delphis delphis*) by month, year, and area covered during each abundance survey, and resulting abundance estimate (N_{best}) and coefficient of variation (CV).

Month/Year	Area	N_{best}	CV
Jul-Aug 2011	Central Virginia to lower Bay of Fundy	67,191	0.29
Jun-Aug 2011	Central Florida to Central Virginia	2,993	0.87
Jun-Aug 2011	Central Florida to lower Bay of Fundy (COMBINED)	70,184	0.28

Minimum Population Estimate

The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally distributed best abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by Wade and Angliss (1997). The best estimate of abundance for common dolphins is 70,184 animals (CV=0.28), derived from the 2011 aerial and shipboard surveys. The minimum population estimate for the western North Atlantic common dolphin is 55,690.

Current Population Trend

A trend analysis has not been conducted for this stock. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval. For example, the power to detect a precipitous decline in abundance (i.e., 50% decrease in 15 years) with estimates of low precision (e.g., CV > 0.30) remains below 80% (alpha = 0.30) unless surveys are conducted on an annual basis (Taylor *et al.*

2007).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. Life history parameter information that could be used to estimate net productivity are there is a peak in parturition during July and August with an average birth day of 28 July. Gestation lasts about 11.7 months and lactation lasts at least a year. Given these results western North Atlantic female common dolphins are likely on a 2-3 year calving interval. Females become sexually mature earlier (8.3 years and 200 cm) than males (9.5 years and 215 cm) as males continue to increase in size and mass. There is significant sexual dimorphism present with males being on average about 9% larger in body length (Westgate 2005; Westgate and Read 2007).

For purposes of this assessment, the maximum net productivity rate was assumed to be 0.04. This value is based on theoretical modeling showing that cetacean populations may not grow at rates much greater than 4% given the constraints of their reproductive life history (Barlow *et al.* 1995).

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of minimum population size, one-half the maximum productivity rate, and a recovery factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size is 55,690 animals. The maximum productivity rate is 0.04, the default value for cetaceans. The recovery factor is 0.5, the default value for stocks of unknown status and the CV of the average mortality estimate is less than 0.3 (Wade and Angliss 1997). PBR for the western North Atlantic stock of common dolphin is 557.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Total annual estimated average fishery-related mortality or serious injury to this stock during 2010–2014 was 409 (CV=0.10) common dolphins.

Fishery information

Detailed fishery information is reported in Appendix III.

Earlier Interactions

Historically, US fishery interactions have been documented with common dolphins in the northeast and mid-Atlantic gillnet fisheries, northeast and mid-Atlantic bottom trawl fisheries, northeast and mid-Atlantic mid-water trawl fishery, and the pelagic longline fishery. See Appendix V for more information on historical takes.

Northeast Sink Gillnet

In 1990, an observer program was started by NMFS to investigate marine mammal takes in the northeast sink gillnet fishery (Appendix III). Common dolphin bycatch in the northern Gulf of Maine occurs primarily from June to September, while in the southern Gulf of Maine, bycatch occurs from January to May and September to December. Annual common dolphin mortalities were estimated using annual ratio-estimator methods (Orphanides 2013; Hatch and Orphanides 2014, 2015, 2016). See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

A study of the effects of two different hanging ratios in the bottom-set monkfish gillnet fishery on the bycatch of cetaceans and pinnipeds was conducted by NEFSC in 2009 and 2010 with 100% observer coverage. Commercial fishing vessels from Massachusetts and New Jersey were used for the study, which took place south of the Harbor Porpoise Take Reduction Team Cape Cod South Management Area (south of 40° 40´N) in February–April. Researchers purposely picked an area of historically high bycatch rates in order to have a chance of finding a significant difference. Eight research strings of fourteen nets each were fished and 159 hauls were completed during the course of the 2009–2010 study. Results showed that while a 0.33 mesh performed better at catching commercially important finfish than a 0.50 mesh, there was no statistical difference in cetacean or pinniped bycatch rates between the two hanging ratios. One common dolphin was caught in this study south of New England in 72 hauls during 2009 and one animal was caught in 72 hauls during the 2010 experiment in the mid-Atlantic (A.I.S., Inc. 2010). The 2010 take is in the time period of this report and is included in the observed interactions and added to the total estimates in Table 2, although these animals and the fishing effort from this experiment were not included in the estimation of the bycatch rate that was expanded to the rest of the fishing effort.

Mid-Atlantic Gillnet

Common dolphins were taken in observed trips during most years. Annual common dolphin mortalities were estimated using annual ratio-estimator methods (Orphanides 2013; Hatch and Orphanides 2014, 2015, 2016). See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

A study of the effects of tie-downs and bycatch rates of Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) in both control and experimental gillnet gear operating in Statistical Area 612 (off New York and New Jersey) between 14 November and 18 December 2010 had 100% observer coverage. This experimental fishery captured 6 common dolphins and 3 unidentified dolphins (unidentified due to lack of photos) during this time period (Fox *et al.* 2011). These 6 takes are included in the observed interactions and added to the total estimates, though these interactions and their associated fishing effort were not included in bycatch rate calculations that was expanded to the rest of the fishery (Table 2).

Northeast Bottom Trawl

This fishery is active in New England waters in all seasons. Annual common dolphin mortalities were estimated using annual stratified ratio-estimator methods (Lyssikatos 2015).See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Mid-Atlantic Bottom Trawl

Annual common dolphin mortalities were estimated using annual stratified ratio-estimator methods (Lyssikatos 2015). See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Northeast Mid-water Trawl Fishery (Including Pair Trawl)

A common dolphin mortality was observed in this fishery in 2010, and another in 2012 (Table 2). An expanded bycatch estimate has not been calculated so the minimum raw count is reported.

Table 2. Summary of the incidental serious injury and mortality of North Atlantic common dolphins (*Delphinus delphis delphis*) by commercial fishery including the years sampled, the type of data used, the annual observer coverage, the serious injuries and mortalities recorded by on-board observers, the estimated annual serious injury and mortality, the combined serious injury and mortality estimate, the estimated CV of the annual combined serious injury and mortality and the mean annual serious injury and mortality estimate (CV in parentheses).

Fishery	Years	Data Type[a]	Observer Coverage[b]	Observed Serious Injury[e]	Observed Mortality	Estimated Serious Injury	Estimated Mortality	Estimated Combined Mortality	Estimated CVs	Mean Annual Combined Mortality
Northeast Sink Gillnet[d]	10-14	Obs. Data, Trip Logbook, Allocated Dealer Data	.17, .19, .15, .11, .18	0, 0, 0, 0, 0	4, 6, 6, 5, 11	0, 0, 0, 0, 0	69, 49, 95, 104, 111	69, 49, 95, 104, 111	.81, .71, .40, .46, .47	83 (.24)
Mid-Atlantic Gillnet[d]	10-14	Obs. Data, Trip Logbook, Allocated Dealer Data	.04, .02, .02, .03, .05	0, 0, 0, 0, 0	10, 3, 1, 2, 1	0, 0, 0, 0, 0	30, 29, 15, 62, 17	30, 29, 15, 62, 17	.48, .53, .93, .67, .86	31(.33)
Northeast Mid-water Trawl - Including Pair Trawl	10-14	Obs. Data Trip Logbook	.54, .41, .45, .37, .42	0, 0, 0, 0, 0	1, 0, 1, 0, 0	0, 0, 0, 0, 0	na, 0, na, 0, 0	1, 0, 1, 0, 0	1, 0, 1, 0, 0	0.4

Northeast Bottom Trawl[c]	10-14	Obs. Data Trip Logbook	.16, .26, .17, .15, .17	2, 0, 0, 0, 0	29, 22, 10, 4, 3	3, 2, 0, 0, 0	111, 70, 40, 17, 17	114, 72, 40, 17, 17	.32, .37, .54, .54, .53	52 (.2)
Mid-Atlantic Bottom Trawl[c]	10-14	Obs. Data Trip Logbook	.06, .08, .05, .06, .08	0, 1, 0, 0, 3	2, 29, 32, 24, 35	1, 8, 7, 0, 24	20, 263, 316, 269, 305	21, 271, 323, 269, 329	.96, .25, .26, .29, .29	243(.14)
TOTAL										409 (.1)

a. Observer data (Obs. Data), used to measure bycatch rates, are collected within the Northeast Fisheries Observer Program and At-sea Monitoring Program. NEFSC collects landings data (unallocated Dealer Data or Allocated Dealer Data) which are used as a measure of total landings and mandatory Vessel Trip Reports (VTR) (Trip Logbook) are used to determine the spatial distribution of landings and fishing effort.

b. Observer coverage is defined as the ratio of observed to total metric tons of fish landed for the gillnet fisheries ,.and the ratio of observed to total trips for bottom trawl and Mid-Atlantic mid-water trawl (including pair trawl) fisheries. Beginning in May 2010 total observer coverage reported for bottom trawl and gillnet gear includes samples collected from the at-sea monitoring program in addition to traditional observer coverage through the Northeast Fisheries Observer Program (NEFOP).

c. Fishery related bycatch rates for years 2010-2014 were estimated using an annual stratified ratio-estimator (Lyssikatos 2015).

d. One common dolphin was incidentally caught in 2010 in the mid-Atlantic gillnet fishery as part of a NEFSC hanging ratio study to examine the impact of gillnet hanging ratio on harbor porpoise bycatch. Six common dolphins were caught in a study of the effects of tie-downs on Atlantic Sturgeon bycatch rates conducted in the mid-Atlantic gillnet fishery in 2010. All research takes are included in the observed interactions and added to the total estimates, though these interactions and their associated fishing effort were not included in bycatch rate calculations that was expanded to the rest of the fishery.

e. Serious injuries were evaluated for the 2010–2014 period using new guidelines and include both at-sea monitor and traditional observer data (Waring *et al.* 2014, 2015Wenzel *et al*. 2015, 2016)

CANADA

Between January 1993 and December 1994, 36 Spanish deep-water trawlers, covering 74 fishing trips (4,726 fishing days and 14,211 sets), were observed in NAFO Fishing Area 3 (off the Grand Banks) (Lens 1997). A total of 47 incidental catches was recorded, which included one common dolphin. The incidental mortality rate for common dolphins was 0.007/set. One common dolphin was reported as a bycatch mortality in Canadian bottom otter trawl fishing on Georges Bank in 2012 (pers. comm. Marine Animal Response Society, Nova Scotia).

Other Mortality

From 2010 to 2014, 698 common dolphins were reported stranded between Maine and Florida (Table 3). The total includes mass-stranded common dolphins in Massachusetts during 2010 (a total of 30 in 8 events), 2011 (a total of 30 animals in 5 events), 2012 (23 group stranding events), 2013 (a total of 9 in 3 events), and 2014 (a total of 14 in 4 events) ,one mass stranding in North Carolina in 2011 (4 animals), and 2 mass strandings in Virginia in 2013 (a total of 6 in 2 events). Eleven animals in 2010, 15 animals in 2011, 71 animals in 2012, 13 in 2013 and 12 in 2014 were released or last sighted alive. In 2010, 7 animals were classified as human interactions, 2 of which were fishery interactions (all Massachusetts mass-stranded animals) and 2 of which (Rhode Island) involved animals last sighted free-swimming. In 2011, 3 animals were classified as having human interactions, 2 of which were fishery interactions (one of these was satellite-tagged and released). Twelve human interaction cases were reported in 2012 (7 in Massachusetts, 3 in New York and 2 in New Jersey), 6 of which (2 in Massachusetts, 2 in New York and 1 in New Jersey) were classified as fisheries interactions. In 2013, 10 cases were classified as human interaction, 4 of which were fishery interactions. In 2014, 5 cases were classified as human interaction, 1 of which was a fishery interaction. In an analysis of mortality causes of stranded marine mammals on Cape Cod and southeastern Massachusetts between 2000 and 2006, Bogomolni (2010) reported that 61% of stranded common dolphins were involved in mass-stranding events, and 37% of all the common dolphin stranding mortalities were disease-related.

The Marine Animal Response Society of Nova Scotia reported one common dolphin stranded in 2010 (released alive), 2 (one a fisheries interaction) in 2011, 0 in 2012 and 2013, and 3 in 2014 (Tonya Wimmer, pers. comm.).

Table 3. Common dolphin (*Delphinus delphis delphis*) reported strandings along the U.S. Atlantic coast, 2010-2014.

STATE	2010	2011	2012	2013	2014	TOTALS
Maine	1	0	2	0	0	**3**
Massachusetts[a]	71	64	221	48	37	**441**
Rhode Island[c]	7	5	6	6	6	**30**
Connecticut	1	0	0	0	0	**1**
New York [c]	9	17	13	24	7	**70**
New Jersey[a, c]	14	9	14	19	8	**64**
Delaware[c]	0	1	1	3	0	**5**
Maryland	0	1	1	3	0	**5**
Virginia[a,c]	5	9	4	13	9	**40**
North Carolina[a,c]	6	18	0	9	6	**39**
TOTALS	**114**	**124**	**262**	**125**	**73**	**698**

a. Massachusetts mass strandings (2010 - 2,2,3,3,3,4,5,8; 2011-3,3,4,7,13; 2012 - 23 group events ranging from 2 to 22 animals each, 2013 - 4, 3 2, 2014 – 2, 2, 5, 5). North Carolina mass stranding of 4 animals in 2011. Two mass strandings in Virginia in April 2013 - a group of 4 and a group of 2. Three animals (one released alive) involved in mass stranding in NJ in 2012.

b. Seven HI cases in 2010 (4 mortalities in MA, 2 released alive in RI, and 1 mortality in New Jersey), 2 of which (Massachusetts) were classified as fishery interactions. Three HI cases in 2011, all in Massachusetts, 2 of which were classified as fishery interactions (but one of those fishery interaction animals was released alive). Twelve HI cases in 2012 (7 in Massachusetts, 3 in New York and 2 in New Jersey), 6 of which (2 in Massachusetts, 2 in New York and 1 in New Jersey) were classified as fisheries interactions. Ten records with indications of human interactions in 2013 (3 in New York, 1 in Rhode Island and 6 in Massachusetts), 4 of which (1 in Massachusetts and 3 in New York) were classified as fishery interactions. Five records of human interaction in 2014 (1 fisheries interaction in Rhode Island, 2 other human interactions in Massachusetts and 2 in Rhode Island). Two of the human interactions in 2014 (1 Massachusetts and 1 Rhode Island) involved live animals.

Stranding data probably underestimate the extent of fishery-related mortality and serious injury because all of the marine mammals that die or are seriously injured may not wash ashore, nor will all of those that do wash ashore necessarily show signs of entanglement or other fishery interaction. Finally, the level of technical expertise among stranding network personnel varies widely as does the ability to recognize signs of fishery interaction. However a recently published human interaction manual (Barco and Moore 2013) and case criteria for human interaction determinations (Moore *etal.* 2013) should help with this.

STATUS OF STOCK

Common dolphins are not listed as threatened or endangered under the Endangered Species Act, and the Western North Atlantic stock is not considered strategic under the Marine Mammal Protection Act. The 2010–2014 average annual human-related mortality does not exceed PBR. The total U.S. fishery-related mortality and serious injury for this stock is not less than 10% of the calculated PBR and, therefore, cannot be considered to be insignificant and approaching zero mortality and serious injury rate. The status of common dolphins, relative to

OSP, in the U.S. Atlantic EEZ is unknown. Population trends for this species have not been investigated.

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COMMON BOTTLENOSE DOLPHIN (*Tursiops truncatus truncatus*): Western North Atlantic Offshore Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

There are two morphologically and genetically distinct common bottlenose dolphin morphotypes (Duffield *et al.* 1983; Mead and Potter 1995; Rosel *et al.* 2009) described as the coastal and offshore forms in the western North Atlantic (Hersh and Duffield 1990; Mead and Potter 1995; Curry and Smith 1997; Rosel *et al.* 2009). The two morphotypes are genetically distinct based upon both mitochondrial and nuclear markers (Hoelzel *et al.* 1998; Rosel *et al.* 2009). The offshore form is distributed primarily along the outer continental shelf and continental slope in the Northwest Atlantic Ocean from Georges Bank to the Florida Keys (Figure 1; CETAP 1982; Kenney 1990), where dolphins with characteristics of the offshore type have stranded. However, common bottlenose dolphins have occasionally been sighted in Canadian waters, on the Scotian Shelf (e.g., Baird *et al.* 1993; Gowans and Whitehead 1995), and these animals are thought to be of the offshore form.

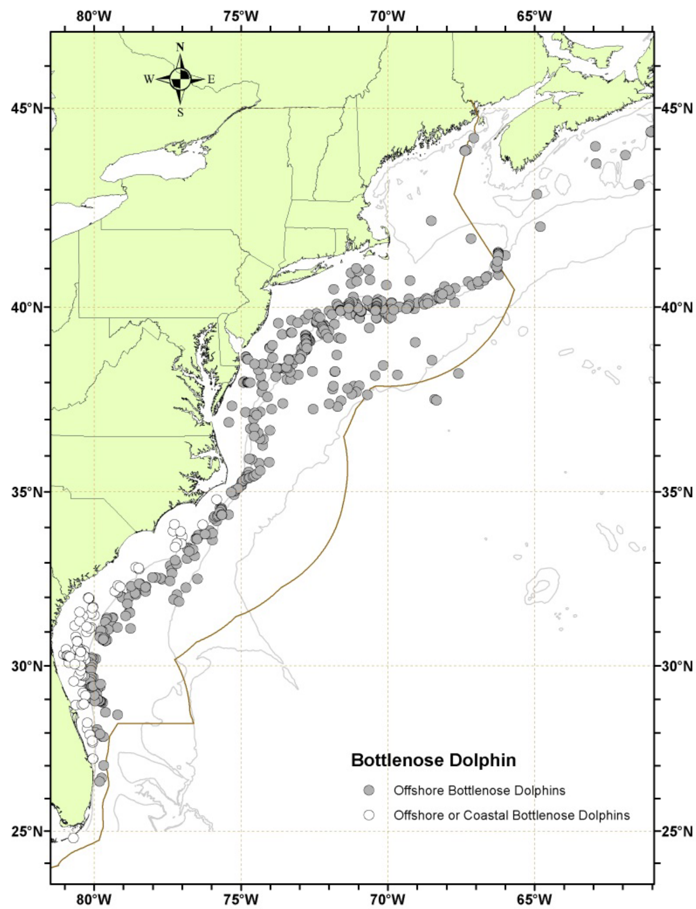

Figure 1. *Distribution of bottlenose dolphin sightings from NEFSC and SEFSC aerial surveys during summer in 1998, 1999, 2002, 2004, 2006 and 2011. Isobaths are the100-m, 1,000-m, and 4,000-m depth contours.*

North of Cape Hatteras, there is separation of the two morphotypes across bathymetry during summer months. Aerial surveys flown during 1979–1981 indicated a concentration of common bottlenose dolphins in waters < 25 m deep corresponding to the coastal morphotype, and an area of high abundance along the shelf break corresponding to the offshore stock (CETAP 1982; Kenney 1990). Biopsy tissue sampling and genetic analysis demonstrated that common bottlenose dolphins concentrated close to shore were of the coastal morphotype, while those in waters > 40 m depth were from the offshore morphotype (Garrison *et al.* 2003). However, south of Cape Hatteras, North Carolina, the ranges of the coastal and offshore morphotypes overlap to some degree. Torres *et al.* (2003) found a statistically significant break in the distribution of the morphotypes at 34 km from shore based upon the genetic analysis of tissue samples collected in nearshore and offshore waters from New York to central Florida. The offshore morphotype was found exclusively seaward of 34 km and in waters deeper than 34 m. Within 7.5 km of shore, all animals were of the coastal morphotype. More recently, offshore morphotype animals have been sampled as close as 7.3 km from shore in water depths of 13 m (Garrison *et al.* 2003). Systematic biopsy collection surveys were conducted coast-wide during the summer and winter between 2001 and 2005 to evaluate the degree of spatial overlap between the two morphotypes. Over the continental shelf south of Cape Hatteras, North Carolina, the two morphotypes overlap spatially, and the probability of a sampled group being from the offshore morphotype increased with increasing depth based upon a logistic regression analysis (Garrison *et al.* 2003). Hersh and Duffield (1990) examined common bottlenose dolphins that stranded along the southeast coast of Florida and found four that had hemoglobin profiles matching that of the offshore morphotype. These strandings suggest the offshore form occurs as far south as southern Florida. The range of the offshore common bottlenose dolphin includes waters beyond the continental slope (Kenney 1990), and also waters beyond the U.S. EEZ, and therefore the offshore stock is a transboundary stock (Figure 1). Offshore common bottlenose dolphins may move between the Gulf of Mexico and the Atlantic (Wells *et al.* 1999).

The western North Atlantic Offshore Stock of common bottlenose dolphins is being considered separate from the Gulf of Mexico Oceanic Stock of common bottlenose dolphins for management purposes. One line of evidence to support this decision comes from Baron *et al.* (2008), who found that Gulf of Mexico common bottlenose dolphin whistles (collected from oceanic waters) were significantly different from those in the western North Atlantic Ocean (collected from continental shelf and oceanic waters) in duration, number of inflection points and number of steps.

POPULATION SIZE

The best available estimate for the offshore stock of common bottlenose dolphins in the western North Atlantic is 77,532 (CV=0.40; Table 1; Palka 2012; Garrison 2016). This estimate is from summer 2011 surveys covering waters from central Florida to the lower Bay of Fundy.

Earlier abundance estimates

Please see Appendix IV for a summary of abundance estimates, including earlier estimates and survey descriptions. As recommended in the GAMMS II Workshop Report (Wade and Angliss 1997), estimates older than 8 years are deemed unreliable for the determination of the current PBR.

Recent surveys and abundance estimates

An abundance estimate of 26,766 (CV=0.52) offshore common bottlenose dolphins was generated from aerial and shipboard surveys conducted during June–August 2011 between central Virginia and the lower Bay of Fundy (Palka 2012). The aerial portion covered 6,850 km of trackline over waters north of New Jersey between the coastline and the 100-m depth contour through the U.S. and Canadian Gulf of Maine, and up to and including the lower Bay of Fundy. The shipboard portion covered 3,811 km of trackline between central Virginia and Massachusetts in waters deeper than the 100-m depth contour out to beyond the U.S. EEZ. Both sighting platforms used a double-platform data-collection procedure, which allows estimation of abundance corrected for perception bias of the detected species (Laake and Borchers 2004). Estimation of the abundance was based on the independent observer approach assuming point independence (Laake and Borchers 2004) and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009).

An abundance estimate of 50,766 (CV=0.55) offshore common bottlenose dolphins was generated from a shipboard survey conducted concurrently (June–August 2011) in waters between central Virginia and central Florida (Garrison 2016). This shipboard survey included shelf-break and inner continental slope waters deeper than the 50-m depth contour within the U.S. EEZ. The survey employed two independent visual teams searching with 25x150 “bigeye” binoculars. A total of 4,445 km of trackline was surveyed, yielding 290 cetacean sightings. The majority of sightings occurred along the continental shelf break with generally lower sighting rates over the continental slope. Estimation of the abundance was based on the independent observer approach assuming point independence (Laake and Borchers 2004) and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009).

Table 1. Summary of recent abundance estimates for western North Atlantic offshore stock of common bottlenose dolphins (*Tursiops truncatus truncatus*) by month, year, and area covered during each abundance survey, and resulting abundance estimate (N_{best}) and coefficient of variation (CV).

Month/Year	Area	N_{best}	CV
Jun–Aug 2011	central Virginia to lower Bay of Fundy	26,766	0.52
Jun–Aug 2011	central Florida to central Virginia	50,766	0.55
Jun–Aug 2011	central Florida to lower Bay of Fundy (COMBINED)	77,532	0.40

Minimum Population Estimate

The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally distributed best abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by Wade and Angliss (1997). The best abundance estimate is 77,532 (CV=0.40). The minimum population estimate for western North Atlantic offshore common bottlenose dolphin is 56,053.

Current Population Trend

A trend analysis has not been conducted for this stock. There are 3 abundance estimates from: 1) summer 1998 surveys (29,774; CV=0.25); 2) summer 2002/2004 surveys (81,588; CV=0.17); and 3) summer 2011 surveys (77,532; CV=0.40). Methodological differences between the estimates need to be evaluated before quantifying trends.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. For purposes of this assessment, the maximum net productivity rate was assumed to be 0.04. This value is based on theoretical modeling showing that cetacean populations may not grow at rates much greater than 4% given the constraints of their reproductive life history (Barlow *et al*. 1995).

POTENTIAL BIOLOGICAL REMOVAL

Potential biological removal (PBR) is the product of minimum population size, one-half the maximum productivity rate, and a "recovery" factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size for offshore common bottlenose dolphins is 56,053. The maximum productivity rate is 0.04, the default value for cetaceans. The "recovery" factor is 0.5 because the stock's status relative to optimum sustainable population (OSP) is unknown and the CV of the average mortality estimate is less than 0.3 (Wade and Angliss 1997). PBR for the western North Atlantic offshore common bottlenose dolphin is therefore 561.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

The estimated mean annual fishery-related mortality and serious injury of offshore common bottlenose dolphins during 2010–2014 was 39.4 (CV=0.29; Table 2) due to interactions with the northeast sink gillnet, northeast bottom trawl, mid-Atlantic bottom trawl, and pelagic longline fisheries. The total annual fishery-related mortality and serious injury for this stock during 2010–2014 is unknown because in addition to observed takes, there was a self-reported take in the unobserved mid-Atlantic tuna hook and line fishery during 2010.

Fisheries Information

The commercial fisheries that interact, or that potentially could interact, with this stock in the Atlantic Ocean are the Category I Atlantic Highly Migratory Species longline; Atlantic Ocean, Caribbean, Gulf of Mexico large pelagics longline; mid-Atlantic gillnet; and northeast sink gillnet fisheries; the Category II mid-Atlantic bottom trawl and northeast bottom trawl fisheries; and the Category III Gulf of Maine, U.S. mid-Atlantic tuna, shark, swordfish hook and line/harpoon fishery. Detailed fishery information is reported in Appendix III.

Earlier Interactions

Historically, U.S. fishery interactions have been documented with common bottlenose dolphins in the pelagic drift gillnet fishery, pelagic pair trawl fishery, northeast and mid-Atlantic bottom trawl fisheries, and the northeast and mid-Atlantic gillnet fisheries. See Appendix V for more information on historical takes.

Longline

The large pelagics longline fishery operates in the U.S. Atlantic (including Caribbean) and Gulf of Mexico EEZ, and pelagic swordfish, tunas and billfish are the target species. The estimated annual average mortality and serious injury attributable to the Atlantic Ocean pelagics longline fishery for the 5-year period from 2010 to 2014 was 12.4 common bottlenose dolphins (CV=0.68; Table 2). During 2010–2014, 3 serious injuries to common bottlenose dolphins were observed: 2 during quarter 1 of 2012 in the South Atlantic Bight (SAB) region, and 1 during quarter 3 of 2012 in the Northeast Coastal (NEC) region (Garrison and Stokes 2013; see also Garrison and Stokes 2012a,b; 2014; 2016). During 2010 (1 animal), 2011 (2 animals), 2012 (2 animals), and 2013 (2 animals), a total of 7 common bottlenose dolphins were observed entangled and released alive in the SAB, Mid-Atlantic Bight (MAB) and NEC regions (Garrison and Stokes 2012a,b; 2013; 2014; 2016). These animals were presumed to have no serious injuries.

Historically in the large pelagics longline fishery, no common bottlenose dolphin mortalities or serious injuries were observed between 2002 and 2008 (Garrison 2003; Garrison and Richards 2004; Garrison 2005; Fairfield Walsh and Garrison 2006; Fairfield-Walsh and Garrison 2007; Fairfield and Garrison 2008; Garrison *et al.* 2009). However, 1 common bottlenose dolphin serious injury was observed during quarter 4 of 2009 in the MAB region

(Garrison and Stokes 2010), and 1 common bottlenose dolphin was observed entangled and released alive, presumed to have no serious injuries, in 2005 in the SAB region (Fairfield Walsh and Garrison 2006).

The Atlantic Highly Migratory Species longline fishery operates outside the U.S. EEZ. No takes of common bottlenose dolphins within high seas waters of the Atlantic Ocean have been observed or reported thus far.

See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical estimates of annual mortality and serious injury.

Table 2. Summary of the incidental mortality and serious injury of Atlantic Ocean offshore common bottlenose dolphins (*Tursiops truncatus truncatus*) by commercial fishery including the years sampled (Years), the type of data used (Data Type), the annual observer coverage (Observer Coverage), the observed mortalities and serious injuries recorded by on-board observers, the estimated annual mortality and serious injury, the combined annual estimates of mortality and serious injury (Estimated Combined Mortality), the estimated CV of the combined estimates (Estimated CVs) and the mean of the combined estimates (CV in parentheses).

Fishery	Years	Data Type[a]	Observer Coverage[b]	Observed Serious Injury	Observed Mortality	Estimated Serious Injury	Estimated Mortality	Estimated Combined Mortality	Est. CVs	Mean Annual Mortality
Northeast Sink Gillnet	10–14	Obs. Data Logbook	.17, .19, .15, .11, 0.18	0,0,0,0,0	0,0,0,1,0	0,0,0,0,0	0,0,0,26,0	0,0,0,26,0	.00, .00, .00, .95, .00	5.2 (0.95)
Northeast Bottom Trawl [c]	10–14	Obs. Data Logbook	.16, .26, .17, .15, .17	0,0,0,0,0	1,0,0,0,0	0,0,0,0,0	4,10,0,0,0	4,10,0,0,0	.53, .84, NA, NA, NA	2.8 (0.62)
Mid-Atlantic Bottom Trawl [c]	10–14	Obs. Data Logbook	.06, .08, .05, .06, .08	0,0,0,0,0	5,2,1,0,3	0,0,0,0,0	20,34, 16,0,25	20,34,16, 0,25	.34, .31, 1.0, NA, .66	19 (0.28)
Pelagic Longline	10–14	Obs. Data Logbook	.08, .09, . 07, .09, . 10	0,0,3,0,0	0,0,0,0,0	0,0, 61.8,0,0	0,0,0,0,0	0,0, 61.8,0,0	NA, NA, .68, NA, NA	12.4 (0.68)
TOTAL										39.4 (0.29)

[a] Observer data (Obs. Data) are used to measure bycatch rates, and the data are collected within the Northeast Fisheries Observer Program. Mandatory logbook data were used to measure total effort for the longline fishery. These data are collected at the Southeast Fisheries Science Center (SEFSC).

[b] Proportion of sets observed (for Pelagic Longline).

[c] Fishery related bycatch rates for 2010–2014 were estimated using an annual stratified ratio-estimator following the methodology described in Lyssikatos (2015).

Northeast Sink Gillnet

During 2010–2014, 1 mortality was observed (in 2013) in the northeast sink gillnet fishery (Orphanides 2013; Hatch and Orphanides 2014; 2015; 2016). No takes were observed during 2010–2012 and 2014. There were no observed injuries of common bottlenose dolphins in the Northeast region during 2010–2014 to assess using new serious injury criteria. See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Northeast Bottom Trawl

During 2010–2014, 5 mortalities were observed in the northeast bottom trawl fishery (Lyssikatos 2015). There were no observed injuries of common bottlenose dolphins in the northeast region during 2010–2014 to assess using new serious injury criteria. See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Through the Marine Mammal Authorization Program (MMAP), there were 2 self-reported incidental takes (mortalities) of common bottlenose dolphins during 2014 off Rhode Island by fishers trawling for *Illex* squid.

Mid-Atlantic Bottom Trawl

During 2010–2014, 11 mortalities were observed in the mid-Atlantic bottom trawl fishery (Lyssikatos 2015). There were no observed injuries of common bottlenose dolphins in the mid-Atlantic region during 2010–2014 to assess using new serious injury criteria. See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Through the MMAP, there were 2 self-reported incidental takes (mortalities) involving 3 common bottlenose dolphins in total during 2011 off Rhode Island and New Jersey by fishers trawling for *Loligo* squid.

U.S. Mid-Atlantic Tuna Hook and Line

Through the MMAP, there was 1 self-reported incidental take (serious-injury) of a common bottlenose dolphin during 2010 off North Carolina by a fisher using hook and line targeting tuna.

Other Mortality

Common bottlenose dolphins are among the most frequently stranded small cetaceans along the Atlantic coast. Many of the animals show signs of human interaction (*i.e.*, net marks, mutilation, etc.); however, it is unclear what proportion of these stranded animals is from the offshore stock because most strandings are not identified to morphotype, and when they are, animals of the offshore form are uncommon. For example, only 19 of 185 *Tursiops* strandings in North Carolina were genetically assigned to the offshore form (Byrd *et al.* 2014).

An Unusual Mortality Event (UME) of bottlenose dolphins and other cetaceans occurred along the mid-Atlantic coast from New York to Brevard County, Florida, from 1 July 2013 to 1 March 2015. The total number of stranded bottlenose dolphins was ~1650. Morbillivirus has been determined to be a primary cause of the event. Post-UME monitoring of bottlenose dolphins will continue over the next few years, and work continues to determine the effect of this event on bottlenose dolphin stocks in the Atlantic.

STATUS OF STOCK

The common bottlenose dolphin in the western North Atlantic is not listed as threatened or endangered under the Endangered Species Act, and the offshore stock is not considered strategic under the MMPA. Total U.S. fishery-related mortality and serious injury for this stock is less than 10% of the calculated PBR and, therefore, can be considered to be insignificant and approaching the zero mortality and serious injury rate. The status of this stock relative to OSP in the U.S. Atlantic EEZ is unknown. There are insufficient data to determine the population trends for this stock.

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HARBOR PORPOISE (*Phocoena phocoena phocoena*): Gulf of Maine/Bay of Fundy Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

This stock is found in U.S. and Canadian Atlantic waters. The distribution of harbor porpoises has been documented by sighting surveys, strandings and takes reported by NMFS observers in the Sea Sampling Programs. During summer (July to September), harbor porpoises are concentrated in the northern Gulf of Maine and southern Bay of Fundy region, generally in waters less than 150 m deep (Gaskin 1977; Kraus *et al.* 1983; Palka 1995), with a few sightings in the upper Bay of Fundy and on Georges Bank (Palka 2000). During fall (October–December) and spring (April–June), harbor porpoises are widely dispersed from New Jersey to Maine, with lower densities farther north and south. They are seen from the coastline to deep waters (>1800 m; Westgate *et al.* 1998), although the majority of the population is found over the continental shelf. During winter (January to March), intermediate densities of harbor porpoises can be found in waters off New Jersey to North Carolina, and lower densities are found in waters off New York to New Brunswick, Canada. There does not appear to be a temporally coordinated migration or a specific migratory route to and from the Bay of Fundy region. However, during the fall, several satellite-tagged harbor porpoises did favor the waters around the 92-m isobath, which is consistent with observations of high rates of incidental catches in this depth range (Read and Westgate 1997). There were two stranding records from Florida during the 1980s (Smithsonian strandings database) and one in 2003 (NE Regional Office/NMFS strandings and entanglement database).

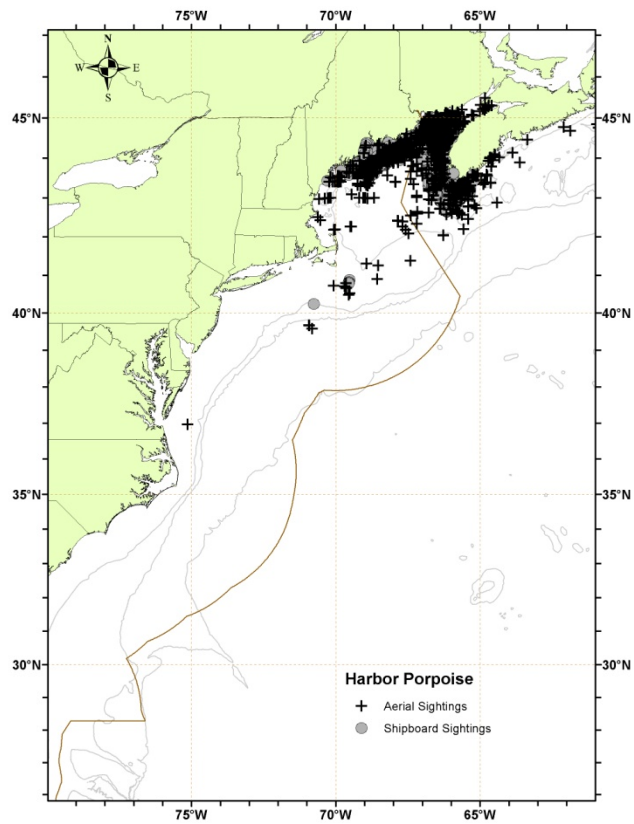

Figure 1. *Distribution of harbor porpoises from NEFSC and SEFSC shipboard and aerial surveys during the summers of 1995, 1998, 1999, 2002, 2004, 2006, 2007, 2008, 2010, and 2011 and DFO's 2007 TNASS survey. Isobaths are the 100-m, 1000-m, and 4000-m depth contours.*

Gaskin (1984, 1992) proposed that there were four separate populations in the western North Atlantic: the Gulf of Maine/Bay of Fundy, Gulf of St. Lawrence, Newfoundland, and Greenland populations. Analyses involving mtDNA (Wang *et al.* 1996; Rosel *et al.* 1999a; 1999b), organochlorine contaminants (Westgate *et al.* 1997; Westgate and Tolley 1999), heavy metals (Johnston 1995), and life history parameters (Read and Hohn 1995) support Gaskin's proposal. Genetic studies using mitochondrial DNA (Rosel *et al.* 1999a) and contaminant studies using total PCBs (Westgate and Tolley 1999) indicate that the Gulf of Maine/Bay of Fundy females were distinct from females from the other populations in the Northwest Atlantic. Gulf of Maine/Bay of Fundy males were distinct from Newfoundland and Greenland males, but not from Gulf of St. Lawrence males according to studies comparing mtDNA (Palka *et al.* 1996; Rosel *et al.* 1999a) and CHLORs, DDTs, PCBs and CHBs (Westgate and Tolley 1999). Nuclear microsatellite markers have also been applied to samples from these four populations, but this analysis failed to detect significant population sub-division in either sex (Rosel *et al.* 1999a). These patterns may be indicative of female philopatry coupled with dispersal of males. Both mitochondrial DNA and microsatellite analyses indicate that the Gulf of Maine/Bay of Fundy stock is not the sole contributor to the aggregation of porpoises found off the mid-Atlantic states during winter (Rosel *et al.* 1999a; Hiltunen 2006). Mixed-stock analyses using twelve microsatellite loci in both Bayesian and likelihood frameworks indicate that the Gulf of Maine/Bay of Fundy is the largest contributor (~60%), followed by Newfoundland (~25%) and then the Gulf of St. Lawrence (~12%), with Greenland making a small contribution (<3%). For Greenland, the lower confidence interval of the likelihood analysis includes zero. For the Bayesian analysis, the lower 2.5% posterior quantiles include zero for both Greenland and the Gulf of St. Lawrence. Intervals that reach zero provide the possibility that these populations contribute no animals to the mid-Atlantic aggregation.

This report follows Gaskin's hypothesis on harbor porpoise stock structure in the western North Atlantic, where the Gulf of Maine and Bay of Fundy harbor porpoises are recognized as a single management stock separate from harbor porpoise populations in the Gulf of St. Lawrence, Newfoundland, and Greenland.

POPULATION SIZE

The best current abundance estimate of the Gulf of Maine/Bay of Fundy harbor porpoise stock is from the 2011 survey: 79,883 (CV=0.32).

Earlier abundance estimates

Please see Appendix IV for a summary of abundance estimates, including earlier estimates and survey descriptions. As recommended in the GAMMS II Workshop Report (Wade and Angliss 1997), estimates older than eight years are deemed unreliable for the determination of the current PBR.

Recent surveys and abundance estimates

An abundance estimate of 79,883 (CV=0.32) harbor porpoises was generated from a shipboard and aerial survey conducted during June–August 2011 (Palka 2012). The aerial portion that contributed to the abundance estimate covered 5,313 km of tracklines that were over waters north of New Jersey from the coastline to the 100-m depth contour through the U.S. and Canadian Gulf of Maine and up to and including the lower Bay of Fundy. The shipboard portion covered 3,107 km of tracklines that were in waters offshore of central Virginia to Massachusetts (waters that were deeper than the 100-m depth contour out to beyond the U.S. EEZ). Both sighting platforms used a double-platform team data-collection procedure, which allows estimation of abundance corrected for perception bias of the detected species (Laake and Borchers 2004). Estimation of the abundance was based on the independent-observer approach assuming point independence (Laake and Borchers 2004) and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009).

No harbor porpoises were detected in an abundance survey that was conducted concurrently (June-August 2011) in waters between central Virginia and central Florida. This shipboard survey included shelf-break and inner continental slope waters deeper than the 50-m depth contour within the U.S. EEZ. The survey employed the double-platform methodology searching with 25x150 “bigeye” binoculars. A total of 4,445 km of tracklines was surveyed, yielding 290 cetacean sightings.

Table 1. Summary of recent abundance estimates for the Gulf of Maine/Bay of Fundy harbor porpoise (*Phocoena phocoena phocoena*) by month, year, and area covered during each abundance survey and the resulting abundance estimate (N_{best}) and coefficient of variation (CV).

Month/Year	Area	N_{best}	CV
Jul-Aug 2011	Central Virginia to lower Bay of Fundy	79,883	0.32

Minimum Population Estimate

The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normal distributed best abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by Wade and Angliss (1997). The best estimate of abundance for harbor porpoises is 79,883 (CV=0.32). The minimum population estimate for the Gulf of Maine/Bay of Fundy harbor porpoise is 61,415.

Current Population Trend

A trend analysis has not been conducted for this stock. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval. For example, the power to detect a precipitous decline in abundance (i.e., 50% decrease in 15 years) with estimates of low precision (e.g., CV > 0.30) remains below 80% (alpha = 0.30) unless surveys are conducted on an annual basis (Taylor *et al.* 2007).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Several attempts have been made to estimate potential population growth rates. Barlow and Boveng (1991), who used a re-scaled human life table, estimated the upper bound of the annual potential growth rate to be 9.4%. Woodley and Read (1991) used a re-scaled Himalayan tahr life table to estimate a likely annual growth rate of 4%. In an attempt to estimate a potential population growth rate that incorporates many of the uncertainties in survivorship and reproduction, Caswell *et al.* (1998) used a Monte Carlo method to calculate a probability distribution of growth rates. The median potential annual rate of increase was approximately 10%, with a 90% confidence interval of 3–15%. This analysis underscored the considerable uncertainty that exists regarding the potential rate of increase in this population. Moore and Read (2008) conducted a Bayesian population modeling analysis to estimate the potential population growth of harbor porpoise in the absence of bycatch mortality. Their method used fertility data, in combination with age-at-death data from stranded animals and animals taken in gillnets, and was applied under two scenarios to correct for possible data bias associated with observed bycatch of calves. Demographic parameter estimates were 'model averaged' across these scenarios. The Bayesian posterior median estimate for potential natural growth rate was 0.046. This last, most recent, value will be the one used for the purpose of this assessment.

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of minimum population size, one-half the maximum productivity rate, and a recovery factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size is 61,415. The maximum productivity rate is 0.046. The recovery factor is 0.5 because stock's status relative to OSP is unknown and the CV of the average mortality estimate is less than 0.3 (Wade and Angliss 1997). PBR for the Gulf of Maine/Bay of Fundy harbor porpoise is 706.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

The total annual estimated average human-caused mortality is 437 harbor porpoises per year. This is derived from two components: 394 harbor porpoise per year (CV=0.18) from U.S. fisheries using observer and MMAP data, and 43 per year (unknown CV) from Canadian fisheries using observer data.

Fishery Information

Recently, Gulf of Maine/Bay of Fundy harbor porpoise takes have been documented in the U.S. northeast sink gillnet, mid-Atlantic gillnet, and northeast bottom trawl fisheries and in the Canadian herring weir fisheries (Table 2). Detailed U.S. fishery information is reported in Appendix III.

Earlier Interactions

One harbor porpoise was observed taken in the Atlantic pelagic drift gillnet fishery during 1991–1998; the fishery ended in 1998. This observed bycatch was notable because it occurred in continental shelf edge waters adjacent to Cape Hatteras (Read *et al.* 1996). See Appendix V for more information on historical takes.

U.S.

Northeast Sink Gillnet

Harbor porpoise bycatch in the northern Gulf of Maine occurs primarily from June to September, while in the southern Gulf of Maine, bycatch occurs from January to May and September to December. Annual bycatch is estimated using ratio estimator techniques that account for the use of pingers (Orphanides 2013; Hatch and Orphanides 2014, 2015, 2016). See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

There appeared to be no evidence of differential mortality in U.S. or Canadian gillnet fisheries by age or sex in animals collected before 1994, although there was substantial inter-annual variation in the age and sex composition of the bycatch (Read and Hohn 1995). Using observer data collected during 1990–1998 and a logit regression model, females were 11 times more likely to be caught in the offshore southern Gulf of Maine region, males were more likely to be caught in the south Cape Cod region, and the overall proportion of males and females caught in a gillnet and brought back to land were not significantly different from 1:1 (Lamb 2000).

Scientific experiments that demonstrated the effectiveness of pingers in the Gulf of Maine were conducted during 1992 and 1993 (Kraus *et al.* 1997). After the scientific experiments, experimental fisheries were allowed in the general fishery during 1994 to 1997 in various parts of the Gulf of Maine and south of Cape Cod areas. During these experimental fisheries, bycatch rates of harbor porpoises in pingered nets were less than in non-pingered nets.

A study on the effects of two different hanging ratios in the bottom-set monkfish gillnet fishery on the bycatch of cetaceans and pinnipeds was conducted by NEFSC in 2009 and 2010 with 100% observer coverage which took place in both the Northeast and mid-Atlantic gillnet fisheries. Commercial fishing vessels from Massachusetts and New Jersey were used for the study, which took place south of the Harbor Porpoise Take Reduction Cape Cod South Management Area (south of 40° 40´N) in February–April. Researchers purposely picked an area of historically high bycatch rates in order to have a chance of finding a significant difference. Eight research strings of fourteen nets each were fished and 159 hauls were completed during the course of the 2009–2010 study. Results showed that while a 0.33 mesh performed better at catching commercially important finfish than a 0.50 mesh, there was no statistical difference in cetacean or pinniped bycatch rates between the two hanging ratios. Twelve harbor porpoises were caught in this project in 79 hauls during 2009 and one animal was caught in 72 hauls during the 2010 experiment in the Northeast (A.I.S., Inc. 2010). The 2010 animal was included in the observed interactions and added into the total estimates (Table 2), though these animals and the fishing effort from this experiment were not included in the estimation of the bycatch rate that was expanded to the rest of the fishing effort. The 2009 takes were included in earlier editions of this report.

Mid-Atlantic Gillnet

Annual bycatch is estimated using ratio estimator techniques (Orphanides 2013; Hatch and Orphanides 2014, 2015, 2016). See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

In the northeast gillnet fishery section above, see the description of the study on the effects of two different hanging rations in the bottom-set gillnet fishery which took place in both the northeast and mid-Atlantic gillnet fisheries. Ten harbor porpoises were caught in 8 hauls in the mid-Atlantic in 2010 as part of this experiment (A.I.S., Inc. 2010). Harbor porpoises that were caught in this study were included in the observed interactions and added into the total estimates (Table 2), though these animals and the fishing effort from this experiment were not included in the estimation of the bycatch rate that was expanded to the rest of the fishing effort.

Northeast Bottom Trawl

Since 1989, harbor porpoise mortalities have been observed in the northeast bottom trawl fishery, but many of these were not attributable to this fishery because decomposed animals are presumed to have been dead prior to being taken by the trawl. New serious injury criteria were applied to all observed interactions retroactive back to 2007 (Waring *et al*. 2014, 2015, Wenzel *et al*. 2015, 2016). Fishery-related bycatch rates for years since 2008 were estimated using an annual stratified ratio-estimator (Lyssikatos 2015). These estimates replace the 2008–2010 annual estimates reported in the 2013 stock assessment report that were generated using a different method. See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information

CANADA

Bay of Fundy Sink Gillnet

The earlier estimated annual mortality estimates were 38 for 1998, 32 for 1999, 28 for 2000, and 73 for 2001 (Trippel and Shepherd 2004). Estimates of variance are not available. However, since 2002 there has been no observer program in the Bay of Fundy region, but the fishery is still active. Bycatch for these years is unknown. The annual average of the most recent five years with available data (1997–2001) was 43 animals, so this value is used to estimate the annual average for more recent years. In 2011 there was little gillnet effort in New Brunswick waters in the summer; thus the Canadian porpoise by-catch estimates could have been near zero. The fishermen that sought groundfish went into the mid-Bay of Fundy where traditionally bycatch levels were extremely low, though current bycatch levels are unknown. Trippel (pers. comm.) estimated that fewer than 10 porpoises were bycaught in the Canadian fisheries in the Bay of Fundy in 2011. Analysis of port catch records might allow estimation of bycatch for more recent times, however, it would be difficult to also accurately account for the changes in the spatial distribution of the harbor porpoises and fisheries.

Herring Weirs

Harbor porpoises are taken in Canadian herring weirs, but there have been no recent efforts to observe takes in the U.S. component of this fishery. Smith *et al.* (1983) estimated that in the 1980s approximately 70 harbor porpoises became trapped annually and, on average, 27 died annually. In 1990, at least 43 harbor porpoises were trapped in Bay of Fundy weirs (Read *et al.* 1994). In 1993, after a cooperative program between fishermen and Canadian biologists was initiated, over 100 harbor porpoises were released alive (Read *et al.* 1994). Between 1992 and 1994, this cooperative program resulted in the live release of 206 of 263 harbor porpoises caught in herring weirs. Mortalities (and releases) were 11 (50) in 1992, 33 (113) in 1993, and 13 (43) in 1994 (Neimanis *et al.* 1995). Since that time, additional harbor porpoises have been documented in Canadian herring weirs: mortalities (releases and unknowns) were 5 (60, 0) in 1995, 2 (4, 0) in 1996, 2 (24, 0) in 1997, 2 (26, 0) in 1998, 3 (89, 0) in 1999, 0 (13, 0) in 2000 (A. Read, pers. comm), 14 (296, 0) in 2001, 3 (46, 4) in 2002, 1 (26, 3) in 2003, 4 (53, 2) in 2004, 0 (19, 5) in 2005, 2 (14, 0) in 2006, 3 (9, 3) in 2007, 0 (8, 6) in 2008, 0 (3,4) in 2009, 1 in 2010 (7, 0), 0 (2, 3) in 2011, 0 (2, 3) in 2012, 0 (2,0) in 2013 and 0 (9, 2) in 2014 (Neimanis *et al.* 2004; H. Koopman and A. Westgate, pers. comm.).

See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information

Table 2. From observer program data, summary of the incidental mortality of Gulf of Maine/Bay of Fundy harbor porpoise (*Phocoena phocoena phocoena*) by commercial fishery including the years sampled, the type of data used, the annual observer coverage, the mortalities and serious injuries recorded by on-board observers, the estimated annual serious injury and mortality, the estimated CV of the annual mortality, and the mean annual combined mortality (CV in parentheses).

Fishery	Years	Data Type [a]	Observer Coverage [b]	Observed Serious Injury[i]	Observed Mortality	Estimated Serious Injury	Estimated Mortality	Combined Serious Injury	Estimated CVs	Mean Annual Combined Mortality
U.S.										
Northeast Sink Gillnet [c, h]	10-14	Obs. Data, Weighout, Trip Logbook	.17, .19, .15, .11, .18	0, 0, 0, 0, 0	50, 66, 34, 20, 28	0, 0, 0, 0, 0	387, 273, 277, 399, 128	387, 273, 277, 399, 128	.27, .20, .59, .33, .27	293 (0.17)
Mid-Atlantic Gillnet [h]	10-14	Obs. Data Weighout	.04, .02, .02, .03, .05	0, 0, 0, 0, 0	18, 11, 2, 1, 1	0, 0, 0, 0, 0	259, 123, 63, 19, 22	259, 123, 63, 19, 22	.88, .41, .83, 1.06, 1.03	97 (0.5)
Northeast bottom trawl [g]	10-14	Obs. Data Weighout	.16, .26, .17, .15, .17	0, 1, 0, 0, 0	0, 1, 0, 1, 1	0, 2, 0, 0, 0	0, 3.9, 0, 7, 5.5	0, 5.9, 0, 7, 5.5	0, .71, 0, .98, .86	3.7 (0.51)[g]
U.S. TOTAL	2010-2014									394 (0.18)
CANADA										
Bay of Fundy Sink Gillnet [f]	1997-2001	Can. Trips	unk		19, 5, 3, 5, 39		43, 38, 32, 28, 73		unk	43 [f] (unk)
Herring Weir [d,e]	10-14	Coop. Data	unk		1, 0, 0, 0, 0		1, 0, 0, 0, 0		NA	0.2 (unk)
CANADIAN TOTAL	2010-2014									43 (unk)
GRAND TOTAL										437 (unk)

NA = Not available.

a. Observer data (Obs. Data) are used to measure bycatch rates; the U.S. data are collected by the Northeast

Fisheries Science Center (NEFSC) Sea Sampling Program and At-Sea Monitoring Program; the Canadian data are collected by DFO. NEFSC collects Weighout (Weighout) landings data that are used as a measure of total effort for the U.S. gillnet fisheries. The Canadian DFO catch and effort statistical system collected the total number of trips fished by the Canadians (Can. Trips), which was the measure of total effort for the Canadian groundfish gillnet fishery. Mandatory vessel trip report (VTR) (Trip Logbook) data are used to determine the spatial distribution of fishing effort in the northeast sink gillnet fishery. Observed mortalities from herring weirs are collected by a cooperative program between fishermen and Canadian biologists (Coop. Data).

b. Observer coverage for the U.S. Northeast and mid-Atlantic coastal gillnet fisheries is based on tons of fish landed. Northeast bottom trawl fishery coverages are ratios based on trips. Total observer coverage reported for bottom trawl gear and gillnet gear in the year 2010 includes only samples collected from traditional fisheries observer, but not the fishery monitors. Monitor trips were incorporated starting in 2011, the first full year of monitor coverage.

c. Since 2002 in the Northeast gillnet fishery, harbor porpoises were taken on pingered strings within strata that required pingers but that stratum also had observed strings without pingers. For estimates made during 1998 and after, a weighted bycatch rate was applied to effort from both pingered and non-pingered hauls within a stratum. The weighted bycatch rate was:

$$\sum_{i}^{ping,non-ping} \frac{\#\,porpoise_i}{sslandings_i} \cdot \frac{\#\,hauls_i}{total\#\,hauls}$$

There were 10, 33, 44, 0, 11, 0, 2, 8, 6, 2, 26, 2, 4, 12, 2, 9, 6, 11, 23, 11, 30, 20, and 27 observed harbor porpoise takes on pinger trips from 1992 to 2014, respectively, that were included in the observed mortality column.

d. There were 255 licenses for herring weirs in the Canadian Bay of Fundy region.

e. Data provided by H. Koopman pers. comm.

f. The Canadian gillnet fishery was not observed during 2002 and afterwards, but the fishery is still active; thus, the current bycatch estimate for this fishery is assumed to be the average estimate using last five years that the fishery was observed in (1997—2001).

g. Fishery related bycatch rates for years 2010–2014 were estimated using an annual stratified ratio-estimator.

h. One harbor porpoise in the Northeast area and 10 in the mid-Atlantic area were incidentally caught in 2010 as part of a 2009-2010 NEFSC gillnet hanging ratio study to examine the impact of hanging ratio on harbor porpoise bycatch in gillnets. These animals were included in the observed interactions and added to the total estimates, though these interactions and their associated fishing effort were not included in the estimation of the bycatch rate that was expanded to the rest of the fishery.

i. Serious injuries were evaluated for the 2010–2014 period using new guidelines and include both at-sea monitor and traditional observer data (Waring *et al.* 2014, 2015, Wenzel *et al*. 2015, 2016)

Other Mortality

U.S.

There is evidence that harbor porpoises were harvested by natives in Maine and Canada before the 1960s, and the meat was used for human consumption, oil, and fish bait (NMFS 1992). The extent of these past harvests is unknown, though it is believed to have been small. Up until the early 1980s, small kills by native hunters (Passamaquoddy Indians) were reported. In recent years it was believed to have nearly stopped (Polacheck 1989) until media reports in September 1997 depicted a Passamaquoddy tribe member dressing out a harbor porpoise. Further articles describing use of porpoise products for food and other purposes were timed to coincide with ongoing legal action in state court.

During 2010, 82 harbor porpoises were reported stranded on Atlantic U.S. beaches. Of these, six stranding mortalities were reported as having signs of human interaction, three of which were reported to be fishery interactions.

During 2011, 164 harbor porpoises were reported stranded on Atlantic U.S. beaches. Of these, nine stranding mortalities were reported as having signs of human interaction, three of which were reported to be fishery interactions.

During 2012, 45 harbor porpoises were reported stranded on Atlantic U.S. beaches. Of these, four stranding mortalities were reported as having signs of human interaction, one of which was reported to be a fishery interaction.

During 2013, 102 harbor porpoises were reported stranded on Atlantic U.S. beaches. Of these, nine stranding mortalities were reported as having signs of human interaction, three of which were reported to be fishery interactions.

During 2014, 39 harbor porpoises were reported stranded on Atlantic U.S. beaches. Of these, one stranding mortality was reported as having signs of human interactions, which was also reported to have been a fishery interaction.

Stranding data probably underestimate the extent of fishery-related mortality and serious injury because all of the marine mammals that die or are seriously injured may not wash ashore, nor will all of those that do wash ashore necessarily show signs of entanglement or other fishery-interaction. Finally, the level of technical expertise among stranding network personnel varies widely as does the ability to recognize signs of fishery interaction.

Table 4. Harbor Porpoise (*Phocoena phocoena phocoena*) reported strandings along the U.S. and Canadian Atlantic coast, 2010-2014.

Area	Year					**Total**
	2010	2011	2012	2013	2014	
Maine[a,e,h]	7	15	7	7	5	**41**
New Hampshire	5	1	3	1	0	**10**
Massachusetts[a, e,f, g, h]	28	102	25	40	16	**211**
Rhode Island[b,f]	0	4	0	3	0	**7**
Connecticut[h]	0	0	0	1	0	**1**
New York[c,f, h]	1	11	3	15	0	**30**
New Jersey[e, h]	7	1	2	8	4	**22**
Pennsylvania	0	0	0	0	0	**0**
Delaware	2	0	0	2	0	**4**
Maryland	4	0	1	3	0	**8**
Virginia[d],[e,f]	10	2	2	15	3	**32**
North Carolina[e]	18	28	2	7	11	**66**
TOTAL U.S.	**82**	**164**	**45**	**102**	**39**	**432**
Nova Scotia/Prince Edward Island[i]	5	13	6	21	9	**54**
Newfoundland and New Brunswick[j]	1	0	0	3	0	**4**
GRAND TOTAL	**88**	**177**	**51**	**126**	**48**	**490**

a. In Massachusetts in 2011, 5 animals were released alive and one taken to rehab. One Maine animal was taken to rehab in 2012. Three Massachusetts live strandings were taken to rehab in 2013 and 1 Maine animal was released alive.

b. In Rhode Island in 2011, one animal classified as human interaction due to fluke amputation.

c. One of the 2012 New York strandings classified as human interaction due to interaction with marine debris.

d. In 2014, one harbor porpoise in Virginia was classified as a fishery interaction.

e. Six total HI cases in 2010; 2 in Massachusetts, 1 in Maine, 1 in North Carolina and 2 in New Jersey. One of the New Jersey records, one of the North Carolina records, and the Maine record were fishery interactions.

f. Nine total HI cases in 2011; 5 in Massachusetts, 1 in Rhode Island, 2 in New York and 1 in Virginia. Two of these Massachusetts animals and the Virginia animal were fishery interactions.

g. Four HI cases in 2012. One of these was a fishery interaction (Massachusetts).
h. Ten total HI cases in 2013 (MA-3, ME-2, NY-3, NJ-1, CT-1), including one released alive (ME). Three of these were considered fishery interactions, including one entangled in gear in Maine.
i. Data supplied by Nova Scotia Marine Animal Response Society (pers. comm.). One of the 2012 animals trapped in mackerel net. Not included in count for 2014 are at least 8 animals released alive from weirs.
j. (Ledwell and Huntington 2010, 2011, 2012a, 2012b, 2013, 2014).

CANADA

Whales and dolphins stranded on the coast of Nova Scotia are recorded by the Marine Animal Response Society and the Nova Scotia Stranding Network, including 5 (1 released alive) in 2010, 13 (4 released alive) in 2011, 6 in 2012, 21 in 2013 and 9 in 2014; Table 3).

One dead stranded harbor porpoise was reported in 2010 by the Newfoundland and Labrador Whale Release and Strandings Program, 0 in 2011 and 2012, 3 in 2013, and 0 in 2014 (Ledwell and Huntington 2010, 2011, 2012a, 2012b, 2013; 2014; Table 3).

STATUS OF STOCK

Harbor porpoise in the Gulf of Maine/Bay of Fundy are not listed as threatened or endangered under the Endangered Species Act, and this stock is not considered strategic under the MMPA. The total U.S. fishery-related mortality and serious injury for this stock is not less than 10% of the calculated PBR and, therefore, cannot be considered to be insignificant and approaching zero mortality and serious injury rate. The status of harbor porpoises, relative to OSP, in the U.S. Atlantic EEZ is unknown. Population trends for this species have not been investigated.

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HARBOR SEAL (*Phoca vitulina vitulina*): Western North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The harbor seal (*Phoca vitulina*) is found in all nearshore waters of the North Atlantic and North Pacific Oceans and adjoining seas above about 30ºN (Burns 2009; Desportes *et al.* 2010). In the western North Atlantic, they are distributed from the eastern Canadian Arctic and Greenland south to southern New England and New York, and occasionally to the Carolinas (Mansfield 1967; Boulva and McLaren 1979; Katona *et al.* 1993;; Baird 2001;Desportes *et al*. 2010). Although the stock structure of the western North Atlantic subspecies (*P. v.* concolor) is unknown, it is thought that harbor seals found along the eastern U.S. and Canadian coasts represent one population (Temte *et al.* 1991; Andersen and Olsen 2010). In U.S. waters, breeding and pupping normally occur in waters north of the New Hampshire/Maine border, although breeding occurred as far south as Cape Cod in the early part of the twentieth century (Temte *et al.* 1991; Katona *et al.* 1993).

Harbor seals are year-round inhabitants of the coastal waters of eastern Canada and Maine (Katona *et al*. 1993), and occur seasonally along the southern New England to New Jersey coasts from September through late May (Schneider and Payne 1983; Schroeder 2000;). Scattered sightings and strandings have been recorded as far south as Florida (NOAA National Marine Mammal Health and Stranding Response Database, accessed 08 October 2015). A general southward movement from the Bay of Fundy to southern New England waters occurs in autumn and early winter (Rosenfeld *et al.* 1988; Whitman and Payne 1990; Jacobs and Terhune 2000). A northward movement from southern New England to Maine and eastern Canada occurs prior to the pupping season, which takes place from mid-May through June along the Maine Coast (Richardson 1976; Wilson 1978; Whitman and Payne 1990; Waring *et al*. 2006). Earlier research identified no pupping areas in southern New England (Payne and Schneider 1984); however, more recent anecdotal reports suggest that some pupping is occurring at high-use haulout sites off Manomet, Massachusetts and the Isles of Shoals, Maine.

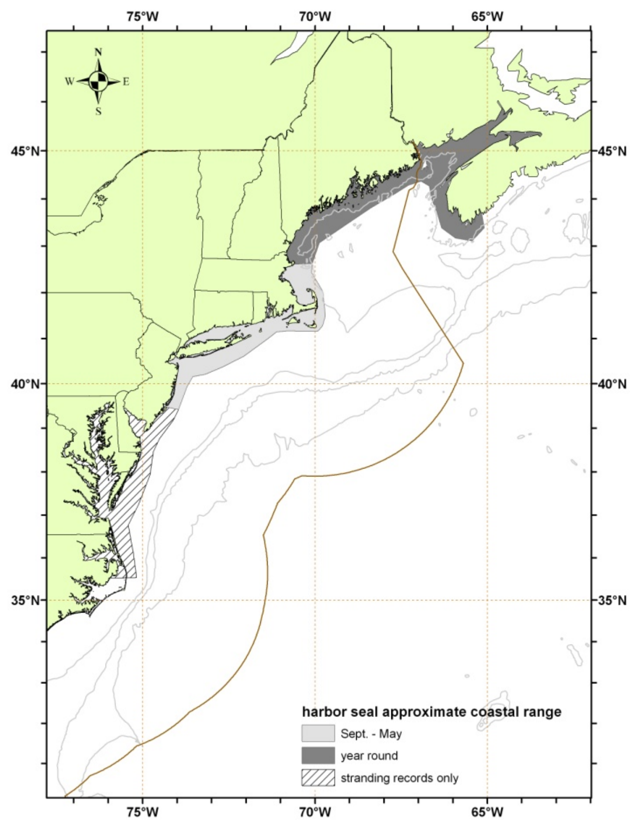

Figure 1. *Approximate coastal range of harbor seals, and distribution of harbor seal sightings at sea from NEFSC and SEFSC shipboard and aerial surveys during the summers of 1995, 1998, 1999, 2002, 2004, 2006, 2007, 2008, 2010, and 2011. Isobaths are the 100-m, 1000-m, and 4000-m depth contours.*

Prior to the spring 2001 live-capture and radio-tagging of adult harbor seals (Waring *et al.* 2006), it was believed that the majority of seals moving into southern New England and mid-Atlantic waters were subadults and juveniles (Whitman and Payne 1990; Katona *et al.* 1993). The 2001 study established that adult animals also made this migration. Seventy-five percent (9/12) of the seals tagged in March in Chatham Harbor were detected at least once during the May/June 2001 abundance survey along the Maine coast (Gilbert *et al.* 2005; Waring *et al.* 2006). Similar findings were made in spring 2011 and 2012 work (Waring *et al.* 2015a).

POPULATION SIZE

The best current abundance estimate of harbor seals is 75,834 (CV=0.15) which is from a 2012 survey (Waring *et. al.* 2015).

Earlier abundance estimates

Please see Appendix IV for earlier abundance estimates. As recommended in the GAMMS Workshop Report (Wade and Angliss 1997), estimates older than eight years are deemed unreliable for determination of the current PBR.

Recent surveys and abundance estimates

The 2001 survey (Gilbert *et al*. 2005), conducted in May/June, included replicate surveys and radio-tagged seals to obtain a correction factor for animals not hauled out. The 2012 survey was designed (Waring *et al*. 2015a) to sample bay units using a single aircraft, and it also included a radio-tracking aircraft and obtained a correction factor. The corrected estimates (pups in parenthesis) for 2001 and 2012, respectively, were 99,340 (23,722) and 75,834 (23,830) (Table 1). The 2001 observed count of 38,014 was 28.7% greater than the 1997 count, whereas the 2012 corrected estimate was 24% lower than the 2001 estimate. In addition, the CV of the 2012 estimate is 0.153 compared to 0.091in 2001.

Although the 2012 population estimate was lower than the 2001 estimate, Waring *et al.* (2015a) did not consider the population to be declining because the two estimates are not significantly different and because the actual estimate was lower is because some fraction of the population was not in the survey area. Evidence for this is that the 31.4% of the count were pups, a percentage that is biologically unlikely. The estimated number of harbor seal pups did not differ significantly between 2001 and 2012. In 2001, there were an estimated 23,722 (CV=0.096) pups in the study area (Gilbert *et al.* 2005); in 2012 there were an estimated 23,830 (CV=0.159) pups in the study area. Therefore it is likely that there were some non-pups in the population that were not available to be counted because it was not in the study area of Coastal Maine. Some number of seals could have remained farther south in New England, more northerly in Canada, or offshore. Currently there is some uncertainty in the patterns of harbor seal abundance and distribution in the northeastern U.S. Johnston *et al.* (2015) document a decline in stranding and bycatch rates of harbor seals, providing support for an apparent decline in abundance. However, much of the data examined centered in southern New England and did not cover the center of the population in Maine. There has been very little systematic research conducted on fine-scale changes in habitat use, particularly in relation to the sympatric population of gray seals, although Russell *et al.* (2015) found little impact of the presence of gray seals on harbor seal time budgets.

Table 1. Summary of recent abundance estimates for the western North Atlantic harbor seal (*Phoca vitulina concolor*) by month, year, and area covered during each abundance survey, and resulting abundance estimate (N_{best}) and coefficient of variation (CV).

Month/Year	Area	N_{best}	CV
May/June 2012	Maine coast	75,834	0.15

Minimum Population Estimate

The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally distributed best abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by Wade and Angliss (1997). The best estimate of abundance for harbor seals is 75,834 (CV=0.15). The minimum population estimate is 66,884 based on corrected available counts along the Maine coast in 2012.

Current Population Trend

A trend analysis has not been conducted for this stock. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval. For example, the power to detect a precipitous decline in abundance (i.e., 50% decrease in 15 years) with estimates of low precision (e.g., CV > 0.30) remains below 80% (alpha = 0.30) unless surveys are conducted on an annual basis (Taylor *et al.* 2007).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. For purposes of this assessment, the maximum net productivity rate was assumed to be 0.12. This value is based on theoretical modeling showing that pinniped populations may not grow at rates much greater than 12% given the constraints of their reproductive life history (Barlow *et al.* 1995).

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of minimum population size, one-half the maximum productivity rate, and a recovery factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size is 66,884 animals. The maximum productivity rate is 0.12, the default value for pinnipeds. The recovery factor (F_R) is 0.5, the default value for stocks of unknown status relative to optimum sustainable population (OSP), and the CV of the average mortality estimate is less than 0.3 (Wade and Angliss 1997). PBR for the western North Atlantic stock of harbor seals is 2,006.

ANNUAL HUMAN-CAUSED SERIOUS INJURY AND MORTALITY

For the period 2010-2014 the total human caused mortality and serious injury to harbor seals is estimated to be 389 per year. The average was derived from three components: 1) 377 (CV=0.13; Table 2) from 2010-2014 observed fisheries; 2) 12 from average 2010-2014 non-fishery-related, human interaction stranding and direct interaction mortalities (NOAA National Marine Mammal Health and Stranding Response Database, accessed 08 October 2015); and 3) 0.2 from U.S. research mortalities. Analysis of bycatch rates from fisheries observer program records likely underestimates lethal (Lyle and Willcox 2008), and greatly under-represents sub-lethal, fishery interactions.

Fishery Information

Detailed fishery information is given in Appendix III.

U.S.

Northeast Sink Gillnet:

Harbor seal bycatch is observed year round where they are most frequently observed in the summer in groundfish trips occurring between Boston, MA and Maine in the coastal Gulf of Maine waters. Williams (1999) aged 261 harbor seals caught in this fishery from 1991 to 1997, and 93% were juveniles (i.e., less than four years old). Since 1997, unidentified seals have not been prorated to a species. This is consistent with the treatment of other unidentified mammals that do not get prorated to a specific species. Revised serious injury guidelines were applied for this period (Waring *et al.* 2014, 2015; Wenzel *et al.* 2015, 2016). See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information. Analysis methodology and results can be found in Hatch and Orphanides (2014, 2015, 2016).

Mid-Atlantic Gillnet

Harbor seal bycatch has been observed in this fishery in waters off Massachusetts and New Jersey and rarely further south. A study on the effects of two different hanging ratios in the bottom-set monkfish gillnet fishery on the bycatch of cetaceans and pinnipeds was conducted by NEFSC in 2009 and 2010 with 100% observer coverage. Commercial fishing vessels from Massachusetts and New Jersey were used for the study, which took place south of the Harbor Porpoise Take Reduction Team Cape Cod South Management Area (south of 40° 40´) in February, March and April. Eight research strings of fourteen nets each were fished, and 159 hauls were completed during the course of the study. Results showed that while a 0.33 mesh performed better at catching commercially important finfish than a 0.50 mesh. There was no statistical difference in cetacean or pinniped bycatch rates between the two hanging ratios. Four harbor seals (3 in mid-Atlantic gillnet and 1 in NE gillnet) were caught in this project during 2010 (AIS 2010).

See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information. Analysis methodology and results can be found in Hatch and Orphanides (2014, 2015, 2016).

Northeast Bottom Trawl

Harbor seals are occasionally observed taken in this fishery. See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Mid-Atlantic Bottom Trawl

Harbor seals are rarely observed taken in this fishery. Annual harbor seal mortalities were estimated using annual stratified ratio-estimator methods (Lyssikatos 2015). See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Northeast Mid-water Trawl Fishery (Including Pair Trawl)

Harbor seals are occasionally observed taken in this fishery. An extended bycatch rate has not been calculated for the current 5-year period. Until this bycatch estimate can be developed, the average annual fishery-related mortality and serious injury for 2010–2014 is calculated as 0.8 animal (4 animals /5 years). See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Mid-Atlantic Mid-water Trawl Fishery (Including Pair Trawl)

A harbor seal mortality was observed in this fishery in 2010. An expanded bycatch estimate has not been generated. Until this bycatch estimate can be developed, the average annual fishery-related mortality and serious injury for 2010–2014 is calculated as 0.2 animals (1 animal/5 years). See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Gulf of Maine Atlantic Herring Purse Seine Fishery

The Gulf of Maine Atlantic Herring Purse Seine Fishery is a Category III fishery. This fishery was not observed until 2003. No mortalities have been observed, but 3 harbor seals were captured and released alive in 2011, 1 in 2012, 1 in 2013 and 0 in 2014. In addition, 8 seals of unknown species were captured and released alive in 2011, and 0 in 2012–2014. One harbor seal and two unknown species in were designated as serious injuries/mortalities in 2011, based on fisheries monitoring logs (Waring *et al.* 2014). An expanded bycatch estimate has not been generated. Until this bycatch estimate can be developed, the average annual fishery-related mortality and serious injury for 2010-2014 is calculated as 0.2 animals (1 animal/5 years). See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

CANADA

Currently, scant data are available on bycatch in Atlantic Canada fisheries due to limited observer programs (Baird 2001). An unknown number of harbor seals have been taken in Newfoundland, Labrador, Gulf of St. Lawrence and Bay of Fundy groundfish gillnets; Atlantic Canada and Greenland salmon gillnets; Atlantic Canada cod traps; and in Bay of Fundy herring weirs (Read 1994; Cairns *et al.* 2000). Furthermore, some of these mortalities (e.g., seals trapped in herring weirs) are the result of direct shooting under nuisance permits.

Table 2. Summary of the incidental mortality of harbor seals (*Phoca vitulina vitulina*) by commercial fishery including the years sampled (Years), the number of vessels active within the fishery (Vessels), the type of data used (Data Type), the annual observer coverage (Observer Coverage), the mortalities recorded by on-board observers (Observed Mortality), the estimated annual mortality (Estimated Mortality), the estimated CV of the annual mortality (Estimated CVs) and the mean annual mortality (CV in parentheses).

Fishery	Years	Data Type [a]	Observer Coverage [b]	Observed Serious Injury[e]	Observed Mortality	Estimated Serious Injury	Estimated Mortality	Estimated Combined Mortality	Estimated CVs	Mean Annual Mortality
Northeast Sink Gillnet[c]	10–14	Obs. Data, Weighout, Logbooks	.17, .19, .15, .11, .18	0, 0, 0, 0, 0	71, 91, 37, 22, 59	0, 0, 0, 0, 0	540, 343, 252, 142, 390	540, 343, 252, 142, 390	.25, .19, .26, .31, .39	334 (0.14)
Mid-Atlantic Gillnet	10–14	Obs. Data, Weighout	.04, .02, .02, .03, .05	0, 0, 0, 0, 0	2, 9, 2, 0, 1	0, 0, 0, 0, 0	89, 21, 0, 0, 19	89, 21, 0, 0, 19	.39, .67, 0, 0, 1.06	26 (0.33)
Northeast Bottom Trawl	10–14	Obs. Data, Weighout	.16, .26, .17, .15, .17	0, 0, 0, 0, 0	0, 3, 1, 1, 2	0, 0, 0, 0, 0	0, 9, 3, 4, 11	0, 9, 3, 4, 11	0, .58, 1, .96, .63	4 (.44)

Mid-Atlantic Bottom Trawl	10–14	Obs. Data Dealer	.06, .08, .05, .06, .08	0, 0, 0, 0, 0	1 ,1, 0, 3, 1	0, 0, 0, 0, 0	11, 0, 23, 11, 10	11, 0, 23, 11, 10	1.1, 0, 1, .96, .95	11 (.62)
Northeast Mid-water Trawl - Including Pair Trawl[d]	10–14	Obs. Data Weighout Trip Logbook	.53, .41, .45, .37, .42	0, 0, 0, 0, 0	2, 0, 1, 0, 1	0, 0, 0, 0, 0	na, 0, na, 0, na	na, 0, na, 0, na	na, 0, na, 0, na	0.8 (na)[d]
Mid-Atlantic Mid-water Trawl - Including Pair Trawl[d]	10–14	Obs. Data Weighout Trip Logbook	.25, .41, .21, .07, .05	0, 0, 0, 0, 0	1, 0, 0, 0, 0	0, 0, 0, 0, 0	na, 0, 0, 0, 0	na, 0, 0, 0, 0	na, 0, 0, 0, 0	0.2 (na)[d]
Herring Purse Seine	10–14	Obs. Data	.12 .33, .17, .17, .08	0, 1, 0, 0, 0	0, 0, 0, 0, 0	0, na, 0, 0, 0	0, 0, 0, 0, 0	0, na, 0, 0, 0	0, na, 0, 0, 0	0.2 (na)
TOTAL										377 (0.13)

[a] Observer data (Obs. Data) are used to measure bycatch rates, and the data are collected within the Northeast Fisheries Observer Program. NEFSC collects landings data (Weighout), and total landings are used as a measure of total effort for the sink gillnet fishery. Mandatory logbook (Logbook) data are used to determine the spatial distribution of fishing effort in the northeast sink gillnet fishery.

[b] The observer coverages for the northeast sink gillnet fishery and the mid-Atlantic gillnet fisheries are ratios based on tons of fish landed and coverages for the bottom and mid-water trawl fisheries are ratios based on trips. Total observer coverage reported for bottom trawl gear and gillnet gear in the years 2010-2014 includes samples collected from traditional fisheries observers in addition to fishery monitors through the Northeast Fisheries Observer Program (NEFOP).

[c] Since 1998, takes from pingered and non-pingered nets within a marine mammal time/area closure that required pingers, and takes from pingered and non-pingered nets not within a marine mammal time/area closure were pooled. The pooled bycatch rate was weighted by the total number of samples taken from the stratum and used to estimate the mortality. In 2010 - 2014, respectively, 23, 32, 12, 11, and 33 takes were observed in nets with pingers. In 2010 – 2014, respectively, 48, 59, 25, 11, and 26 takes were observed in nets without known pingers.

[d.] Analyses of bycatch mortality attributed to the mid-water trawl fisheries for 2010 – 2014 have not been generated.

[e.] Serious injuries were evaluated for the 2010–2014 period using new guidelines and include both at-sea monitor and traditional observer data (Waring *et al.* 2014, 2015; Wenzel *et al.* 2015, 2016.)

Other Mortality

U.S.

Historically, harbor seals were bounty-hunted in New England waters, which may have caused a severe decline of this stock in U.S. waters (Katona *et al*. 1993; Lelli *et al*. 2009). Bounty-hunting ended in the mid-1960s.

Other sources of harbor seal mortality include human interactions, storms, abandonment by the mother, disease (Anthony *et al.* 2012), and predation (Katona *et al.* 1993; NOAA National Marine Mammal Health and Stranding Response Database, accessed 08 October 2015; Jacobs and Terhune 2000). Mortalities caused by human interactions include research mortalities, boat strikes, fishing gear interactions, oil spill/exposure, harassment, and shooting.

Harbor seals strand each year throughout their migratory range. Stranding data provide insight into some of these sources of mortality. From 2010 to 2014, 1,368 harbor seal stranding mortalities were reported between Maine and Florida (Table 3; NOAA National Marine Mammal Health and Stranding Response Database, accessed 08 October 2015). Seventy-five (5.4%) of the dead harbor seals stranded during this five-year period showed signs of human interaction (20 in 2010, 20 in 2011, 9 in 2012, 15 in 2013, and 11 in 2014), with 15 (1.0%) having some sign of fishery interaction (6 in 2010, 2 in 2011, 2 in 2012, 3 in 2013, and 2 in 2014). Five harbor seals during this period were reported as having been shot.

An Unusual Mortality Event (UME) was declared for harbor seals in northern Gulf of Maine waters in 2003 and continued into 2004. No consistent cause of death could be determined. The UME was declared over in spring 2005 (MMC 2006). NMFS declared another UME in the Gulf of Maine in autumn 2006 based on infectious disease. A UME was declared in November of 2011 that involved 567 harbor seal stranding mortalities between June 2011 and October 2012 in Maine, New Hampshire, and Massachusetts. The UME was declared closed in February 2013.

Stobo and Lucas (2000) have documented shark predation as an important source of natural mortality at Sable Island, Nova Scotia. They suggest that shark-inflicted mortality in pups, as a proportion of total production, was less than 10% in 1980-1993, approximately 25% in 1994–1995, and increased to 45% in 1996. Also, shark predation on adults was selective towards mature females. The decline in the Sable Island population appears to result from a combination of shark-inflicted mortality on both pups and adult females and inter-specific competition with the much more abundant gray seal for food resources (Stobo and Lucas 2000; Bowen *et al.* 2003).

CANADA

Aquaculture operations in eastern Canada are licensed to shoot nuisance seals, but the number of seals killed is unknown (Jacobs and Terhune 2000; Baird 2001). Small numbers of harbor seals are taken in subsistence hunting in northern Canada (DFO 2011).

Table 3. Harbor seal (*Phoca vitulina vitulina*) stranding mortalities along the U.S. Atlantic coast (2010-2014) with subtotals of animals recorded as pups in parentheses[a].

State	2010	2011	2012	2013	2014	Total
Maine[a]	70 (64)	147 (115)	131 (101)	99 (74)	127 (94)	574
New Hamphire[a]	20 (15)	77 (63)	24 (18)	16 (6)	35 (22)	172
Massachusetts[a]	82 (26)	133 (80)	54 (35)	95 (39)	58 (15)	422
Rhode Island	4 (0)	7 (0)	14 (0)	9 (3)	7 (1)	41
Connecticut	0	1 (1)	1 (1)	2 (1)	0	4
New York	15 (0)	17 (0)	14 (1)	11 (2)	13 (4)	70
New Jersey	21 (0)	10 (0)	7 (0)	4 (0)	2 (1)	44
Delaware	0	0	0	0	2 (0)	2
Maryland	0	1 (0)	0	1 (0)	2 (0)	4
Virginia	1 (0)	4 (0)	0	5 (0)	2 (0)	12
North Carolina	11 (1)	2 (0)	2 (0)	3 (0)	3 (1)	21
South Carolina	1	0	0	0	1 (0)	2
Total	**225**	**399**	**247**	**245**	**252**	**1368**
Unspecified seals (all states)	22	63	28	25	38	176

a. Unusual Mortality event (UME) declared for harbor seals in southern Maine to northern Massachusetts in 2011.

STATUS OF STOCK

Harbor seals are not listed as threatened or endangered under the Endangered Species Act, and the western North Atlantic stock is not considered strategic under the Marine Mammal Protection Act. The 2010–2014 average annual human-caused mortality and serious injury does not exceed PBR. The status of the western North Atlantic harbor seal stock, relative to OSP, in the U.S. Atlantic EEZ is unknown. Total fishery-related mortality and serious injury for this stock is not less than 10% of the calculated PBR and, therefore, cannot be considered to be insignificant and approaching zero mortality and serious injury rate.

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GRAY SEAL (*Halichoerus grypus atlantica*): Western North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The gray seal (*Halichoerus grypus atlantica*) is found on both sides of the North Atlantic, with three major populations: eastern Canada, northwestern Europe and the Baltic Sea (Katona *et al.* 1993). The western North Atlantic stock is equivalent to the eastern Canada population, and ranges from New Jersey to Labrador (Davies 1957; Mansfield 1966; Katona *et al.* 1993; Lesage and Hammill 2001). This stock is separated by geography, differences in the breeding season, and mitochondrial and nuclear DNA variation from the northeastern Atlantic stocks (Bonner 1981; Boskovic *et al.* 1996; Lesage and Hammill 2001; Klimova *et al.* 2014). There are three breeding aggregations in eastern Canada: Sable Island, Gulf of St. Lawrence, and along the coast of Nova Scotia (Laviguer and Hammill 1993). Outside the breeding period, there is overlap in the distribution of animals from the three colonies (Lavigueur and Hammill 1993; Harvey *et al.* 2008; Breed *et al.* 2006, 2009) and they are considered a single population based on genetic similarity (Boskovic *et al.* 1996; Wood *et al.* 2011). In the mid-1980s, small numbers of animals and pupping were observed on several isolated islands along the Maine coast and in Nantucket-Vineyard Sound, Massachusetts (Katona *et al.* 1993; Rough 1995: Gilbert *et al.* 2005). In December 2001, NMFS initiated aerial surveys to monitor gray seal pup production on Muskeget Island and adjacent sites in Nantucket Sound, and Green and Seal Islands off the coast of Maine (Wood *et al.* 2007). Tissue samples collected from Canadian and US populations were examined for genetic variation using microsatellite loci (Wood et al. 2011). All individuals were identified as belonging to one population, confirming that recolonization by Canadian gray seals is the source of the U.S. population.

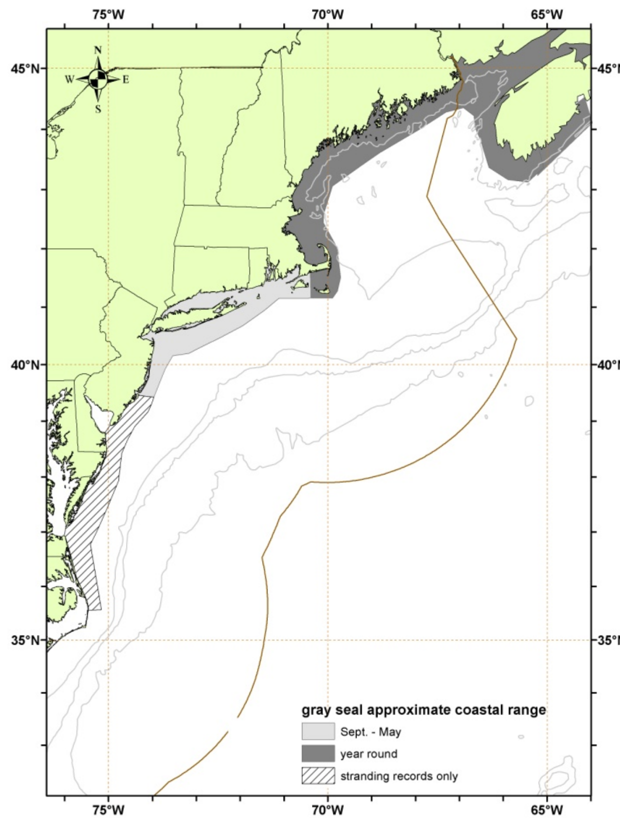

Figure 1. Approximate coastal range of gray seals. Isobaths are the 100-m, 1000-m, and 4000-m depth contours.

POPULATION SIZE

Current estimates of the total western Atlantic gray seal population are not available; although estimates of portions of the stock are available for select time periods. The Canadian gray seal stock assessment (DFO 2014) reports gray seal pup production in 2014 for the three Canadian aggregations (Gulf of St. Lawrence, Sable Island, and Nova Scotia) as 93,000 (95%CI=48,000-137,000) animals; these are projected using population models to total population levels of 505,000 (95%CI=329,000-682,000) animals.

In U.S. waters, gray seals primarily pup at four established colonies: Muskeget and Monomoy islands in Massachusetts, and Green and Seal islands in Maine. Since 2010 pupping has also been observed at Noman's Island in Massachusetts and Wooden Ball and Matinicus Rock in Maine. Although white-coated pups have stranded on eastern Long Island beaches, no pupping colonies have been detected in that region. Gray seals have been observed using the historic pupping site on Muskeget Island in Massachusetts since 1988. Pupping has taken place on Seal and Green Islands in Maine since at least the mid-1990s. Aerial survey data from these sites indicate that pup production is increasing (Table 2), although aerial survey quality and coverage has varied significantly among surveys. A minimum of 2,620 pups (Muskeget= 2,095, Green= 59, Seal= 466) were born in the U.S. in 2008 (Wood LaFond 2009). Table 2 summarizes single-day pup counts from three of the U.S. pupping colonies from 2001/2002 to 2007/2008 pupping periods.

There are several published counts of gray seals in the Northeast U.S. outside of the pupping season. In April–May 1994 a maximum count of 2,010 was obtained for Muskeget Island and Monomoy Island combined (Rough 1995). Maine coast-wide surveys conducted during summer estimated 597 and 1,731 gray seals in 1993 and 2001, respectively (Gilbert *et al.* 2005). In March 1999 a maximum count of 5,611 was obtained in the region south of Maine (between Isles of Shoals, Maine and Woods Hole, Massachusetts) (Barlas 1999).

Table 1. Summary of recent abundance estimates for the western North Atlantic gray seal (*Halichoerus grypus atlantica*) by year, and area covered during each abundance survey, resulting total abundance estimate and 95% confidence interval.

Month/Year	**Area**	**N_{best} [a]**	**CI**
2012[b]	Gulf of St Lawrence + Nova Scotia Eastern Shore + Sable Island	331,000	95% CI 263,000-458,000
2014[c]	Gulf of St Lawrence + Nova Scotia Eastern Shore + Sable Island	505,000	95%CI=329,000-682,000

[a]These are model based estimates derived from pup surveys.
[b] DFO 2013
[c] DFO 2014

Table 2. Single day pup counts from three of the U.S. pupping colonies during 2001-2008 from aerial surveys. As single day pup counts, these counts do not represent the entire number of pups born in a pupping season.

Pupping Season	Muskeget Island	Seal Island	Green Island
2001-2	883	No data	34
2002-3	509	147	No data
2003-4	824	150	26
2004-5	992	365	33
2005-6	868	239	43
2006-7	1704	364	57
2007-8	2095	466	59

Minimum Population Estimate

Based on modeling, the total Canadian gray seal population was estimated to be 505,000 (95% CI = 329,000-682,000; DFO 2014). Present data are insufficient to calculate the minimum population estimate for U.S. waters.

Current Population Trend

Gray seal abundance is likely increasing in the U.S. Atlantic Exclusive Economic Zone (EEZ), but the rate of increase is unknown. An increasing trend in abundance in U.S. waters is supported by analysis of trends in gray seal strandings and bycatch records from the Northeastern U.S. (Johnston *et al.* 2015).

The population in eastern Canada was greatly reduced by hunting and bounty programs, and in the 1950s the gray seal was considered rare (Lesage and Hammill 2001). The Sable Island, Nova Scotia, population was less affected and has been increasing for several decades. Pup production on Sable Island increased exponentially at a rate of 12.8% per year between the 1970s and 1997 (Stobo and Zwanenburg 1990; Mohn and Bowen 1996; Bowen *et al.* 2003; Trzcinski *et al.* 2005; Bowen *et al.* 2007; DFO 2011). Recent population modeling indicates that the combined population increased at an annual rate of 5.2% between 2007 and 2010, and since then has continued to grow at a rate of 4.5% per year (DFO 2011, 2014). The non-Sable Island population increased from approximately 25,000 in the mid-1980s to a peak of 112,000 in 2014 (Thomas *et al.* 2011; DFO 2014). Modeling estimates of pup production increased from approximately 6,000 in 1985 to 21,500 in 2014 (Thomas *et al.* 2011; DFO 2014). Approximately 75% of the western North Atlantic population is from the Sable Island stock. In the early 1990s pupping was established on Hay Island, off the Cape Breton coast (Lesage and Hammill 2001; Hammill *et al*. 2007, Hamill and Stenson 2010).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. Recent studies estimated the current annual rate of increase at 4.5% for the combined breeding aggregations in Canada (DFO 2014), continuing a decline in the rate of increase (Trzcinski *et al*. 2005; Bowen *et al*. 2007; Thomas *et al*. 2011; DFO 2014). For purposes of this assessment, the maximum net productivity rate was assumed to be 0.12. This value is based on theoretical modeling showing that pinniped populations may not grow at rates much greater than 12% given the constraints of their reproductive life history (Barlow *et al.* 1995).

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of minimum population size, one-half the maximum productivity rate, and a recovery factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size is unknown. The maximum productivity rate is 0.12, the default value for pinnipeds. The recovery factor (F_R) for this stock is 1.0, the value for stocks of unknown status, but which are known to be increasing. PBR for the portion of the western North Atlantic gray seal stock in U.S. waters is unknown.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

For the period 2010–2014, the average annual estimated human caused mortality and serious injury to gray seals was 4,937 per year. The average was derived from six components: 1) 1,162 (CV=0.10) (Table 3) from the 2010–2014 U.S. observed fishery; 2) 7.8 from average 2010–2014 non-fishery related, human interaction stranding mortalities; 136 from average 2010–2014 kill in the Canadian hunt*;* 4) 82 from DFO scientific collections (DFO 2011); 5) 3,549 removals of nuisance animals in Canada (DFO 2014); and 6) 0.4 from U.S. research mortalities. . Analysis of bycatch rates from fisheries observer program records likely underestimates lethal (Lyle and Willcox 2008), and greatly under-represents sub-lethal, fishery interactions.

Fishery Information

Detailed fishery information is given in Appendix III.

U.S.

Northeast Sink Gillnet

Gray seal bycatch in the northeast sink gillnet fishery were usually observed in the first half of the year in waters to the east and south of Cape Cod, Massachusetts in 12-inch gillnets fishing for skates and monkfish (Orphanides 2013; Hatch and Orphanides 2014, 2015, 2016). There were 7, 9, 1, 8, and 8 unidentified seals observed during 2010–2014, respectively. Since 1997 unidentified seals have not been prorated to a species. This is consistent with the treatment of other unidentified mammals that do not get prorated to a specific species. See Table 3 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Mid-Atlantic Gillnet

Gray seal interactions were first observed in this fishery in 2010, since then, when they are observed, it is usually in waters off New Jersey in gillnets that have mesh sizes ≥ 7 in (Orphanides 2013; Hatch and Orphanides 2014, 2015, 2016). See Table 3 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Northeast Mid-Water Trawl

One gray seal mortality was observed in 2012 and one in 2013 in this fishery. An expanded bycatch estimate has not been generated. Until this bycatch estimate can be developed, the average annual fishery-related mortality and serious injury for 2010–2014 is calculated as 0.4 animals (2 animals /5 years). See Table 3 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Mid-Atlantic Mid-Water Trawl

One gray seal mortality was observed in 2010 in this fishery. An expanded bycatch estimate has not been generated. Until this bycatch estimate can be developed, the average annual fishery-related mortality and serious injury for 2010–2014 is calculated as 0.2 animals (1 animal /5 years). See Table 3 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Gulf of Maine Atlantic Herring Purse Seine Fishery

The Gulf of Maine Atlantic Herring Purse Seine Fishery is a Category III fishery. This fishery was not observed until 2003, and was not observed in 2006. No mortalities have been observed, but during this time period 4 gray seals were captured and released alive in 2010, 34 in 2011, 33 in 2012, 1 in 2013, and 2 in 2014. In addition, during this time period 8 seals of unknown species were captured and released alive in 2011. See Table 3 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Northeast Bottom Trawl

Vessels in the North Atlantic bottom trawl fishery, a Category III fishery under MMPA, were observed in order to meet fishery management, rather than marine mammal management needs. No mortalities were observed prior to 2005, when four mortalities were attributed to this fishery. See Table 2 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Mid-Atlantic Bottom Trawl

Three gray seal mortalities were observed in this fishery in 2011, 1 in 2012, 2 in 2013, and 1 in 2014 (Table 2). See Table 3 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

CANADA

Historically, an unknown number of gray seals have been taken in Newfoundland and Labrador, Gulf of St. Lawrence, and Bay of Fundy groundfish gillnets; Atlantic Canada and Greenland salmon gillnets; Atlantic Canada cod traps, and Bay of Fundy herring weirs (Read 1994).

Table 3. Summary of the incidental serious injury and mortality of gray seal (*Halichoerus grypus atlantica*) by commercial fishery including the years sampled, the type of data used, the annual observer coverage, the serious injuries and mortalities recorded by on-board observers, the estimated annual mortality, the estimated CV of the annual mortality and the mean annual combined mortality (CV in parentheses).

Fishery	Years	Data Type [a]	Observer Coverage [b]	Observed Serious Injury[e]	Observed Mortality	Estimated Serious Injury	Estimated Mortality	Estimated Combined Mortality	Estimated CVs	Mean Annual Combined Mortality
Northeast Sink Gillnet[c]	10–14	Obs. Data,Weighout, Trip Logbook	.17, .19, .15, .11, .18	0, 0, 0, 0, 0	107, 222, 91, 69, 159	0, 0, 0, 0, 0	1155, 1491, 542, 1,127, 917	1155, 1491, 542, 1,127, 917	.28, .22, .19, .20, .14	1046 (0.10)
Mid-Atlantic Gillnet	10–14	Obs. Data, Trip Logbook, Allocated Dealer Data	.04, .02, .02, .03, .05	0, 0, 0, 0, 0	9, 2, 1 , 0, 1	0, 0, 0, 0, 0	267, 19, 14, 0, 22	267, 19, 14, 0, 22	.75, .60, .98, 0, 1.09	64 (0.63)
Northeast Bottom Trawl [d]	10–14	Obs. Data,Trip Logbook	.16, .26, 17, .15, .17	0, 0, 0, 0, 0	9, 19, 8, 5, 4	0, 0, 0, 0, 0	30, 58, 37, 20, 19	30, 58, 37, 20, 19	.34, .25, .49, .37, .45	33 (0.17)
Mid-Atlantic Bottom Trawl	10–14	Obs. Data,Trip Logbook	.06, .08, .05, .06, .08	0, 0, 0, 0, 0	0, 3, 1, 2, 1	0, 0, 0, 0, 0	0, 25, 30, 29, 7	0, 25, 30, 29, 7	0, .57, 1.1, .67, .96	18 (0.5)

Northeast Mid-water Trawl - Including Pair Trawl	10–14	Obs. Data, Trip Logbook	.53, .41, .45, .37, .42	0, 0, 0, 0, 0	0, 0, 1, 1, 0	0, 0, 0, 0, 0	0, 0, na, na, 0	0, 0, na, na, 0	0, 0, na, na, 0	0.4 (na) [d]
Mid-Atlantic Mid-water Trawl - Including Pair Trawl	10–14	Obs. Data, Trip Logbook	.25, .41, .21, .07, .05	0, 0, 0, 0, 0	1, 0, 0, 0, 0	0, 0, 0, 0, 0	na, 0, 0, 0, 0	na, 0, 0, 0, 0	na, 0, 0, 0, 0	0.2 (na)
TOTAL										1,162 (0.10)

a. Observer data (Obs. Data) are used to measure bycatch rates, and the data are collected within the Northeast Fisheries Observer Program. The Northeast Fisheries Observer Program collects landings data (Weighout), and total landings are used as a measure of total effort for the sink gillnet fishery. Mandatory logbook (Logbook) data are used to determine the spatial distribution of fishing effort in the Northeast multispecies sink gillnet fishery.

b. The observer coverages for the northeast sink gillnet fishery and the mid-Atlantic gillnet fisheries are ratios based on tons of fish landed. North Atlantic bottom trawl mid-Atlantic bottom trawl, and mid-Atlantic mid-water trawl fishery coverages are ratios based on trips. Total observer coverage reported for bottom trawl gear and gillnet gear in the years 2010–2014 includes traditional fisheries observers in addition to fishery monitors through the Northeast Fisheries Observer Program (NEFOP).

c. Since 1998, takes from pingered and non-pingered nets within a marine mammal time/area closure that required pingers, and takes from pingered and non-pingered nets not within a marine mammal time/area closure were pooled. The pooled bycatch rate was weighted by the total number of samples taken from the stratum and used to estimate the mortality. In 2010– 2014, respectively, 17, 125, 54, 38, and 85 takes were observed in nets with pingers. In 2010 -2014, respectively, 39, 90, 97, 10, 31, and 74 takes were observed in nets without pingers.

d. Fishery related bycatch rates for years 2010–2014 were estimated using an annual stratified ratio-estimator. These estimates replace the 2008-2011 annual estimates reported in the 2013 stock assessment report that were generated using a different method (Lyssikatos *et al.* 2015).

e. Serious injuries were evaluated for the 2010–2014 period using new guidelines (Waring *et al.* 2014, 2015; Wenzel *et al.* 2015, 2016)

Other Mortality

U.S

Gray seals, like harbor seals, were hunted for bounty in New England waters until the late 1960s (Katona *et al.* 1993; Lelli *et al*. 2009). This hunt may have severely depleted this stock in U.S. waters (Rough 1995; Lelli *et al*. 2009). Other sources of mortality include human interactions, storms, abandonment by the mother, disease, and shark predation. Mortalities caused by human interactions include research mortalities, boat strikes, fishing gear interactions, power plant entrainment, oil spill/exposure, harassment, and shooting. Seals entangled in netting have been reported at several major haul-out sites in the Gulf of Maine.

From 2010 to 2014, 521 gray seal stranding mortalities were recorded, extending from Maine to North Carolina (Table 4; NOAA National Marine Mammal Health and Stranding Response Database, accessed 08 October 2015). Most stranding mortalities were in Massachusetts, which is the center of gray seal abundance in U.S. waters. Sixty-one (12%) of the total stranding mortalities showed signs of human interaction (12 in 2010, 20 in 2011, 4 in 2012, and 17 in 2013, and 8 in 2014), 22 of which had some indication of fishery interaction (4 in 2010, 5 in 2011, 2 in 2012, 9 in 2013 and 2 in 2014). Ten gray seals are recorded in the stranding database during the 2010 to 2014 period as having been shot—1 in Maine and 2 in Massachusetts in 2010, 6 in Massachusetts in 2011, and none in 2012 – 2014.

Canada

Between 2010-2014, the average annual human caused mortality and serious injury to gray seals in Canadian waters from commercial harvest was 136 per year (DFO 2014; http://www.dfo-mpo.gc.ca/fm-gp/seal-phoque/statistics-eng.htm accessed 3/25/2016), though more is permitted (up to 60,000 seals/year, see http://www.dfo-mpo.gc.ca/decisions/fm-2015-gp/atl-001-eng.htm). This included: 58 in 2010, 215 in 2011, 218 in 2012, 106 in 2013, and 82 in 2014. In addition, between 2009 and 2013 (the most recent time series for nuisance removals), an average of 3,549 nuisance animals per year were killed. This included 5,218 in 2009, 1,853 in 2010, 1,722 in 2011, 5,428 in 2012, and 3,525 in 2013 (DFO 2014). Lastly, DFO took 320 animals in 2011 and 90 animals in 2012 for scientific collections (DFO 2014).

Table 4. Gray seal (*Halichoerus grypus atlantica*) stranding mortalities along the U.S. Atlantic coast (2010-2014) with subtotals of animals recorded as pups in parentheses.

State	2010	2011	2012	2013	2014	Total
ME	8 (4)	4 (2)	10 (2)	9 (4)	3 (1)	34
NH	0	8 (1)	1 (1)	1 (0)	3 (2)	13
MA	43 (5)	89 (14)	38 (21)	82 (8)	62 (6)	314
RI	8 (3)	14 (2)	13 (5)	11 (2)	8 (1)	54
CT	0	2 (0)	0	0	0	2
NY	10 (7)	22 (6)	5 (3)	18 (5)	7 (4)	62
NJ	4 (1)	10 (0)	4 (0)	7 (2)	7 (6)	32
DE	0	0	0	0	3 (3)	3
MD	1 (0)	4 (2)	0	0	1 (0)	6
VA	1 (0)	1 (0)	0	0	0	2
NC	1 (0)	2 (2)	0	0	2 (2)	5
Total	76 (20)	156 (29)	71 (32)	128 (21)	96 (25)	527
Unspecified seals (all states)	22	63	28	25	38	176

STATUS OF STOCK

Gray seals are not listed as threatened or endangered under the Endangered Species Act, and the western North Atlantic stock is not considered strategic under the Marine Mammal Protection Act. The level of human-caused mortality and serious injury in the U.S. Atlantic EEZ is low relative to the total stock size. The status of the gray seal population relative to OSP in U.S. Atlantic EEZ waters is unknown, but the stock's abundance appears to be increasing in Canadian and U.S. waters. The total U.S. fishery-related mortality and serious injury for this stock is low relative to the stock size in Canadian and U.S. waters and can be considered insignificant and approaching zero mortality and serious injury rate.

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COMMON BOTTLENOSE DOLPHIN (*Tursiops truncatus truncatus*): Northern Gulf of Mexico Bay, Sound, and Estuary Stocks

NOTE – NMFS is in the process of writing individual stock assessment reports for each of the 31 bay, sound and estuary stocks of common bottlenose dolphins that are included in this report. Until this effort is completed and this report is replaced by 31 individual reports, basic information for all individual bay, sound and estuary stocks will remain in this report: "Northern Gulf of Mexico Bay, Sound and Estuary Stocks". To date, four stocks have individual reports completed (Barataria Bay Estuarine System; Mississippi Sound, Lake Borgne, Bay Boudreau; Choctawhatchee Bay; St. Joseph Bay) and the remaining 27 stocks are assessed in this report.

STOCK DEFINITION AND GEOGRAPHIC RANGE

Common bottlenose dolphins are distributed throughout the bays, sound and estuaries of the Gulf of Mexico (Mullin 1988). The identification of biologically-meaningful "stocks" of bottlenose dolphins in these waters is complicated by the high degree of behavioral variability exhibited by this species (Shane *et al.* 1986; Wells and Scott 1999; Wells 2003), and by the lack of requisite information for much of the region.

Distinct stocks are delineated in each of 31 areas of contiguous, enclosed or semi-enclosed bodies of water adjacent to the northern Gulf of Mexico (i.e., U.S. Gulf of Mexico; Table 1; Figure 1). The genesis of the delineation of these stocks was work initiated in the 1970s in Sarasota Bay, Florida (Irvine *et al.* 1981), and in bays in Texas (Shane 1977; Gruber 1981). These studies documented year-round residency of individual bottlenose dolphins in estuarine waters. As a result, the expectation of year-round resident populations was extended to bay, sound and estuary (BSE) waters across the northern Gulf of Mexico when the first stock assessment reports were established in 1995. Since these early studies, long-term (year-round, multi-year) residency has been reported from nearly every site where photographic identification (photo-ID) or tagging studies have been conducted in the Gulf of Mexico. In Texas, long-term resident dolphins have been reported in the Matagorda-Espiritu Santo Bay area (Gruber 1981; Lynn and Würsig 2002), Aransas Pass (Shane 1977; Weller 1998), San Luis Pass (Maze and Würsig 1999; Irwin and Würsig 2004), and Galveston Bay (Bräger 1993; Bräger *et al.* 1994; Fertl 1994). In Louisiana, Miller (2003) concluded the bottlenose dolphin population in the Barataria Basin was relatively closed. Hubard *et al.* (2004) reported sightings of dolphins in Mississippi Sound that were known from tagging efforts there 12–15 years prior. In Florida, long-term residency has been reported from Tampa Bay (Wells 1986; Wells *et al.* 1996b; Urian *et al.* 2009), Sarasota Bay (Irvine and Wells 1972; Irvine *et al.* 1981; Wells 1986; 1991; 2003; 2014; Wells *et al.* 1987; Scott *et al.* 1990; Wells 1991; 2003), Lemon Bay (Wells *et al.* 1996a; Bassos-Hull *et al.* 2013), Charlotte Harbor/Pine Island Sound (Shane 1990; Wells *et al.* 1996a; Wells *et al.* 1997; Shane 2004; Bassos-Hull *et al.* 2013) and Gasparilla Sound (Bassos-Hull *et al.* 2013). In Sarasota Bay, which has the longest research history, at least 5 concurrent generations of identifiable residents have been identified, including some of those first identified in 1970 (Wells 2014). Maximum immigration and emigration rates of about 2–3% have been estimated (Wells and Scott 1990).

Genetic data also support the concept of relatively discrete BSE stocks. Analyses of mitochondrial DNA haplotype distributions indicate the existence of clinal variations along the Gulf of Mexico coastline (Duffield and Wells 2002). Differences in reproductive seasonality from site to site also suggest genetic-based distinctions between communities (Urian *et al.* 1996). Mitochondrial DNA analyses suggest finer-scale structural levels as well. For example, dolphins in Matagorda Bay, Texas, appear to be a localized population, and differences in haplotype frequencies distinguish among adjacent communities in Tampa Bay, Sarasota Bay and Charlotte Harbor/Pine Island Sound, along the central west coast of Florida (Duffield and Wells 1991; 2002). Additionally, Sellas *et al.* (2005) examined population subdivision among dolphins sampled in Sarasota Bay, Tampa Bay, Charlotte Harbor, Matagorda Bay, and the coastal Gulf of Mexico (1–12 km offshore) from just outside Tampa Bay to the southern end of Lemon Bay, and found evidence of significant population structure among all areas on the basis of both mitochondrial DNA control region sequence data and 9 nuclear microsatellite loci. The Sellas *et al.* (2005) findings support the separate identification of BSE populations from those occurring in adjacent Gulf coastal waters.

In many cases, residents occur primarily in BSE waters, with limited movements through passes to the Gulf of Mexico (Shane 1977; 1990; Gruber 1981; Irvine *et al.* 1981; Maze and Würsig 1999; Lynn and Würsig 2002; Fazioli *et al.* 2006). These habitat use patterns are reflected in the ecology of the dolphins in some areas; for example, residents of Sarasota Bay, Florida, lacked squid in their diet, unlike non-resident dolphins stranded on nearby Gulf beaches (Barros and Wells 1998). However, in some areas year-round residents may co-occur with non-resident dolphins. For example, about 14–17% of group sightings involving resident Sarasota Bay dolphins include at least 1 non-resident as well (Wells *et al.* 1987; Fazioli *et al.* 2006). Mixing of inshore residents and non-residents has been seen at San Luis Pass, Texas (Maze and Würsig 1999), Cedar Keys, Florida (Quintana-Rizzo and Wells 2001), and Pine Island Sound, Florida (Shane 2004). Non-residents exhibit a variety of movement patterns, ranging from apparent nomadism recorded as transience to a given area, to apparent seasonal or non-seasonal migrations. Passes, especially the mouths of the larger estuaries, serve as mixing areas. For example, dolphins from several different areas were documented at the mouth of Tampa Bay, Florida (Wells 1986), and most of the dolphins identified in the mouths of Galveston Bay and Aransas Pass, Texas, were considered transients (Henningsen 1991; Bräger 1993; Weller 1998).

Seasonal movements of dolphins into and out of some of the bays, sounds and estuaries have also been documented. In Sarasota Bay, Florida, and San Luis Pass, Texas, residents have been documented moving into Gulf coastal waters in fall/winter, and returning inshore in spring/summer (Irvine *et al.* 1981; Maze and Würsig 1999). Fall/winter increases in abundance have been noted for Tampa Bay (Scott *et al.* 1989) and are thought to occur in Matagorda Bay (Gruber 1981; Lynn and Würsig 2002) and Aransas Pass (Shane 1977; Weller 1998). Spring/summer increases in abundance occur in Mississippi Sound (Hubard *et al.* 2004) and are thought to occur in Galveston Bay (Henningsen 1991; Bräger 1993; Fertl 1994).

Spring and fall increases in abundance have been reported for St. Joseph Bay, Florida. Mark-recapture abundance estimates were highest in spring and fall and lowest in summer and winter (Table 1; Balmer *et al.* 2008). Individuals with low site-fidelity indices were sighted more often in spring and fall, whereas individuals sighted during summer and winter displayed higher site-fidelity indices. In conjunction with health assessments, 23 dolphins were radio tagged during April 2005 and July 2006. Dolphins tagged in spring 2005 displayed variable utilization areas and variable site fidelity patterns. In contrast, during summer 2006 the majority of radio tagged individuals displayed similar utilization areas and moderate to high site-fidelity patterns. The results of the studies suggest that during summer and winter St. Joseph Bay hosts dolphins that spend most of their time within this region, and these may represent a resident community. In spring and fall, St. Joseph Bay is visited by dolphins that range outside of this area (Balmer *et al.* 2008).

The current BSE stocks are delineated as described in Table 1. There are some estuarine areas that are not currently part of any stock's range. Many of these are areas that dolphins cannot readily access. For example, the marshlands between Galveston Bay and Sabine Lake and between Sabine Lake and Calcasieu Lake are fronted by long, sandy beaches that prohibit dolphins from entering the marshes. The region between the Calcasieu Lake and Vermilion Bay/Atchafalaya Bay stocks has some access, but these marshes are predominantly freshwater rather than saltwater marshes, making them unsuitable for long-term survival of a viable population of bottlenose dolphins. In other regions, there is insufficient estuarine habitat to harbor a demographically independent population, for instance between the Matagorda Bay and West Bay Stocks in Texas, and/or sufficient isolation of the estuarine habitat from coastal waters. The regions between the south end of the Estero Bay Stock area to just south of Naples and between Little Sarasota Bay and Lemon Bay are highly developed and contain little appropriate habitat. South of Naples to San Marco Island and Gullivan Bay is also not currently covered in a stock boundary. This region may reasonably contain bottlenose dolphins, but the relationship of any dolphins in this region to other BSE stocks is unknown. They may be members of the Gullivan to Chokoloskee Bay stock as there is passage behind San Marco Island that would allow dolphins to move north. The regions between Apalachee Bay and Cedar Key/Waccasassa Bay, between Crystal Bay and St. Joseph Sound and between Chokoloskee Bay and Whitewater Bay are comprised of thin strips of marshland with no barriers to adjacent coastal waters. Further work is necessary to determine whether year-round resident dolphins use these thin marshes or whether dolphins in these areas are members of the coastal stock that use the fringing marshland as well. Finally, the region between the eastern border of the Barataria Bay Stock and the Mississippi Delta Stock to the east may harbor dolphins, but the area is small and work is necessary to determine whether any dolphins utilizing this habitat come from an adjacent BSE stock.

As more information becomes available, combination or division of these stocks, or alterations to stock boundaries, may be warranted. Recent research based on photo-ID data collected by Bassos-Hull *et al.* (2013) recommended combining B21, Lemon Bay, with B22–23, Gasparilla Sound, Charlotte Harbor, Pine Island Sound. Therefore, these stocks have been combined (see Table 1). However, it should be noted this change was made in the absence of genetic data and could be revised again in the future when genetic data are available. Additionally, a number of geographically and socially distinct subgroupings of dolphins in regions such as Tampa Bay, Charlotte Harbor, Pine Island Sound, Aransas Pass and Matagorda Bay have been identified, but the importance of these distinctions to stock designations remains undetermined (Shane 1977; Gruber 1981; Wells *et al.* 1996a; 1996b;

1997; Lynn and Würsig 2002; Urian 2002). For Tampa Bay, Urian *et al.* (2009) described 5 discrete communities (including the adjacent Sarasota Bay community) that differed in their social interactions and ranging patterns. Structure was found despite a lack of physiographic barriers to movement within this large, open embayment. Urian *et al.* (2009) further suggested that fine-scale structure may be a common element among bottlenose dolphins in the southeastern U.S. and recommended that management should account for fine-scale structure that exists within current stock designations.

Table 1. Most recent common bottlenose dolphin abundance (N_{BEST}), coefficient of variation (CV) and minimum population estimate (N_{MIN}) in northern Gulf of Mexico bays, sounds and estuaries. Because they are based on data collected more than 8 years ago, most estimates are considered unknown or undetermined for management purposes. Blocks refer to aerial survey blocks illustrated in Figure 1. PBR – Potential Biological Removal; UNK – unknown; UND – undetermined.

Blocks	Gulf of Mexico Estuary	N_{BEST}	CV	N_{MIN}	PBR	Year	Reference
B51	Laguna Madre	80	1.57	UNK	UND	1992	A
B52	Nueces Bay, Corpus Christi Bay	58	0.61	UNK	UND	1992	A
B50	Copano Bay, Aransas Bay, San Antonio Bay, Redfish Bay, Espiritu Santo Bay	55	0.82	UNK	UND	1992	A
B54	Matagorda Bay, Tres Palacios Bay, Lavaca Bay	61	0.45	UNK	UND	1992	A
B55	West Bay	32	0.15	UNK	UND	2001	B
B56	Galveston Bay, East Bay, Trinity Bay	152	0.43	UNK	UND	1992	A
B57	Sabine Lake	0[a]	-		UND	1992	A
B58	Calcasieu Lake	0[a]	-		UND	1992	A
B59	Vermilion Bay, West Cote Blanche Bay, Atchafalaya Bay	0[a]	-		UND	1992	A
B60	Terrebonne Bay, Timbalier Bay	100	0.53	UNK	UND	1993	A
B61	Barataria Bay†	138	0.08	UNK	UND	2001	C
B30	Mississippi River Delta	332	0.93	170	1.7	2011–12	D
B02–05, 29, 31	Mississippi Sound, Lake Borgne, Bay Boudreau†	901	0.63	551	5.6	2012	D
B06	Mobile Bay, Bonsecour Bay	122	0.34	UNK	UND	1993	A
B07	Perdido Bay	0[a]	-		UND	1993	A
B08	Pensacola Bay, East Bay	33	0.80	UNK	UND	1993	A
B09	Choctawhatchee Bay†	179	0.04	UNK[c]	UND[c]	2007	E
B10	St. Andrew Bay	124	0.57	UNK	UND	1993	A
B11	St. Joseph Bay†	152	0.08	UNK[c]	UND[c]	2007	F
B12–13	St. Vincent Sound, Apalachicola Bay, St. George Sound	439	0.14	UNK	UND	2007	G
B14–15	Apalachee Bay	491	0.39	UNK	UND	1993	A
B16	Waccasassa Bay, Withlacoochee Bay, Crystal Bay	UNK	-	UNK	UND		
B17	St. Joseph Sound, Clearwater Harbor	UNK	-	UNK	UND		
B32–34	Tampa Bay	UNK	-	UNK	UND		
B20, 35	Sarasota Bay, Little Sarasota Bay	158	0.27	126	1.3	2015	H
B21–23	Pine Island Sound, Charlotte Harbor, Gasparilla Sound, Lemon Bay	826	0.09	UNK	UND	2006	I
B36	Caloosahatchee River	0[a,b]	-		UND	1985	J
B24	Estero Bay	UNK	-	UNK	UND		
B25	Chokoloskee Bay, Ten Thousand Islands, Gullivan Bay	UNK	-	UNK	UND		
B27	Whitewater Bay	UNK	-	UNK	UND		
B28	Florida Keys (Bahia Honda to Key	UNK	-	UNK	UND		

	West)
References: A – Blaylock and Hoggard 1994; B – Irwin and Würsig 2004; C – Miller 2003; D – Garrison 2017; E – Conn *et al.* 2011; F – Balmer *et al.* 2008; G – Tyson *et al.* 2011; H – Tyson and Wells 2016; I – Bassos-Hull *et al.* 2013; J –Scott *et al.* 1989 Notes: [a] During earlier surveys (Scott *et al.* 1989), the range of seasonal abundances was as follows: B57, 0–2 (CV=0.38); B58, 0–6 (0.34); B59, 0–0; B30, 0–182 (0.14); B07, 0–0; B21, 0–15 (0.43); and B36, 0–0. [b] Block not surveyed during surveys reported in Blaylock and Hoggard (1994). [c] The individual SAR for this stock has not been updated yet to reflect this change. †An individual stock assessment report is available for this stock.	

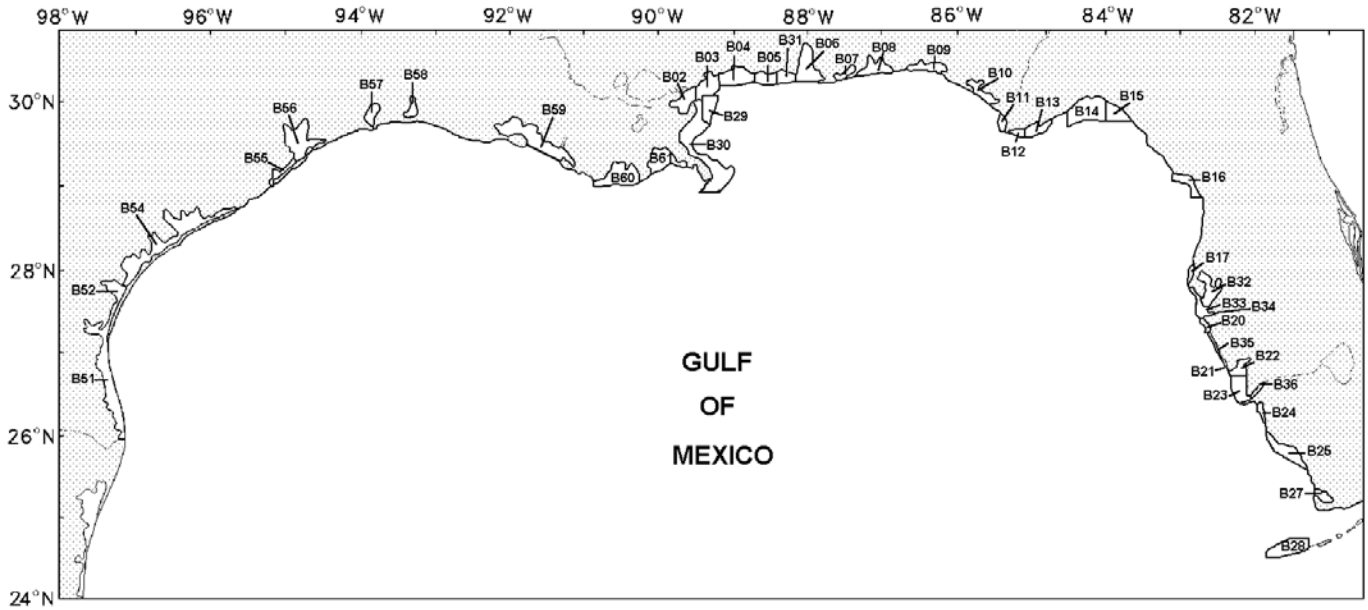

Figure 1. *Northern Gulf of Mexico bays, sounds and estuaries. Each of the alpha-numerically designated blocks corresponds to one of the NMFS Southeast Fisheries Science Center logistical aerial survey areas listed in Table 1. The common bottlenose dolphins inhabiting each bay, sound or estuary are considered to comprise a unique stock for purposes of this assessment. Four stocks have their own stock assessment report (see Table 1).*

POPULATION SIZE

Population size estimates for most of the stocks are greater than 8 years old and therefore the current population sizes for all but 3 of these stocks are considered unknown (Wade and Angliss 1997). However, a capture-mark-recapture population size estimate for 2015 is available for Sarasota Bay, Little Sarasota Bay (Tyson and Wells 2016). Recent aerial survey line-transect population size estimates are available for Mississippi River Delta and Mississippi Sound, Lake Borgne, Bay Boudreau (Garrison 2017; Table 1). Population size estimates for many stocks were generated from preliminary analyses of line-transect data collected during aerial surveys conducted in September-October 1992 in Texas and Louisiana and in September–October 1993 in Louisiana, Mississippi, Alabama and the Florida Panhandle (Blaylock and Hoggard 1994; Table 1). Standard line-transect perpendicular sighting distance analytical methods (Buckland *et al.* 1993) and the computer program DISTANCE (Laake *et al.* 1993) were used.

Minimum Population Estimate

The population sizes for all but 3 stocks are currently unknown and the minimum population estimates are given for those 3 stocks in Table 1. The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally distributed abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by Wade and Angliss (1997). The minimum population estimate was calculated for each block from the estimated population size and its associated coefficient of variation.

Current Population Trend

The data are insufficient to determine population trends for most of the Gulf of Mexico BSE common bottlenose dolphin stocks.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are not known for these stocks. The maximum net productivity rate was assumed to be 0.04. This value is based on theoretical modeling showing that cetacean populations may not grow at rates much greater than 4% given the constraints of their reproductive life history (Barlow *et al.* 1995).

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of minimum population size, one-half the maximum productivity rate and a recovery factor (Wade and Angliss 1997). The recovery factor is 0.5 because these stocks are of unknown status. PBR is undetermined for all but 3 stocks because the population size estimates are more than 8 years old. PBR for those stocks with population size estimates less than 8 years old is given in Table 1.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

The total annual human-caused mortality and serious injury for these stocks during 2010–2014 is unknown because these stocks interact with unobserved fisheries (see below). Five-year unweighted mean mortality estimates for 2007–2011 for the commercial shrimp trawl fishery were calculated at the state level (see Shrimp Trawl section below).

Fishery Information

The commercial fisheries that interact, or that potentially could interact, with these stocks in the Gulf of Mexico are the Category II Southeastern U.S. Atlantic, Gulf of Mexico shrimp trawl; Gulf of Mexico menhaden purse seine; Southeastern U.S. Atlantic, Gulf of Mexico stone crab trap/pot; and Gulf of Mexico gillnet fisheries; and the Category III Gulf of Mexico blue crab trap/pot; Florida spiny lobster trap/pot; and Atlantic Ocean, Gulf of Mexico, Caribbean commercial passenger fishing vessel (hook and line) fisheries (Appendix III).

In the following sections the number of documented interactions of common bottlenose dolphins with each of these fisheries during 2010–2014 is reported. The likely stock(s) of origin for each interaction has been inferred based on the location of the interaction and distribution of the fishery.

Shrimp Trawl

During 2010–2014, there were no documented mortalities or serious injuries of common bottlenose dolphins from Gulf of Mexico BSE stocks by commercial shrimp trawls because observer coverage of this fishery does not include BSE waters. Between 1997 and 2011, 5 common bottlenose dolphins and 7 unidentified dolphins, which could have been either common bottlenose dolphins or Atlantic spotted dolphins, became entangled in the lazy line, turtle excluder device or tickler chain gear in the commercial shrimp trawl fishery in the Gulf of Mexico. All dolphin bycatch interactions resulted in mortalities except for 1 unidentified dolphin that was released alive in 2009. Soldevilla *et al.* (2015) provided mortality estimates calculated from analysis of shrimp fishery effort data and NMFS's Observer Program bycatch data. Observer program coverage does not extend into BSE waters; time-area stratified bycatch rates were extrapolated into inshore waters to estimate bycatch mortalities from inshore fishing effort. Annual mortality estimates were calculated for the years 1997–2011 from stratified annual fishery effort and bycatch rates, and a 5-year unweighted mean mortality estimate for 2007–2011 was calculated for Gulf of Mexico dolphin stocks. The 4-area (Texas, Louisiana, Mississippi/Alabama, Florida) stratification method was chosen because it best approximates how fisheries operate (Soldevilla *et al.* 2015). The BSE stock mortality estimates were aggregated at the state level as this was the spatial resolution at which fishery effort is modeled (e.g., Nance *et al.* 2008). The mean annual mortality estimates for the BSE stocks were as follows: Texas BSE (from Galveston Bay, East Bay, Trinity Bay south to Laguna Madre): 0; Louisiana BSE (from Sabine Lake east to Barataria Bay): 88 (CV=1.01); Mississippi/Alabama BSE (from Mississippi River Delta east to Mobile Bay, Bonsecour Bay): 41 (CV=0.67); and Florida BSE (from Perdido Bay east and south to the Florida Keys): 3.4 (CV=0.99). These estimates do not include skimmer trawl effort, which may represent up to 50% of shrimp fishery effort in Louisiana, Alabama, and Mississippi inshore waters, because observer program coverage of skimmer trawls is limited. Limitations and biases of annual bycatch mortality estimates are described in detail in Soldevilla *et al.* (2015).

One mortality (2009) and 1 live release without serious injury (2012) occurred in Alabama bays during non-commercial shrimp trawling (see "Other Mortality" below for details).

Menhaden Purse Seine

During 2010–2014, there were 2 mortalities and 1 animal released alive without serious injury documented within BSE waters involving the menhaden purse seine fishery. All 3 interactions occurred within the waters of the Mississippi Sound, Lake Borgne, Bay Boudreau Stock (also reported in that SAR).

There is currently no observer program for the Gulf of Mexico menhaden purse seine fishery; however, recent incidental takes have been reported via two sources. First, during 2011, a pilot observer program operated from May through September, and observers documented 3 dolphins trapped within purse seine nets. All 3 were released alive without serious injury (Maze-Foley and Garrison 2016a). Two of the 3 dolphins were trapped within a single purse seine within waters of the Western Coastal Stock. The third animal was trapped in waters of the Mississippi Sound, Lake Borgne, Bay Boudreau Stock. Second, through the Marine Mammal Authorization Program (MMAP), there have been 13 self-reported incidental takes (all mortalities) of common bottlenose dolphins in northern Gulf of Mexico coastal and estuarine waters by the menhaden purse seine fishery during 2000–2014. Specific self-reported takes under the MMAP likely involving BSE stocks are as follows: 2 dolphins were reported taken in a single purse seine during 2012 in Mississippi Sound (Mississippi Sound, Lake Borgne, Bay Boudreau Stock); 1 take of a single bottlenose dolphin was reported in Louisiana waters during 2004 that likely belonged to the Mississippi River Delta Stock; 1 take of a single unidentified dolphin reported during 2002 likely belonged to the Mississippi Sound, Lake Borgne, Bay Boudreau Stock; 1 take of a single bottlenose dolphin was reported in Louisiana waters during 2001 that likely belonged to Mississippi River Delta Stock or Northern Coastal Stock; during 2000, 1 take of a single bottlenose dolphin was reported in Louisiana waters that likely belonged to Mississippi River Delta Stock or Northern Coastal Stock; and also in 2000, 3 bottlenose dolphins were reported taken in a single purse seine in Mississippi waters that likely belonged to Mississippi Sound, Lake Borgne, Bay Boudreau Stock.

Without an ongoing observer program, it is not possible to obtain statistically reliable information for this fishery on the incidental take and mortality rates, and the stocks from which bottlenose dolphins are being taken.

Blue Crab, Stone Crab and Florida Spiny Lobster Trap/Pot

During 2010–2014 there were 4 documented interactions with trap/pot fisheries and BSE stocks. During 2013, 1 animal was disentangled and released alive from Florida spiny lobster trap/pot gear (it could not be determined if the animal was seriously injured following mitigation (disentanglement) efforts; the initial determination (pre-mitigation) was seriously injured [Maze-Foley and Garrison 2016c]). This animal likely belonged to the Florida Keys Stock. During 2011, 1 mortality occurred and 1 live animal was disentangled and released (it could not be determined if the animal was seriously injured [Maze-Foley and Garrison 2016a]). The BSE stocks involved were likely Waccasassa Bay, Withlacoochee Bay, Crystal Bay and Galveston Bay, East Bay, Trinity Bay, respectively. In 2010, a calf likely belonging to the Copano Bay, Aransas Bay, San Antonio Bay, Redfish Bay, Espiritu Santo Bay Stock was disentangled by stranding network personnel from a crab trap line wrapped around its peduncle. The animal swam away with no obvious injuries, but was considered seriously injured because it is unknown whether it was reunited with its mother (Maze-Foley and Garrison 2016a). The specific fishery could not be identified for the trap/pot gear involved in the 2011 and 2010 interactions. All mortalities and animals released alive were included in the stranding database (NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 15 June 2015) and are included in the stranding totals in Table 1. Because there is no systematic observer program, it is not possible to estimate the total number of interactions or mortalities associated with crab traps/pots.

Gillnet

No marine mammal mortalities associated with gillnet fisheries have been reported or observed in recent years, but stranding data suggest that gillnet and marine mammal interactions do occur, causing mortality and serious injury. During 2010–2014, a total of 12 entanglements in research-related gillnets were reported in BSE stocks: 8 dolphins in Texas, 2 in Louisiana and 2 in Florida. Three of the 12 entanglements resulted in mortalities, and 1 in a serious injury (see “Other Mortality” below for details on recent and historical research-related entanglements).

There has been no observer coverage of this fishery in federal waters. Beginning in November 2012, NMFS began placing observers on commercial vessels in the coastal waters of Alabama, Mississippi and Louisiana (state waters only). No takes have been observed to date (Mathers *et al.* 2016). In 1995, a Florida state constitutional amendment banned gillnets and large nets from bays, sounds, estuaries and other inshore waters. Commercial and recreational gillnet fishing is also prohibited in Texas state waters.

Hook and Line (Rod and Reel)

During 2010–2014 there were 29 documented interactions (entanglements or ingestions) with hook and line gear and BSE stocks—20 mortalities and 9 live animals for which disentanglement efforts were made. Available evidence from stranding data was examined for the 20 mortalities. For 12 of these mortalities, evidence suggested the hook and line gear interaction contributed to the cause of death. For 4 mortalities, evidence suggested the hook and line gear interaction was incidental and was not a contributing factor to cause of death. For 4 mortalities, it could not be determined if the hook and line gear interaction contributed to cause of death. Attempts were made to disentangle 9 live animals from hook and line gear, 2 of which were considered seriously injured by the gear based on observations during mitigation (disentanglement) efforts. Four live animals were considered seriously injured by the gear prior to mitigation efforts, but based on observations during mitigations, they were considered not seriously injured post-mitigation. For the remaining 3 live animals, it could not be determined if the animals were seriously injured (Maze Foley and Garrison 2016a,b,c,d). In summary, the evidence available from stranding data suggested that at least 12 mortalities and 2 serious injuries to animals from BSE stocks were a result of interactions with rod and reel hook and line gear.

Interactions by year with hook and line gear were as follows: During 2010 there were 3 mortalities, and 1 live animal was disentangled and released, considered seriously injured (Maze-Foley and Garrison 2016a). During 2011, there were 2 mortalities, and 2 live animals were disentangled from hook and line gear. One of the live animals was considered seriously injured, and 1 was not seriously injured (Maze-Foley and Garrison 2016a). During 2012 there were 8 mortalities, and 2 live animals were disentangled from hook and line gear (1 considered not seriously injured, 1 could not be determined if it was seriously injured) (Maze-Foley and Garrison 2016b). During 2013 there were 3 mortalities and 3 live animals disentangled from hook and line gear. One of the live animals was considered not seriously injured and for the other 2, it could not be determined whether they were seriously injured (Maze-Foley and Garrison 2016c). Finally, during 2014 there were 4 mortalities and 1 live animal disentangled from hook and line gear considered not seriously injured (Maze-Foley and Garrison 2016d).

The mortalities and serious injuries likely involved animals from the following BSE stocks: Pensacola Bay, East Bay; Waccasassa Bay, Withlacoochee Bay, Crystal Bay; Tampa Bay; Sarasota Bay, Little Sarasota Bay; Pine Island Sound, Charlotte Harbor, Gasparilla Sound, Lemon Bay; Caloosahatchee River; Estero Bay; Chokoloskee Bay, Ten Thousand Islands, Gullivan Bay; Galveston Bay, East Bay, Trinity Bay; West Bay; Copano Bay, Aransas Bay, San Antonio Bay, Redfish Bay, Espiritu Santo Bay; and Neuces Bay, Corpus Christi Bay.

All mortalities and live entanglements were included in the stranding database (NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 15 June 2015) and are included in the stranding totals presented in Table 1. It should be noted that, in general, it cannot be determined if rod and reel hook and line gear originated from a commercial (i.e., charter boat and headboat) or recreational angler because the gear type used by both sources is typically the same. Also, it is not possible to estimate the total number of interactions with hook and line gear because there is no systematic observer program.

Strandings

A total of 564 common bottlenose dolphins were found stranded within bays, sounds and estuaries of the northern Gulf of Mexico from 2010 through 2014 (Table 2; NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 15 June 2015). It could not be determined if there was evidence of human interaction for 452 of these strandings. For 27 dolphins, no evidence of human interaction was detected. Evidence of human interactions was detected for 85 of these dolphins. Human interactions were from numerous sources, including 29 entanglements with hook and line gear, 4 entanglements with trap/pot gear, 12 incidental takes in research gillnet gear, 1 stabbing with a screwdriver, 2 animals shot by arrow and 1 with gunshot, 1 entanglement in a non-commercial shrimp trawl, 1 entanglement in research longline gear, 2 strandings with visible, external oil, and 1 entrapment between oil booms (see Table 1). Strandings with evidence of fishery-related interactions are reported above in the respective gear sections. Bottlenose dolphins are known to become entangled in, or ingest recreational and commercial fishing gear (Wells and Scott 1994; Gorzelany 1998; Wells *et al.* 1998, 2008), and some are struck by vessels (Wells and Scott 1997; Wells *et al.* 2008).

There are a number of difficulties associated with the interpretation of stranding data. Except in rare cases, such as Sarasota Bay, Florida, where residency can be determined, it is possible that some or all of the stranded dolphins may have been from a nearby coastal stock. However, the proportion of stranded dolphins belonging to another stock cannot be determined because of the difficulty of determining from where the stranded carcasses originated. Stranding data probably underestimate the extent of human and fishery-related mortality and serious injury because not all of the dolphins that die or are seriously injured in human interactions wash ashore, or, if they do, they are not all recovered (Peltier *et al*. 2012; Wells *et al*. 2015). Additionally, not all carcasses will show evidence of human interaction, entanglement or other fishery-related interaction due to decomposition, scavenger damage, etc. (Byrd *et al*. 2014). Finally, the level of technical expertise among stranding network personnel varies widely as does the ability to recognize signs of human interaction.

Since 1990, there have been 13 bottlenose dolphin die-offs or Unusual Mortality Events (UMEs) in the northern Gulf of Mexico (Litz *et al.* 2014; http://www.nmfs.noaa.gov/pr/health/mmume/events.html, accessed 11 January 2016). 1) From January through May 1990, a total of 344 bottlenose dolphins stranded in the northern Gulf of Mexico. Overall this represented a two-fold increase in the prior maximum recorded number of strandings for the same period, but in some locations (i.e., Alabama) strandings were 10 times the average number. The cause of the 1990 mortality event could not be determined (Hansen 1992), however, morbillivirus may have contributed to this event (Litz *et al.* 2014). 2) A UME was declared for Sarasota Bay, Florida, in 1991 involving 31 bottlenose dolphins. The cause was not determined, but it is believed biotoxins may have contributed to this event (Litz *et al.* 2014). 3) In March and April 1992, 119 bottlenose dolphins stranded in Texas - about 9 times the average number. The cause of this event was not determined, but low salinity due to record rainfall combined with pesticide runoff and exposure to morbillivirus were suggested as potential contributing factors (Duignan *et al.* 1996; Colbert *et al.* 1999; Litz *et al.* 2014). 4) In 1993–1994 a UME of bottlenose dolphins caused by morbillivirus started in the Florida Panhandle and spread west with most of the mortalities occurring in Texas (Lipscomb 1993; Lipscomb *et al.* 1994; Litz *et al.* 2014). From February through April 1994, 236 bottlenose dolphins were found dead on Texas beaches, of which 67 occurred in a single 10-day period. 5) In 1996 a UME was declared for bottlenose dolphins in Mississippi when 31 bottlenose dolphins stranded during November and December. The cause was not determined, but a *Karenia brevis* (red tide) bloom was suspected to be responsible (Litz *et al.* 2014). 6) Between August 1999 and May 2000, 150 bottlenose dolphins died coincident with *K. brevis* blooms and fish kills in the Florida Panhandle (additional strandings included 3 Atlantic spotted dolphins, *Stenella frontalis*, 1 Risso's dolphin, *Grampus griseus*, 2 Blainville's beaked whales, *Mesoplodon densirostris*, and 4 unidentified dolphins. Brevetoxin was determined to be the cause of this event (Twiner *et al.* 2012; Litz *et al.* 2014). 7) In March and April 2004, in another Florida Panhandle UME attributed to *K. brevis* blooms, 105 bottlenose dolphins and 2 unidentified dolphins stranded dead (Litz *et al.* 2014). Although there was no indication of a *K. brevis* bloom at the time, high levels of brevetoxin were found in the stomach contents of the stranded dolphins (Flewelling *et al.* 2005; Twiner *et al.* 2012). 8) In 2005, a particularly destructive red tide (*K. brevis*) bloom occurred off central west Florida. Manatee, sea turtle, bird and fish mortalities were reported in the area in early 2005 and a manatee UME had been declared. Dolphin mortalities began to rise above the historical averages by late July 2005, continued to increase through October 2005, and were then declared to be part of a multi-species UME. The multi-species UME extended into 2006, and ended in November 2006. In total, 190 dolphins were involved, primarily bottlenose dolphins (plus strandings of 1 Atlantic spotted dolphin, *S. frontalis*, and 23 unidentified dolphins). The evidence suggests a red tide bloom contributed to the cause of this event (Litz *et al.* 2014). 9) A separate UME was declared in the Florida Panhandle after elevated numbers of dolphin strandings occurred in association with a *K. brevis* bloom in September 2005. Dolphin strandings remained elevated through the spring of 2006 and brevetoxin was again detected in the tissues of most of the stranded dolphins and determined to be the cause of the event (Twiner *et al.* 2012; Litz *et al.* 2014). Between September 2005 and April 2006 when the event was officially declared over, a total of 88 bottlenose dolphin strandings occurred (plus strandings of 5 unidentified dolphins). 10) During February and March of 2007 an event was declared for northeast Texas and western Louisiana involving 64 bottlenose dolphins and 2 unidentified dolphins. Decomposition prevented conclusive analyses on most carcasses (Litz *et al.* 2014). 11) During February and March of 2008 an additional event was declared in Texas involving 111 bottlenose dolphin strandings (plus strandings of 1 unidentified dolphin and 1 melon-headed whale, *Peponocephala electra*). Most of the animals recovered were in a decomposed state. The investigation is closed and a direct cause could not be identified. However, there were numerous, co-occurring harmful algal bloom toxins detected during the time period of this UME which may have contributed to the mortalities (Fire *et al.* 2011). 12) A UME was declared for cetaceans in the northern Gulf of Mexico beginning 1 February 2010 and ending 31 July 2014 (Litz *et al.* 2014; http://www.nmfs.noaa.gov/pr/health/mmume/cetacean_gulfofmexico.htm, accessed 1 June 2016). The UME began a few months prior to the *Deepwater Horizon* (DWH) oil spill, however most of the strandings prior to May 2010 were in Lake Pontchartrain, Louisiana, and western Mississippi and were likely a result of low salinity and cold temperatures (Venn Watson *et al.* 2015a). The largest increase in strandings (compared to historical data) occurred after May 2010 following the DWH spill, and strandings were focused in areas exposed to DWH oil. Investigations to date have determined that the DWH oil spill is the primary underlying cause of the elevated stranding numbers in the northern Gulf of Mexico after the spill (e.g., Schwacke *et al.* 2014; Venn-Watson *et al.* 2015b). 13) A UME occurred from November 2011 to March 2012 across 5 Texas counties and included 126 bottlenose dolphin strandings. The strandings were coincident with a harmful algal bloom of *K. brevis*, but researchers have not determined that was the cause of the event. During 2011, 6 animals from BSE stocks were considered to be part of the UME; during 2012, 24 animals.

Table 2. Common bottlenose dolphin strandings occurring in bays, sounds and estuaries in the northern Gulf of Mexico from 2010 to 2014, as well as number of strandings for which evidence of human interaction was detected and number of strandings for which it could not be determined (CBD) if there was evidence of human interaction. Data are from the NOAA National Marine Mammal Health and Stranding Response Database (unpublished data, accessed 15 June 2015). Please note human interaction does not necessarily mean the interaction caused the animal's death. Please also note that this table does not include strandings from Barataria Bay Estuarine System; Mississippi Sound, Lake Borgne, Bay Boudreau; Choctawhatchee Bay; or St. Joseph Bay.

Stock	Category	2010	2011	2012	2013	2014	Total
Bay, Sound and Estuary	Total Stranded	96[a]	106[b]	124[c]	131[d]	107[e]	564
	Human Interaction						
	---Yes	15[f]	13[g]	23[h]	22[i]	12[j]	85
	---No	7	6	4	4	6	27
	---CBD	74	87	97	105	89	452

[a] This total includes animals that are part of the Northern Gulf of Mexico UME.

[b] This total includes animals that are part of the Northern Gulf of Mexico UME, and also includes 6 animals that were part of the 2011–2012 UME in Texas.

[c] This total includes animals that are part of the Northern Gulf of Mexico UME, and also includes 24 animals that were part of the 2011–2012 UME in Texas.

[d] This total includes animals that are part of the Northern Gulf of Mexico UME.

[e] This total includes animals that are part of the Northern Gulf of Mexico UME.

[f] Includes 4 entanglement interactions with hook and line gear (3 mortalities and 1 animal released alive seriously injured); 1 entanglement interaction with unidentified trap/pot gear (released alive seriously injured); 2 entanglement interactions with research gillnet gear (1 released alive without serious injury, 1 released alive that could not be determined if seriously injured or not); 1 live release without serious injury following entrapment between oil booms (animal was initially seriously injured, but due to mitigation efforts, was released without serious injury); 1 animal visibly oiled (mortality); and 1 entanglement interaction with unknown gear (released alive without serious injury [animal was initially seriously injured, but due to mitigation efforts, was released without serious injury]) .

[g] Includes 4 entanglement interactions with hook and line gear (2 mortalities, 1 animal released alive seriously injured, 1 released alive without serious injury [this animal was initially seriously injured, but due to mitigation efforts, was released without serious injury]); 2 entanglement interactions with research gillnet gear (1 mortality, 1 released alive without serious injury); 2 entanglement interactions with trap/pot gear (1 mortality, 1 released alive that could not be determined if seriously injured or not); and 1 animal visibly oiled (mortality).

[h] Includes 10 entanglement interactions with hook and line gear (8 mortalities, 1 released alive without serious injury [animal was initially seriously injured, but due to mitigation efforts, was released without serious injury], 1 released alive that could not be determined if seriously injured or not); 4 entanglement interactions with research gillnet gear (1 released alive seriously injured, 3 released alive without serious injury); 1 entanglement in a non-commercial shrimp trawl net (released alive without serious injury); 1 stabbing (mortality); and 1 entanglement interaction with unknown fishing gear (released alive without serious injury [animal was initially seriously injured, but due to mitigation efforts, was released without serious injury]).

[i] Includes 6 entanglement interactions with hook and line gear (3 mortalities, 1 animal released alive without serious injury [animal was initially seriously injured, but due to mitigation efforts, was released without serious injury], 2 animals released alive that could not be determined if seriously injured or not); 4 entanglement interactions with research gillnet gear (2 mortalities, 1 animal released alive without serious injury, 1 animal released alive that could not be determined if seriously injured or not); 1 interaction with Florida spiny lobster trap/pot gear (released alive, could not be determined if seriously injured or not [this animal was initially seriously injured, but mitigation efforts were made]); 1 interaction with research longline gear (released alive, seriously injured); and 1 animal that was gunshot (mortality).

[j] Includes 5 entanglement interactions with hook and line gear (4 mortalities, 1 released alive without serious injury [animal was initially seriously injured, but due to mitigation efforts, was released without serious injury]) and 2 animals shot by arrow (mortalities).

Other Mortality

There were 3 live dolphins included in the stranding database during 2010–2014 that were entangled in unidentified fishing gear or unidentified gear. One animal was seriously injured in 2013 in the Pine Island Sound, Charlotte Harbor, Gasparilla Sound, Lemon Bay Stock area (Maze-Foley and Garrison 2016c). Two animals were initially considered seriously injured, but following mitigation efforts, were released alive without serious injury in 2010 (Sarasota Bay, Little Sarasota Bay Stock) and 2012 (Pine Island Sound, Charlotte Harbor, Gasparilla Sound, Lemon Bay Stock) (Maze-Foley and Garrison 2016a,b). In addition, during 2012 in Alabama (Perdido Bay Stock), a dolphin was disentangled from a shrimp trawling net being used in a local ecotour. The animal was considered not seriously injured (Maze-Foley and Garrison 2016b), and was also included in the stranding database (NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 15 June 2015).

In addition to animals included in the stranding database, during 2010–2014, there were 20 at-sea observations in BSE stock areas of common bottlenose dolphins entangled in fishing gear or unidentified gear (hook and line, crab trap/pot and unidentified gear/line/rope). In 8 of these cases the animals were seriously injured, in 1 case the animal was not seriously injured, and for the remaining 11 cases, it could not be determined (CBD) if the animals were seriously injured (Maze-Foley and Garrison 2016a,b,c,d; see Table 3).

Table 3. At-sea observations of common bottlenose dolphins entangled in fishing gear or unidentified gear during 2010–2014, including the serious injury determination (mortality, serious injury, not a serious injury, or could not be determined (CBD) if seriously injured) and stock to which each animal likely belonged based on sighting location. Further details can be found in Maze-Foley and Garrison (2016a,b,c,d).

Year	Determination	Stock
2010	Serious injury	Mobile Bay, Bonsecour Bay
2010	CBD	Terrebonne, Timbalier Bay
2011	Serious injury	Copano Bay, Aransas Bay, San Antonio Bay, Redfish Bay, Espiritu Santo Bay
2011	Serious injury	Pensacola Bay, East Bay
2011	CBD	Tampa Bay
2012	Serious injury	Caloosahatchee River
2012	Serious injury	Sarasota Bay, Little Sarasota Bay
2012	CBD	Chokoloskee Bay, Ten Thousand Islands, Gullivan Bay
2012	CBD	Pine Island Sound, Charlotte Harbor, Gasparilla Sound, Lemon Bay
2012	CBD	Tampa Bay
2013	Serious injury	Pine Island Sound, Charlotte Harbor, Gasparilla Sound, Lemon Bay
2013	Serious injury	Estero Bay
2013	Not serious	Chokoloskee Bay, Ten Thousand Islands, Gullivan Bay
2013	CBD	Copano Bay, Aransas Bay, San Antonio Bay, Redfish Bay, Espiritu Santo Bay
2013	CBD	Copano Bay, Aransas Bay, San Antonio Bay, Redfish Bay, Espiritu Santo Bay
2013	CBD	Tampa Bay
2013	CBD	Pine Island Sound, Charlotte Harbor, Gasparilla Sound, Lemon Bay
2014	Serious injury	St. Joseph Sound, Clearwater Harbor
2014	CBD	Chokoloskee Bay, Ten Thousand Islands, Gullivan Bay
2014	CBD	St. Andrew Bay

Common bottlenose dolphins are also known to interact with research-fishery gear. During 2010–2014, a dolphin was seriously injured during a research longline survey (Maze-Foley and Garrison 2016c; see Table 4) and 12 dolphins were entangled in research-related gillnets—in Texas (8), Louisiana (2) and Florida (2). Three of the 12 entanglements resulted in mortalities; 1 entanglement resulted in a serious injury; 6 entanglements were released alive without serious injury; and for 2 entanglements, it could not be determined if the animals were seriously injured (Maze-Foley and Garrison 2016a,b,c,d; see Table 4). All of the interactions with research gear were included in the stranding database (NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 15 June 2015).

Table 4. Research-related takes of common bottlenose dolphins during 2010–2014, including the serious injury determination for each animal (mortality, serious injury, not a serious injury, or could not be determined (CBD) if seriously injured) and stock to which each animal likely belonged based on location of the interaction. All of these interactions were included in the stranding database (NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 15 June 2015). Further details on injury determinations can be found in Maze-Foley and Garrison (2016a,b,c,d).

Year	Gear Type	Determination	Stock
2013	Longline	Serious injury	Mobile Bay, Bonsecour Bay
2010	Gillnet	Not serious	Copano Bay, Aransas Bay, San Antonio Bay, Redfish Bay, Espiritu Santo Bay
2010	Gillnet	CBD	Copano Bay, Aransas Bay, San Antonio Bay, Redfish Bay, Espiritu Santo Bay
2011	Gillnet	Mortality	Copano Bay, Aransas Bay, San Antonio Bay, Redfish Bay, Espiritu Santo Bay
2011	Gillnet	Not serious	Copano Bay, Aransas Bay, San Antonio Bay, Redfish Bay, Espiritu Santo Bay
2012	Gillnet	Serious injury	Copano Bay, Aransas Bay, San Antonio Bay, Redfish Bay, Espiritu Santo Bay
2012	Gillnet	Not serious	Neuces Bay, Corpus Christi Bay
2012	Gillnet	Not serious	Copano Bay, Aransas Bay, San Antonio Bay, Redfish Bay, Espiritu Santo Bay
2012	Gillnet	Not serious	Laguna Madre
2013	Gillnet	Not serious	Mississippi River Delta
2013	Gillnet	Mortality	Mississippi River Delta
2013	Gillnet	Mortality	Pine Island Sound, Charlotte Harbor, Gasparilla Sound, Lemon Bay
2013	Gillnet	CBD	Pine Island Sound, Charlotte Harbor, Gasparilla Sound, Lemon Bay

The problem of dolphin depredation of fishing gear is increasing in Gulf of Mexico coastal and estuary waters. There was a recent case within BSE waters of a shrimp fisherman illegally taking a common bottlenose dolphin in Mississippi Sound (Mississippi Sound, Lake Borgne, Bay Boudreau Stock) during summer 2012. In December 2013 the fisherman was convicted under the MMPA for knowingly shooting a dolphin with a shotgun while shrimping.

In addition to the above case where it was confirmed the fisherman retaliated against depredation by dolphins, there have been several other documented shootings of BSE common bottlenose dolphins in recent years, both by arrows and guns. During 2014 in Cow Bayou, Texas (Sabine Lake Stock), a dolphin was shot with a compound bow resulting in mortality. In 2014 near Orange Beach, Alabama (Perdido Bay Stock), a dolphin was shot with a hunting arrow. In the arrow cases, there was no evidence the acts were committed due to dolphin depredation of fishing gear. In 2014 within Choctawhatchee Bay, Florida (Choctawhatchee Bay Stock), a pregnant bottlenose dolphin was found dead with a bullet lodged in its lung. Necropsy results indicated the dolphin died of the gunshot wound. Two individual bottlenose dolphins were shot with buckshot-like ammunition in Louisiana waters: 1 in 2014 within Barataria Bay (Barataria Bay Stock), and 1 in 2013 in a canal off Terrebonne Bay (Terrebonne Bay, Timbalier Bay Stock). In 2013 in Mississippi Sound, a dolphin was found with a bullet lodged in its lung. Necropsy results indicated the bullet had been there for several months and likely was not the cause of death. In the gunshot cases, it is unknown whether the animals were shot due to depredation of fishing gear, but it is possible one or more of these acts was related to depredation. All of these shootings were included in the stranding database and in Table 2. During 2012 a dolphin was observed swimming in Perdido Bay with a screwdriver protruding from its melon and was found dead the next day. This stabbing was included in the stranding database and in Table 2.

Illegal feeding or provisioning of wild bottlenose dolphins has been documented in Florida, particularly near Panama City Beach in the Panhandle (Samuels and Bejder 2004) and in and near Sarasota Bay (Cunningham-Smith *et al.* 2006; Powell and Wells 2011), and also in Texas near Corpus Christi (Bryant 1994). Feeding wild dolphins is defined under the MMPA as a form of 'take' because it can alter their natural behavior and increase their risk of injury or death. Nevertheless, a high rate of provisioning was observed near Panama City Beach in 1998 (Samuels and Bejder 2004), and provisioning has been observed south of Sarasota Bay since 1990 (Cunningham-Smith *et al.* 2006; Powell and Wells 2011). There are emerging questions regarding potential linkages between provisioning and depredation of recreational fishing gear and associated entanglement and ingestion of gear, which is increasing through much of Florida. During 2006, at least 2% of the long-term resident dolphins of Sarasota Bay died from ingestion of recreational fishing gear (Powell and Wells 2011).

Swimming with wild bottlenose dolphins has also been documented in Florida in Key West (Samuels and Engleby 2007) and near Panama City Beach (Samuels and Bejder 2004). Near Panama City Beach, Samuels and Bejder (2004) concluded that dolphins were amenable to swimmers due to illegal provisioning. Swimming with wild dolphins may cause harassment, and harassment is illegal under the MMPA.

As noted previously, bottlenose dolphins are known to be struck by vessels (Wells and Scott 1997; Wells *et al.* 2008). During 2010–2014, 19 stranded bottlenose dolphins (of 564 total strandings) showed signs of a boat collision (NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 15 June 2015). It is possible some of the instances were post-mortem collisions. In addition to vessel collisions, the presence of vessels may also impact bottlenose dolphin behavior in bays, sounds and estuaries. Nowacek *et al.* (2001) reported that boats pass within 100 m of each bottlenose dolphin in Sarasota Bay once every 6 minutes on average, leading to changes in dive patterns and group cohesion. Buckstaff (2004) noted changes in communication patterns of Sarasota Bay dolphins when boats approached. Miller *et al.* (2008) investigated the immediate responses of bottlenose dolphins to “high-speed personal watercraft” (i.e., boats) in Mississippi Sound. They found an immediate impact on dolphin behavior demonstrated by an increase in traveling behavior and dive duration, and a decrease in feeding behavior for non-traveling groups. The findings suggested dolphins attempted to avoid high-speed personal watercraft. It is unclear whether repeated short-term effects will result in long-term consequences like reduced health and viability of dolphins. Further studies are needed to determine the impacts throughout the Gulf of Mexico.

As part of its annual coastal dredging program, the Army Corps of Engineers conducts sea turtle relocation trawling during hopper dredging as a protective measure for marine turtles. No interactions have been documented during the most recent 5 years, 2010–2014, that fall within BSE stocks in this report; however, 1 interaction occurred within the boundaries of the Mississippi Sound, Lake Borgne, Bay Boudreau Stock (please see that SAR for details). In earlier years, 5 interactions, including 4 mortalities (2003, 2005, 2006, 2007), were documented in the Gulf of Mexico involving bottlenose dolphins and relocation trawling activities. It is likely that 2 of these animals belonged to BSE stocks (2003, 2006).

There have been documented mortalities of common bottlenose dolphins during health-assessment research projects in the Gulf of Mexico, but none have occurred during the most recent 5 years, 2010–2014. Historically, 1 mortality occurred within Sarasota Bay in 2002, and 1 mortality occurred in St. Joseph Bay in 2006.

Some of the BSE communities were the focus of a live-capture fishery for bottlenose dolphins which supplied dolphins to the U.S. Navy and to oceanaria for research and public display for more than 2 decades (Reeves and Leatherwood 1984; Scott 1990). Between 1973 and 1988, 533 bottlenose dolphins were removed from Southeastern U.S. waters (Scott 1990). The impact of these removals on the stocks is unknown. In 1989, the Alliance of Marine Mammal Parks and Aquariums declared a self-imposed moratorium on the capture of bottlenose dolphins in the Gulf of Mexico (Corkeron 2009).

HABITAT ISSUES

The DWH MC252 drilling platform, located approximately 50 miles southeast of the Mississippi River Delta in waters about 1500 m deep, exploded on 20 April 2010. The rig sank, and over 87 days up to ~4.9 million barrels of oil were discharged from the wellhead until it was capped on 15 July 2010 (McNutt *et al.* 2012). During the response effort dispersants were applied extensively at the seafloor and at the sea surface (Lehr *et al.* 2010; OSAT 2010). In-situ burning, or controlled burning of oil at the surface, was also used extensively as a response tool (Lehr *et al.* 2010). The oil, dispersant and burn residue compounds present ecological concerns (Buist *et al.* 1999; NOAA 2011). The magnitude of this oil spill was unprecedented in U.S. history, causing impacts to wildlife, natural habitats and human communities along coastal areas from western Louisiana to the Florida Panhandle (NOAA 2011). It could be years before the entire scope of damage is ascertained (NOAA 2011).

A substantial number of beaches and wetlands along the Louisiana coast experienced heavy or moderate oiling (OSAT-2 2011; Michel *et al.* 2013). The heaviest oiling in Louisiana occurred west of the Mississippi River on the Mississippi Delta and in Barataria and Terrebonne Bays, and to the east of the river on the Chandeleur Islands. Some heavy to moderate oiling occurred on Alabama and Florida beaches, with the heaviest stretch occurring from Dauphin Island, Alabama, to Gulf Breeze, Florida. Light to trace oil was reported along the majority of Mississippi's mainland coast, from Gulf Breeze to Panama City, Florida, and outside of Atchafalaya and Vermilion Bays in western Louisiana. Heavy to light oiling occurred on Mississippi's barrier islands (Michel *et al.* 2013). Thus, it is likely that some BSE stocks were exposed to oil. Dolphins were observed with tar balls attached to them and seen swimming through oil slicks close to shore and inland bays. The effects of oil exposure on marine mammals depend on a number of factors including the type and mixture of chemicals involved, the amount, frequency and duration of exposure, the route of exposure (inhaled, ingested, absorbed, or external) and biomedical risk factors of the particular animal (Geraci 1990; Helm *et al.* 2015). In general, direct external contact with petroleum compounds or dispersants with skin may cause skin irritation, chemical burns and infections. Inhalation of volatile petroleum compounds or dispersants may irritate or injure the respiratory tract, which could lead to pneumonia or inflammation. Ingestion of petroleum compounds may cause injury to the gastrointestinal tract, which could affect an animal's ability to digest or absorb food. Absorption of petroleum compounds or dispersants may damage kidney, liver and brain function in addition to causing immune suppression and anemia. Long term chronic effects such as lowered reproductive success and decreased survival may occur (Geraci 1990; Helm *et al.* 2015).

Shortly after the oil spill, the Natural Resource Damage Assessment (NRDA) process was initiated under the Oil Pollution Act of 1990. A variety of NRDA research studies are being conducted to determine potential impacts of the spill on marine mammals. These studies have focused on identifying the type, magnitude, severity, length and impact of oil exposure to oceanic, continental shelf, coastal and estuarine marine mammals. The research is ongoing. For coastal and estuarine dolphins, the NOAA-led efforts include: active surveillance to detect stranded animals in remote locations; aerial surveys to document the distribution, abundance, species and exposure relative to oil from the DWH spill; assessment of sublethal and chronic health impacts on coastal and estuarine bottlenose dolphins in Barataria Bay, Louisiana, Mississippi Sound, and a reference site in Sarasota Bay, Florida; and assessment of injuries to dolphin stocks in Barataria Bay and Chandeleur Sound, Louisiana, Mississippi Sound, and as a reference site, St. Joseph Bay, Florida.

The nearshore habitat occupied by many of these stocks is adjacent to areas of high human population, and in some bays, such as Mobile Bay in Alabama and Galveston Bay in Texas, is highly industrialized. The area surrounding Galveston Bay, for example, has a coastal population of over 3 million people. More than 50% of all chemical products manufactured in the U.S. are produced there, and 17% of the oil produced in the Gulf of Mexico is refined there (Henningsen and Würsig 1991). Many of the enclosed bays in Texas are surrounded by agricultural lands which receive periodic pesticide applications.

Concentrations of chlorinated hydrocarbons and metals were examined in conjunction with an anomalous mortality event of bottlenose dolphins in Texas bays in 1990 and found to be relatively low in most; however, some had concentrations at levels of possible toxicological concern (Varanasi *et al.* 1992). No studies to date have determined the amount, if any, of indirect human-induced mortality resulting from pollution or habitat degradation.

Analyses of organochlorine concentrations in the tissues of bottlenose dolphins in Sarasota Bay, Florida, have found that the concentrations in male dolphins exceeded toxic threshold values that may result in adverse effects on health or reproductive rates (Schwacke *et al.* 2002). Studies of contaminant concentrations relative to life history parameters showed higher levels of mortality in first-born offspring, and higher contaminant concentrations in these calves and in primiparous females (Wells *et al.* 2005). While there are no direct measurements of adverse effects of pollutants on estuary dolphins, the exposure to environmental pollutants and subsequent effects on population health are areas of concern and active research.

STATUS OF STOCKS

The status of these stocks relative to OSP is unknown and this species is not listed as threatened or endangered under the Endangered Species Act. The occurrence of 13 Unusual Mortality Events (UMEs) among common bottlenose dolphins along the northern Gulf of Mexico coast since 1990 (Litz *et al.* 2014; http://www.nmfs.noaa.gov/pr/health/mmume/events.html, accessed 11 January 2016) is cause for concern. Notably, stock areas in Louisiana, Mississippi, Alabama and the western Florida panhandle have been impacted by a UME of unprecedented size and duration (began 1 February 2010, and as of December 2015, the event is under consideration for closure). However, the effects of the mortality events on stock abundance have not yet been determined, in large part because it has not been possible to assign mortalities to specific stocks due to a lack of empirical information on stock identification.

Human-caused mortality and serious injury for each of these stocks is not known. Considering the evidence from stranding data (Table 2) and the low PBRs for stocks with recent abundance estimates, the total fishery-related mortality and serious injury likely exceeds 10% of the total known PBR or previous PBR, and therefore, it is probably not insignificant and not approaching the zero mortality and serious injury rate. NMFS considers each of these stocks to be strategic because most of the stock sizes are currently unknown, but likely small and relatively few mortalities and serious injuries would exceed PBR.

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ROUGH-TOOTHED DOLPHIN (*Steno bredanensis*): Northern Gulf of Mexico Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The rough-toothed dolphin is distributed worldwide in tropical to warm temperate waters (Leatherwood and Reeves 1983; Miyazaki and Perrin 1994; West *et al.* 2011). Rough-toothed dolphins occur in oceanic and to a lesser extent continental shelf waters in the northern Gulf of Mexico (i.e., U.S. Gulf of Mexico) (Figure 1; Fulling *et al.* 2003; Mullin and Fulling 2004; Maze-Foley and Mullin 2006). Rough-toothed dolphins were seen in all seasons during GulfCet aerial surveys of the northern Gulf of Mexico between 1992 and 1998 (Hansen *et al.* 1996; Mullin and Hoggard 2000). Four dolphins from a mass stranding of 62 animals in the Florida Panhandle in December 1997 were rehabilitated and released in 1998, and satellite-linked transmitters on 3 of these were tracked for 4 to 112 days. A report after 5 months indicated that the animals returned to, and remained in, northeastern Gulf waters averaging about 195 m deep offshore of the original stranding site (Wells *et al.* 1999).

Although there are only a few records from Gulf of Mexico waters beyond U.S. boundaries (e.g., Jefferson and Schiro 1997, Ortega Ortiz 2002), rough-toothed dolphins almost certainly occur throughout the oceanic Gulf of Mexico (Jefferson *et al.* 2008), which is also composed of waters belonging to Mexico and Cuba where there is currently little information on cetacean species abundance and distribution. U.S. waters comprise only about 40% of the entire Gulf of Mexico and 35% of the oceanic (i.e., >200 m) Gulf of Mexico. The Gulf of Mexico population is being considered 1 stock for management purposes, although there is currently no information to differentiate this stock from the Atlantic Ocean stock(s), nor information on whether more than 1 stock may exist in the Gulf of Mexico. Additional morphological, genetic and/or behavioral data are needed to provide further information on stock delineation.

POPULATION SIZE

The current population size for the rough-toothed dolphin in the northern Gulf of Mexico is 624 (CV=0.99; Table 1; Garrison 2016). This estimate is from a summer 2009 oceanic survey covering waters from the 200-m isobath to the seaward extent of the U.S. Exclusive Economic Zone (EEZ).

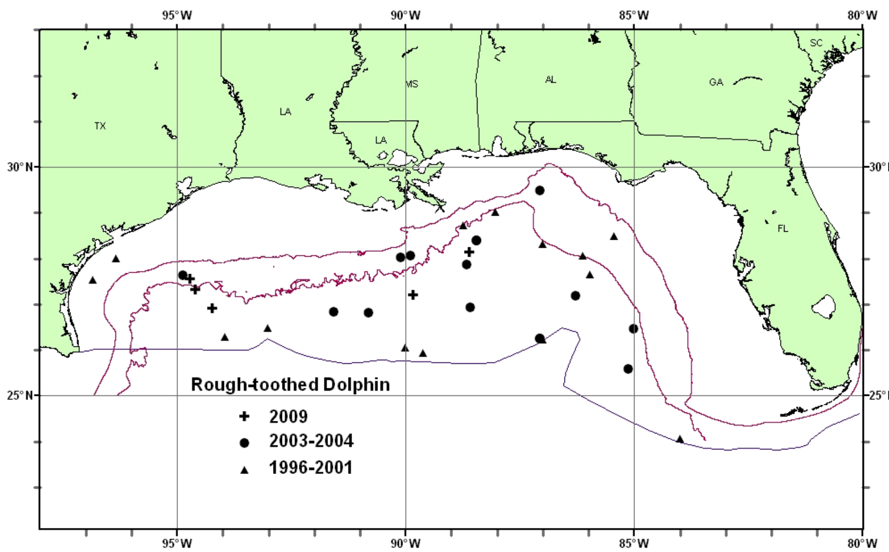

Figure 1. *Distribution of rough-toothed dolphin sightings from SEFSC vessel surveys during spring and fall 1996-2001, summer 2003 and spring 2004, and summer 2009. All the on-effort sightings are shown, though not all were used to estimate abundance. Solid lines indicate the 100-m and 1,000-m isobaths and the offshore extent of the U.S. EEZ.*

Earlier abundance estimates

Estimates of abundance were derived through the application of distance sampling analysis (Buckland *et al.* 2001) and the computer program DISTANCE (Thomas *et al.* 1998) to line-transect survey data. During summer 2003 and spring 2004, ship surveys dedicated to estimating cetacean abundance were conducted in oceanic waters along a grid of uniformly-spaced transect lines from a random start. The abundance estimate for rough-toothed dolphins in oceanic waters, pooled from 2003 to 2004, was 1,508 (CV=0.39) (Mullin 2007).

Please see Appendix IV for a summary of abundance estimates, including earlier estimates and survey descriptions.

Recent surveys and abundance estimates

During summer 2009, a line-transect shipboard survey dedicated to estimating the abundance of oceanic cetaceans was conducted in the northern Gulf of Mexico covering waters depths from the 200-m isobath to the seaward extent of the U.S. EEZ (Garrison 2016). Survey lines were stratified in relation to depth and the location of the Loop Current. In total, 4,600 km of trackline were surveyed using a single visual observation team. The abundance estimate for rough-toothed dolphins in oceanic waters during 2009 was 624 (CV=0.99; Table 1; Garrison 2016). This is the most reliable current estimate for the northern Gulf of Mexico but it is probably an underestimate. This estimate does not include Gulf of Mexico continental shelf waters where an estimate based on 1998–2001 surveys was over 1,000 rough-toothed dolphins (Fulling *et al.* 2003). There is not a recent estimate for continental shelf waters.

Table 1. Most recent abundance estimates (N_{best}) and coefficient of variation (CV) of rough-toothed dolphins in the northern Gulf of Mexico oceanic waters (200 m to the offshore extent of the EEZ) during spring/summer 2003–2004 and summer 2009.

Month/Year	**Area**	**N_{best}**	**CV**
Spring/Summer 2003–2004	Oceanic	1,508	0.39
Summer 2009	Oceanic	624	0.99

Minimum Population Estimate

The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normal distributed abundance estimate. This is equivalent to the 20th percentile of the log-normal distributed abundance estimate as specified by Wade and Angliss (1997). The best estimate of abundance for rough-toothed dolphins is 624 (CV=0.99). The minimum population estimate for northern Gulf of Mexico rough-toothed dolphins is 311.

Current Population Trend

A trend analysis has not been conducted for this stock. Two point estimates of rough-toothed dolphin abundance have been made based on data from oceanic surveys during 2003–2004 and 2009 (Table 1). The estimates vary by a factor of more than two. To determine whether changes in oceanic abundance have occurred over this period, an analysis of all the survey data needs to be conducted which incorporates covariates (e.g., survey conditions, season) that could potentially affect estimates. It should be noted that since this is a transboundary stock and the abundance estimates are for U.S. waters only, it will be difficult to interpret any detected trends. Additionally, the extent to which rough-toothed dolphins inhabit continental shelf waters and whether there is movement between these waters and oceanic waters needs to be resolved.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. For purposes of this assessment, the maximum net productivity rate was assumed to be 0.04. This value is based on theoretical modeling showing that cetacean populations may not grow at rates much greater than 4% given the constraints of their reproductive history (Barlow *et al.* 1995).

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of the minimum population size, one half the maximum net productivity rate and a recovery factor (MMPA Sec. 3.16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size is 311. The maximum productivity rate is 0.04, the default value for cetaceans. The recovery factor is 0.40 because the CV of the average mortality estimate is greater than 0.8 (Wade and Angliss 1997). PBR for the northern Gulf of Mexico rough-toothed dolphin is 2.5.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

The estimated mean annual fishery-related mortality and serious injury for this stock during 2010–2014 was 0.8 rough-toothed dolphins (CV=1.0; Table 2) due to interactions with the pelagic longline fishery.

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998; Andersen *et al*. 2008; NMFS 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fisheries Information

The commercial fishery that interacts, or that potentially could interact, with this stock in the Gulf of Mexico is the Atlantic Ocean, Caribbean, Gulf of Mexico large pelagics longline fishery (Appendix III). Pelagic swordfish, tunas and billfish are the targets of the large pelagics longline fishery operating in the northern Gulf of Mexico. For the 5-year period 2010–2014, the estimated annual combined serious injury and mortality attributable to the large pelagics longline fishery in the northern Gulf of Mexico was 0.8 (CV=1.0) rough-toothed dolphins (Table 2). During the second quarter of 2014, 2 serious injuries were observed (Garrison and Stokes 2016). There were no reports of mortality or serious injury to rough-toothed dolphins by this fishery in the northern Gulf of Mexico during 1998–2013 (Yeung 1999; Yeung 2001; Garrison 2003; Garrison and Richards 2004; Garrison 2005; Fairfield Walsh and Garrison 2006; Fairfield-Walsh and Garrison 2007; Fairfield and Garrison 2008; Garrison *et al.* 2009; Garrison and Stokes 2010; 2012a,b; 2013; 2014; 2016).

During the second quarters (15 April – 15 June) of 2010–2014, observer coverage in the Gulf of Mexico large pelagics longline fishery was greatly enhanced (approaching 55%) to collect more robust information on the interactions between pelagic longline vessels and spawning bluefin tuna. Therefore, the high annual observer coverage rates during 2010–2014 (Table 2) primarily reflect high coverage rates during the second quarter of each year. During the second quarter, this elevated coverage results in an increased probability that relatively rare interactions will be detected. Species within the oceanic Gulf of Mexico are presumed to be resident year-round; however, it is unknown if the bycatch rate observed during the second quarter is representative of that which occurs throughout the year.

Table 2. Summary of the incidental mortality and serious injury of northern Gulf of Mexico rough-toothed dolphins in the pelagic longline commercial fishery including the years sampled (Years), the number of vessels active within the fishery (Vessels), the type of data used (Data Type), the annual observer coverage (Observer Coverage), the annual observed serious injury and mortality recorded by on-board observers, the annual estimated serious injury and mortality, the combined annual estimates of serious injury and mortality (Estimated Combined Mortality), the estimated CV of the combined annual mortality estimates (Est. CVs) and the mean of the combined mortality estimates (CV in parentheses).

Fishery	Years	Vessels [a]	Data Type [b]	Observer Coverage [c]	Observed Serious Injury	Observed Mortality	Estimated Serious Injury	Estimated Mortality	Estimated Combined Mortality	Est. CVs	Mean Annual Mortality
Pelagic Longline	2010–2014	46, 42, 47, 47, 44	Obs. Data Logbook	.28, .18, .11, .25, .18	0, 0, 0, 0, 1	0, 0, 0, 0, 0	0, 0, 0, 0, 4.2	0, 0, 0, 0, 0	0, 0, 0, 0, 4.2	NA, NA, NA, NA, 1.00	0.8 (1.0)

[a] Number of vessels in the fishery is based on vessels reporting effort to the pelagic longline logbook.

[b] Observer data (Obs. Data) are used to measure bycatch rates, and the data are collected within the Northeast Fisheries Observer Program. Mandatory logbook data were used to measure total effort for the longline fishery. These data are collected at the Southeast Fisheries Science Center (SEFSC). Observer coverage in the GOM is dominated by very high coverage rates during April–June associated with efforts to improve estimates of bluefin tuna bycatch.

[c] Proportion of sets observed.

Other Mortality

There were 4 stranded rough-toothed dolphins in the northern Gulf of Mexico during 2010–2014 (NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 15 June 2015). No evidence of human interaction was detected for 2 stranded animals, and for the remaining 2, it could not be determined if there was evidence of human interaction. Stranding data probably underestimate the extent of human and fishery-related mortality and serious injury because not all of the dolphins that die or are seriously injured in human interactions wash ashore, or, if they do, they are not all recovered (Peltier *et al*. 2012; Wells *et al*. 2015).

Additionally, not all carcasses will show evidence of human interaction, entanglement or other fishery-related interaction due to decomposition, scavenger damage, etc. (Byrd *et al*. 2014). Finally, the level of technical expertise among stranding network personnel varies widely as does the ability to recognize signs of human interaction.

An Unusual Mortality Event (UME), involving primarily bottlenose dolphins, was declared for cetaceans in the northern Gulf of Mexico beginning 1 February 2010 and ending 31 July 2014 (Litz *et al.* 2014; http://www.nmfs.noaa.gov/pr/health/mmume/cetacean_gulfofmexico.htm, accessed 1 June 2016). Investigations to date have determined that the DWH oil spill is the primary underlying cause of the elevated stranding numbers in the northern Gulf of Mexico after the spill (e.g., Schwacke *et al.* 2014; Venn-Watson *et al.* 2015). During 2010–2014, 1 animal from this stock was considered to be part of the UME, a 2013 stranding in Destin, Florida.

HABITAT ISSUES

The DWH MC252 drilling platform, located approximately 50 miles southeast of the Mississippi River Delta in waters about 1500 m deep, exploded on 20 April 2010. The rig sank, and over 87 days up to ~4.9 million barrels of oil were discharged from the wellhead until it was capped on 15 July 2010 (McNutt *et al.* 2012). During the response effort dispersants were applied extensively at the seafloor and at the sea surface (Lehr *et al.* 2010; OSAT 2010). In-situ burning, or controlled burning of oil at the surface, was also used extensively as a response tool (Lehr *et al.* 2010). The oil, dispersant and burn residue compounds present ecological concerns (Buist *et al.* 1999; NOAA 2011). The magnitude of this oil spill was unprecedented in U.S. history, causing impacts to wildlife, natural habitats and human communities along coastal areas from western Louisiana to the Florida Panhandle (NOAA 2011). It could be years before the entire scope of damage is ascertained (NOAA 2011).

Shortly after the oil spill, the Natural Resource Damage Assessment (NRDA) process was initiated under the Oil Pollution Act of 1990. A variety of NRDA research studies are being conducted to determine potential impacts of the spill on marine mammals. These studies have focused on identifying the type, magnitude, severity, length and impact of oil exposure to oceanic, continental shelf, coastal and estuarine marine mammals. For continental shelf and oceanic cetaceans, the NOAA-led efforts include: aerial surveys to document the distribution, abundance, species and exposure relative to oil from the DWH spill; and ship surveys to evaluate exposure to oil and other chemicals and to assess changes in animal behavior and distribution relative to oil exposure through visual and acoustic surveys, deployment of passive acoustic monitoring systems, collection of tissue samples, and deployment of satellite-linked tags on sperm and Bryde's whales.

Vessel and aerial surveys documented common bottlenose dolphins, Atlantic spotted dolphins, rough-toothed dolphins, spinner dolphins, pantropical spotted dolphins, Risso's dolphins, striped dolphins, sperm whales, dwarf/pygmy sperm whales and a Cuvier's beaked whale swimming in oil or potentially oil-derived substances (e.g., sheen, mousse) in offshore waters of the northern Gulf of Mexico following the DWH oil spill. The effects of oil exposure on marine mammals depend on a number of factors including the type and mixture of chemicals involved, the amount, frequency and duration of exposure, the route of exposure (inhaled, ingested, absorbed, or external) and biomedical risk factors of the particular animal (Geraci 1990; Helm *et al.* 2015). In general, direct external contact with petroleum compounds or dispersants with skin may cause skin irritation, chemical burns and infections. Inhalation of volatile petroleum compounds or dispersants may irritate or injure the respiratory tract, which could lead to pneumonia or inflammation. Ingestion of petroleum compounds may cause injury to the gastrointestinal tract, which could affect an animal's ability to digest or absorb food. Absorption of petroleum compounds or dispersants may damage kidney, liver and brain function in addition to causing immune suppression and anemia. Long term chronic effects such as lowered reproductive success and decreased survival may occur (Geraci 1990; Helm *et al.* 2015).

STATUS OF STOCK

Rough-toothed dolphins are not listed as threatened or endangered under the Endangered Species Act, and the northern Gulf of Mexico stock is not considered strategic under the MMPA. Total fishery-related mortality and serious injury for this stock is not less than 10% of the calculated PBR and therefore cannot be considered to be insignificant and approaching zero mortality and serious injury rate. The status of rough-toothed dolphins in the northern Gulf of Mexico, relative to OSP, is unknown. There are insufficient data to determine the population trends for this stock.

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APPENDIX I: Estimated serious injury and mortality (SI&M) of Western North Atlantic marine mammals listed by U.S. observed fisheries. Marine mammal species with zero (0) observed SI&M are not shown in this table. (unk = unknown).

Category, Fishery, Species	Yrs. observed	observer coverage	Est. SI by Year (CV)	Est. Mortality by Year (CV)	Mean Annual Mortality (CV)	PBR
CATEGORY I						
Gillnet Fisheries: Northeast gillnet						
Harbor porpoise	2010-2014	.17, .19, .15, .11, .18		387(.27), 273(.20), 277(.59), 399(.33), 128(.27)	293(.17)	706
Atlantic white sided dolphin	2010-2014	.17, .19, .15, .11, .18	4, 1, 0, 0, 0	66(.9), 18(.43), 9(.92), 4(1.03), 10(.66)	21(.57)	304
Common dolphin	2010-2014	.17, .19, .15, .11, .18		69(.81), 49(.71), 95(.40), 104(.46), 111(.47)	83(.24)	557
Long-finned pilot whale	2010-2014	.17, .19, .15, .11, .18		3(.82), 0, 0, 0, 0	0.6(.82)	35
Risso's dolphin	2010-2014	.17, .19, .15, .11, .18		0, 0, 6(.87), 23(1.0), 0	5.8 (.79)	126
Bottlenose dolphin (offshore)	2010-2014	.17, .19, .15, .11, .18		0, 0, 0, 26(.95), 0	5.2(.95)	561
Harbor seal	2010-2014	.17, .19, .15, .11, .18		540(.25), 343(.19), 252(.26), 142(.31), 390(.39)	334 (.14)	2,006
Gray seal	2010-2014	.17, .19, .15, .11, .18		1155(.28), 1550(.22), 542(.19), 1127(.20), 917(.14)	1046(.10)	unk
Harp seal	2007-2011	.07, .05, .04, .17, .19		238(.38), 415(.27), 253(.61), 14(.46)	208(.21)	unk
Gillnet Fisheries:US Mid-Atlantic gillnet						
Harbor porpoise	2010-2014	.04, .02, .02, .03, .05		259(.88), 123(.41), 63(.83), 19(1.06), 22(1.03)	97(.05)	706
Common dolphin	2010-2014	.04, .02, .02, .03, .05		30(.48), 29(.53), 15(.93), 62(.67), 17(.86)	31(.33)	557
Harbor seal	2010-2014	.04, .02, .02, .03, .05		89(.39), 21(.67), 0, 0, 19(1.06)	26(.33)	2,006
Harp Seal	2007-2011	.05, .03, .03, .04, .02		176(.74), 70(.67), 32(.93), 0	63(.46)	unk
Gray Seal	2010-2014	.04, .02, .02, .03, .05		267(.75), 19(.60), 14(98), 0, 22(1.09)	64(.63)	unk
Longline Fisheries: Pelagic longline (excluding NED-E)						
Risso's dolphin	2010-2014	.08, .09, .07, .09, .10	0, 12(.63), 15 (1.0), 1.9(1.0), 7.7(1.0)	0, 0, 0, 0, 0	7.3(.52)	126
Short-finned pilot whale	2010-2014	.08, .09, .07, .09, .10	127(.78), 286 (.29), 170(.33), 124(.32), 233(.24)	0, 19, 0, 0, 0	192 (.17)	159
Long-finned pilot whale	2010-2014	08, .09, .07, .09, .10	0, 0, 0, 0, 9.6	0, 0, 0, 0, 0	1.9(.43)	35
Bottlenose dolphin (offshore)	2010-2014	.08, .09, .07, .09, .10	0,0, 61.8(.68), 0,0	0, 0, 0, 0, 0	12.4(.68)	561
Kogia spp.	2010-2014	.08, .09, .07, .09, .10	0, 17, 0, 0, 0	0, 0, 0, 0, 0	3.5(1.0)	21

Category, Fishery, Species	Yrs. observed	observer coverage	Est. SI by Year (CV)	Est. Mortality by Year (CV)	Mean Annual Mortality	PBR
CATEGORY II						
Mid-Atlantic Mid-Water Trawl – Including Pair Trawl						
Gray Seal	2010-2014	.25, .41, .21, .07, .05		na, 0, 0, 0, 0	0.2(na)	unk
Harbor Seal	2010-2014	.25, .41, .21, .07, .05		na, 0, 0, 0, 0	0.2(na)	2,006
Trawl Fisheries:Northeast bottom trawl						
Harp seal	2007-2011	.06, .08, .09, .16, .26		unk, 0, 0, 0, unk	unk	unk
Harbor seal	2010-2014	.16, .26, .17, .15, .17	0, 0, 0, 0, 0	0, 9(.58), 3(1), 4(.96), 11(.63)	4(.44)	2,006
Gray seal	2010-2014	.16, .26, .17, .15, .17		30(.34), 58(.25), 37(.49), 30(.37), 19(.45)	33(.17)	unk
Risso's dolphin	2010-2014	.16, .26, .17, .15, .17		2(.55), 3(.55), 0, 0, 4.2(.91)	1.8 (.47)	126
Bottlenose dolphin (offshore)	2010-2014	.16, .26, .17, .15, .17	0, 0, 0, 0, 0	4(.53),10(.84), 0, 0, 0	2.8(.62)	561
Long-finned pilot whale	2010-2014	.16, .26, .17, .15, .17	6, 12, 10, 0, 6,	30 (43), 55(.18), 33(.32), 16(.42), 25(.44)	33(.15)	35
Common dolphin	2010-2014	.16, .26, .17, .15, .17	3, 2, 0, 0, 0	111(.32), 70(.37), 40(.54), 17(.54), 17(.53)	52 (.2)	557
Atlantic white-sided dolphin	2010-2014	.16, .26, .17, .15, .17	1, 3, 0, 0, 0	36(.32), 138(.24), 27(.47), 33(.31), 16(.5)	51(.16)	304
Harbor porpoise	2010-2014	.16, .26, .17, .15, .17	0, 2, 0, 0, 0	0, 0, 3.9(.71), 0, 7(.98), 5.5(.86)	3.7(.51)	706
Mid-Atlantic Bottom Trawl						
Common dolphin	2010-2014	.06, .08, .05, .06, .08	1, 8, 7, 0, 0	20(.96), 263(.25), 316(.26), 269(.29), 329(.29)	243 (.14)	57
Atlantic white-sided dolphin	2010-2014	.06, .08, .05, .06, .08	0, 0, 0, 0, 0	0, 0, 0, 0, 9.7(.94)	1.9(.94)	304
Risso's dolphin	2010-2014	.06, .08, .05, .06, .08		54(.74), 62(.56), 7(1.0), 46(.71), 21(.93)	38 (.35)	126
Bottlenose dolphin (offshore)	2010-2014	.06, .08, .05, .06, .08	0, 0, 0, 0, 0	20(.34),34(.31), 16(1.0), 0, 25(.66)	19(.28)	561
Harbor seal	2010-2014	.06, .08, .05, .06, .08	0, 0, 0, 0, 0	11(1.1), 0, 23(1), 11(.96), 10(.95)	11(0.62)	2,006
Gray seal	2010-2014	.06, .08, .05, .06, .08	0, 0, 0, 0, 0	0, 25(.57) 30(1.1), 29(.67), 7(.96)	18(.45)	unk
Northeast Mid-Water Trawl Including Pair Trawl						
Long -finned pilot whale	2010-2014	.41, .17, .45, .37, .42	0, 0, 0, 0, 0	0, 1, 1, 3, 4	1.8(na)	35
Common dolphin	2010-2014	.41, .17, .45, .37, .42	0, 0, 0, 0, 0	1, 0, 1, 0, 0	0.4(na)	557
Harbor seal	2010-2014	.41, .17, .45, .37, .42	0, 0, 0, 0, 0	na, 0, na, 0, na	0.8(na)	2,006
Gray seal	2010-2014	.41, .17, .45, .37, .42	0, 0, 0, 0, 0	0, 0, na, na, 0	0.4(na)	unk
Minke whale	2010-2014	.41, .17, .45, .37, .42	0, 0, 0, 0, 0	0, 0, 0, na, 0	0.2(na)	14

Appendix II. Summary of the confirmed anecdotal human-caused mortality and serious injury (SI) events involving baleen whale stocks along the Gulf of Mexico Coast, US East Coast, and adjacent Canadian Maritimes, 2010–2014, with number of events attributed to entanglements or vessel collisions by year.

Stock	Mean annual mortality and SI rate (PBR[1] for reference)	Entanglements			Vessel Collisions		
		Annual rate (US waters / Canadian waters/unknown first sighted in US/unknown first sighted in Canada)	Confirmed mortalities (2010, 2011, 2012, 2013, 2014)	Confirmed SIs (2010, 2011, 2012, 2013, 2014)	Annual rate (US waters / Canadian waters/unknown first sighted in US/unknown first sighted in Canada)	Confirmed mortalities (2010, 2011, 2012, 2013, 2014)	Confirmed SIs (2010, 2011, 2012, 2013, 2014)
Western North Atlantic right whale *(Eubalaena glacialis)*	5.66 (1)	4.65 (0.40/ 0.00/ 2.5/ 1.75)	(3, 1, 2, 0, 2)	(1, 5, 2, 1, 7)	1.01 (0.81/ 0.00/ 0.20/ 0.00)	(1, 1, 0, 0, 0)	(0, 2, 1, 0, 0)
Gulf of Maine humpback whale *(Megaptera novaeangliae)*	9.05 (13)	7.25 (1.8/ 035/ 4.55/ 0.70)	(4, 0, 0, 2, 2)	(8, 9, 5, 2, 3)	1.8 (1.40/ 0.00/ 0.00/ 0.00)	(3, 3, 0, 2, 1)	0
Western North Atlantic fin whale *(Balaenoptera physalus)*	3.8 (2.5)	1.8 (0.20/ 0.80/ 0.8/ 0)	(0, 3, 0, 0, 1)	(0, 1, 2, 1, 0)	2.0 (2.00/ 0.00/ 0.00/ 0.00)	(2, 1, 4, 1, 2)	0
Nova Scotian sei whale *(B. borealis)*	0.8 (0.5)	0	0	0	0.8 (0.80/ 0.00/ 0.00/ 0.00)	(0, 1, 0, 0, 3)	0
Canadian East Coast minke whale *(B. acutorostrata)*	8.25 (14)	6.65 (1.90/ 2.5/ 2.25/ 0.00)	(2, 4, 6, 1, 3)	(2, 5, 7, 3, 1)	1.6 (1.2/ 0.4/ 0.00/ 0.00)	(1, 3, 1, 0, 3)	0

[1] Potential Biological Removal (PBR)

[2] Stock abundance estimates outdated; no PBR established for this stock.

Appendix III
Fishery Descriptions

This appendix is broken into two parts: Part A describes commercial fisheries that have documented interactions with marine mammals in the Atlantic Ocean; and Part B describes commercial fisheries that have documented interactions with marine mammals in the Gulf of Mexico. A complete list of all known fisheries for both oceanic regions, the List of Fisheries, is published in the *Federal Register* annually. Each part of this appendix contains three sections: I. data sources used to document marine mammal mortality/entanglements and commercial fishing effort trip locations, II. links to fishery descriptions for Category I, II and some category III fisheries that have documented interactions with marine mammals and their historical level of observer coverage, and III. historical fishery descriptions.

Part A. Description of U.S Atlantic Commercial Fisheries

I. Data Sources

Items 1-5 describe sources of marine mammal mortality, serious injury or entanglement data; items 6-9 describe the sources of commercial fishing effort data used to summarize different components of each fishery (i.e. active number of permit holders, total effort, temporal and spatial distribution) and generate maps depicting the location and amount of fishing effort.

1. Northeast Region Fisheries Observer Program (NEFOP)

In 1989 a Fisheries Observer Program was implemented in the Northeast Region (Maine-Rhode Island) to document incidental bycatch of marine mammals in the Northeast Region Multi-species Gillnet Fishery. In 1993 sampling was expanded to observe bycatch of marine mammals in Gillnet Fisheries in the Mid-Atlantic Region (New York-North Carolina). The Northeast Fisheries Observer Program (NEFOP) has since been expanded to sample multiple gear types in both the Northeast and Mid-Atlantic Regions for documenting and monitoring interactions of marine mammals, sea turtles and finfish bycatch attributed to commercial fishing operations. At sea observers onboard commercial fishing vessels collect data on fishing operations, gear and vessel characteristics, kept and discarded catch composition, bycatch of protected species, animal biology, and habitat (NMFS-NEFSC 2003).

2. Southeast Region Fishery Observer Programs

Three Fishery Observer Programs are managed by the Southeast Fisheries Science Center (SEFSC) that observe commercial fishery activity in U.S. Atlantic waters. The Pelagic Longline Observer Program (POP) administers a mandatory observer program for the U.S. Atlantic Large Pelagics Longline Fishery. The program has been in place since 1992 and randomly allocates observer effort by eleven geographic fishing areas proportional to total reported effort in each area and quarter. Observer coverage levels are mandated under the Highly Migratory Species Fisheries Management Plan (HMS FMP, 50 CFR Part 635). The second program is the Shark Gillnet Observer Program that observes the Southeastern U.S. Atlantic Shark Gillnet Fishery. The Observer Program is mandated under the HMS FMP, the Atlantic Large Whale Take Reduction Plan (ALWTRP) (50 CFR Part 229.32), and the Biological Opinion under Section 7 of the Endangered Species Act. Observers are deployed on any active fishing vessel reporting shark drift gillnet effort. In 2005, this program also began to observe sink gillnet fishing for sharks along the southeastern U.S. coast. The observed fleet includes vessels with an active directed shark permit and fish with sink gillnet gear (Carlson and Bethea 2007). The third program is the Southeastern Shrimp Otter Trawl Fishery Observer Program. Prior to 2007, this was a voluntary program administered by SEFSC in cooperation with the Gulf and South Atlantic Fisheries Foundation. The program was funding and project dependent, therefore observer coverage is not necessarily randomly allocated across the fishery. In 2007, the observer program was expanded, and it became mandatory for fishing vessels to take an observer if selected. The program now includes more systematic sampling of the fleet based upon reported landings and effort patterns. The total level of observer coverage for this program is approximately 1% of the total fishery effort. In each Observer Program, the observers record information on the total target species catch, the number and type of interactions with protected species (including both marine mammals and sea turtles), and biological information on species caught.

3. Regional Marine Mammal Stranding Networks

The Northeast and Southeast Region Stranding Networks are components of the Marine Mammal Health and Stranding Response Program (MMHSRP). The goals of the MMHSRP are to facilitate collection and dissemination of data, assess health trends in marine mammals, correlate health with other biological and environmental parameters, and coordinate effective responses to unusual mortality events (Becker *et al.* 1994). Since 1997, the Northeast Region Marine Mammal Stranding Network has been collecting and storing data on marine mammal strandings and entanglements that occur from Maine through Virginia. The Southeast Region Strandings Program is responsible for data collection and stranding response coordination along the Atlantic coast from North Carolina to Florida, along the U.S. Gulf of Mexico coast from Florida through Texas, and in the U.S. Virgin Islands and Puerto Rico. Prior to 1997, stranding and entanglement data were maintained by the New England Aquarium and the National Museum of Natural History, Washington, D.C. Volunteer participants, acting under a letter of agreement, collect data on stranded animals that include: species; event date and location; details of the event (i.e., signs of human interaction) and determination on cause of death; animal disposition; morphology; and biological samples. Collected data are reported to the appropriate Regional Stranding Network Coordinator and are maintained in regional and national databases.

4. Marine Mammal Authorization Program

Commercial fishing vessels engaging in Category I or II fisheries are automatically registered under the Marine Mammal Authorization Program (MMAP) in order to lawfully take a non-endangered/threatened marine mammal incidental to fishing operations. These fishermen are required to carry an Authorization Certificate onboard while participating in the listed fishery, must be prepared to carry a fisheries observer if selected, and must comply with all applicable take reduction plan regulations. All vessel owners, regardless of the category of fishery they are operating in, are required to report, within 48 hours of the incident and even if an observer has recorded the take, all incidental injuries and mortalities of marine mammals that have occurred as a result of fishing operations (NMFS-OPR 2003). Events are reported by fishermen on the Marine Mammal Mortality/Injury forms then submitted to and maintained by the NMFS Office of Protected Resources. The data reported include: captain and vessel demographics; gear type and target species; date, time and location of event; type of interaction; animal species; mortality or injury code; and number of interactions. Reporting forms are available online at http://www.nmfs.noaa.gov/pr/pdfs/interactions/mmap_reporting_form.pdf.

5. Other Data Sources for Protected Species Interactions/Entanglements/Ship Strikes

In addition to the above, data on fishery interactions/entanglements and vessel collisions with large cetaceans are reported from a variety of other sources including the New England Aquarium (Boston, Massachusetts); Provincetown Center for Coastal Studies (Provincetown, Massachusetts); U.S. Coast Guard; whale watch vessels; Canadian Department of Fisheries and Oceans (DFO)); and members of the Atlantic Large Whale Disentanglement Network. These data, photographs, etc. are maintained by the Protected Species Division at the Greater Atlantic Regional Fisheries Office (GARFO), the Protected Species Branch at the Northeast Fisheries Science Center (NEFSC) and the Southeast Fisheries Science Center (SEFSC).

6. Northeast Region Vessel Trip Reports

The Northeast Region Vessel Trip Report Data Collection System is a mandatory, but self-reported, commercial fishing effort database (Wigley *et al.* 1998). The data collected include: species kept and discarded; gear types used; trip location; trip departure and landing dates; port; and vessel and gear characteristics. The reporting of these data is mandatory only for vessels fishing under a federal permit. Vessels fishing under a federal permit are required to report in the Vessel Trip Report even when they are fishing within state waters.

7. Southeast Region Fisheries Logbook System

The Fisheries Logbook System (FLS) is maintained at the SEFSC and manages data submitted from mandatory Fishing Vessel Logbook Programs under several FMPs. In 1986 a comprehensive logbook program was initiated for the Large Pelagics Longline Fishery and this reporting became mandatory in 1992. Logbook reporting has also been initiated since the 1990s for a number of other fisheries including: Reef Fish Fisheries; Snapper-Grouper Complex Fisheries; federally managed Shark Fisheries; and King and Spanish Mackerel Fisheries. In each case, vessel captains are required to submit information on the fishing location, the amount and type of fishing gear used, the total amount of fishing effort (e.g., gear sets) during a given trip, the total weight and composition of the catch, and the disposition of the catch during each unit of effort (e.g., kept, released alive, released dead). FLS data are used to estimate the total amount of fishing effort in the fishery and thus expand bycatch rate estimates from observer data to estimates of the total incidental take of marine mammal species in a given fishery. More information is available at http://www.sefsc.noaa.gov/fisheries/logbook.htm.

8. Northeast Region Dealer Reported Data

The Northeast Region Dealer Database houses trip level fishery statistics on fish species landed by market category, vessel ID, permit number, port location and date of landing, and gear type utilized. The data are collected by both federally permitted seafood dealers and NMFS port agents. Data are considered to represent a census of both vessels actively fishing with a federal permit and total fish landings. It also includes vessels that fish with a state permit (excluding the state of North Carolina) that land a federally managed species. Some states submit the same trip level data to the Northeast Region, but contrary to the data submitted by federally permitted seafood dealers, the trip level data reported by individual states does not include unique vessel and permit information. Therefore, the estimated number of active permit holders reported within this appendix should be considered a minimum estimate. It is important to note that dealers were previously required to report weekly in a dealer call in system. However, in recent years the NER regional dealer reporting system has instituted a daily electronic reporting system. Although the initial reports generated from this new system did experience some initial reporting problems, these problems have been addressed and the new daily electronic reporting system is providing better real time information to managers.

9. Northeast At Sea Monitoring Program

At-sea monitors collect scientific, management, compliance, and other fisheries data onboard commercial fishing vessels through interviews of vessel captains and crew, observations of fishing operations, photographing catch, and measurements of selected portions of the catch and fishing gear. At-sea monitoring requirements are detailed under Amendment 16 to the NE Multispecies Fishery Management Plan with a planned implementation date of May 1st, 2010. At-sea monitoring coverage is an integral part of catch monitoring to ensure that Annual Catch Limits are not exceeded. At-sea monitors collect accurate information on catch composition and the data are used to estimate total discards by sectors (and common pool), gear type, and stock area. Coverage levels are expected around 30%.

II. Marine Mammal Protection Act's List of Fisheries

The List of Fisheries (LOF) classifies U.S. commercial fisheries into one of three Categories according to the level of incidental mortality or serious injury of marine mammals:

I. frequent incidental mortality or serious injury of marine mammals
II. occasional incidental mortality or serious injury of marine mammals
III. remote likelihood of/no known incidental mortality or serious injury of marine mammals

The Marine Mammal Protection Act (MMPA) mandates that each fishery be classified by the level of mortality or serious injury and mortality of marine mammals that occurs incidental to each fishery as reported in the annual Marine Mammal Stock Assessment Reports for each stock. A fishery may qualify as one Category for one marine mammal stock and another Category for a different marine mammal stock. A fishery is typically categorized on the LOF according to its highest level of classification (e.g., a fishery that qualifies for Category III for one marine mammal stock and Category II for another marine mammal stock will be listed under Category II). The fisheries listed below are linked to classification based on the most current LOF published in the *Federal Register*.

III. U.S Atlantic Commercial Fisheries

Northeast Sink Gillnet:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/ne_sink_gillnet.html
Northeast Anchored Float Gillnet Fishery:
http://www.nmfs.noaa.gov/pr/pdfs/fisheries/lof2012/northeast_anchored_float_gillnet.pdf
Northeast Drift Gillnet Fishery:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/ne_dgn.htmlMid-Atlantic Gillnet:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/midatl_gillnet.html
Mid-Atlantic Bottom Trawl:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/ma_bottom_trawl.htmlNortheast Bottom Trawl:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/ne_bottom_trawl.htmlNortheast Mid-Water Trawl Fishery (includes pair trawls): http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/ne_mw_trawl.html
Mid-Atlantic Mid-Water Trawl Fishery (includes pair trawls):
http://www.nmfs.noaa.gov/pr/pdfs/fisheries/lof2014/mid-atlantic-mid-water-trawl.pdf

Bay of Fundy Herring Weir
Gulf of Maine Atlantic Herring Purse Seine Fishery:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/GME_Atlantic_herring_purse_seine.html
Northeast/Mid-Atlantic American Lobster Trap/Pot:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/ne_ma_lobster_trap_pot.html
Atlantic Mixed Species Trap/Pot Fishery:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/atl_mixed_trap_pot.htmlAtlantic Ocean, Caribbean, Gulf of Mexico Large Pelagics Longline:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/ao_car_gmx_pelagics_longline.html
Southeast Atlantic Gillnet:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/se_atl_gn.htmlSoutheastern U.S. Atlantic Shark Gillnet Fishery:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/se_shark_gn.html
Atlantic Blue Crab Trap/Pot:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/se_bluecrab_trap_pot.htmlMid-Atlantic Haul/Beach Seine:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/ma_haul_beachseine.html
North Carolina Inshore Gillnet Fishery:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/nc_inshore_gn.htmlNorth Carolina Long Haul Seine”
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/nc_longhaulseine.html
North Carolina Roe Mullet Stop Net:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/nc_roemullet_stopnet.htmlVirginia Pound Net:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/va_poundnet.htmlMid-Atlantic Menhaden Purse Seine:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/ma_men_purse_seine.htmlSoutheastern U.S. Atlantic/Gulf of Mexico Shrimp Trawl:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/segom_shrimp_trawl.html
Southeastern U.S. Atlantic, Gulf of Mexico Stone Crab Trap/Pot Fishery:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/segom_stonecrab_trap_pot.html

IV. Historical Fishery Descriptions

Atlantic Foreign Mackerel

Prior to 1977, there was no documentation of marine mammal bycatch in DWF activities off the Northeast coast of the U.S. With implementation of the Magnuson Fisheries Conservation and Management Act (MFCMA) in that year, an Observer Program was established which recorded fishery data and information on incidental bycatch of marine mammals. DWF effort in the U.S. Atlantic Exclusive Economic Zone (EEZ) under MFCMA had been directed primarily towards Atlantic Mackerel and Squid. From 1977 through 1982, an average mean of 120 different foreign vessels per year (range 102-161) operated within the U.S. Atlantic EEZ. In 1982, there were 112 different foreign vessels; 16%, or 18, were Japanese Tuna longline vessels operating along the U.S. east coast. This was the first year that the Northeast Regional Observer Program assumed responsibility for observer coverage of the longline vessels. Between 1983 and 1991, the numbers of foreign vessels operating within the U.S. Atlantic EEZ each year were 67, 52, 62, 33, 27, 26, 14, 13, and 9 respectively. Between 1983 and 1988, the numbers of DWF vessels included 3, 5, 7, 6, 8, and 8 respectively, Japanese longline vessels. Observer coverage on DWF vessels was 25-35% during 1977-1982, and increased to 58%, 86%, 95% and 98%, respectively, in 1983-1986. One hundred percent observer coverage was maintained during 1987-1991. Foreign fishing operations for Squid ceased at the end of the 1986 fishing season and for Mackerel at the end of the 1991 season. Documented interactions with white sided dolphins were reported in this fishery.

Pelagic Drift Gillnet

In 1996 and 1997, NMFS issued management regulations which prohibited the operation of this fishery in 1997. The fishery operated during 1998. Then, in January 1999 NMFS issued a Final Rule to prohibit the use of drift net gear in the North Atlantic Swordfish Fishery (50 CFR Part 630). In 1986, NMFS established a mandatory self-reported fisheries information system for Large Pelagic Fisheries. Data files are maintained at the SEFSC. The estimated total number of hauls in the Atlantic Pelagic Drift Gillnet Fishery increased from 714 in 1989 to 1,144 in 1990; thereafter, with the introduction of quotas, effort was severely reduced. The estimated number of hauls from 1991 to 1996 was 233, 243, 232, 197, 164, and 149 respectively. Fifty-nine different vessels participated in this fishery at one time or another between 1989 and 1993. In 1994 to 1998 there were 11, 12, 10, 0, and 11 vessels, respectively, in the fishery. Observer coverage, expressed as percent of sets observed, was 8% in 1989, 6% in 1990, 20% in 1991, 40% in 1992, 42% in 1993, 87% in 1994, 99% in 1995, 64% in 1996, no fishery in 1997, and 99% coverage during 1998. Observer coverage dropped during 1996 because some vessels were deemed too small or unsafe by the contractor that provided observer coverage to NMFS. Fishing effort was concentrated along the southern edge of Georges Bank and off Cape Hatteras, North Carolina. Examination of the species composition of the catch and locations of the fishery throughout the year suggest that the Drift Gillnet Fishery was stratified into two strata: a southern, or winter, stratum and a northern, or summer, stratum. Documented interactions with North Atlantic right whales, humpback whales, sperm whales, pilot whale spp., Mesoplodon spp., Risso's dolphins, common dolphins, striped dolphins and white sided dolphins were reported in this fishery.

Atlantic Tuna Purse Seine

The Tuna Purse Seine Fishery occurring between the Gulf of Maine and Cape Hatteras, North Carolina is directed at large medium and giant Bluefin Tuna (BFT). Spotter aircraft are typically used to locate fish schools. The official start date, set by regulation, is 15 July of each year. Individual Vessel Quotas (IVQs) and a limited access system prevent a derby fishery situation. Catch rates for large medium and giant Tuna can be high and consequently, the season can last only a few weeks, however, over the last number of years, effort expended by this sector of the BFT fishery has diminished dramatically due to the unavailability of BFT on the fishing grounds.

The regulations allocate approximately 18.6% of the U.S. BFT quota to this sector of the fishery (5 IVQs) with a tolerance limit established for large medium BFT (15% by weight of the total amount of giant BFT landed.

Limited observer data is available for the Atlantic Tuna Purse Seine Fishery. Out of 45 total trips made in 1996, 43 trips (95.6%) were observed. Forty-four sets were made on the 43 observed trips and all sets were observed. A total of 136 days were covered. No trips were observed during 1997 through 1999. Two trips (seven hauls) were observed in October 2000 in the Great South Channel Region. Four trips were observed in September 2001. No marine mammals were observed taken during these trips. Documented interactions with pilot whale spp. were reported in this fishery.

Atlantic Tuna Pelagic Pair Trawl

The Pelagic Pair Trawl Fishery operated as an experimental fishery from 1991 to 1995, with an estimated 171 hauls in 1991, 536 in 1992, 586 in 1993, 407 in 1994, and 440 in 1995. This fishery ceased operations in 1996 when NMFS rejected a petition to consider pair trawl gear as an authorized gear type in the Atlantic Tuna Fishery. The fishery operated from August to November in 1991, from June to November in 1992, from June to October in 1993 (Northridge 1996), and from mid-summer to December in 1994 and 1995. Sea sampling began in October of 1992 (Gerrior *et al.* 1994) where 48 sets (9% of the total) were sampled. In 1993, 102 hauls (17% of the total) were sampled. In 1994 and 1995, 52% (212) and 55% (238), respectively, of the sets were observed. Nineteen vessels have operated in this fishery. The fishery operated in the area between 35N to 41N and 69W to 72W. Approximately 50% of the total effort was within a one degree square at 39N, 72W, around Hudson Canyon, from 1991 to 1993. Examination of the 1991-1993 locations and species composition of the bycatch, showed little seasonal change for the six months of operation and did not warrant any seasonal or areal stratification of this fishery (Northridge 1996). During the 1994 and 1995 Experimental Pelagic Pair Trawl Fishing Seasons, fishing gear experiments were conducted to collect data on environmental parameters, gear behavior, and gear handling practices to evaluate factors affecting catch and bycatch (Goudy 1995, 1996), but the results were inconclusive. Documented interactions with pilot whale spp., Risso's dolphin and common dolphins were reported in this fishery.

Part B. Description of U.S. Gulf of Mexico Fisheries

I. Data Sources

Items 1 and 2 describe sources of marine mammal mortality, serious injury or entanglement data, and item 3 describes the source of commercial fishing effort data used to generate maps depicting the location and amount of fishing effort and the numbers of active permit holders. In general, commercial fisheries in the Gulf of Mexico have had little directed observer coverage and the level of fishing effort for most fisheries that may interact with marine mammals is either not reported or highly uncertain.

1. Southeast Region Fishery Observer Programs

Two fishery observer programs are managed by the SEFSC that observe commercial fishery activity in the U.S. Gulf of Mexico. The Pelagic Longline Observer Program (POP) administers a mandatory observer program for the U.S. Atlantic Large Pelagics Longline Fishery. The program has been in place since 1992, and randomly allocates observer effort by eleven geographic fishing areas proportional to total reported effort in each area and quarter. Observer coverage levels are mandated under the Highly Migratory Species FMP (HMS FMP, 50 CFR Part 635). The second is the Southeastern Shrimp Otter Trawl Fishery Observer Program. Prior to 2007, this was a voluntary program administered by SEFSC in cooperation with the Gulf and South Atlantic Fisheries Foundation. The program was funding and project dependent, therefore observer coverage is not necessarily randomly allocated across the fishery. In 2007, the observer program was expanded, and it became mandatory for fishing vessels to take an observer if selected. The program now includes more systematic sampling of the fleet based upon reported landings and effort patterns. The total level of observer coverage for this program is ~ 1% of the total fishery effort. In each Observer Program, the observers record information on the total target species catch, the number and type of interactions with protected species (including both marine mammals and sea turtles), and biological information on species caught. In each Observer Program, the observers record information on the total target species catch, the number and type of interactions with protected species including both marine mammals and sea turtles, and biological information on species caught.

2. Regional Marine Mammal Stranding Networks

The Southeast Regional Stranding Network is a component of the Marine Mammal Health and Stranding Response Program (MMHSRP). The goals of the MMHSRP are to facilitate collection and dissemination of data, assess health trends in marine mammals, correlate health with other biological and environmental parameters, and coordinate effective responses to unusual mortality events (Becker *et al.* 1994). The Southeast Region Strandings Program is responsible for data collection and stranding response coordination along the U.S. Gulf of Mexico coast from Florida through Texas. Prior to 1997, stranding and entanglement data were maintained by the New England Aquarium and the National Museum of Natural History, Washington, D.C. Volunteer participants, acting under a letter of agreement with NOAA Fisheries, collect data on stranded animals that include: species; event date and location; details of the event including evidence of human interactions; determinations of the cause of death; animal disposition; morphology; and biological samples. Collected data are reported to the appropriate Regional Stranding Network Coordinator and are maintained in regional and national databases.

3. Southeast Region Fisheries Logbook System

The FLS is maintained at the SEFSC and manages data submitted from mandatory fishing vessel logbook programs under several FMPs. In 1986, a comprehensive logbook program was initiated for the Large Pelagics Longline Fisheries, and this reporting became mandatory in 1992. Logbook reporting has also been initiated since the early 1990s for a number of other fisheries including: reef fish fisheries; snapper-grouper complex fisheries; federally managed shark fisheries; and king and Spanish mackerel fisheries. In each case, vessel captains are required to submit information on the fishing location, the amount and type of fishing gear used, the total amount of fishing effort (e.g., gear sets) during a given trip, the total weight and composition of the catch, and the disposition of the catch during each unit of effort (e.g., kept, released alive, released dead). FLS data are used to estimate the total amount of fishing effort in the fishery and thus expand bycatch rate estimates from observer data to estimates of the total incidental take of marine mammal species in a given fishery.

4. Marine Mammal Authorization Program

Commercial fishing vessels engaging in Category I or II fisheries are automatically registered under the Marine Mammal Authorization Program (MMAP) in order to lawfully take a non-endangered/threatened marine mammal incidental to fishing operations. These fishermen are required to carry an Authorization Certificate onboard while participating in the listed fishery, must be prepared to carry a fisheries observer if selected, and must comply with all applicable take reduction plan regulations.. All vessel owners, regardless of the category of fishery they are operating in, are required to report, within 48 hours of the incident even if an observer has recorded the take, all incidental injuries and mortalities of marine mammals that have occurred as a result of fishing operations (NMFS-OPR 2003). Events are reported by fishermen on the Marine Mammal Mortality/Injury forms then submitted to and maintained by the NMFS Office of Protected Resources. The data reported include: captain and vessel demographics; gear type and target species; date, time and location of event; type of interaction; animal species; mortality or injury code; and number of interactions. Reporting forms are available online at http://www.nmfs.noaa.gov/pr/pdfs/interactions/mmap_reporting_form.pdf.

II. Gulf of Mexico Commercial Fisheries

Spiny Lobster Trap/Pot Fishery:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/FL_spiny_lobster_trap_pot.html
Southeastern U.S. Atlantic, Gulf of Mexico Stone Crab Trap/Pot Fishery:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/segom_stonecrab_trap_pot.htmlGulf of Mexico Menhaden Purse Seine Fishery:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/gom_men_purseseine.htmlGulf of Mexico Gillnet Fishery:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/gom_gn.html

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http://www.nmfs.noaa.gov/prot_res/PR2/Fisheries_Interactions/MMAP.html.
accessed on 11/05/2003

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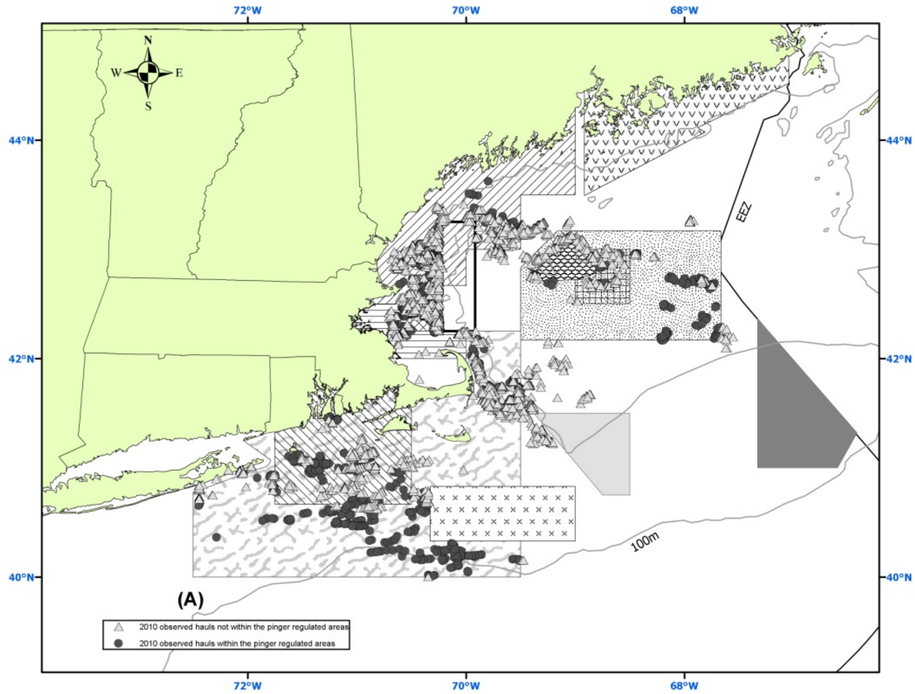
Appendix III: Fishery Descriptions - List of Figures

Figure 1. 2010 Northeast sink gillnet observed hauls (A) and observed takes (B).



Multispecies Fisheries Management Plan year-round closures:

Closed Area 1 · Closed Area 2 · Western Gulf of Maine Closed Area · Nantucket Lightship Closed Area · Cashes Ledge Closure

Harbor porpoise Take Reduction Plan management areas:

Offshore Closure · Northeast Closure · MidCoast Closure · Mass Bay Closure · Cape Cod South Closure · Cashes Ledge Closure

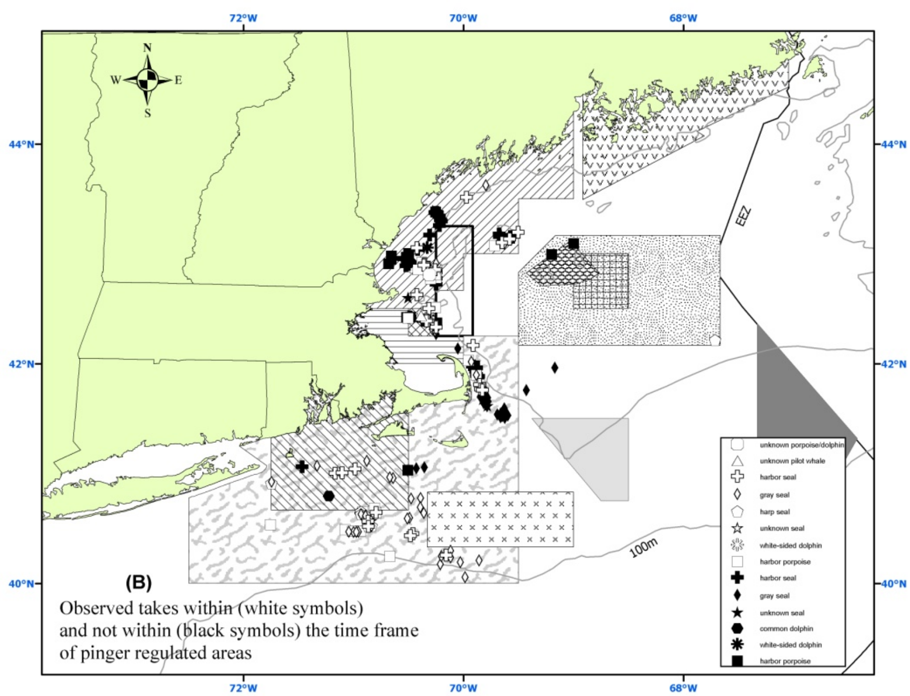
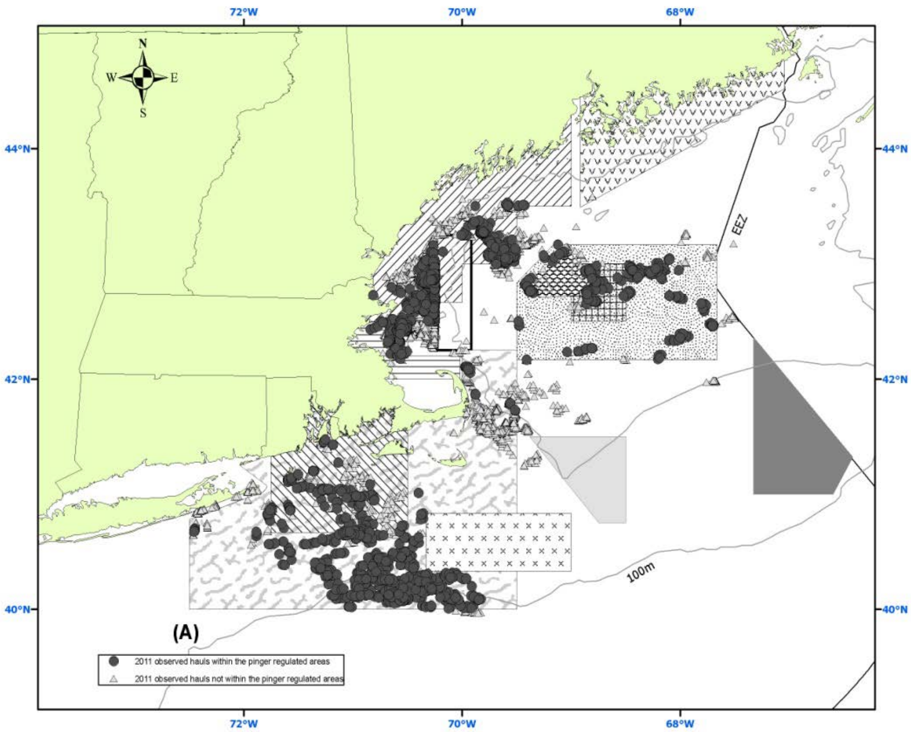


Figure 2. 2011 Northeast sink gillnet observed hauls (A) and observed takes (B).



Multispecies Fisheries Management Plan year-round closures:

Closed Area 1 | Closed Area 2 | Western Gulf of Maine Closed Area | Nantucket Lightship Closed Area | Cashes Ledge Closure

Harbor porpoise Take Reduction Plan management areas:

Offshore Closure | Northeast Closure | MidCoast Closure | Mass Bay Closure | Cape Cod South Closure | Cashes Ledge Closure

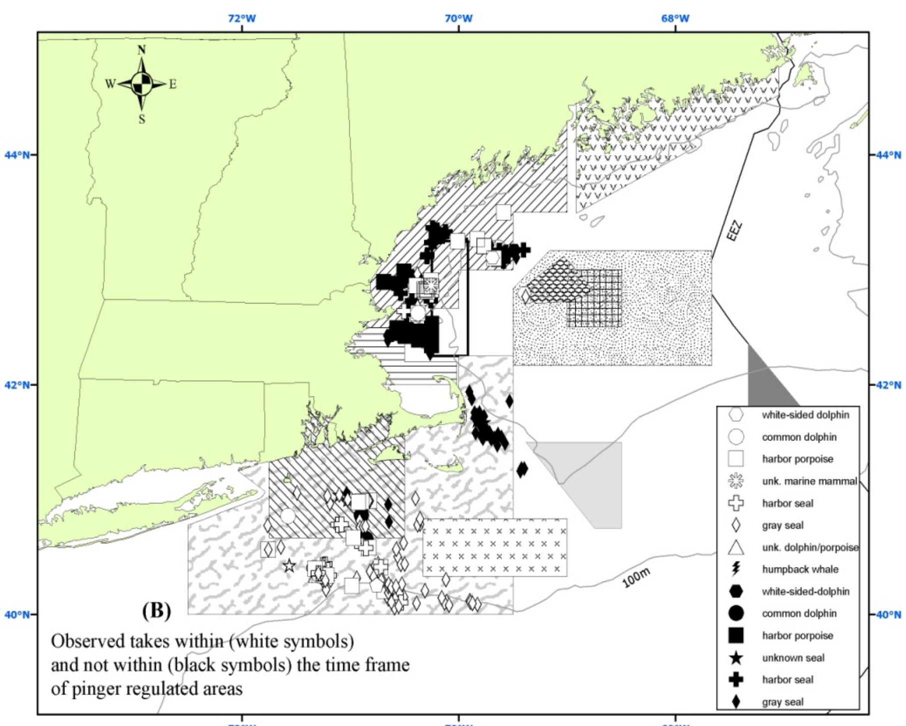
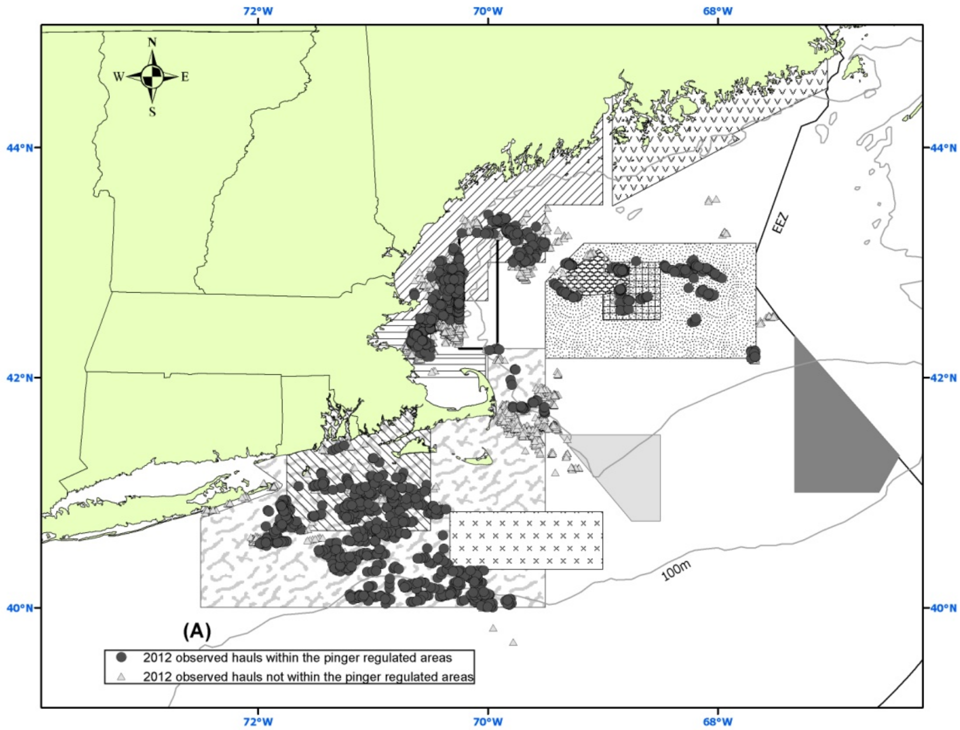


Figure 3. 2012 Northeast sink gillnet observed hauls (A) and observed takes (B).



Multispecies Fisheries Management Plan year-round closures:

Closed Area 1 | Closed Area 2 | Western Gulf of Maine Closed Area | Nantucket Lightship Closed Area | Cashes Ledge Closure

Harbor porpoise Take Reduction Plan management areas:

Offshore Closure | Northeast Closure | MidCoast Closure | Mass Bay Closure | Cape Cod South Closure | Cashes Ledge Closure

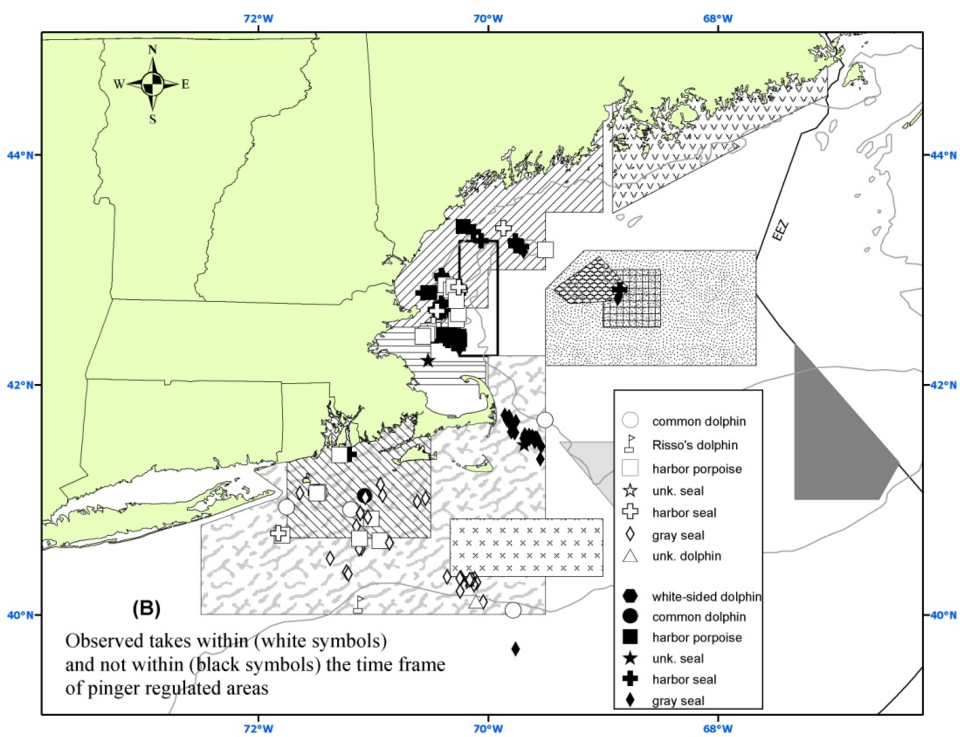
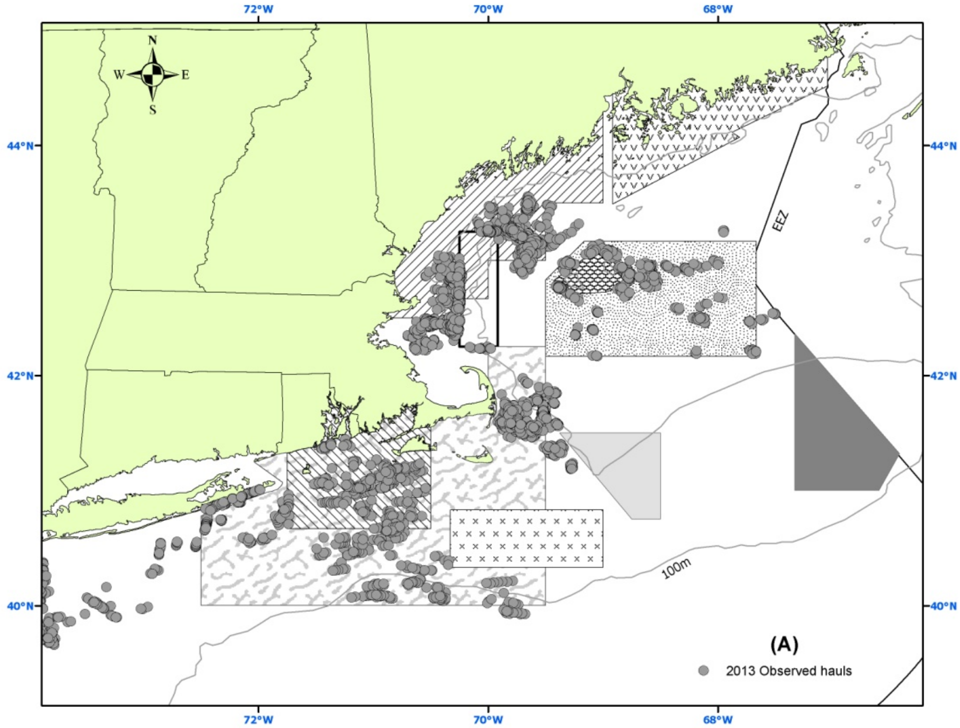


Figure 4. 2013 Northeast sink gillnet observed hauls (A) and observed takes (B).



Multispecies Fisheries Management Plan year-round closures:

Closed Area 1 | Closed Area 2 | Western Gulf of Maine Closed Area | Nantucket Lightship Closed Area | Cashes Ledge Closure

Harbor porpoise Take Reduction Plan management areas:

Offshore Closure | Northeast Closure | MidCoast Closure | Mass Bay Closure | Cape Cod South Closure | Cashes Ledge Closure

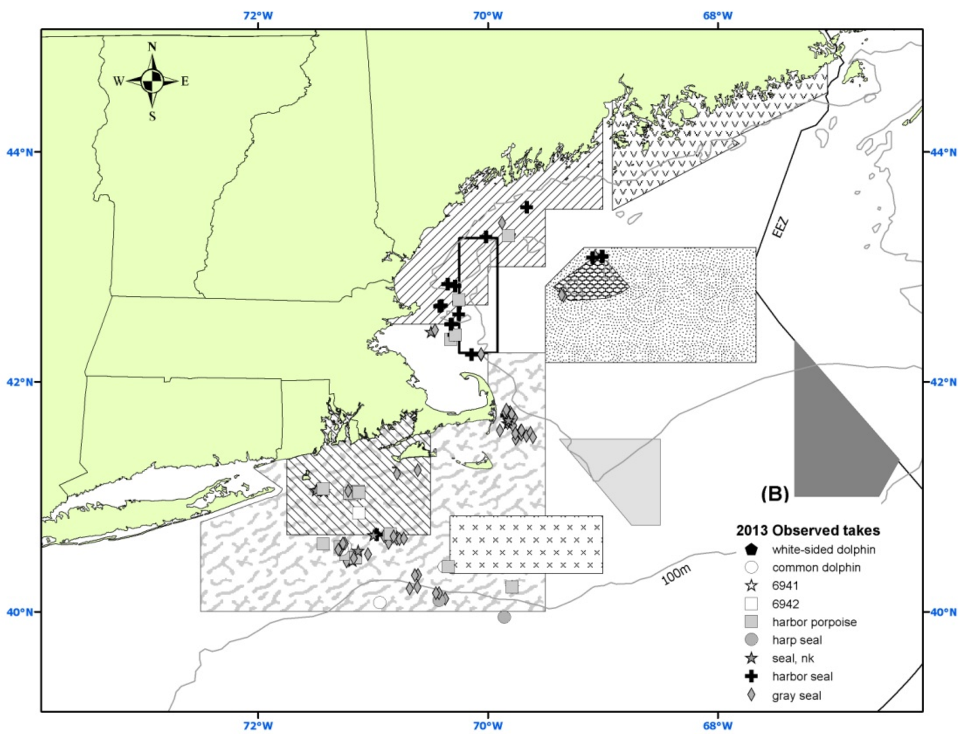
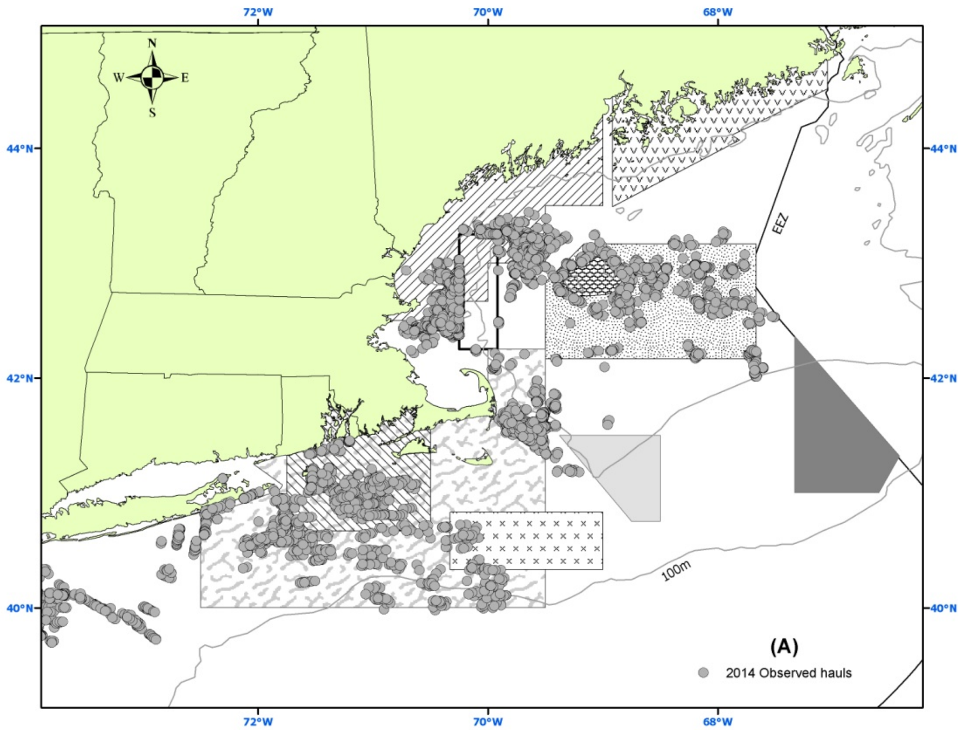


Figure 5. 2014 Northeast sink gillnet observed hauls (A) and observed takes (B).



Multispecies Fisheries Management Plan year-round closures:

Closed Area 1 | Closed Area 2 | Western Gulf of Maine Closed Area | Nantucket Lightship Closed Area | Cashes Ledge Closure

Harbor porpoise Take Reduction Plan management areas:

Offshore Closure | Northeast Closure | MidCoast Closure | Mass Bay Closure | Cape Cod South Closure | Cashes Ledge Closure

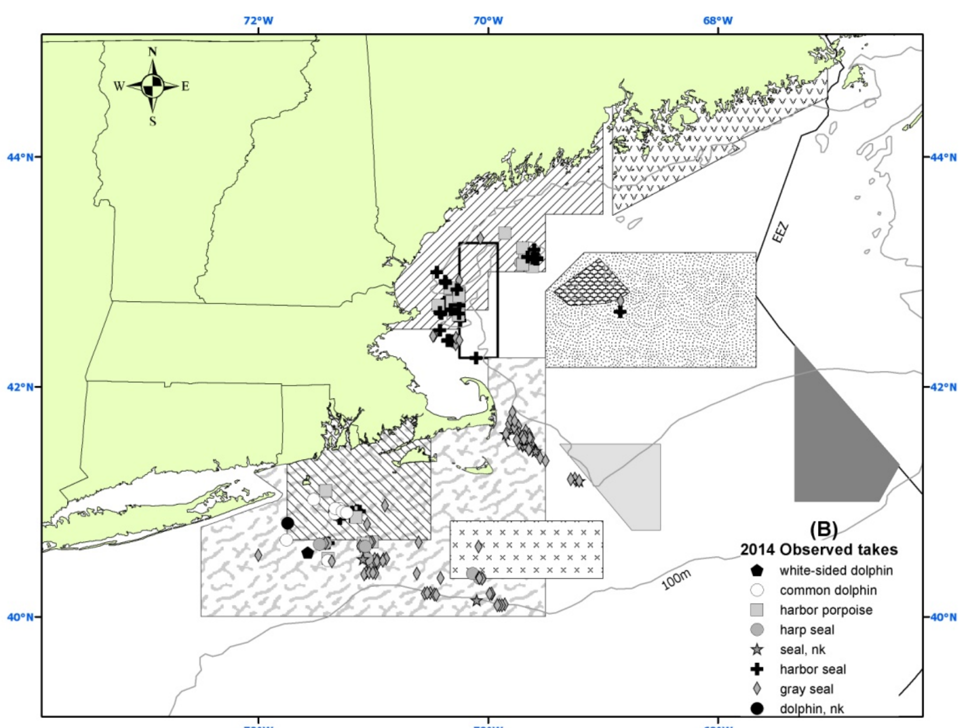
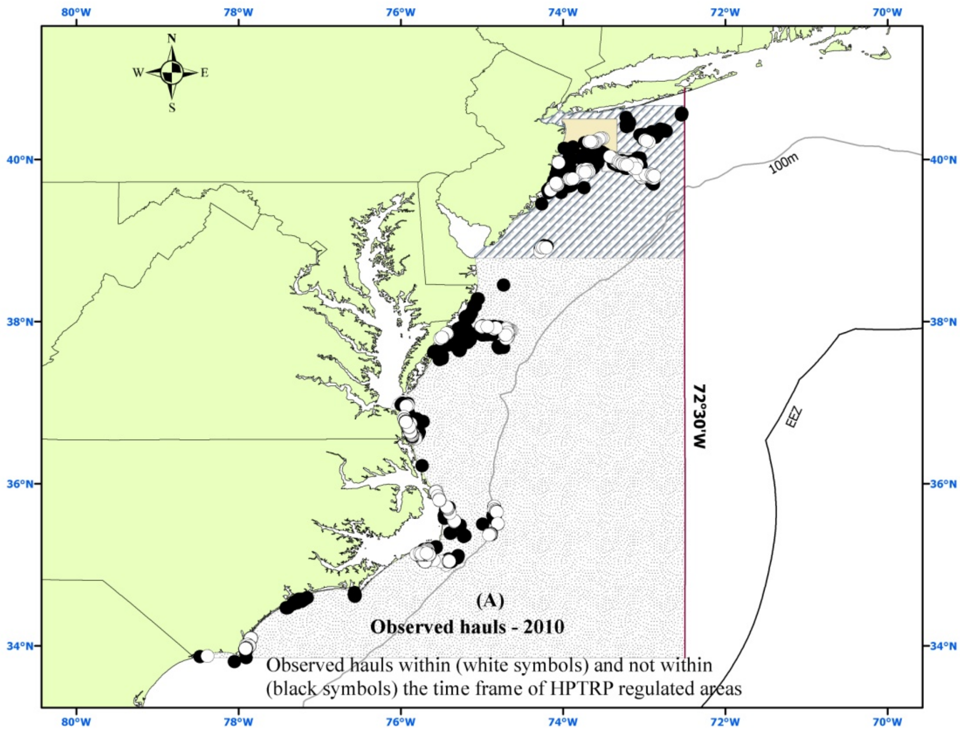


Figure 6. 2010 Mid-Atlantic gillnet observed hauls (A) and observed takes (B).



Harbor porpoise Take Reduction Plan management areas:

Southern mid-Atlantic waters   New Jersey Mudhole   waters off New Jersey

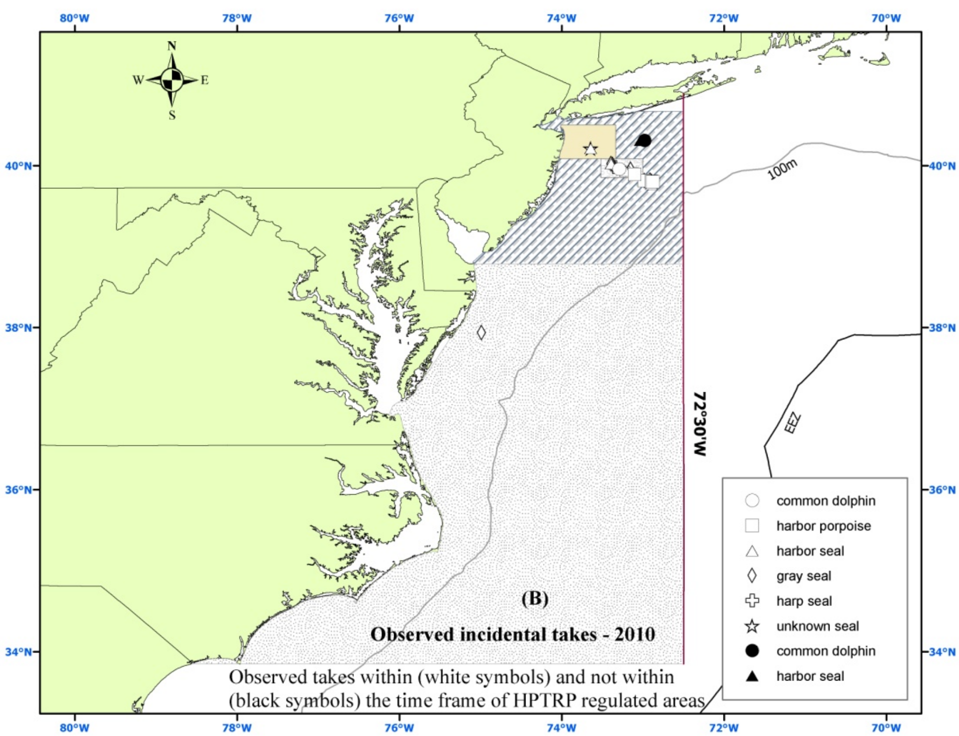
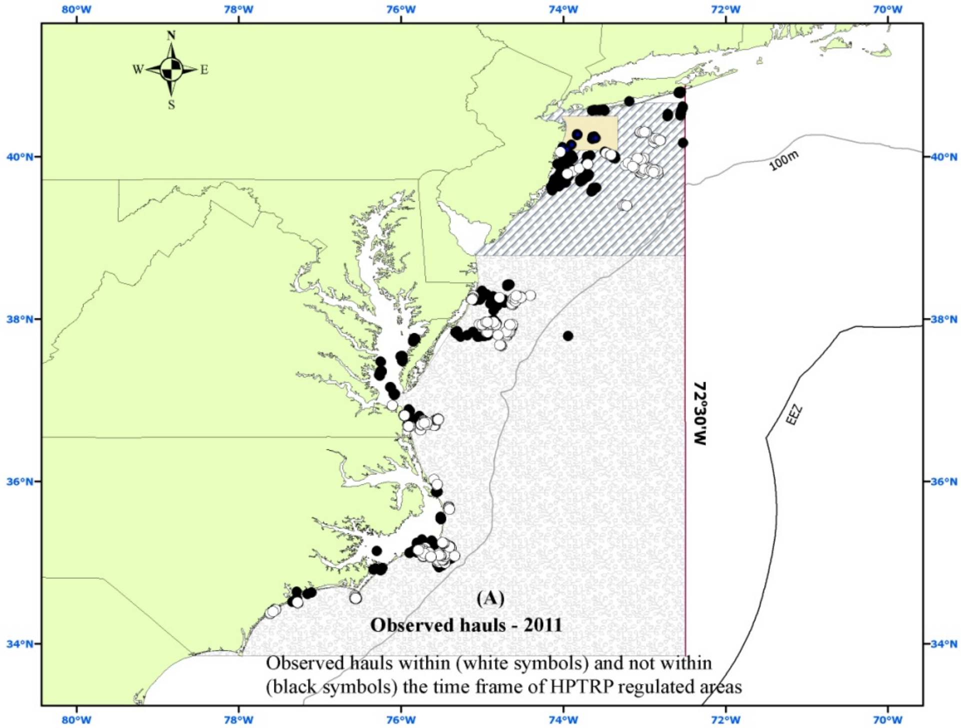


Figure 7. 2011 Mid-Atlantic gillnet observed hauls (A) and observed takes (B).



Harbor porpoise Take Reduction Plan management areas:

Southern mid-Atlantic waters | New Jersey Mudhole | waters off New Jersey

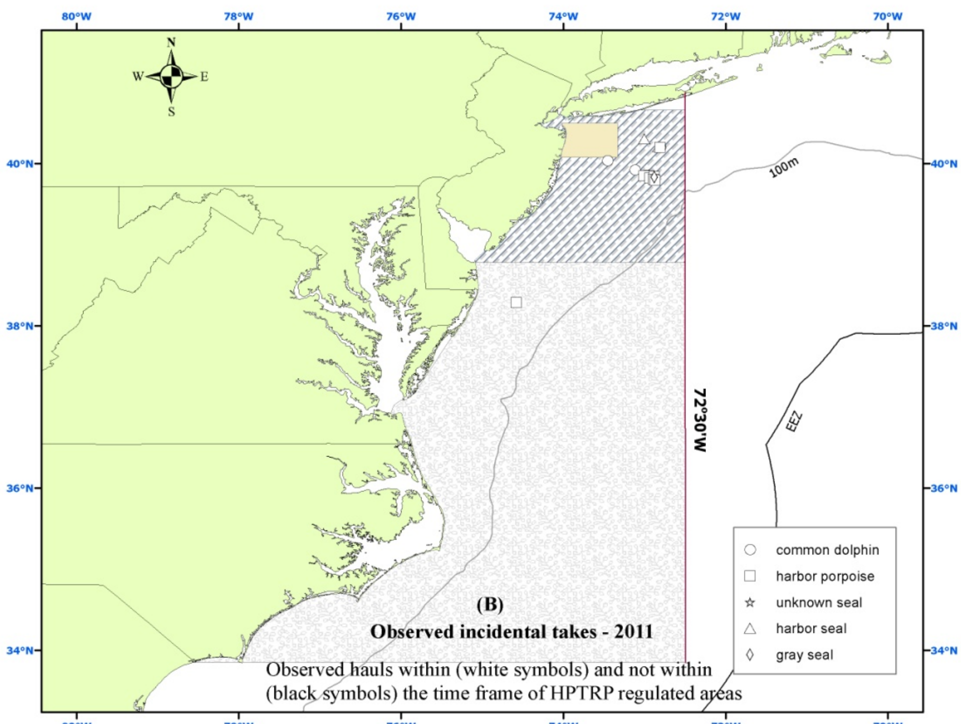
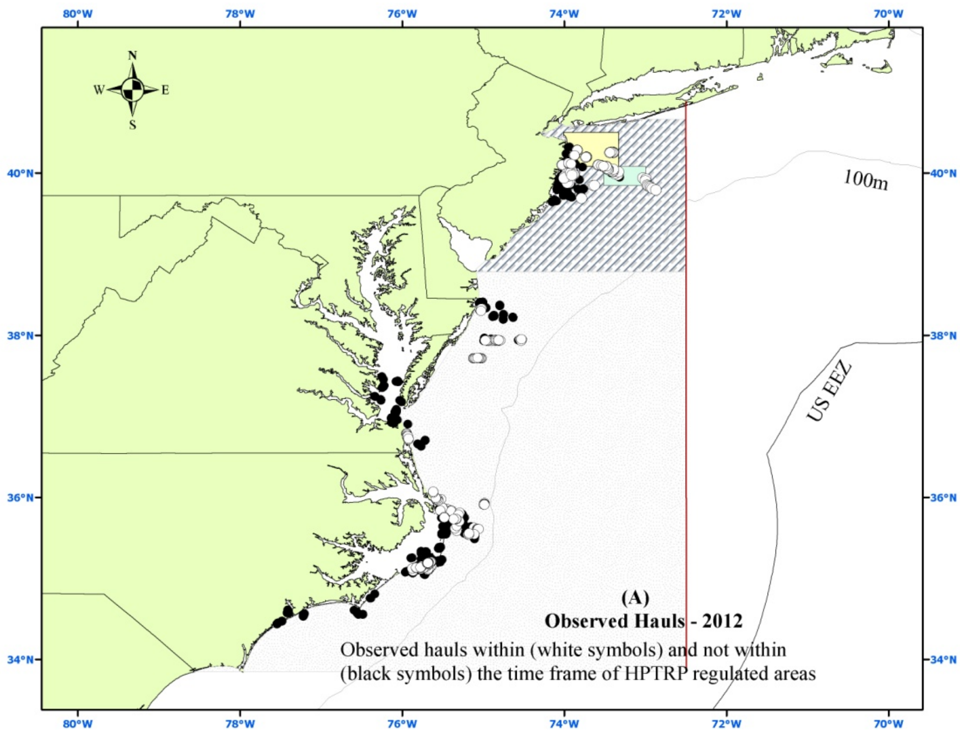


Figure 8. 2012 Mid-Atlantic gillnet observed hauls (A) and observed takes (B).



Harbor porpoise Take Reduction Plan management areas:

Southern mid-Atlantic waters | New Jersey Mudhole | waters off New Jersey

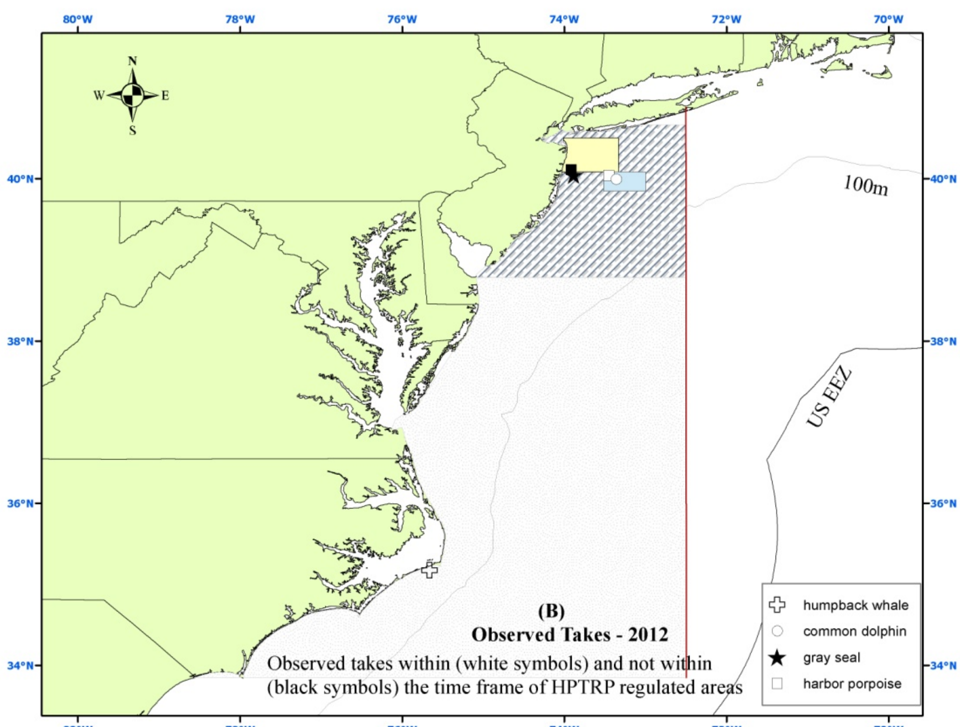
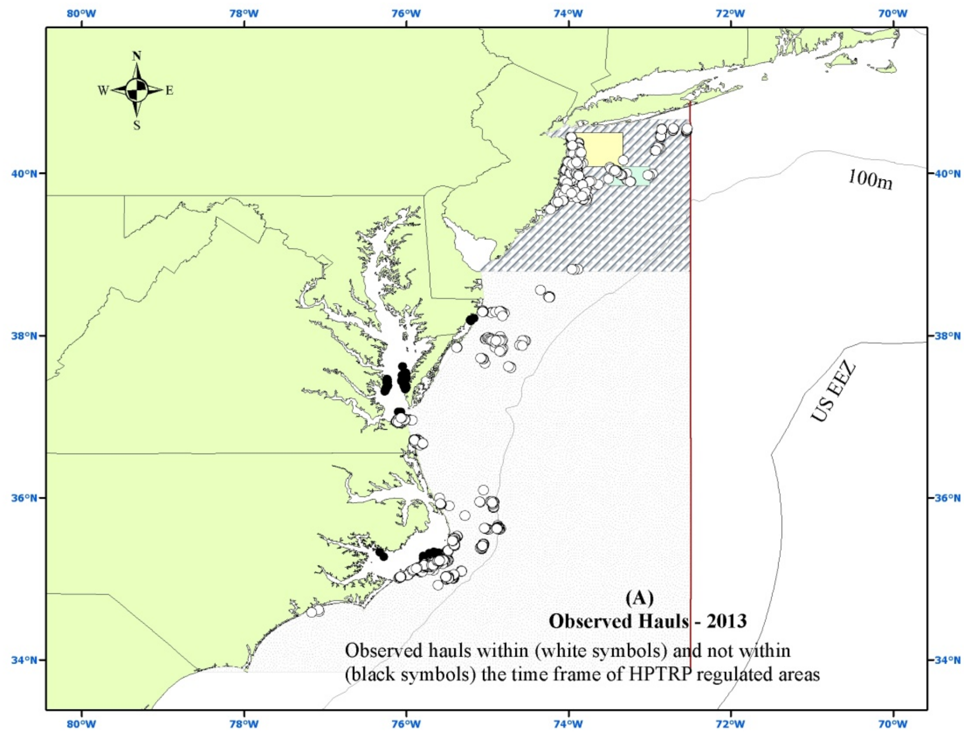


Figure 9. 2013 Mid-Atlantic gillnet observed hauls (A) and observed takes (B).



Harbor porpoise Take Reduction Plan management areas:

Southern mid-Atlantic waters | New Jersey Mudhole | waters off New Jersey

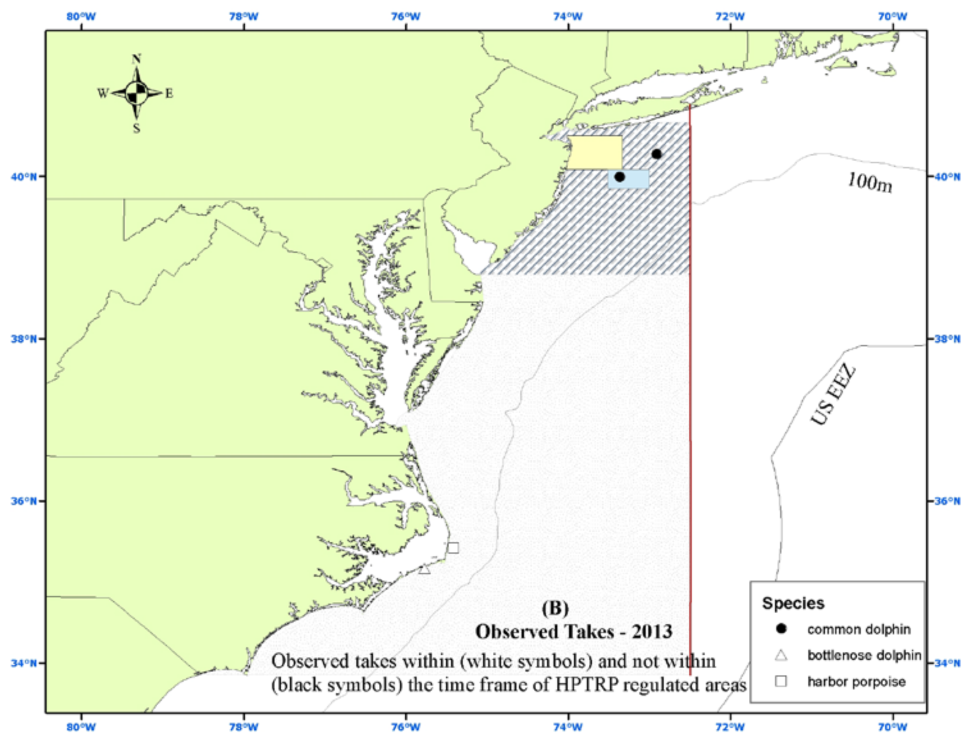
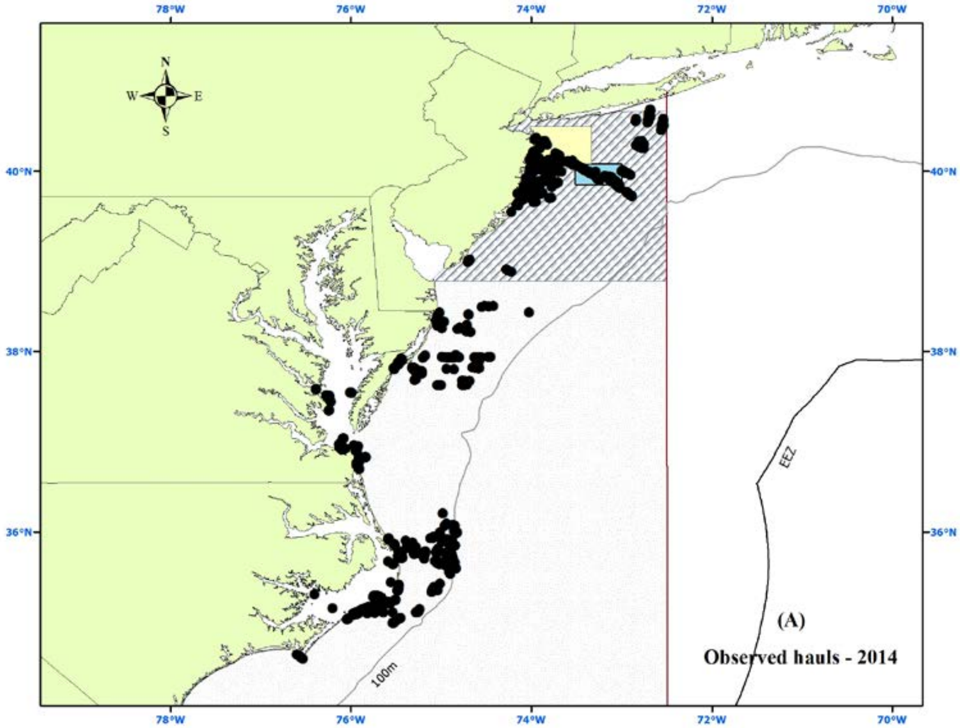


Figure 10. 2014 Mid-Atlantic gillnet observed hauls (A) and observed takes (B).



Harbor porpoise Take Reduction Plan management areas:

Southern mid-Atlantic waters New Jersey Mudhole waters off New Jersey

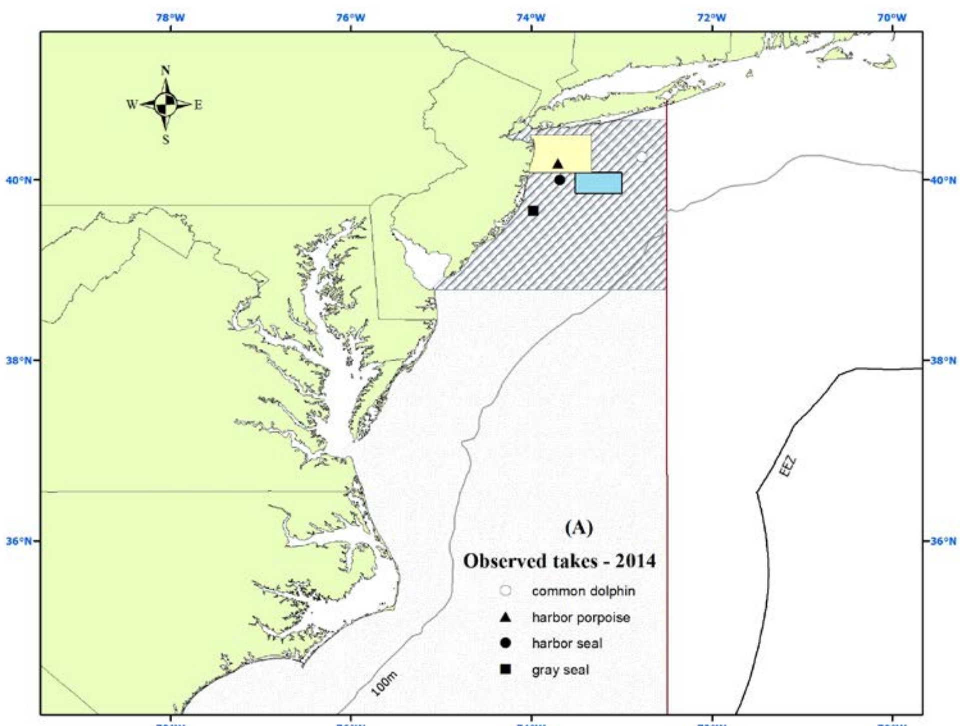


Figure 11. 2010 Mid-Atlantic bottom trawl observed tows (A) and observed takes (B).

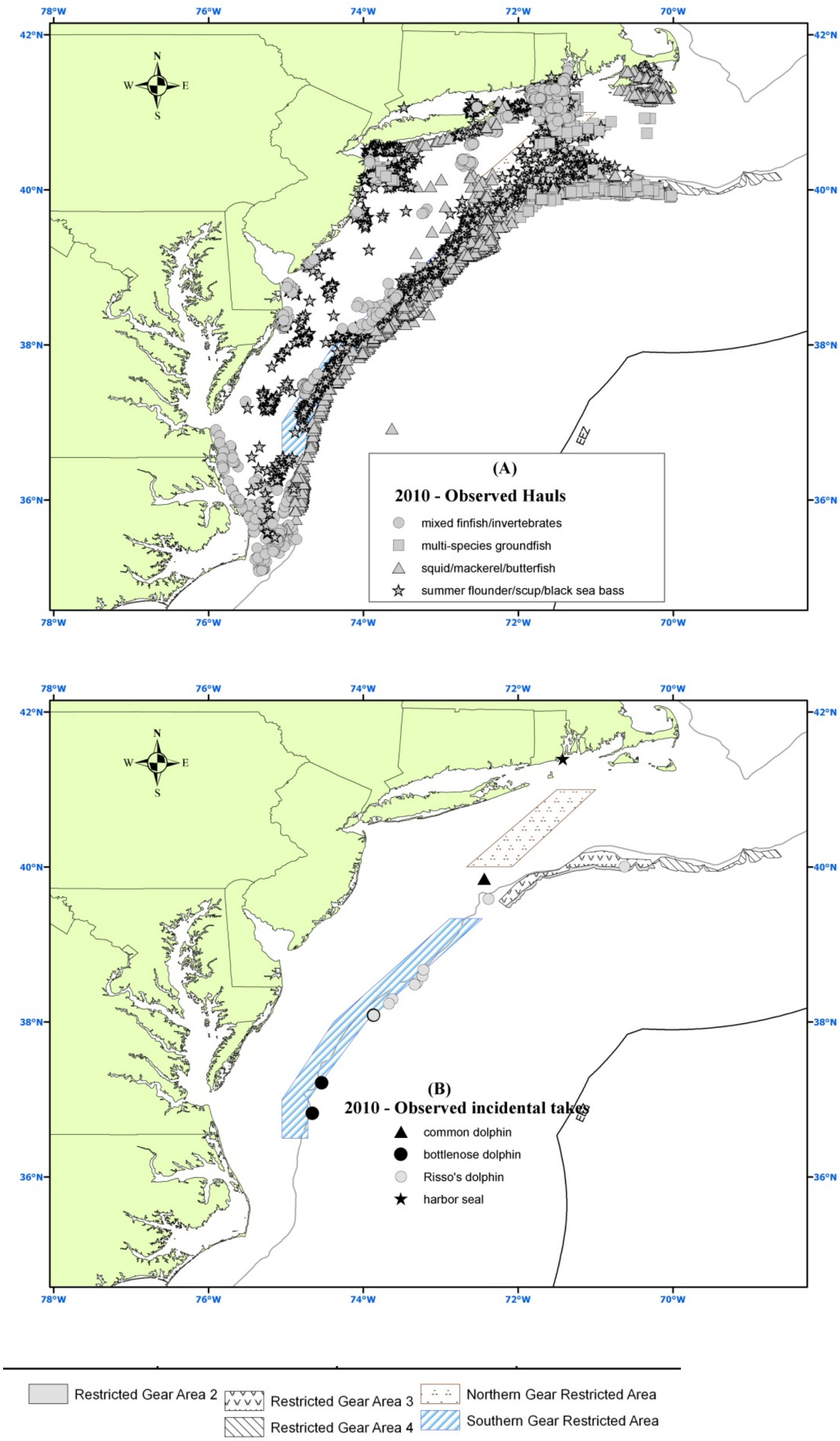


Figure 12. 2011 Mid-Atlantic bottom trawl observed tows (A) and observed takes (B).

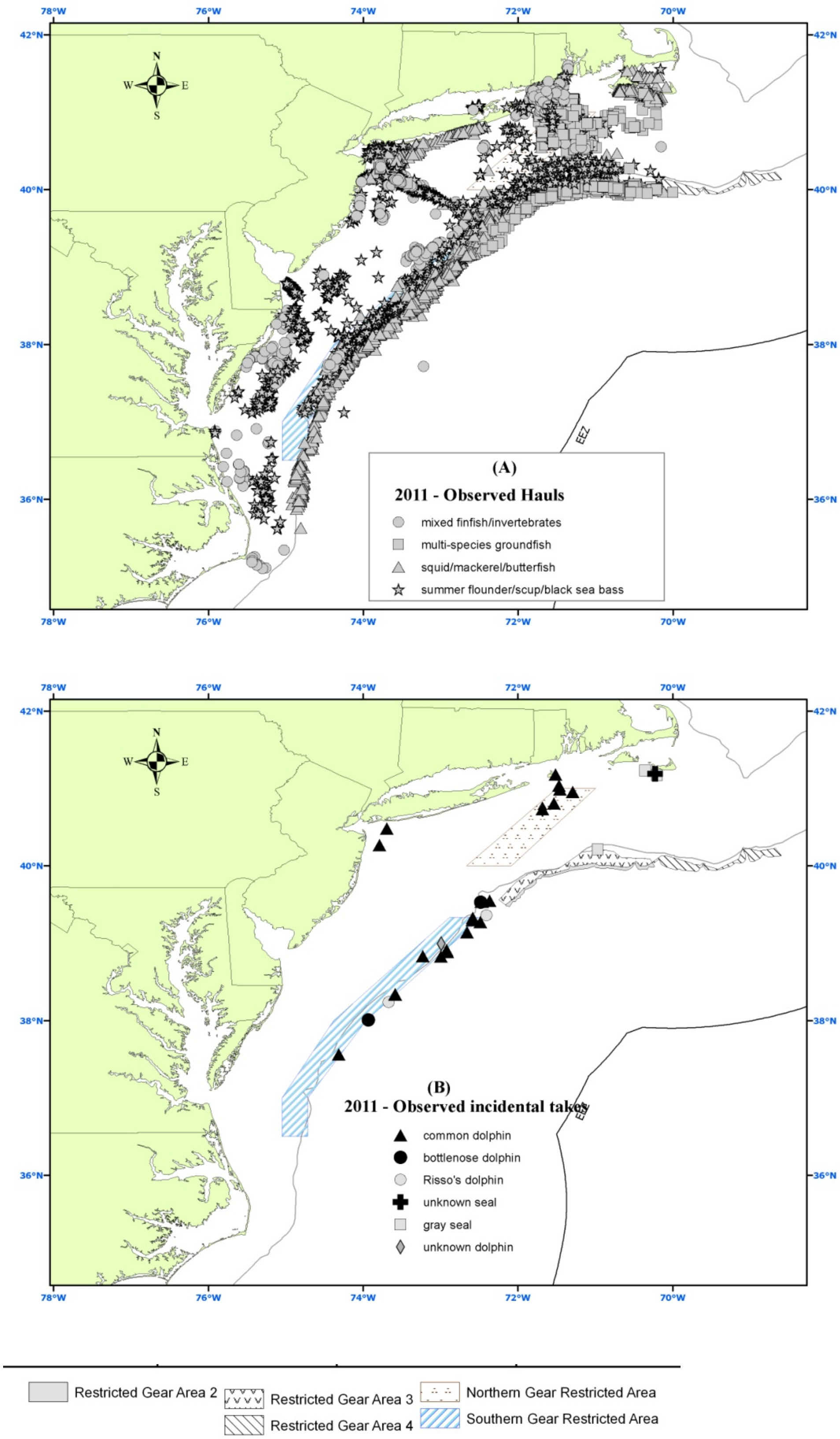


Figure 13. 2012 Mid-Atlantic bottom trawl observed tows (A) and observed takes (B).

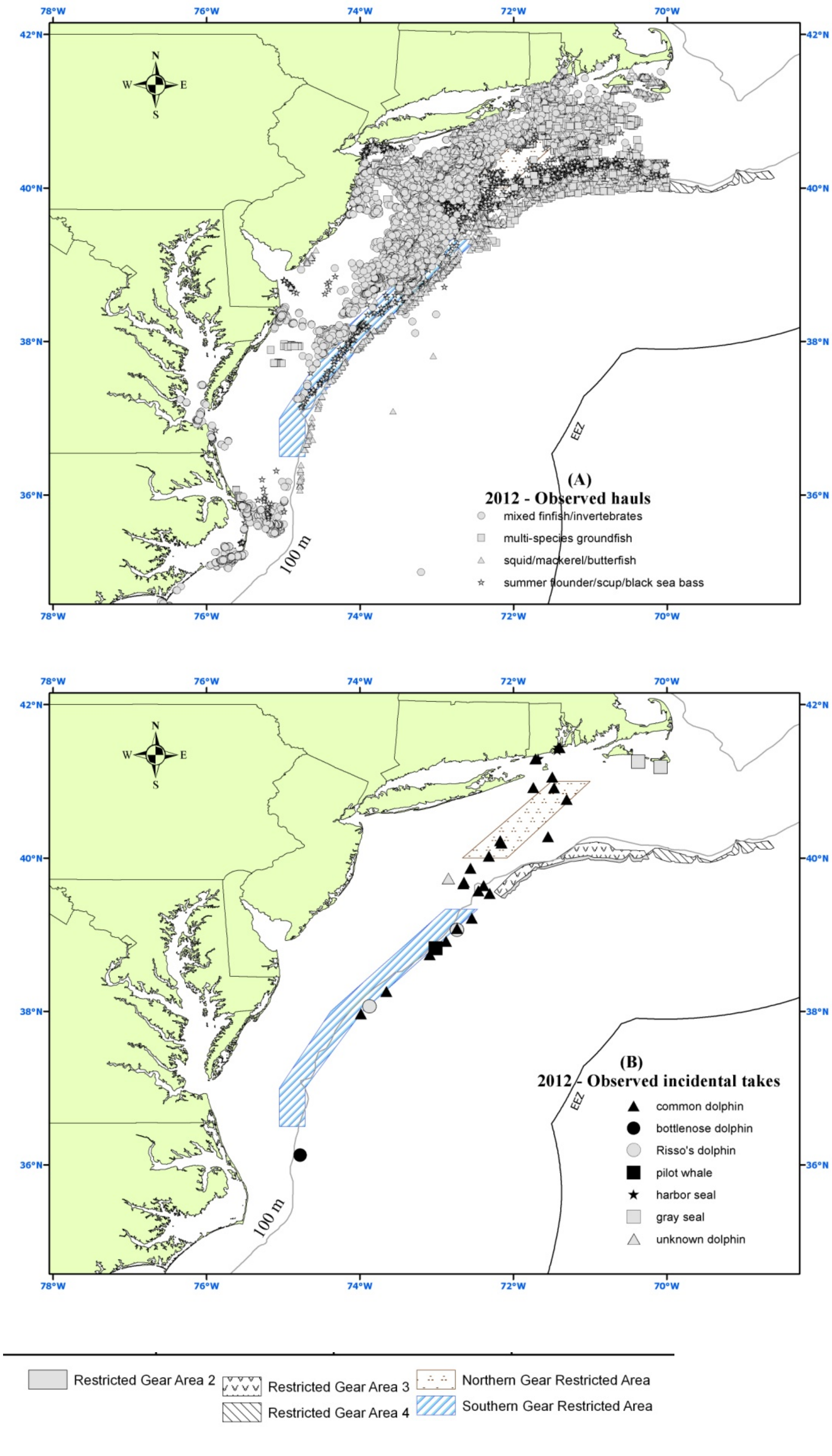


Figure 14. 2013 Mid-Atlantic bottom trawl observed tows (A) and observed takes (B).

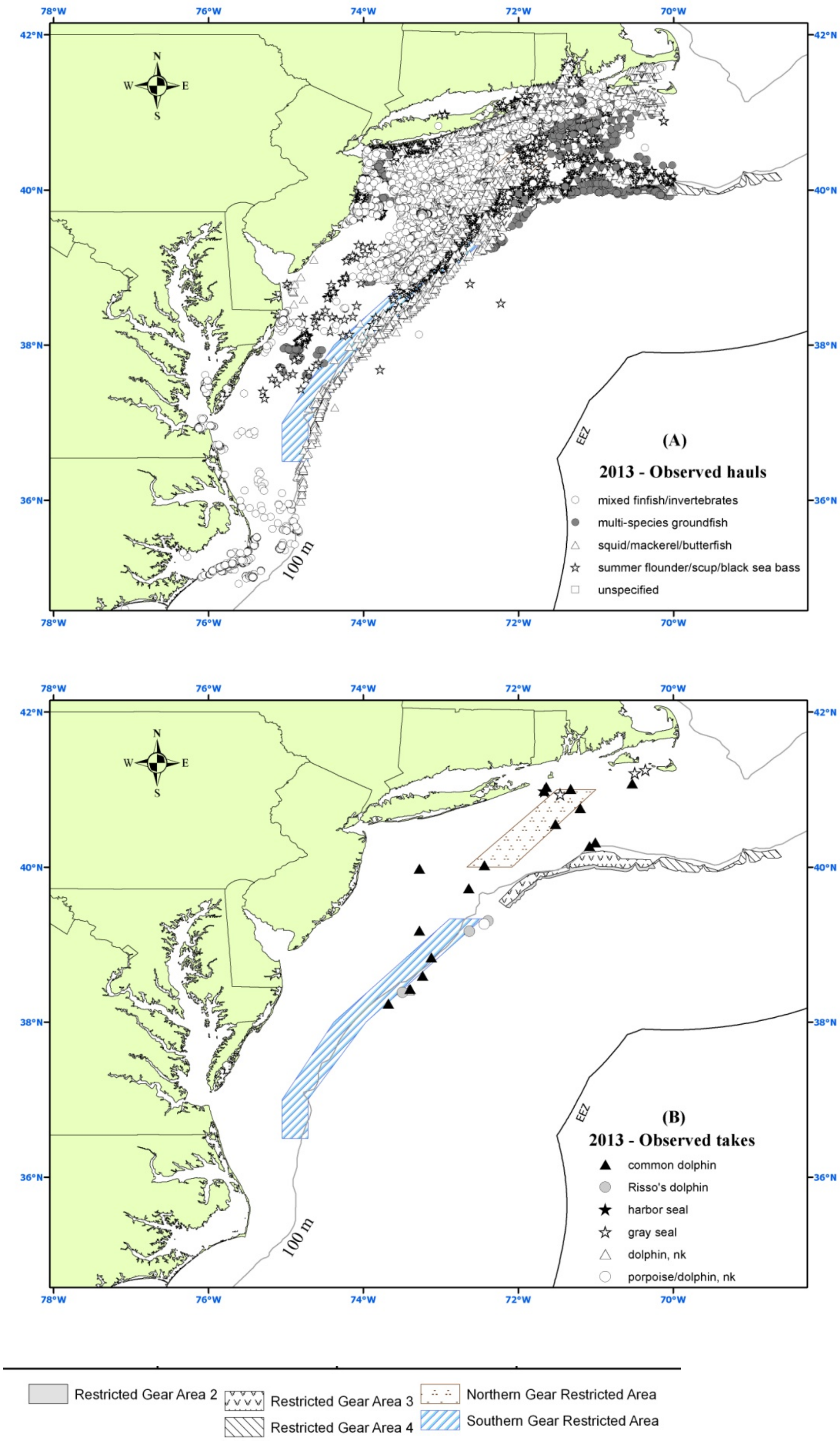


Figure 15. 2014 Mid-Atlantic bottom trawl observed tows (A) and observed takes (B).

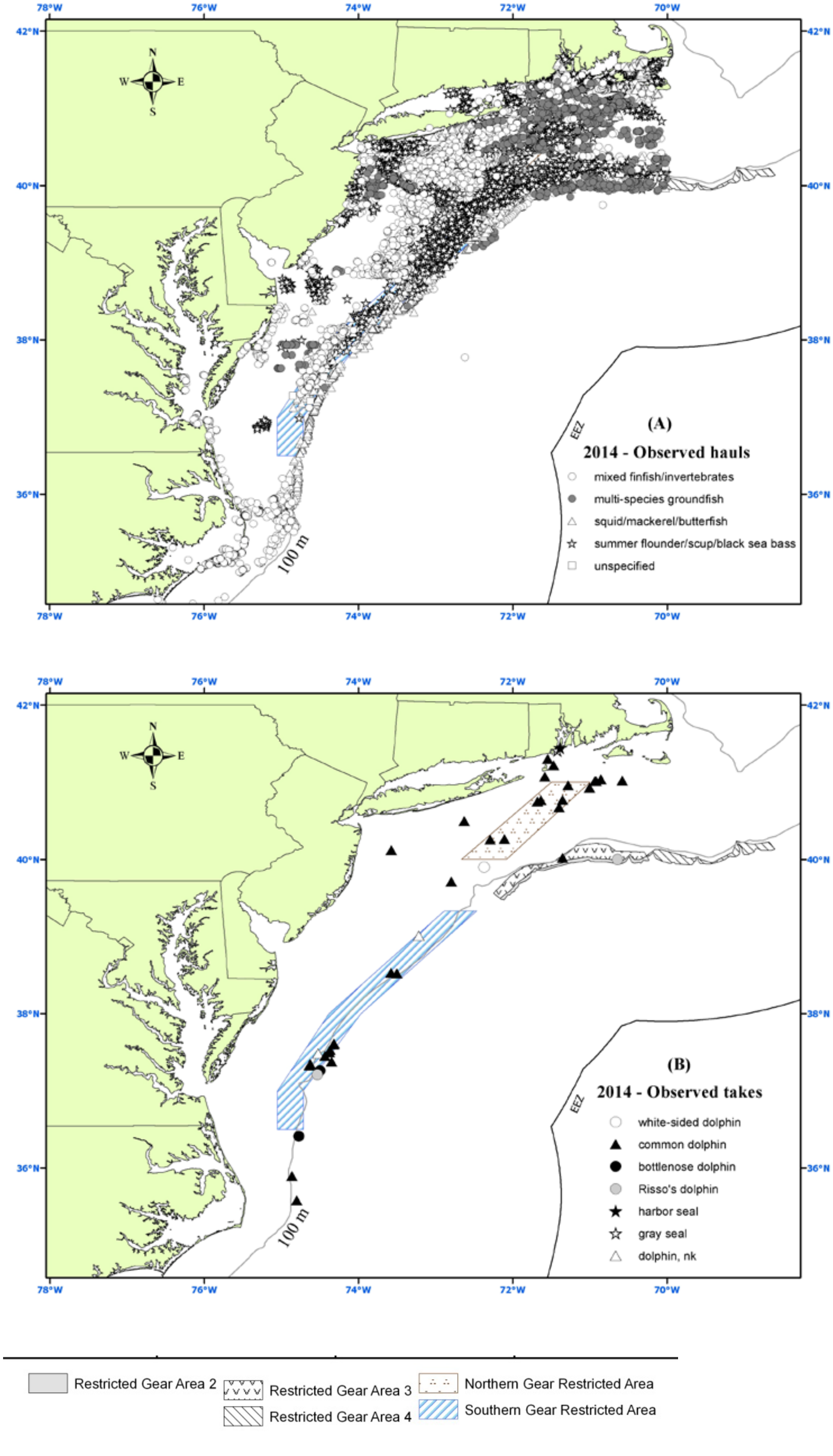


Figure 16. 2010 Northeast bottom trawl observed tows (A) and observed takes (B).

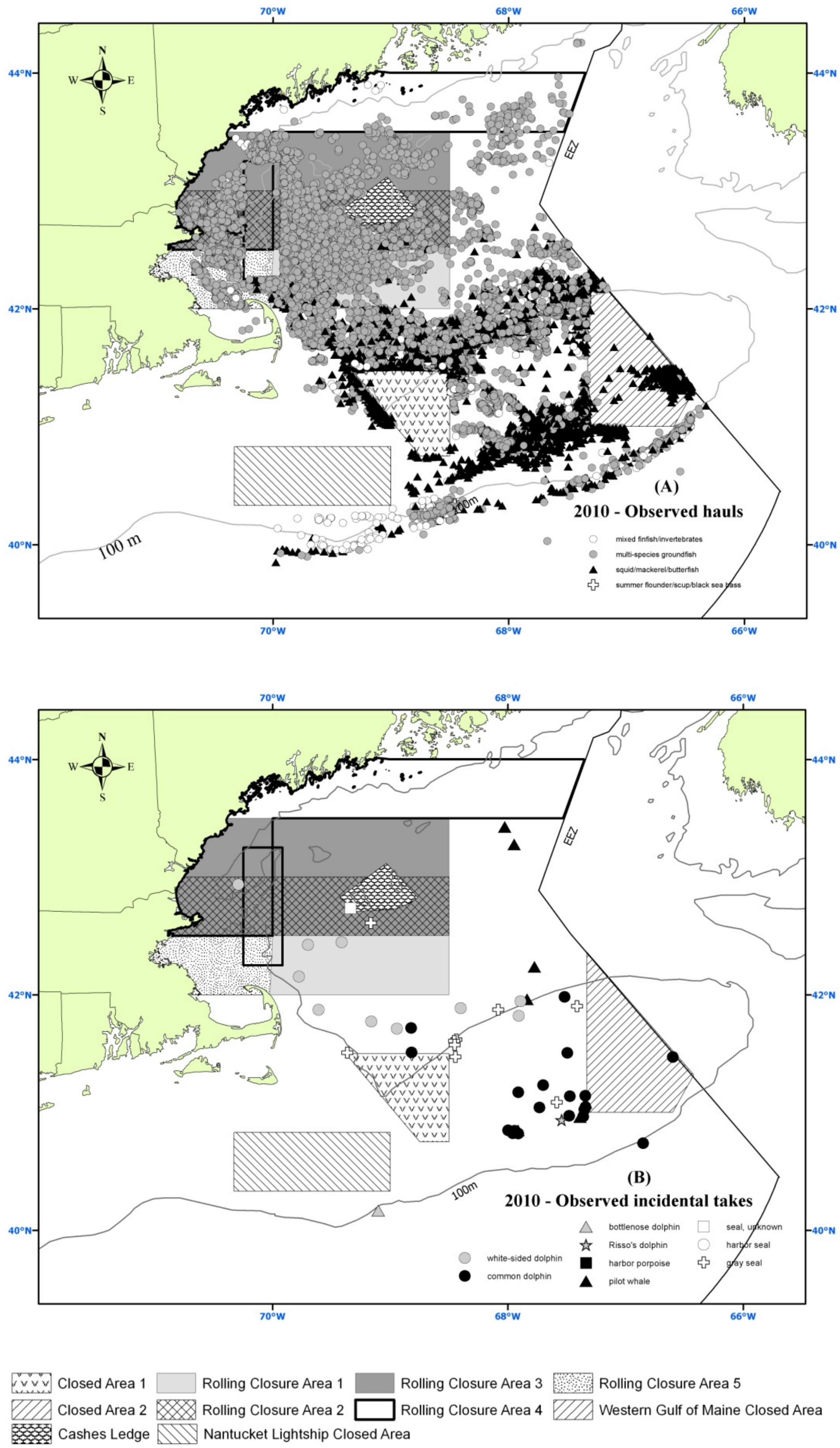


Figure 17. 2011 Northeast bottom trawl observed tows (A) and observed takes (B).

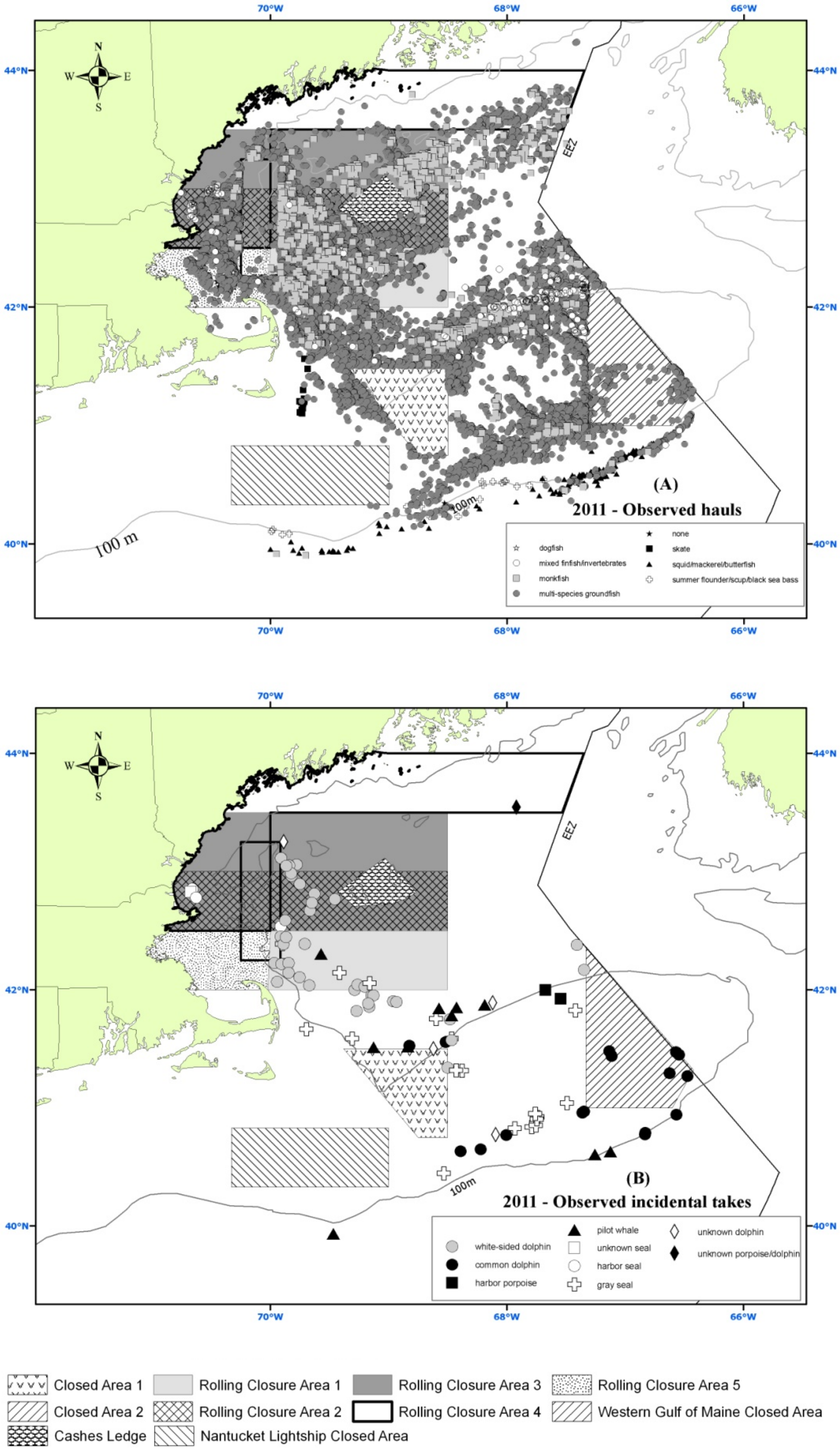


Figure 18. 2012 Northeast bottom trawl observed tows (A) and observed takes (B).

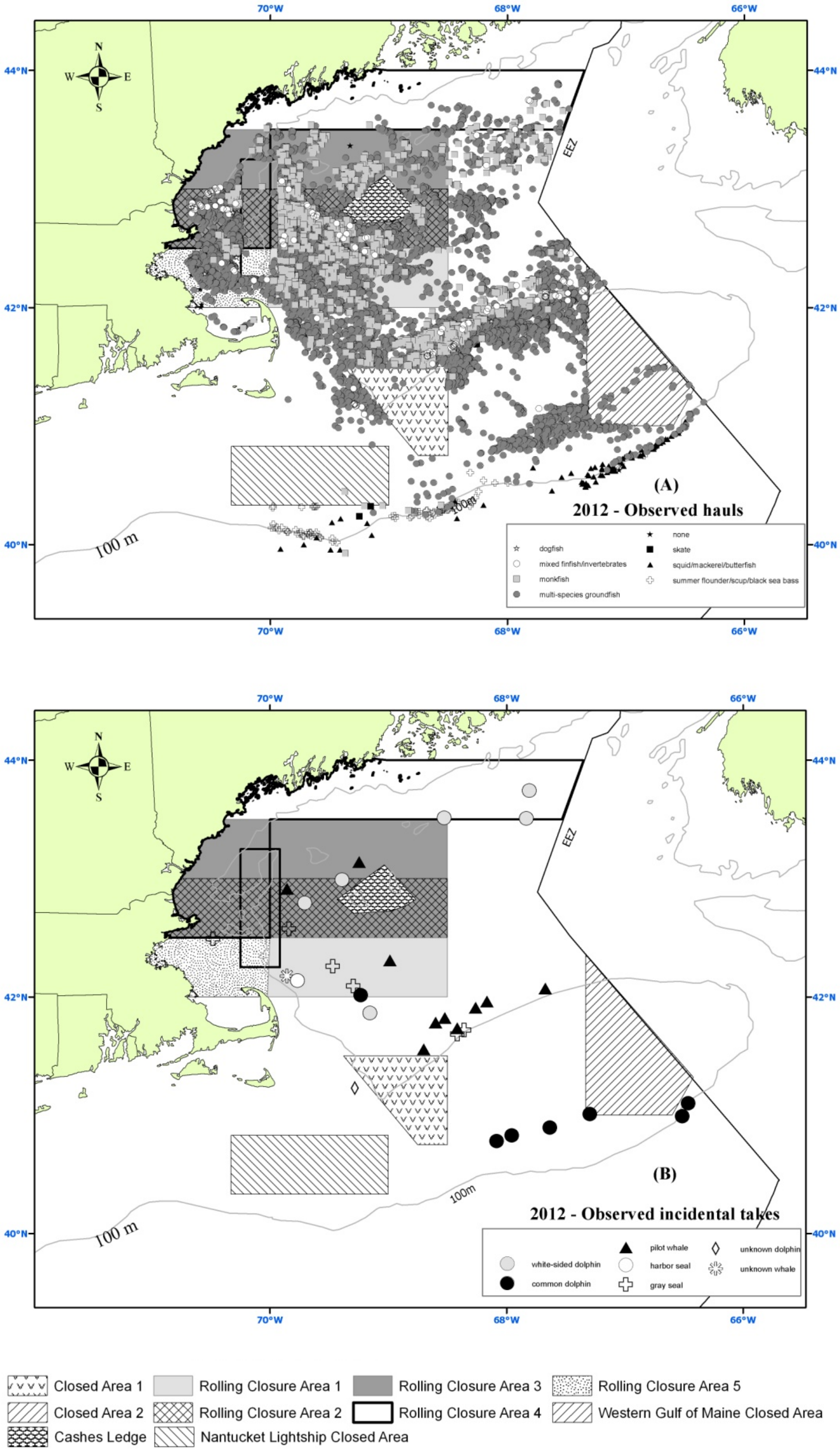


Figure 19. 2013 Northeast bottom trawl observed tows (A) and observed takes (B).

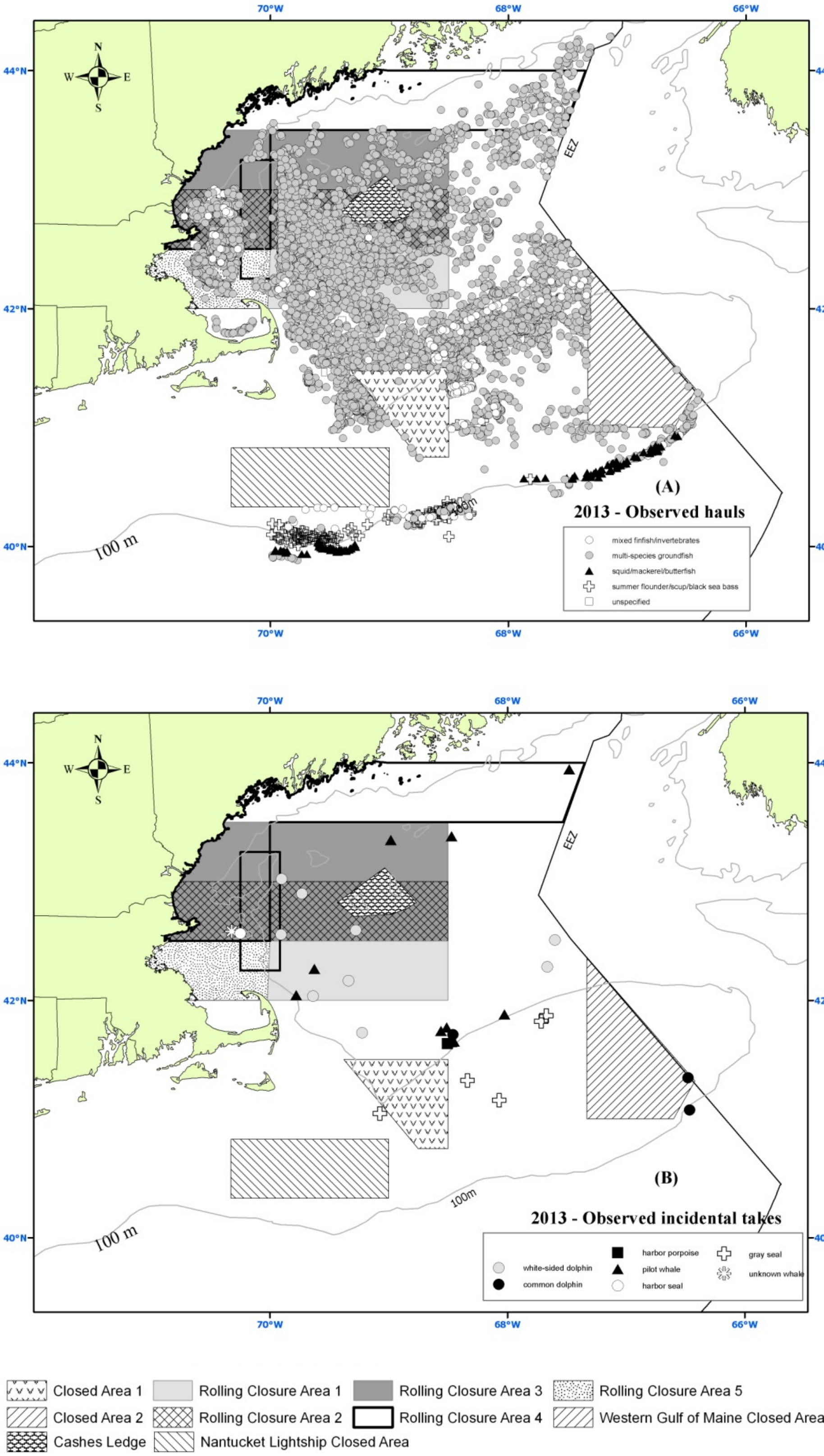


Figure 20. 2014 Northeast bottom trawl observed tows (A) and observed takes (B).

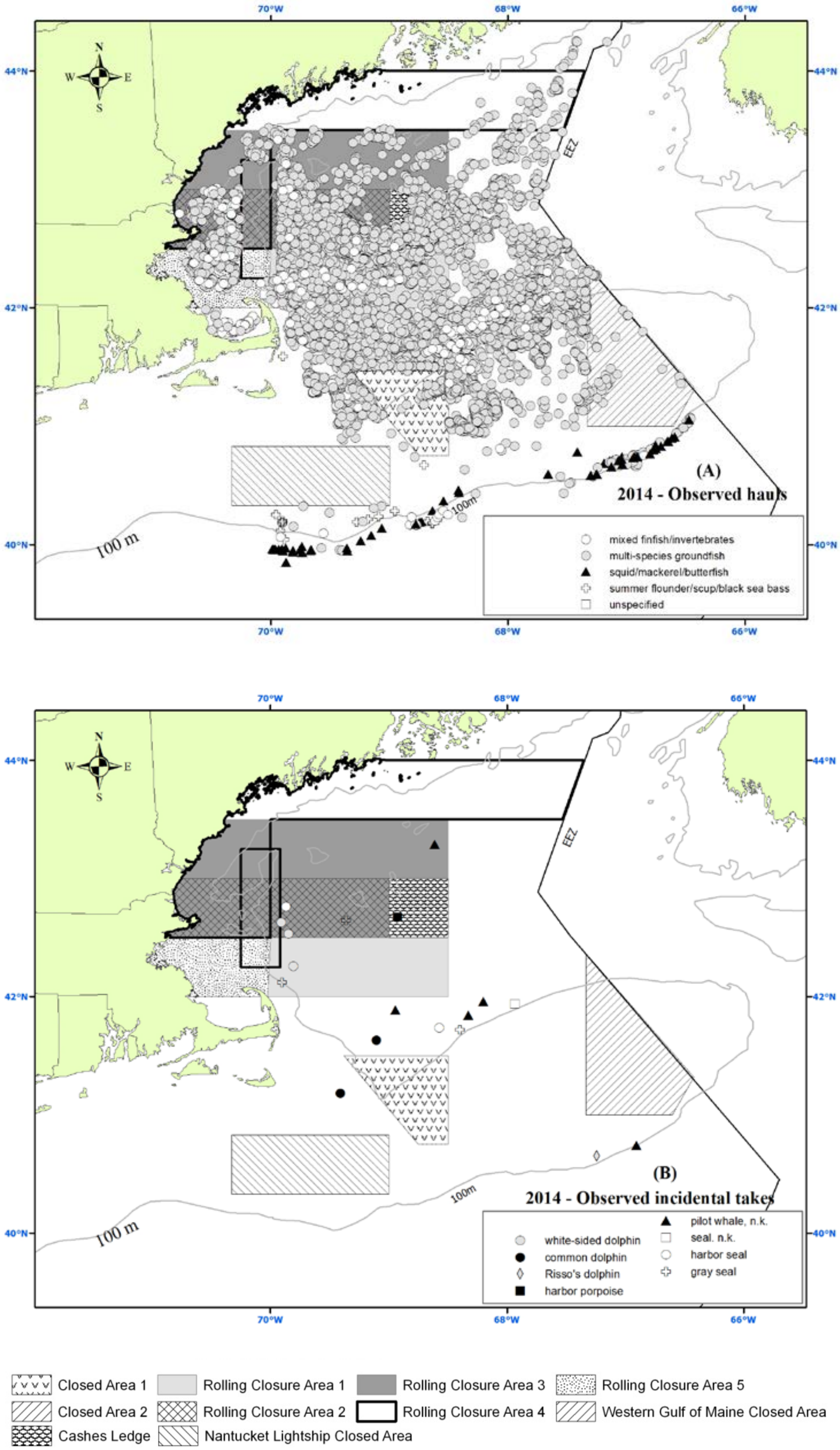
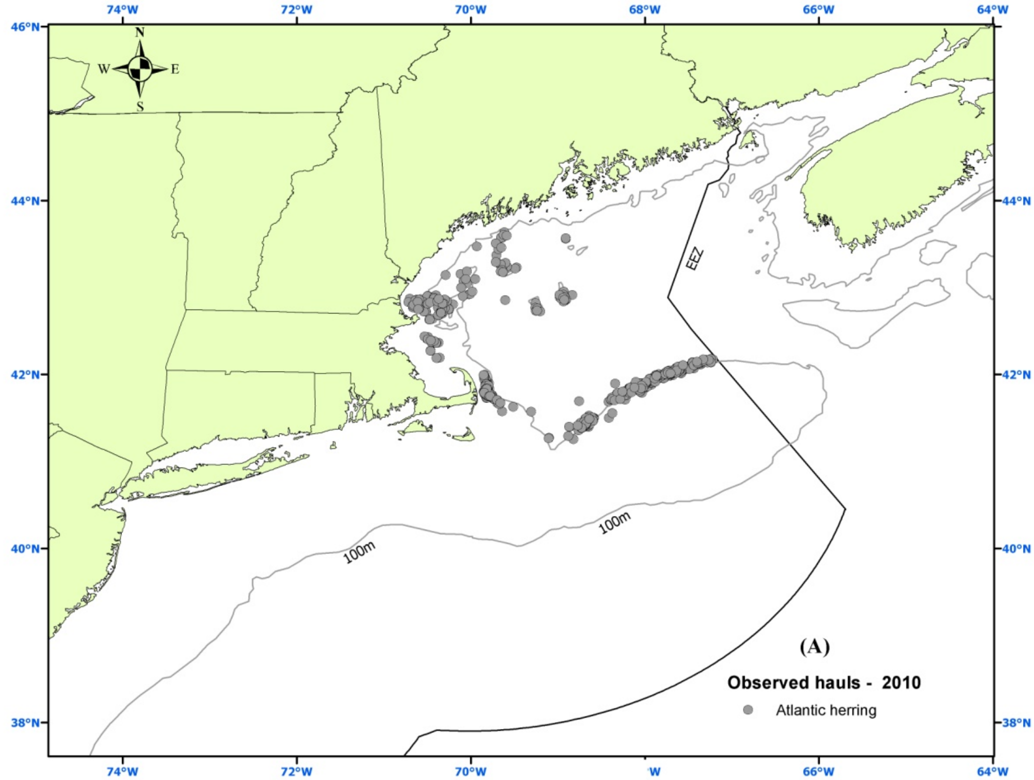


Figure 21. 2010 Northeast mid-water trawl observed tows (A) and observed takes (B).



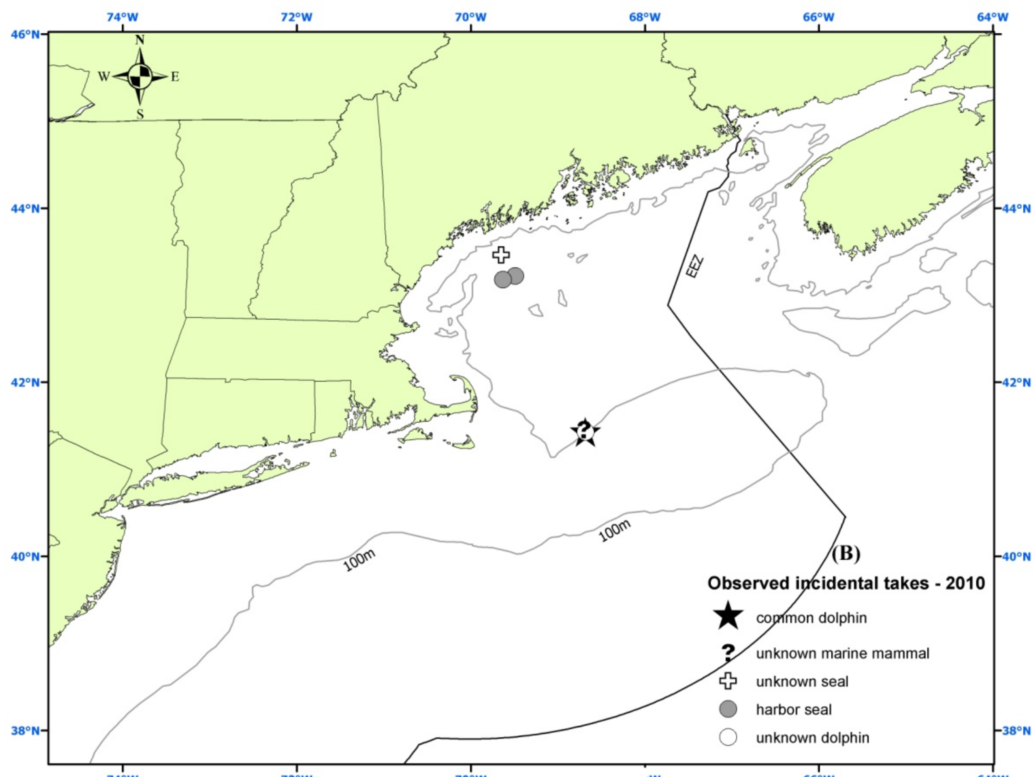
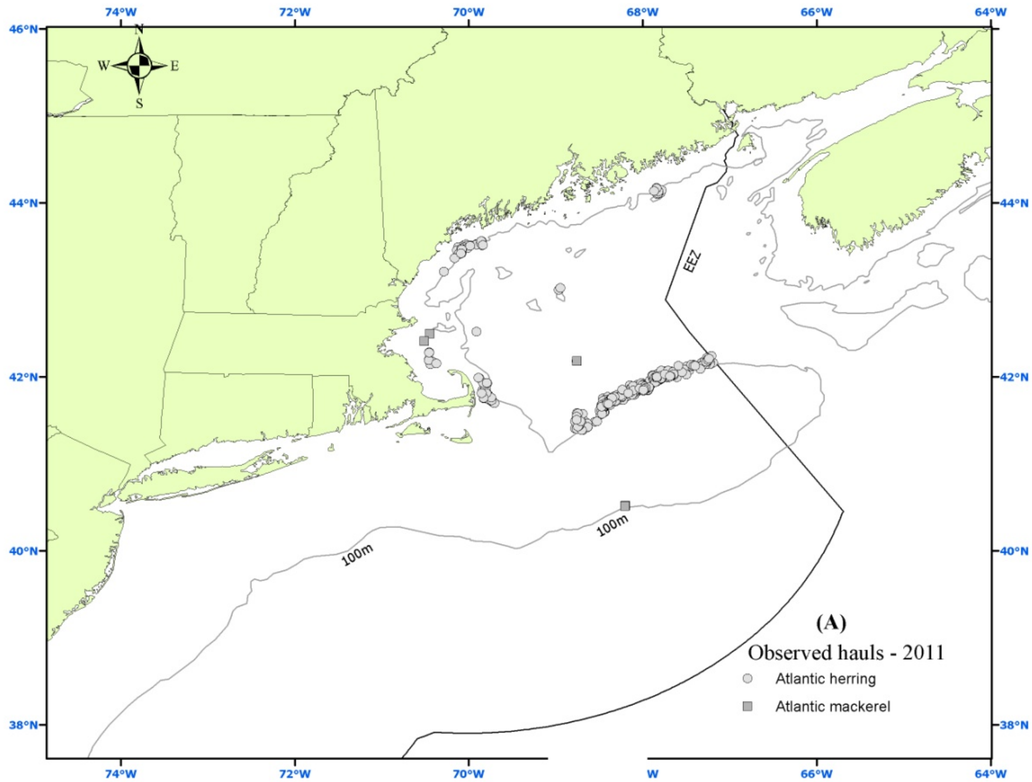


Figure 22. 2011 Northeast mid-water trawl observed tows (A) and observed takes (B).



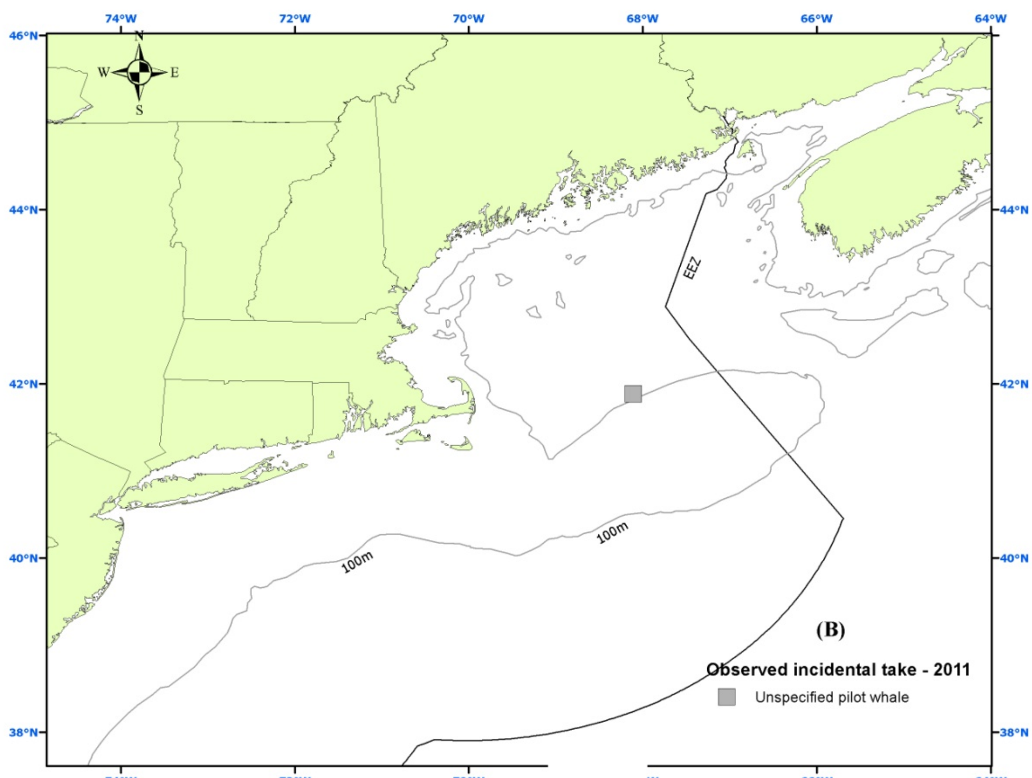
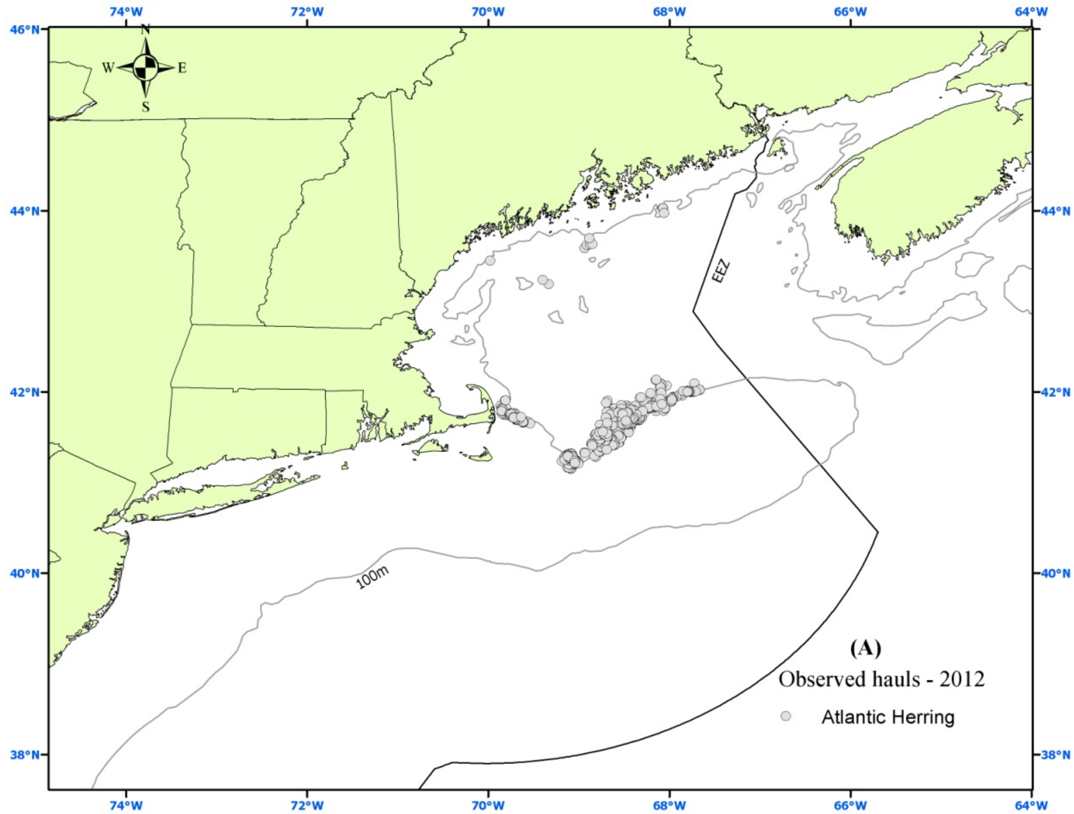


Figure 23. 2012 Northeast mid-water trawl observed tows (A) and observed takes (B).



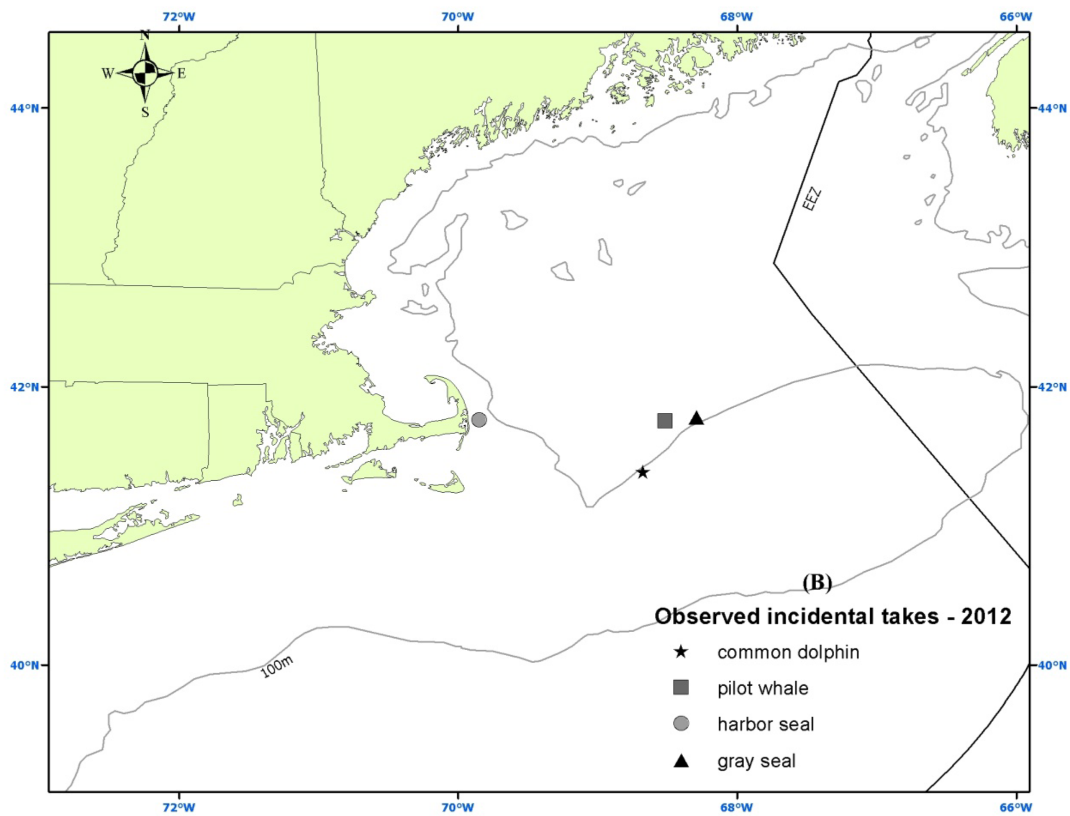
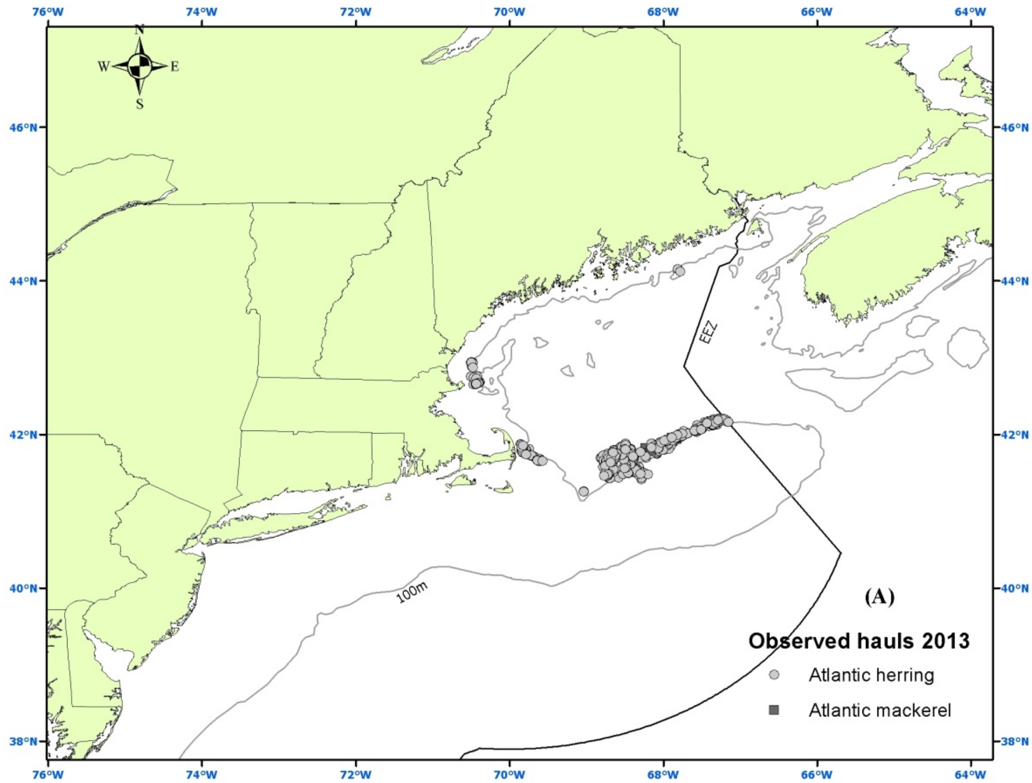


Figure 24. 2013 Northeast mid-water trawl observed tows (A) and observed takes (B).



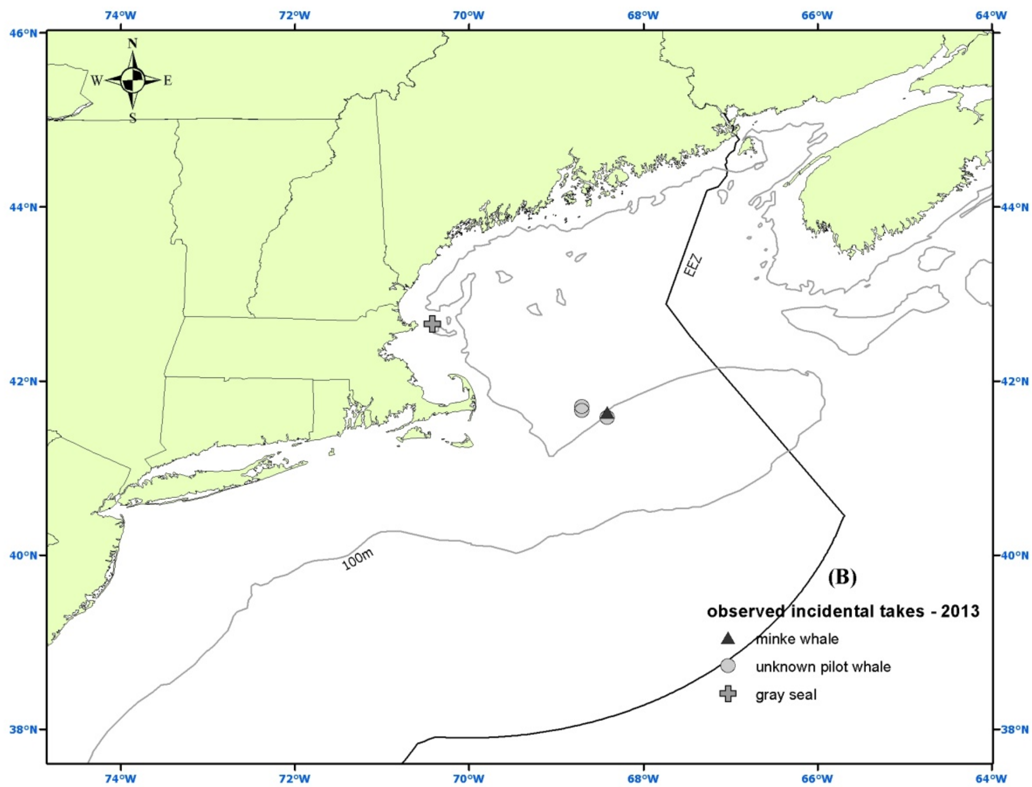
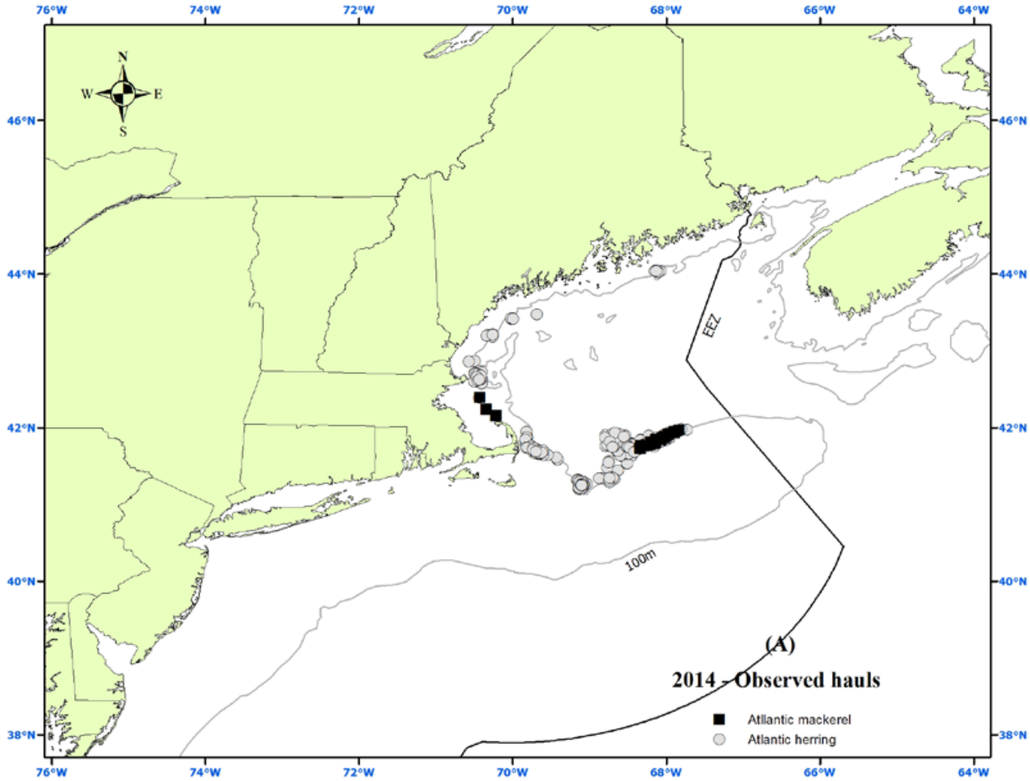


Figure 25. 2014 Northeast mid-water trawl observed tows (A) and observed takes (B).



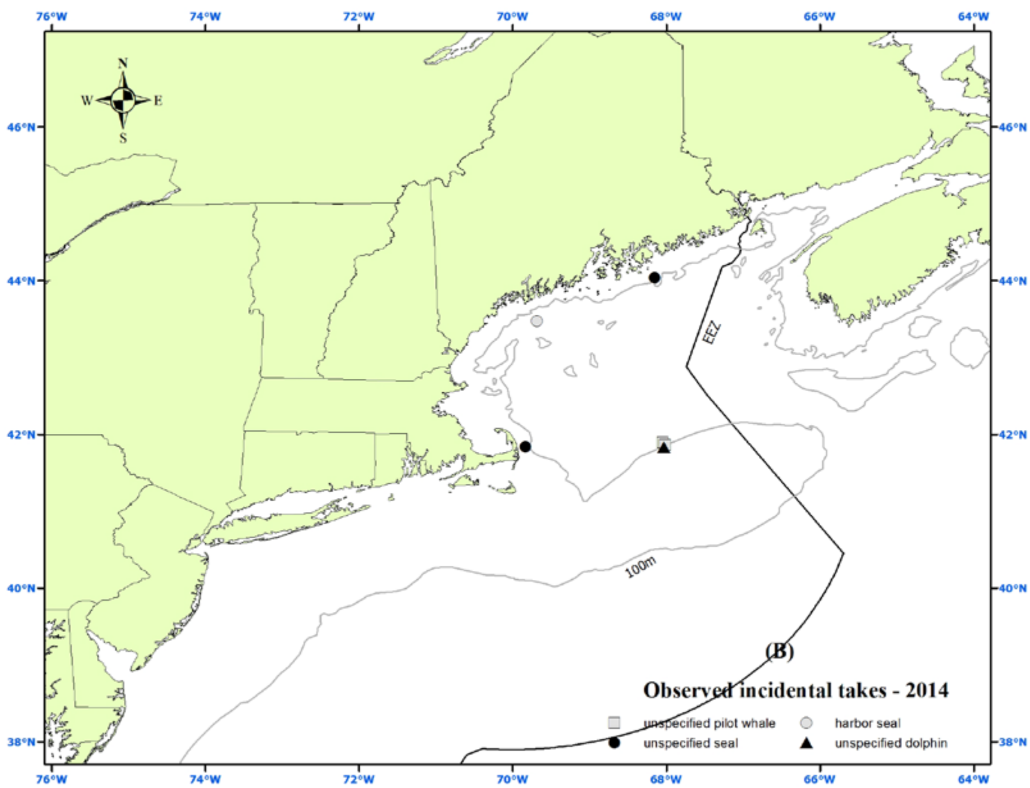
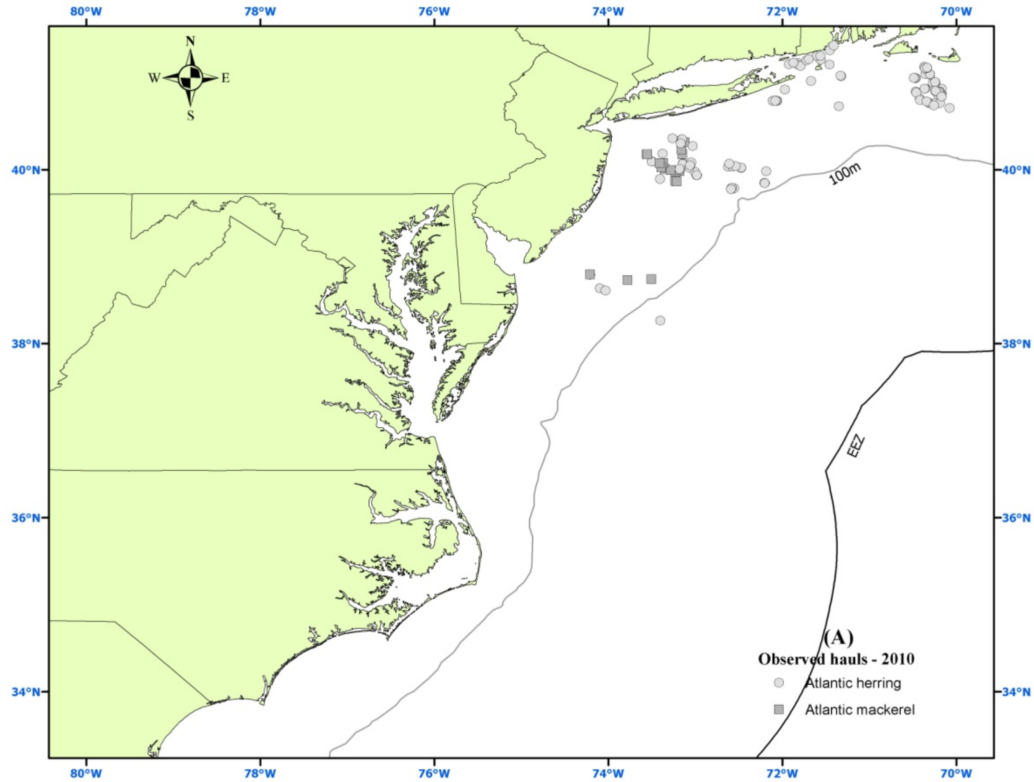


Figure 26. 2010 Mid-Atlantic mid-water trawl observed tows (A) and observed takes (B).



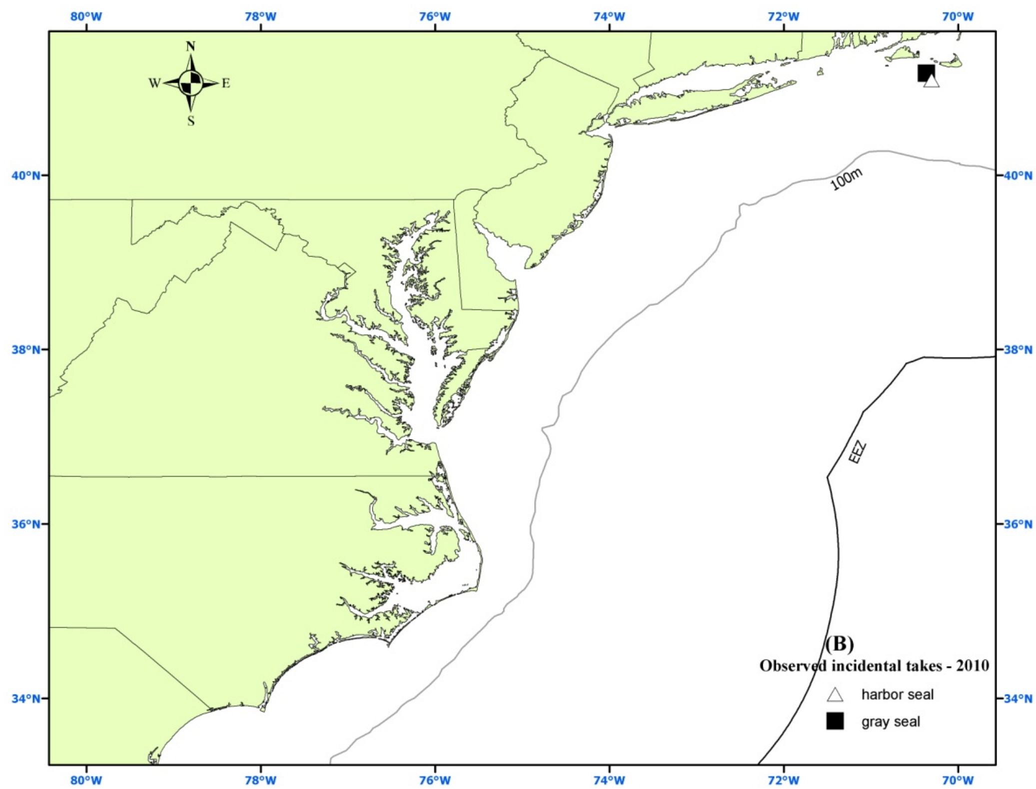
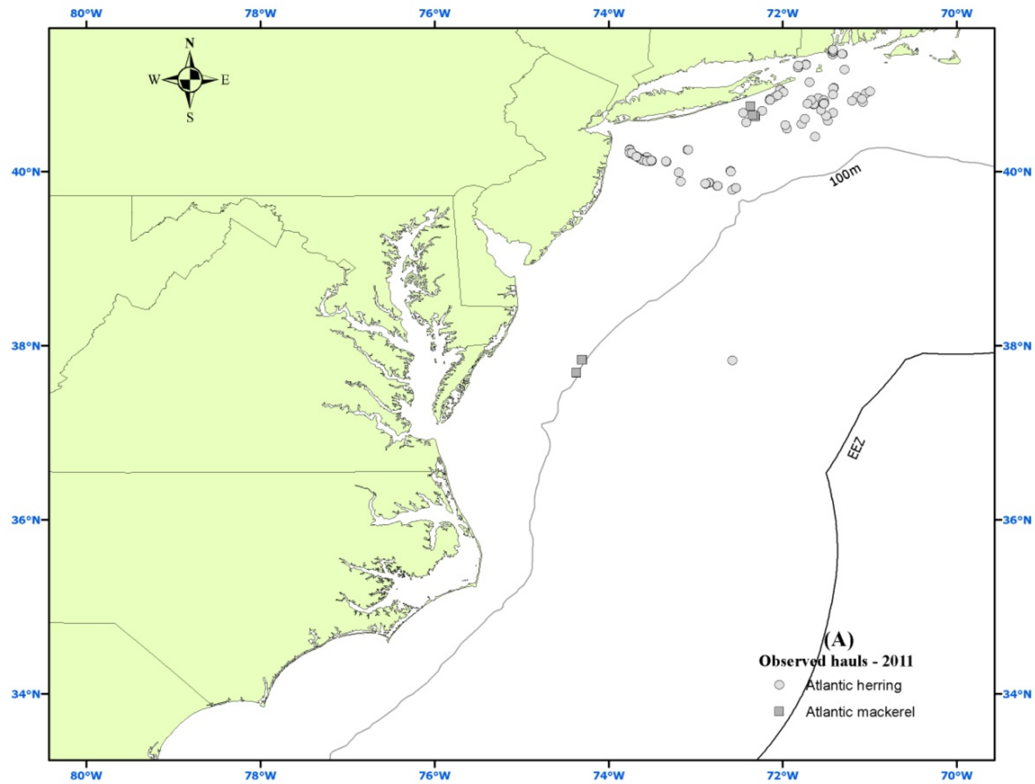


Figure 27. 2011 Mid-Atlantic mid-water trawl observed tows (A) and observed takes (B).



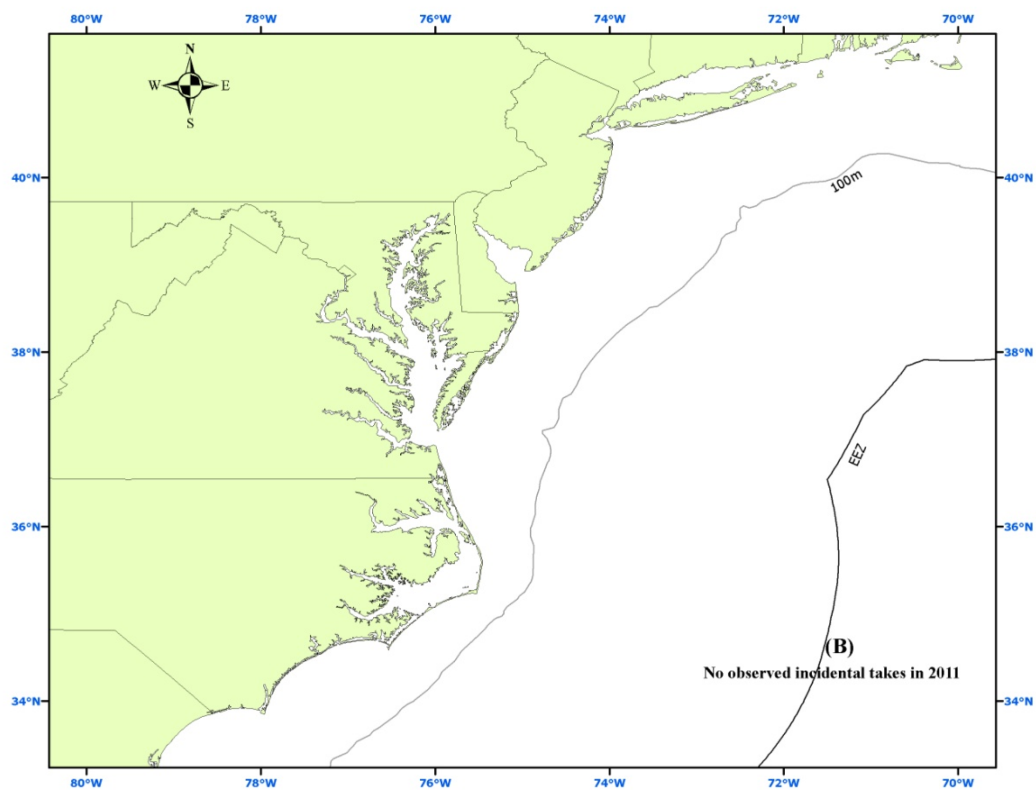
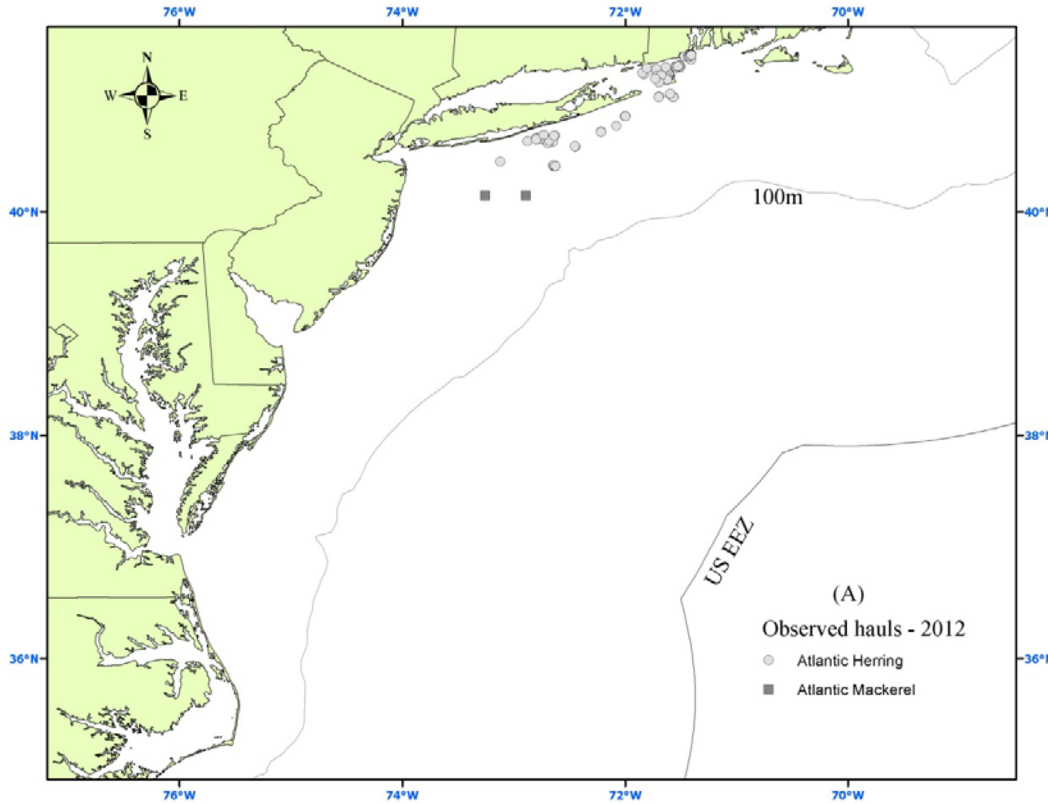


Figure 28. 2012 Mid-Atlantic mid-water trawl observed tows (A) and observed takes (B).



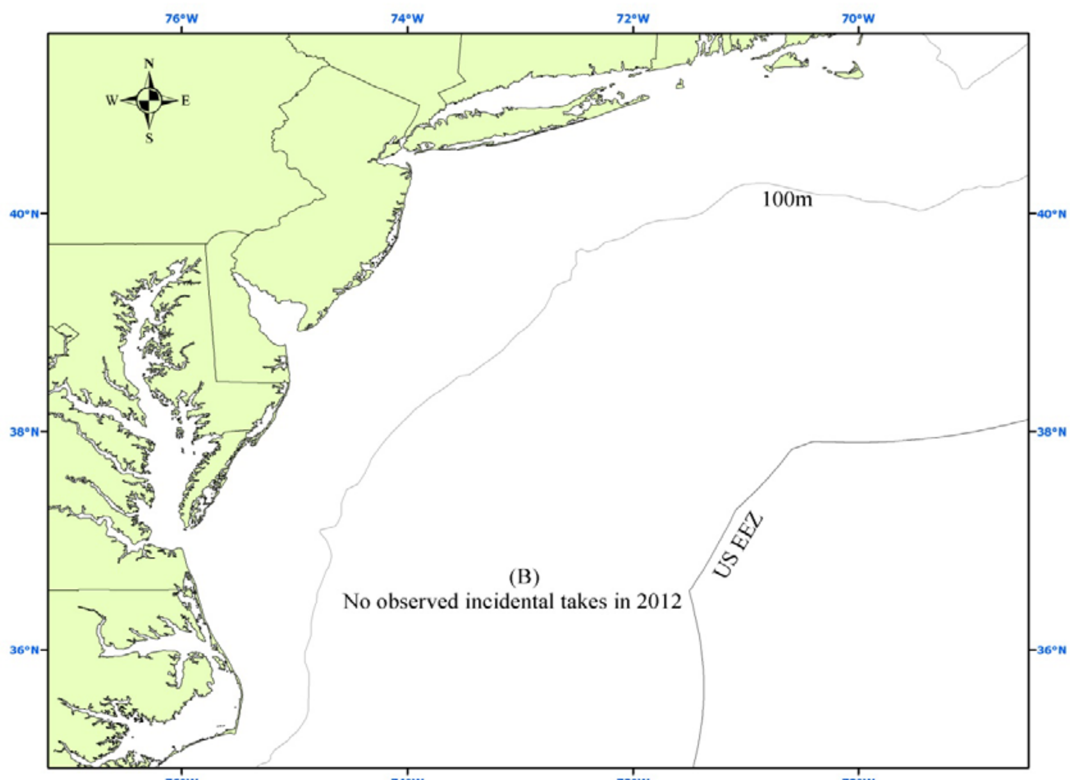
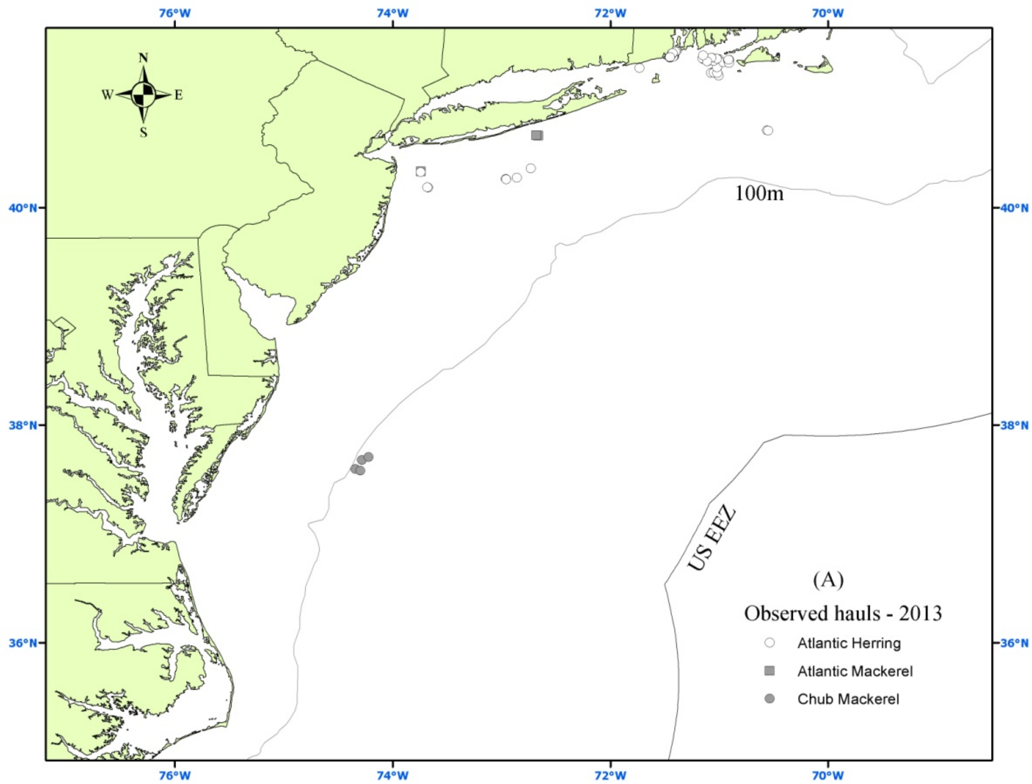


Figure 29. 2013 Mid-Atlantic mid-water trawl observed tows (A) and observed takes (B).



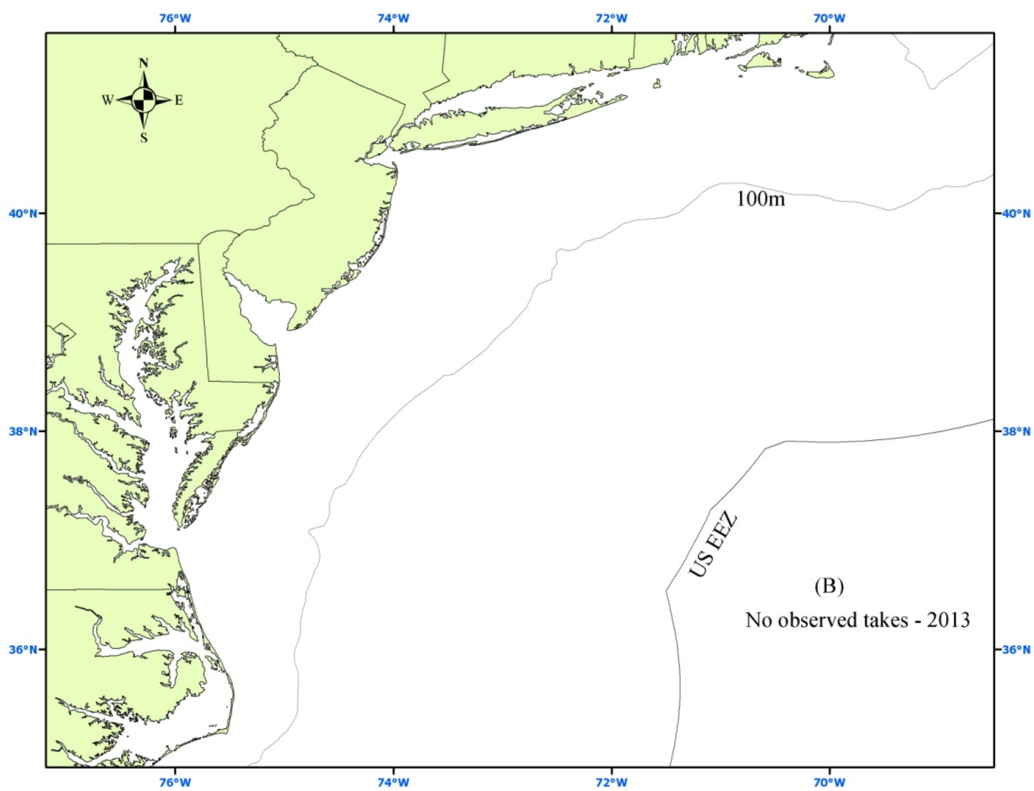
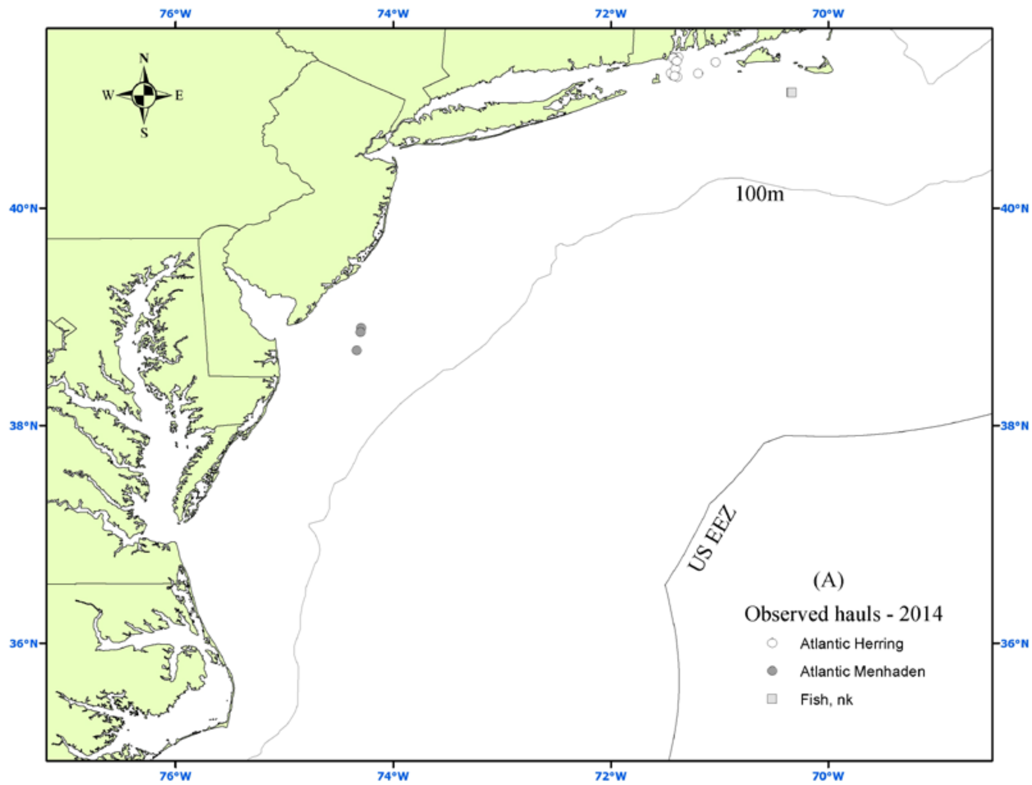


Figure 30. 2014 Mid-Atlantic mid-water trawl observed tows (A) and observed takes (B).



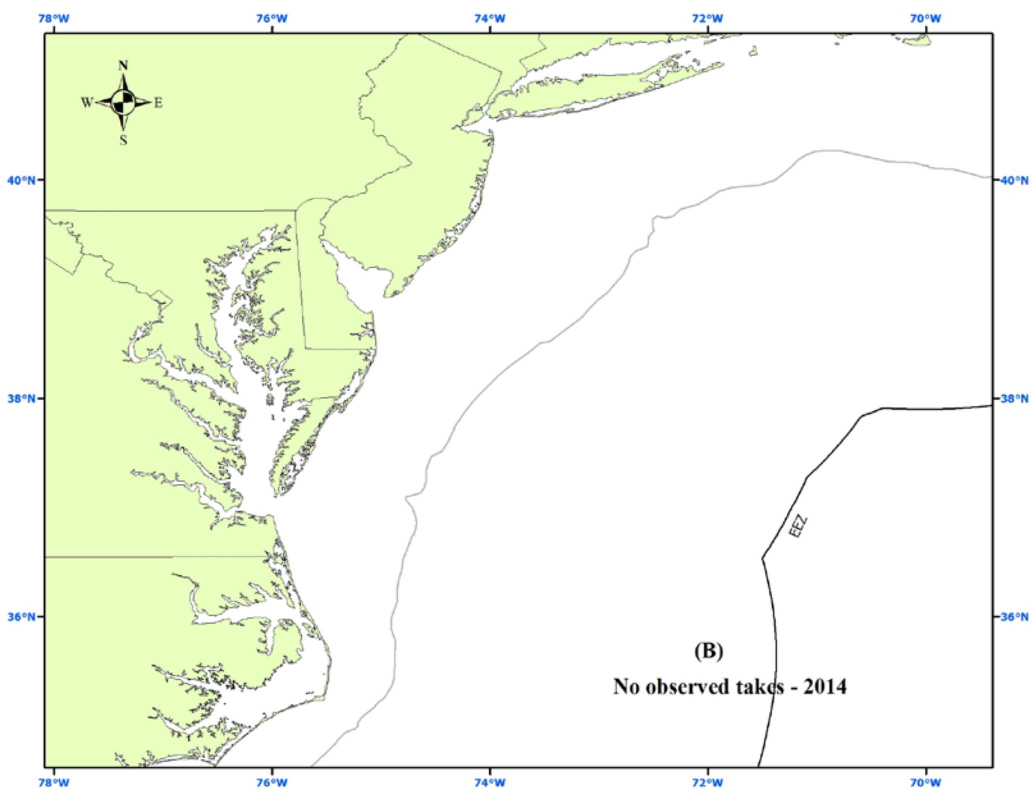


Figure 31. 2010 Herring Purse Seine observed hauls (A) and observed takes (B).

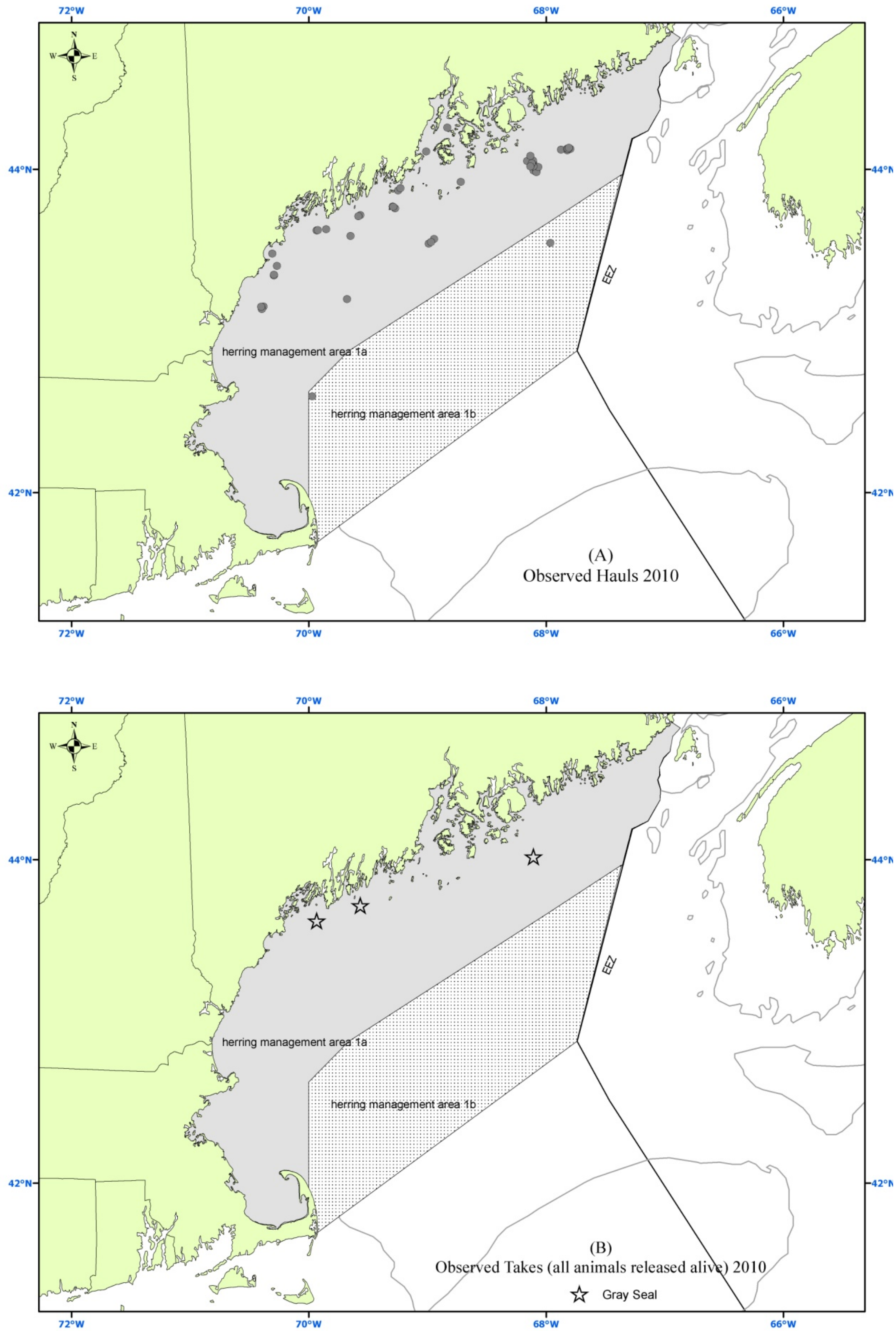


Figure 32. 2011 Herring Purse Seine observed hauls (A) and observed takes (B).

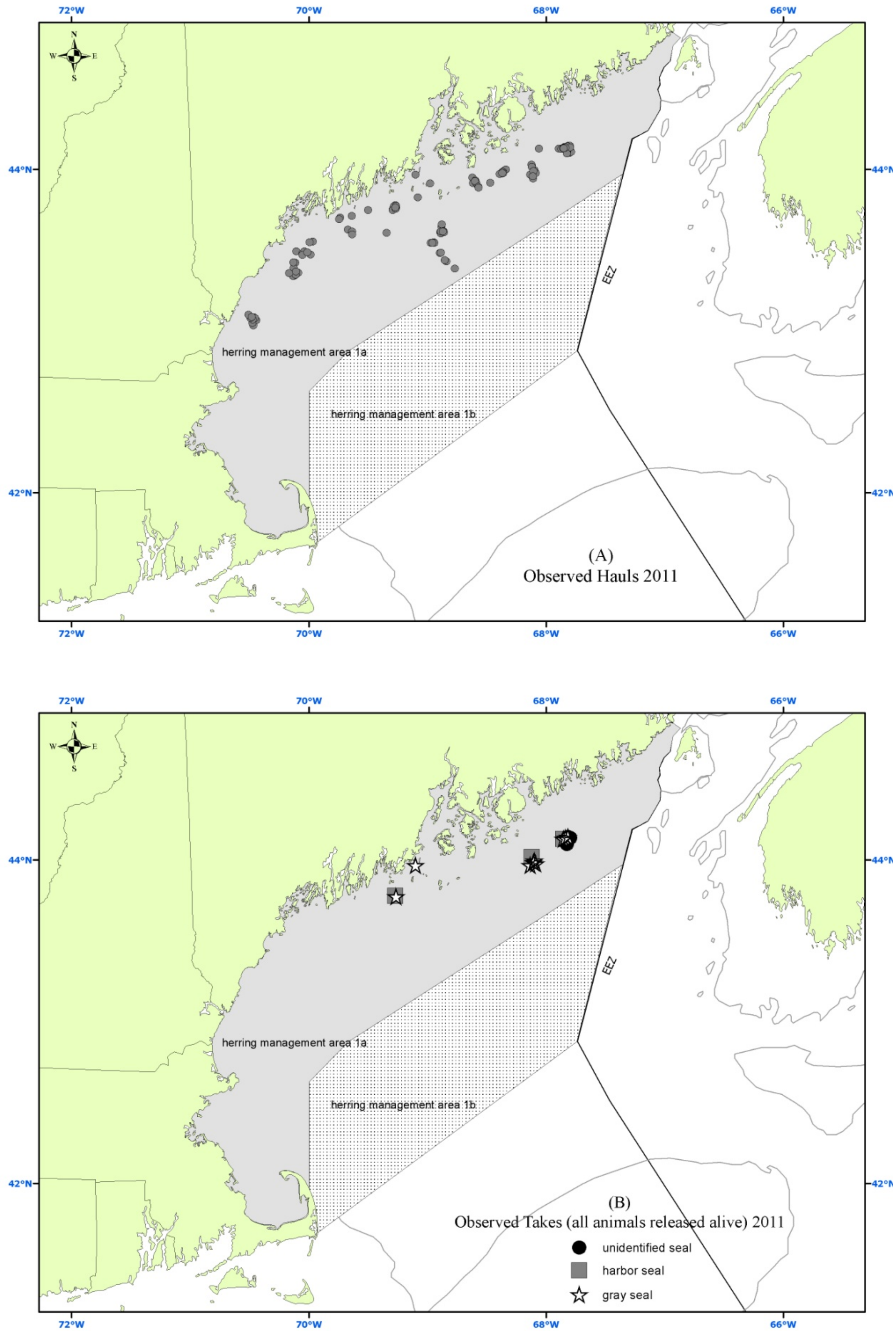


Figure 33. 2012 Herring Purse Seine observed hauls (A) and observed takes (B).

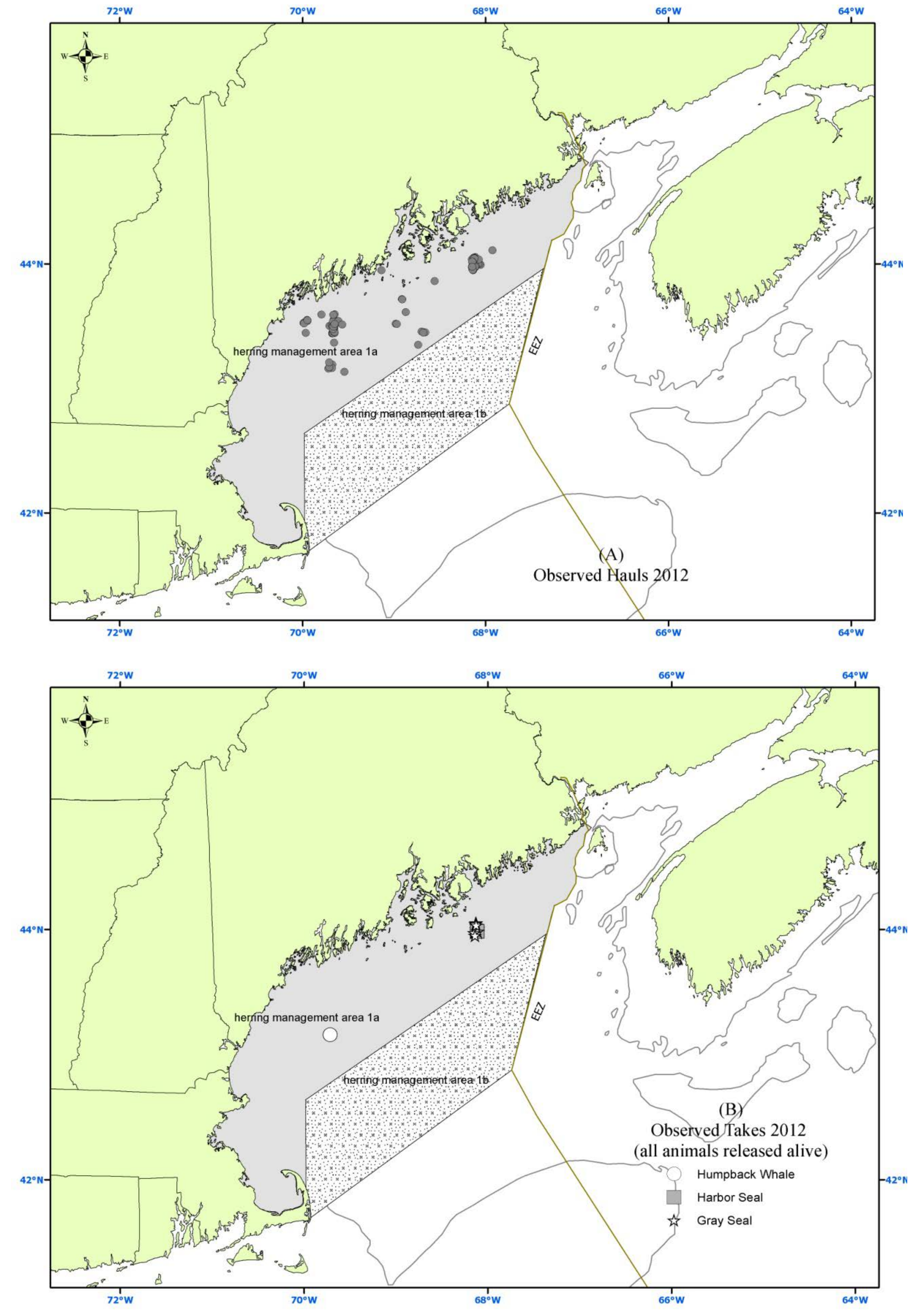
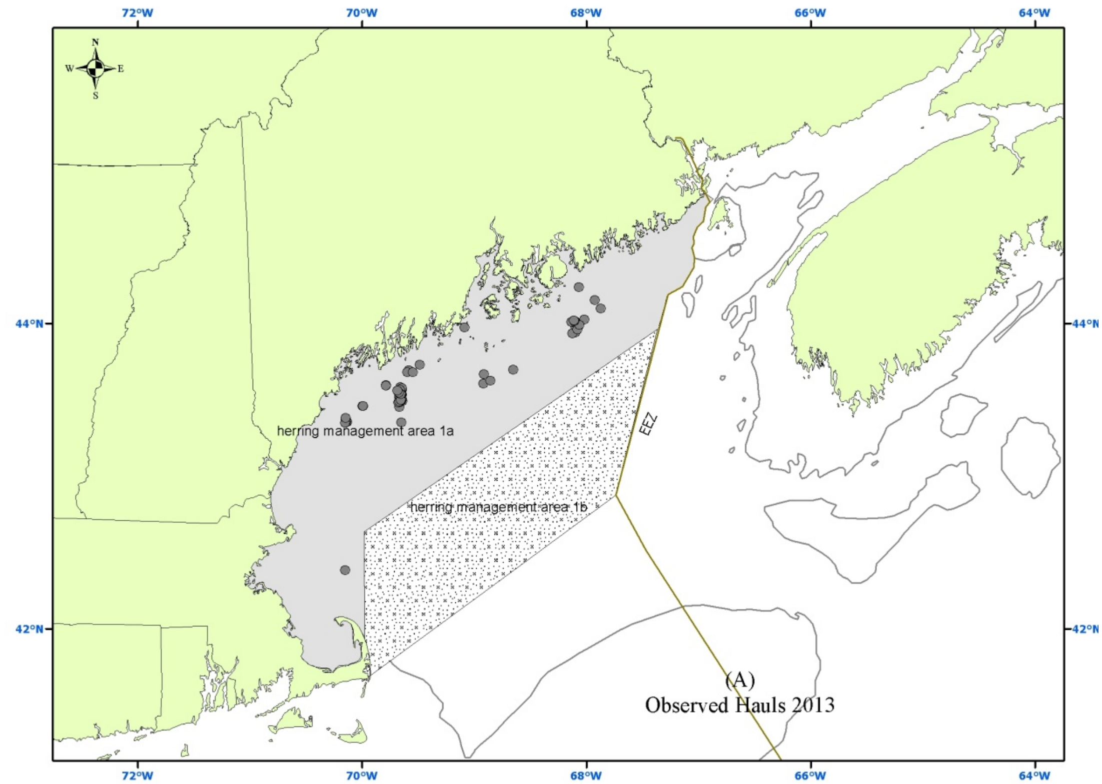


Figure 34. 2013 Herring Purse Seine observed hauls (A) and observed takes (B).



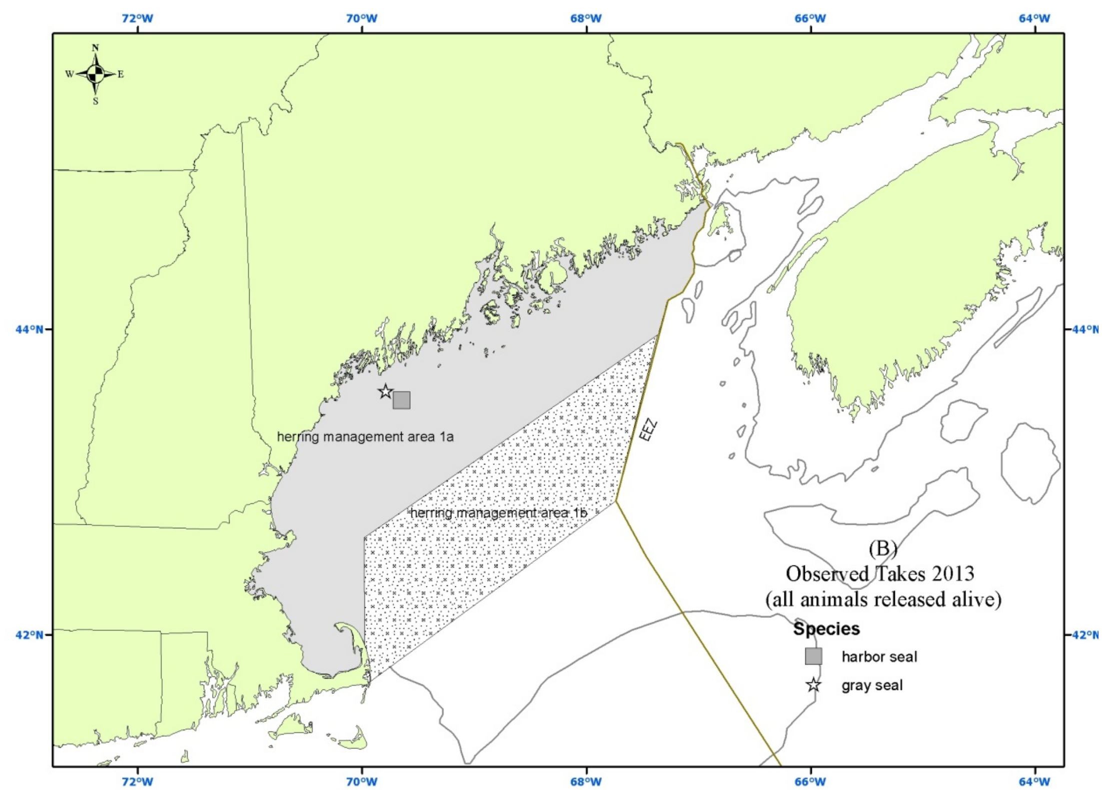
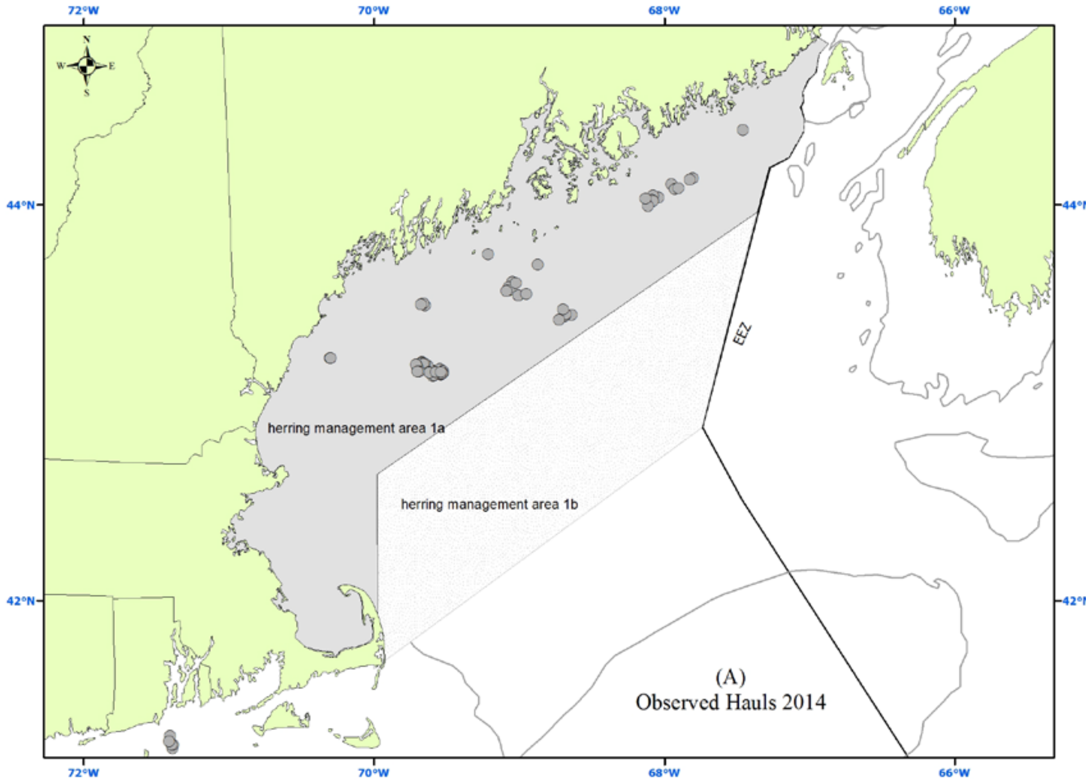


Figure 35. 2014 Herring Purse Seine observed hauls (A) and observed takes (B).



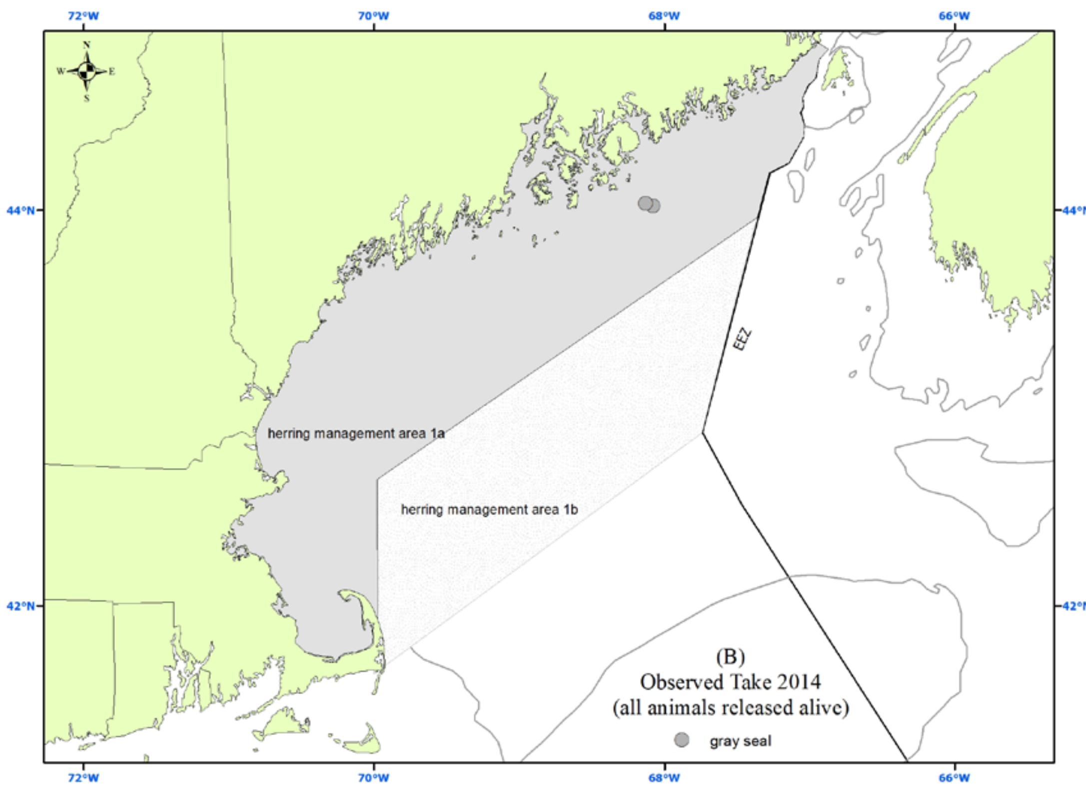


Figure 36. Observed sets and marine mammal interactions in the Pelagic longline fishery along the U.S. Atlantic coast during 2010. The boundaries of the Florida East Coast (FEC), South Atlantic Bight (SAB), Mid-Atlantic Bight (MAB), Northeast Coastal (NEC), and Sargasso Sea (SAR) fishing areas are shown. Seasonal closed areas instituted in 2001 under the HMS FMP are shown as hatched areas.

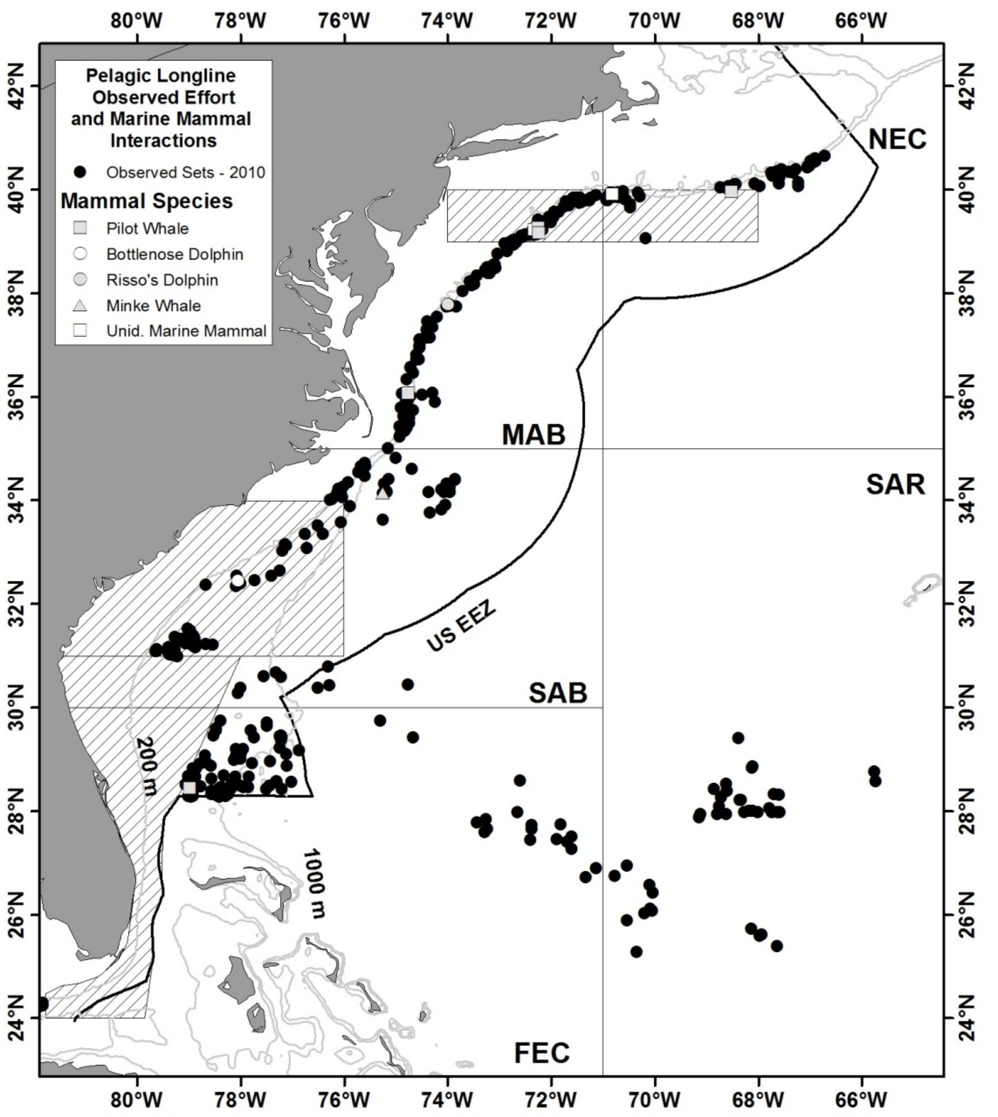


Figure 37. Observed sets and marine mammal interactions in the Pelagic longline fishery along the U.S. Atlantic coast during 2011. The boundaries of the Florida East Coast (FEC), South Atlantic Bight (SAB), Mid-Atlantic Bight (MAB), Northeast Coastal (NEC), and Sargasso Sea (SAR) fishing areas are shown. Seasonal closed areas instituted in 2001 under the HMS FMP are shown as hatched areas.

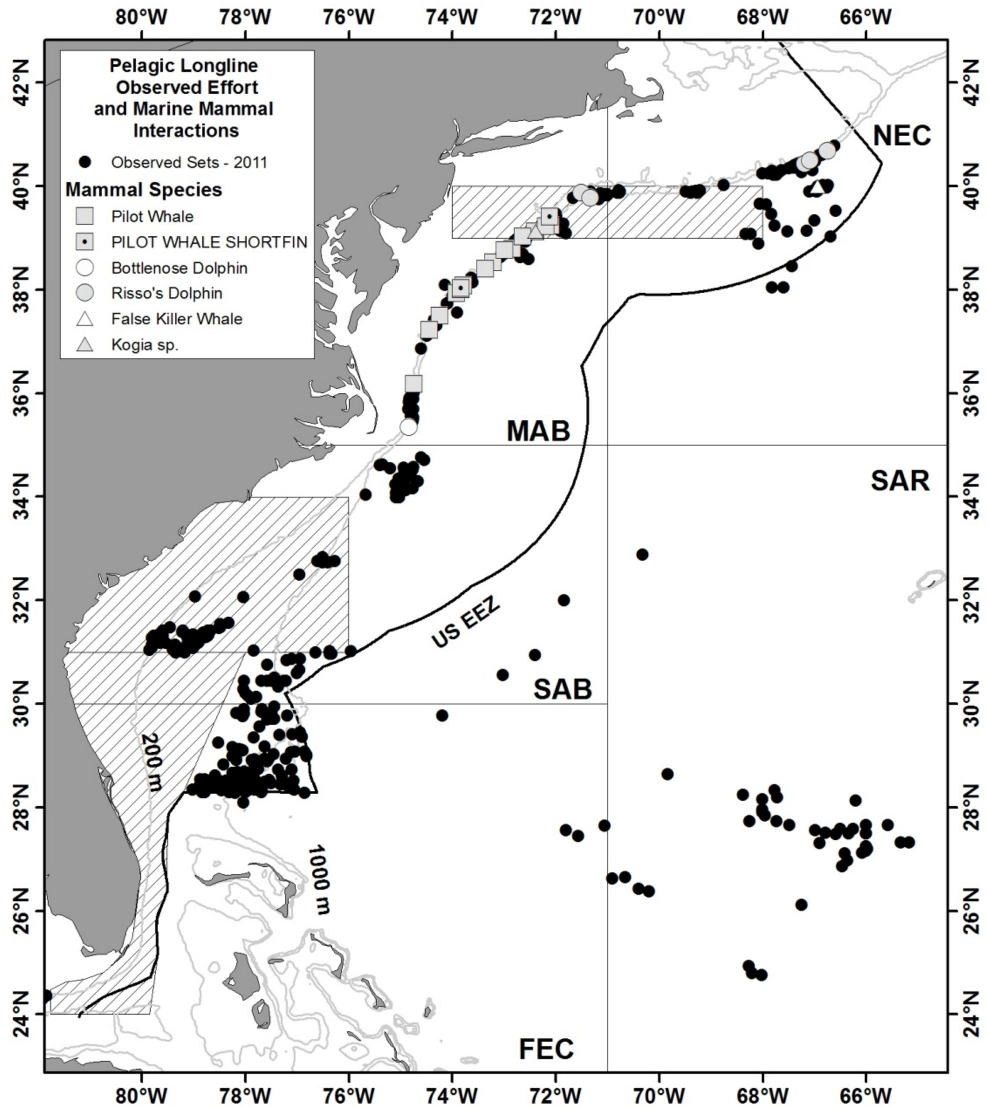


Figure 38. Observed sets and marine mammal interactions in the Pelagic longline fishery along the U.S. Atlantic coast during 2012. The boundaries of the Florida East Coast (FEC), South Atlantic Bight (SAB), Mid-Atlantic Bight (MAB), Northeast Coastal (NEC), and Sargasso Sea (SAR) fishing areas are shown. Seasonal closed areas instituted in 2001 under the HMS FMP are shown as hatched areas.

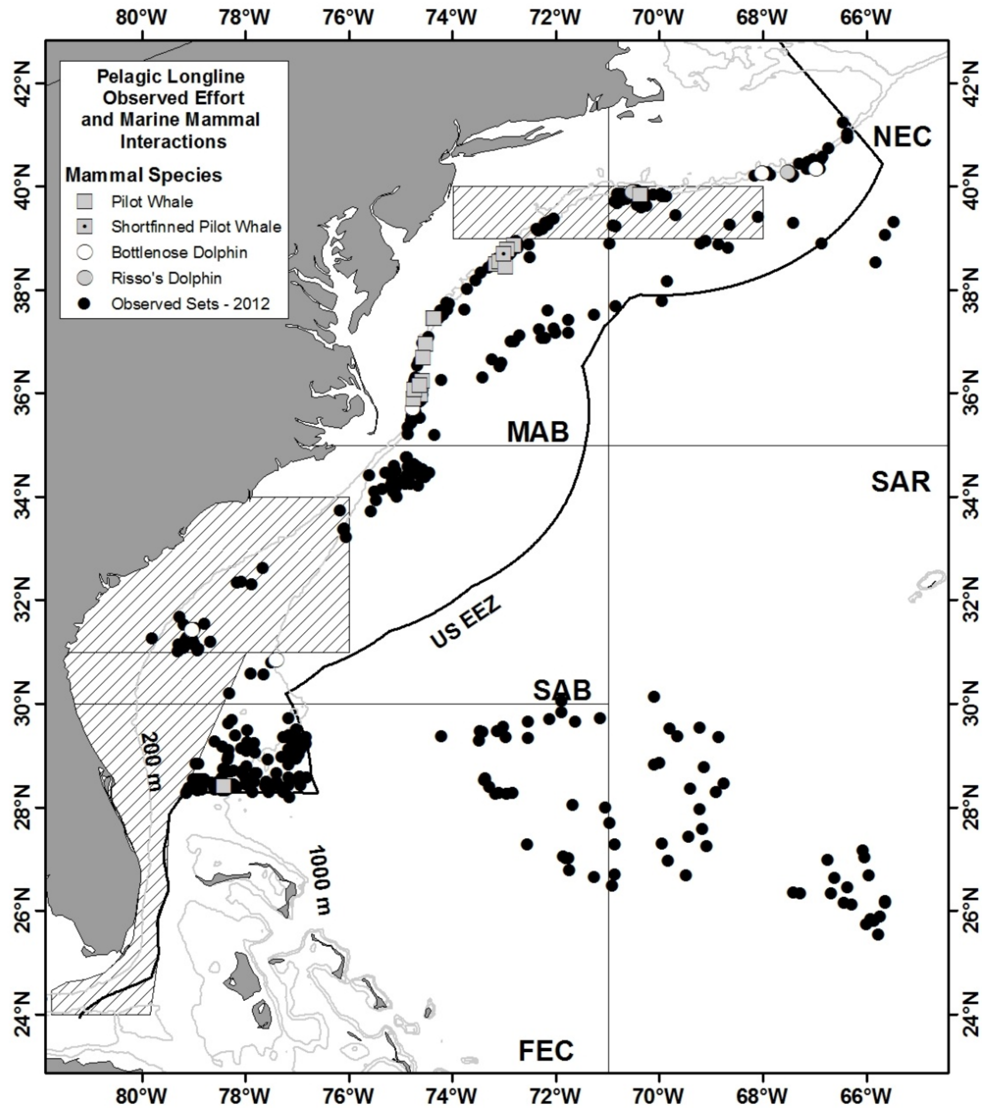


Figure 39. Observed sets and marine mammal interactions in the Pelagic longline fishery along the U.S. Atlantic coast during 2013. The boundaries of the Florida East Coast (FEC), South Atlantic Bight (SAB), Mid-Atlantic Bight (MAB), Northeast Coastal (NEC), and Sargasso Sea (SAR) fishing areas are shown. Seasonal closed areas instituted in 2001 under the HMS FMP are shown as hatched areas.

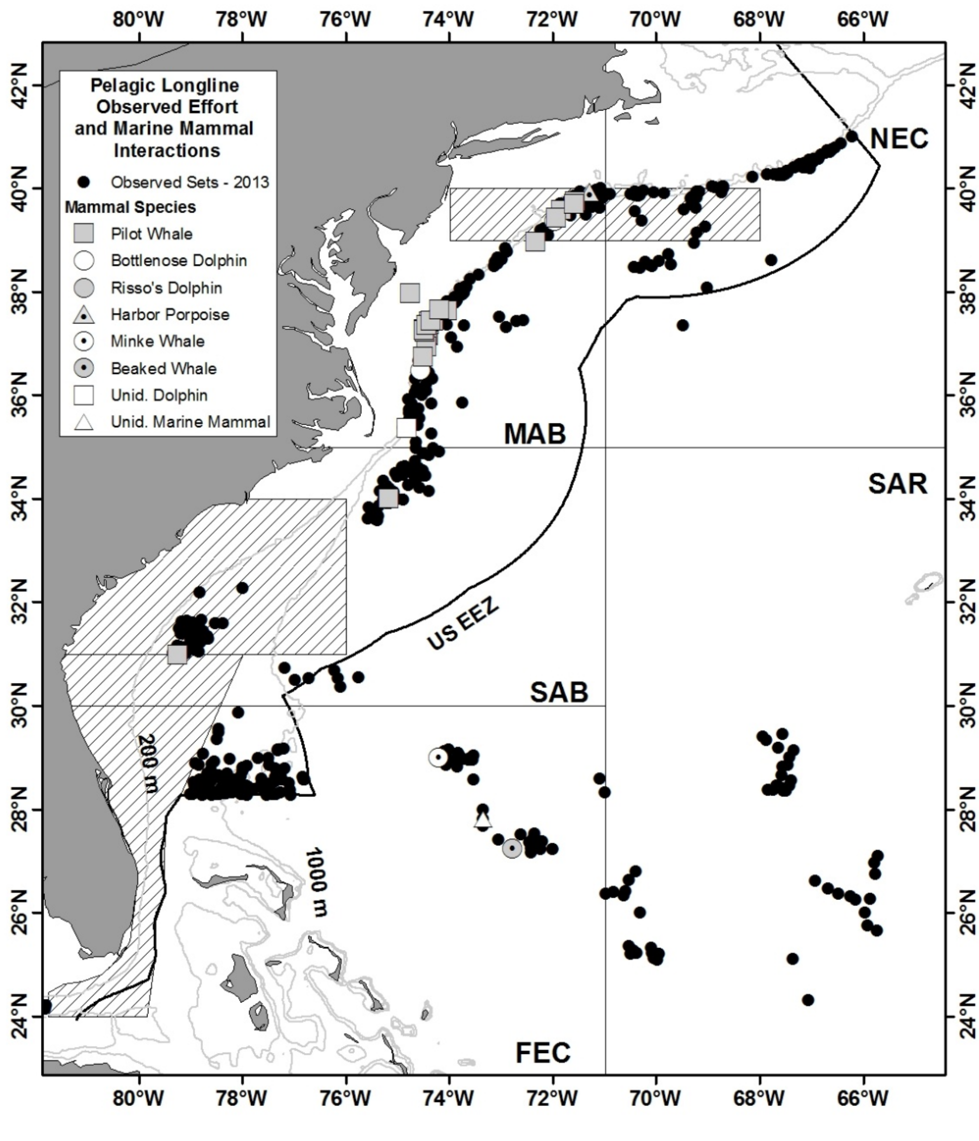


Figure 40. Observed sets and marine mammal interactions in the Pelagic longline fishery along the U.S. Atlantic coast during 2014. The boundaries of the Florida East Coast (FEC), South Atlantic Bight (SAB), Mid-Atlantic Bight (MAB), Northeast Coastal (NEC), and Sargasso Sea (SAR) fishing areas are shown. Seasonal closed areas instituted in 2001 under the HMS FMP are shown as hatched areas.

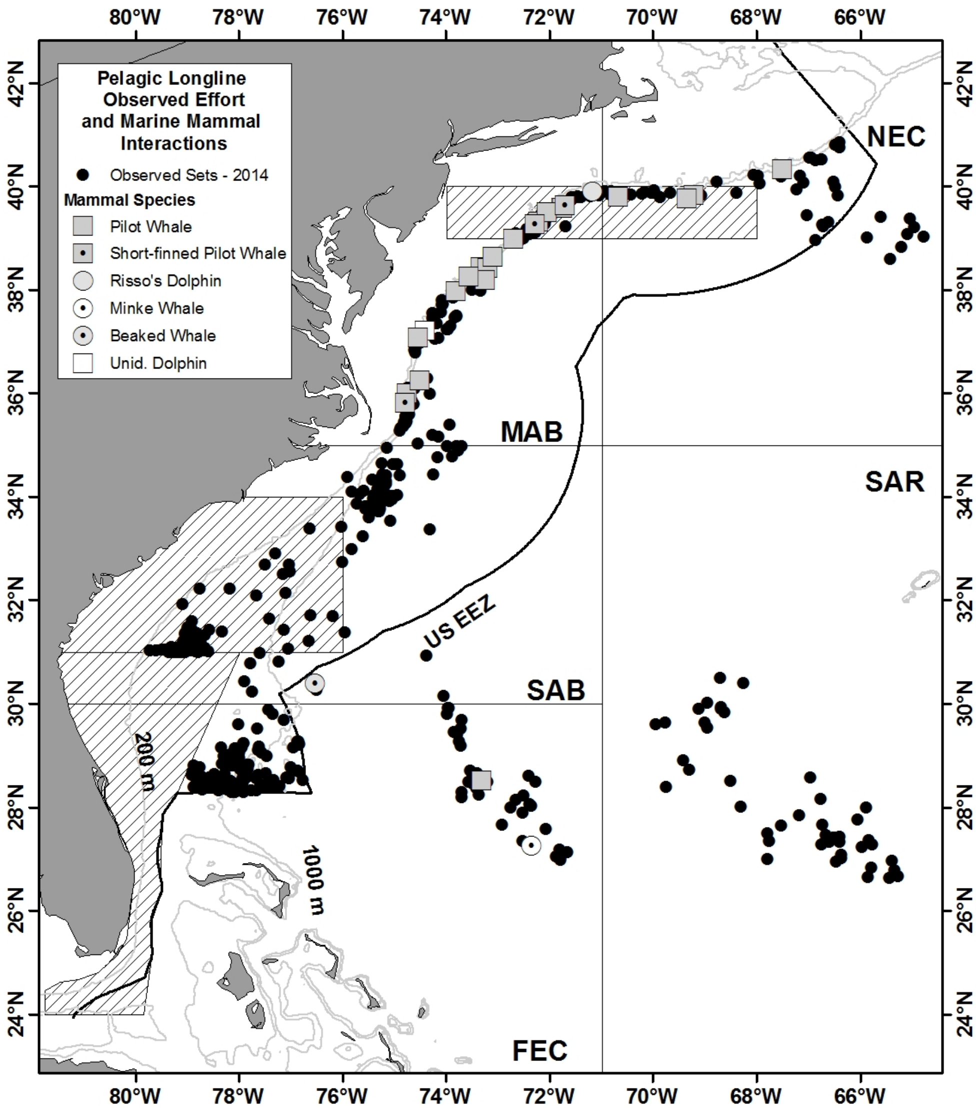


Figure 41. Observed sets in the Pelagic longline fishery in the Gulf of Mexico during 2010. Closed areas in the DeSoto canyon instituted in 2010 are shown as hatched areas.

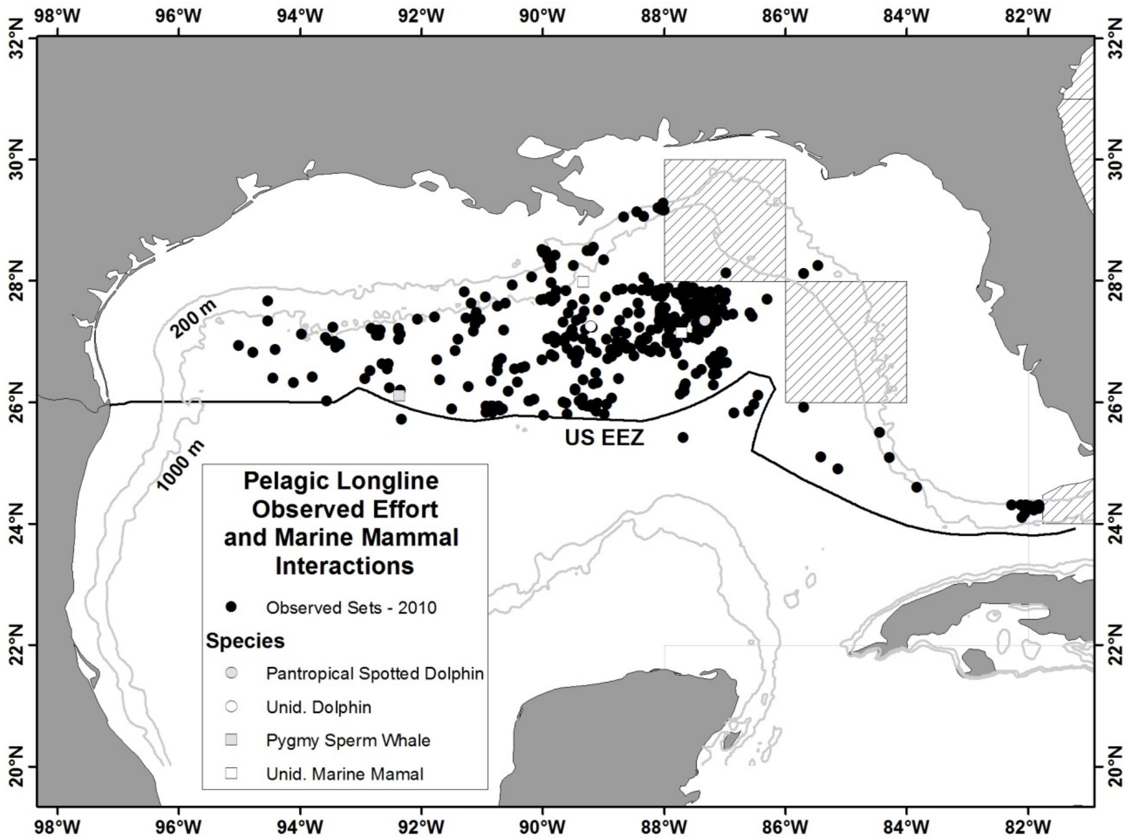


Figure 42. Observed sets in the Pelagic longline fishery in the Gulf of Mexico during 2011. Closed areas in the DeSoto canyon instituted in 2001 are shown as hatched areas.

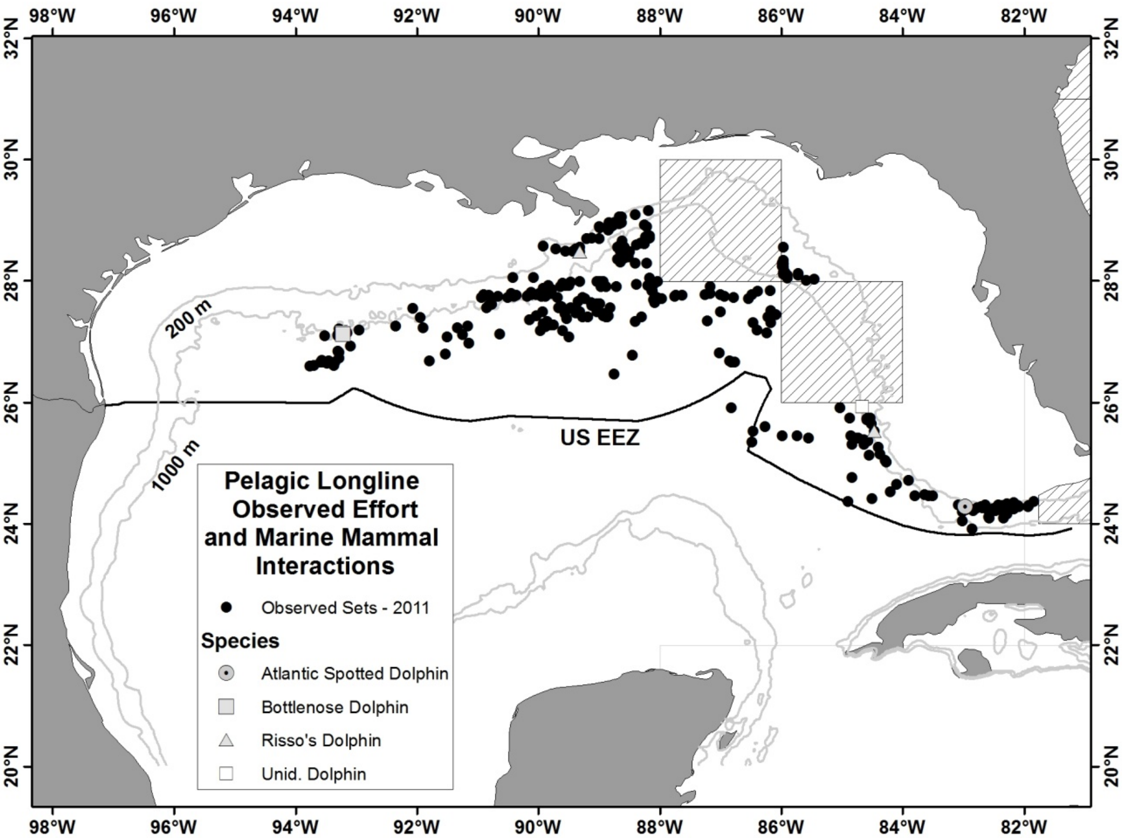


Figure 43. Observed sets in the Pelagic longline fishery in the Gulf of Mexico during 2012. Closed areas in the DeSoto canyon instituted in 2001 are shown as hatched areas.

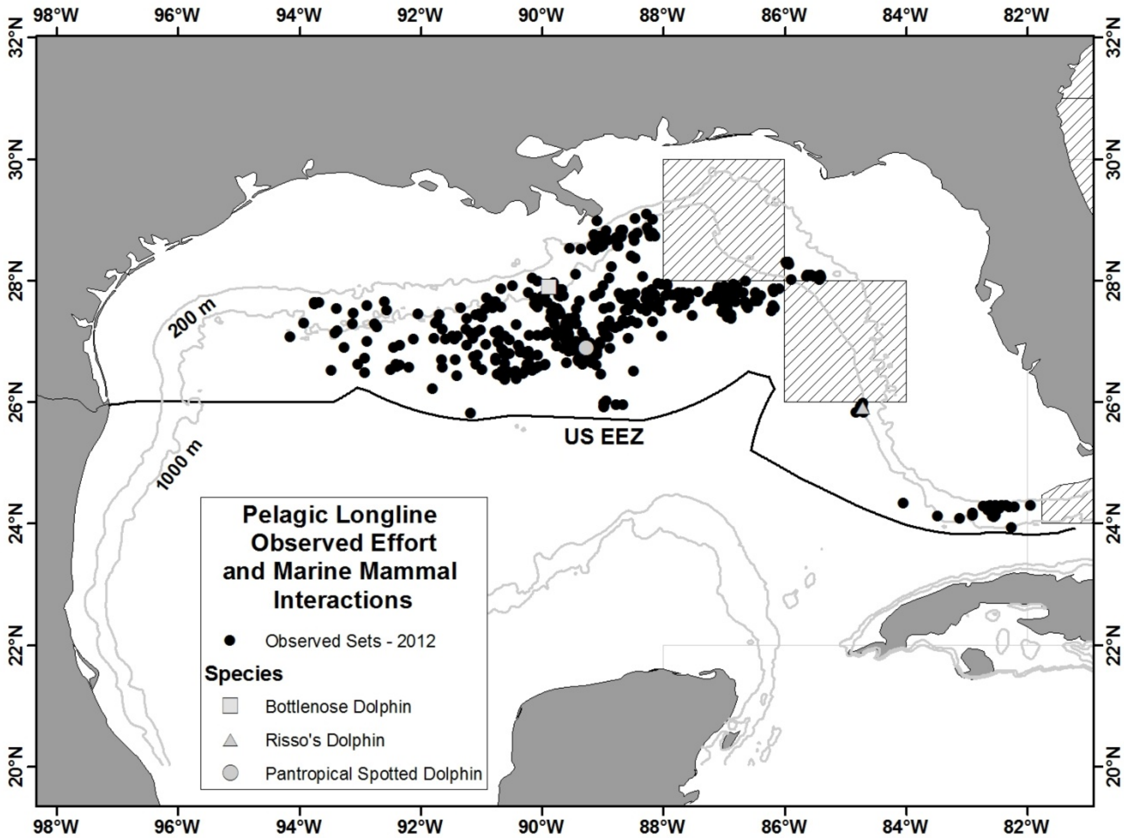


Figure 44. Observed sets in the Pelagic longline fishery in the Gulf of Mexico during 2013. Closed areas in the DeSoto canyon instituted in 2001 are shown as hatched areas.

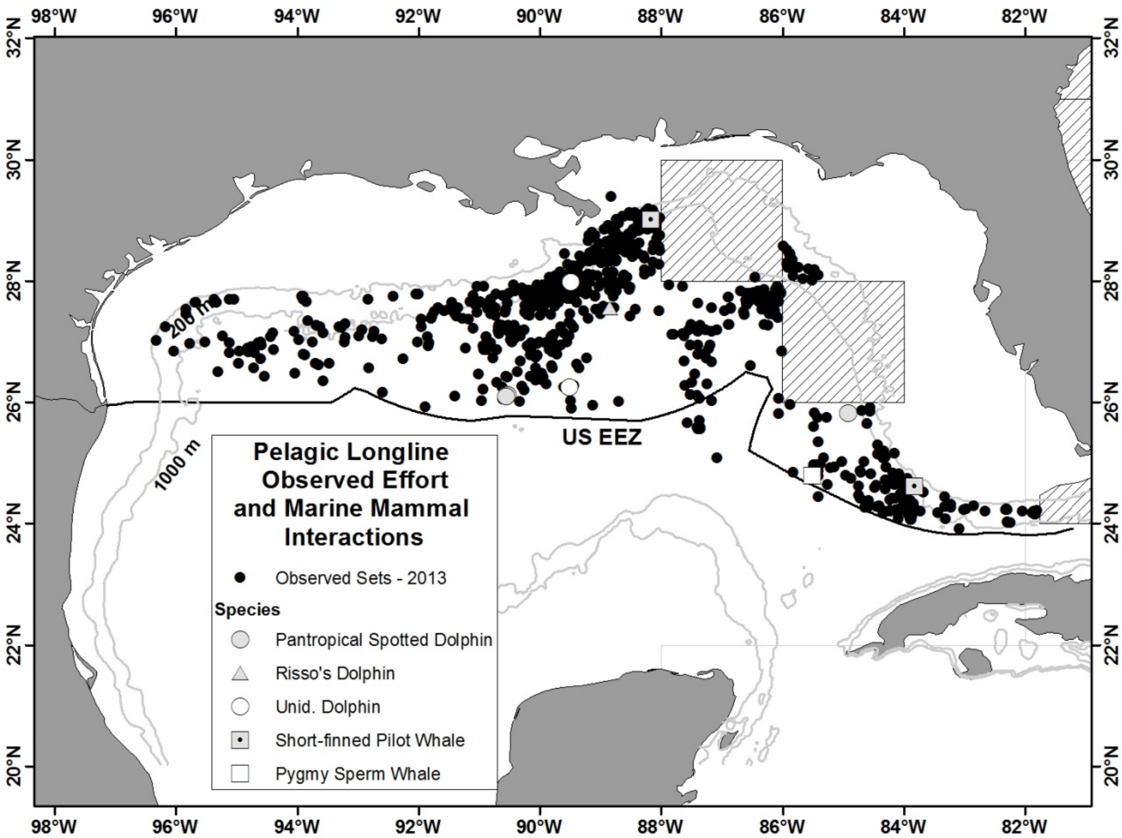
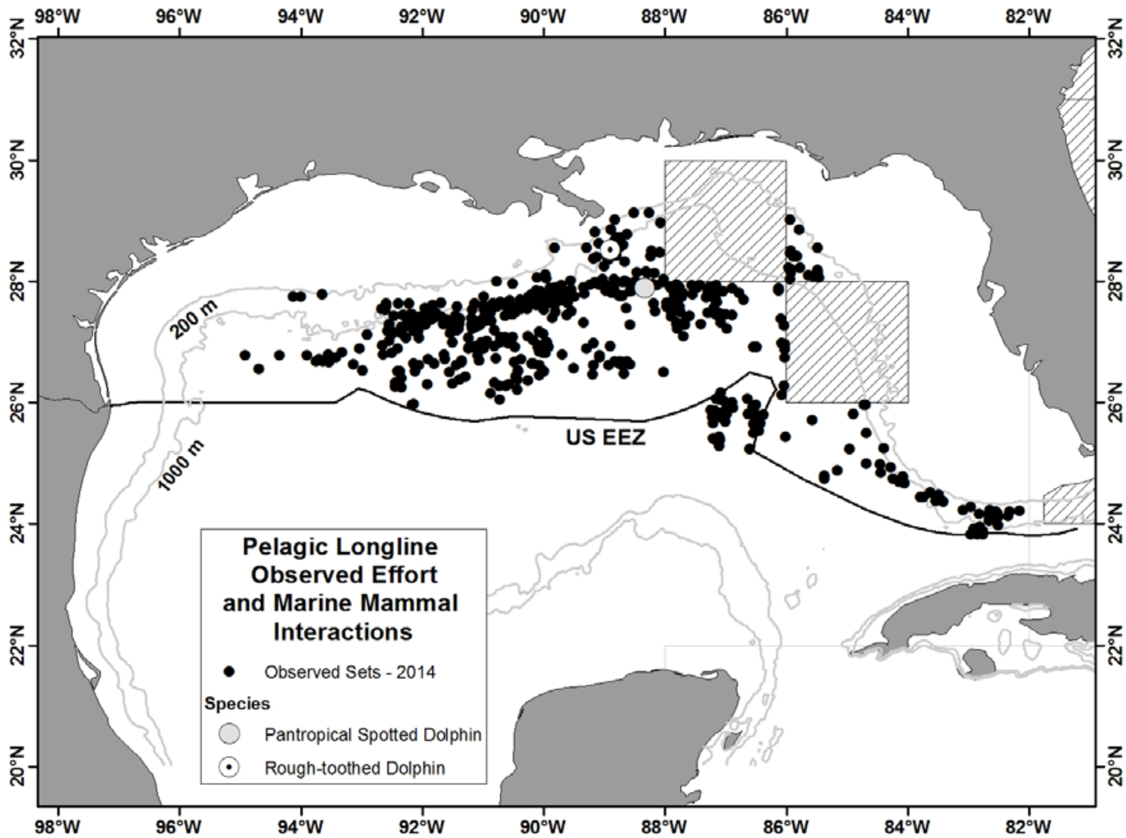


Figure 45. Observed sets in the Pelagic longline fishery in the Gulf of Mexico during 2014. Closed areas in the DeSoto canyon instituted in 2001 are shown as hatched areas.



Appendix IV

Surveys and Abundance Estimates

APPENDIX IV: Table A. Surveys

Survey Number	Year	Season	Platform	Track line length (km)	Area	Agency / Program	Analysis	Corrected for g(0)	Reference
1	1982	year-round	plane	211,585	Cape Hatteras, NC to Nova Scotia, continental shelf and shelf edge waters	CETAP	Line transect analyses of distance data	N	CETAP 1982
2	1990	Aug	ship (Chapman)	2,067	Cape Hatteras, NC to Southern New England, north wall of the Gulf Stream	NEC	One team data analyzed by DISTANCE	N	NMFS 1990
3	1991	Jul-Aug	ship (Abel-J)	1,962	Gulf of Maine, lower Bay of Fundy, southern Scotian Shelf	NEC	Two independent team data analyzed with modified direct duplicate method.	Y	Palka 1995
4	1991	Aug	boat (Sneak Attack)	640	inshore bays of Maine	NEC	One team data analyzed by DISTANCE.	Y	Palka 1995
5	1991	Aug-Sep	plane 1(AT-11)	9,663	Cape Hatteras, NC to Nova Scotia, continental shelf and shelf edge waters	NEC/SEC	One team data analyzed by DISTANCE.	N	NMFS 1991
6	1991	Aug-Sep	plane 2 (Twin Otter)		Cape Hatteras, NC to Nova Scotia, continental shelf and shelf edge waters	NEC/SEC	One team data analyzed by DISTANCE.	N	NMFS 1991
7	1991	Jun-Jul	ship (Chapman)	4,032	Cape Hatteras to Georges Bank, between 200 and 2,000m isobaths	NEC	One team data analyzed by DISTANCE.	N	Waring et al. 1992; Waring 1998
8	1992	Jul-Sep	ship (Abel-J)	3,710	N. Gulf of Maine and lower Bay of Fundy	NEC	Two independent team data analyzed with modified direct duplicate method.	Y	Smith et al. 1993

9	1993	Jun-Jul	ship (Delaware II)	1,874	S. edge of Georges Bank, across the Northeast Channel, to the SE. edge of the Scotian Shelf	NEC	One team data analyzed by DISTANCE.		NMFS 1993
10	1994	Aug-Sep	ship (Relentless)	534	shelf edge and slope waters of Georges Bank	NEC	One team data analyzed by DISTANCE.	N	NMFS 1994
11	1995	Aug-Sep	plane (Skymaster)	8,427	Gulf of St. Lawrence	DFO	One team data analyzed using quenouille's jackknife bias reduction procedure that modeled the left truncated sighting curve	N	Kingsley and Reeves 1998
12	1995	Jul-Sep	2 ships (Abel-J and Pelican) and plane (Twin Otter)	32,600	Virginia to the mouth of the Gulf of St. Lawrence	NEC	Ship: two independent team data analyzed with modified direct duplicate method. Plane: one team data analyzed by DISTANCE.	Y/N	Palka 1996
13	1996	Jul-Aug	plane	3,993	Northern Gulf of St. Lawrence	DFO	Quenouille's jackknife bias reduction procedure on line transect methods that modeled the left truncated sighting curve	N	Kingsley and Reeves 1998
14	1998	Jul-Aug	ship	4,163	south of Maryland	SEC	One team data analyzed by DISTANCE.	N	Mullin and Fulling 2003
15	1998	Aug-Sep	plane (1995 and 1998)		Gulf of St. Lawrence	DFO			Kingsley and Reeves 1998
16	1998	Jul-Sep	ship (Abel-J) and plane (Twin Otter)	15,900	north of Maryland	NEC	Ship: two independent team data analyzed with the modifed direct duplicate or Palka & Hammond analysis methods, depending on the presence of responsive movement. Plane: one team data analyzed by DISTANCE.	Y	

17	1999	Jul-Aug	ship (Abel-J) and plane (Twin Otter)	6,123	south of Cape Cod to mouth of Gulf of St. Lawrence	NEC	Ship: two independent team data analyzed with modified direct duplicate or Palka & Hammond analysis methods, depending on the presence of responsive movement. Plane: circle-back data pooled with aerial data collected in 1999, 2002, 2004, 2006, 2007, and 2008 to calculate pooled g(0)'s and year-species specific abundance estimates for all years except 2008.	Y	
18	2002	Jul-Aug	plane (Twin Otter)	7,465	Georges Bank to Maine	NEC	Same as for plane in survey 17.	Y	Palka 2006
19	2002	Feb-Apr	ship (Gunter)	4,592	SE US continental shelf Delaware - Florida	SEC	One team data analyzed by DISTANCE.	N	
20	2002	Jun-Jul	plane	6,734	Florida to New Jersey	SEC	Two independent team data analyzed with modified direct duplicate method.	Y	
21	2004	Jun-Aug	ship (Gunter)	5,659	Florida to Maryland	SEC	Two independent team data analyzed with modified direct duplicate method.	Y	Garrison et al. 2010
22	2004	Jun-Aug	ship (Endeavor) and plane (Twin Otter)	10,761	Maryland to Bay of Fundy	NEC	Same methods used in survey 17.	Y	Palka 2006
23	2006	Aug	plane (Twin Otter)	10,676	Georges Bank to Bay of Fundy	NEC	Same as for plane in survey 17.	Y	Palka 2005
24	2007	Aug	ship (Bigelow) and plane (Twin Otter)	8,195	Georges Bank to Bay of Fundy	NEC	Ship: Tracker data analyzed by DISTANCE. Plane: same as for plane in survey 17.	Y	Palka 2005

25	2007	Jul-Aug	plane	46,804	Canadian waters from Nova Scotia to Newfoundland	DFO	uncorrected counts	N	Lawson and Gosselin 2009
26	2008	Aug	plane (Twin Otter)	6,267	NY to Maine in US waters	NEC	Same as for plane in survey 17.	Y	Palka 2005
27	2001	May-Jun	plane		Maine coast	NEC/UM	corrected counts	N	Gilbert et al. 2005
28	1999	Mar	plane		Cape Cod	NEC	uncorrected counts	N	Barlas 1999
29	1983-1986	1983 (Fall); 1984 (Winter, Spring, Summer);1985 (Summer, Fall); 1986 (Winter)	plane (Beechcraft D-18S modified with a bubbleno se)	103,490	northern Gulf of Mexico bays and sounds, coastal waters from shoreline to 18-m isobath, and OCS waters from 18-m isobath to 9.3 km past the 18-m isobath	SEC	One team data analyzed with Line-transect theory	N	Scott et al. 1989
30	1991-1994	Apr-Jun	ship (Oregon II)	22,041	northern Gulf of Mexico from 200 m to U.S. EEZ	SEC	One team data analyzed by DISTANCE	N	Hansen et al. 1995
31	1992-1993	Sep-Oct	plane (Twin Otter)		northern Gulf of Mexico bays and sounds, coastal waters from shoreline to 18-m isobath, and OCS waters from 18-m isobath to 9.3 km past the 18-m isobath	GOMEX92, GOMEX93	One team data analyzed by DISTANCE	N	Blaylock and Hoggard 1994
33	1996-1997,1999-2001	Apr-Jun	ship (Oregon II and Gunter)	12,162	northern Gulf of Mexico from 200 m to U.S. EEZ	SEC	One team data analyzed by DISTANCE	N	Mullin and Fulling 2004
34	1998-2001	end Aug-early Oct	ship (Gunter and Oregon II)	2,196	northern Gulf of Mexico outer continental shelf (OCS, 20-200 m)	SEC	One team data analyzed by DISTANCE	N	Fulling et al. 2003
36	2004	12-13 Jan	helicopter		Sable Island	DFO	Pup count	na	Bowen et al. 2007
37	2004		plane		Gulf of St Lawrence and Nova Scotia Eastern Shore	DFO	Pup count	na	Hammill 2005

38	2009	10 Jun-13 Aug	ship	4,600	northern Gulf of Mexico from 200m to U.S. EEZ	SEC	One team data analyzed by DISTANCE		
39	2007	17 Jul-8 Aug	plane		northern Gulf of Mexico from shore to 200m(majority of effort 0- 20m)	SEC	One team data analyzed by DISTANCE		
40	2011	4 Jun-1 Aug	ship (Bigelow)	3,107	Virginia to Massachusetts (waters that were deeper than the 100-m depth contour out to beyond the US EEZ)	NEC	Two-independent teams, both using big-eyes. Analyzed using DISTANCE, the independent observer option assuming point independence	Y	Palka 2012
41	2011	7-26 Aug	Plane (Twin Otter)	5,313	Massachusetts to New Brunswick, Canada (waters north of New Jersey and shallower than the 100-m depth contour, through the US and Canadian Gulf of Maine and up to and including the lower Bay of Fundy)	NEC	Two-independent teams, both using naked eye in the same plane. Analyzed using DISTANCE, the independent observer option assuming point independence	Y	Palka 2012
42	2011	19 Jun- 1 Aug	Ship (Gunter)	4,445	Florida to Virginia	SEC	Two-independent teams, both using naked eye in the same plane. Analyzed using DISTANCE, the independent observer option assuming point independence	Y	
43	2012	May-Jun	plane		Maine coast	NEC	corrected counts	N	Waring et al. 2015
44	1992	Jan–Feb	Ship (Oregon II)	3,464	Cape Canaveral to Cape Hatteras, US EEZ	SEC		N	NMFS 1992

45	2010	24 July–14 Aug	plane	7,944	southeastern Florida to Cape May, New Jersey	SEC	Two-independent teams, both using naked eye in the same plane.		
46	2011	6 –29 July	plane	8,665	southeastern Florida to Cape May, New Jersey	SEC	Two-independent teams, both using naked eye in the same plane.		

APPENDIX IV: Table B. Abundance estimates – "Survey Number" refers to surveys described in Table A. "Best" estimate for each species in bold font .

Species	Stock	Year	Nbest	CV	Survey Number	Notes
Humpback Whale	Gulf of Maine	1992	501			minimum pop'n size estimated from photo-ID data
		1993	652	0.29		YONAH sampling (Clapham *et al.* 2003)
		1997	497			minimum pop'n size estimated from photo-ID data
		1999	902	0.45	17	
		2002	521	0.67	18	Palka 2006
		2004	359	0.75	22	Palka 2006
		2006	847	0.55	23	Palka 2005
		2008	**823**			Mark-recapture estimate Robbins 2010
		2011	335	0.42	40+41	Palka 2012
Fin Whale	Western North Atlantic	1995	2,200	0.24	12	Palka 1996
		1999	2,814	0.21	18	Palka 2006
		2002	2,933	0.49	18	Palka 2006
		2004	1,925	0.55	22	Palka 2006
		2006	2,269	0.37	23	Palka 2005
		2007	3,522	0.27	25	Lawson and Gosselin 2009
		2011	1,595	0.33	40+41	Palka 2012
		2011	23	0.87	42	
		2011	**1,618**	**0.33**	**40+41+42**	Estimate summed from north and south surveys
Sei Whale	Nova Scotia Stock	1977	1,393-2,248			based on tag-recapture data (Mitchell and Chapman 1977)
		1977	870			based on census data (Mitchell and Chapman 1977)
		1982	280		1	CETAP 1982
		2002	71	1.01	18	Palka 2006
		2004	386	0.85	22	Palka 2006
		2006	207	0.62	23	Palka 2005
		2011	**357**	**0.52**	**40+41**	Palka 2012
Minke Whale	Canadian East Coast	1982	320	0.23	1	CETAP 1982
		1992	2,650	0.31	3+8	

		1993	330	0.66	9	
		1995	2,790	0.32	12	Palka 1996
		1995	1,020	0.27	11	
		1996	620	0.52	13	
		1999	2,998	0.19	17	
		2002	756	0.9	18	Palka 2006
		2004	600	0.61	22	Palka 2006
		2006	3,312	0.74	23	
		2007	**20,741**	**0.3**	**25**	Lawson and Gosselin 2009
		2011	2,591	0.81	40+41	Palka 2012
Sperm Whale	North Atlantic	1982	219	0.36	1	CETAP 1982
		1990	338	0.31	2	
		1991	736	0.33	7	Waring *et al.*1992:1998
		1991	705	0.66	6	
		1991	337	0.5	5	
		1993	116	0.4	9	
		1994	623	0.52	10	
		1995	2,698	0.67	12	Palka 1996
		1998	2,848	0.49	16	
		1998	1,181	0.51	14	Mullin and Fulling 2003
		2004	2,607	0.57	22	Palka 2006
		2004	2,197	0.47	21	Garrison *et al.* 2010
		2004	4,804	0.38	21+22	Estimate summed from north and south surveys
		2011	1,593	0.36	40+41	Palka 2012
		2011	695	0.39	42	
		2011	**2,288**	**0.28**	**40+41+42**	Estimate summed from north and south surveys
Kogia spp.	Western North Atlantic	1998	115	0.61	16	
		1998	580	0.57	14	Mullin and Fulling 2003
		2004	358	0.44	22	Palka 2006
		2004	37	0.75	21	Garrison *et al.* 2010
		2004	395	0.4	21+22	Estimate summed from north and south surveys
		2011	1,783	0.62	40+41	Palka 2012
		2011	2,002	0.69	42	
		2011	**3,785**	**0.47**	**40+41+42**	Estimate summed from north and south surveys
Beaked Whales	Western North Atlantic	1982	120	0.71	1	CETAP 1982
		1990	442	0.51	2	
		1991	262	0.99	7	Waring *et al.*1992:1998
		1991	370	0.65	6	
		1991	612	0.73	5	
		1993	330	0.66	9	
		1994	99	0.64	10	
		1995	1,519	0.69	12	Palka 1996

		1998	2,600	0.4	16	
		1998	541	0.55	14	Mullin and Fulling 2003
		2004	2,839	0.78	22	Palka 2006
		2004	674	0.36	21	Garrison *et al.* 2010
		2004	3,513	0.63	21+22	Estimate summed from north and south surveys
		2006	922	1.47	23	
		2011	5,500	0.67	40+41	2011 estimates are for *Mesoplodon* spp. beaked whales alone (not including *Ziphias*; Palka 2012)
		2011	1,592	0.67	42	2011 estimates are for *Mesoplodon* spp. beaked whales alone (not including *Ziphias*)
		2011	**7,092**	**0.54**	**40+41+42**	2011 estimates are for *Mesoplodon* spp. beaked whales alone (not including *Ziphias*); Estimate summed from north and south surveys
Cuvier's Beaked Whale	Western North Atlantic	2011	4,962	0.37	40+41	Palka 2012
		2011	1,570	0.65	42	
		2011	**6,532**	**0.32**	**40+41+42**	Estimate summed from north and south surveys
Risso's Dolphin	Western North Atlantic	1982	4,980	0.34	1	CETAP 1982
		1991	11,017	0.58	7	Waring *et al.*1992:1998
		1991	6,496	0.74	5	
		1991	16,818	0.52	6	
		1993	212	0.62	9	
		1995	5,587	1.16	12	Palka 1996
		1998	18,631	0.35	17	
		1998	9,533	0.5	15	
		1998	28,164	0.29	15+17	Estimate summed from north and south surveys
		2002	69,311	0.76	18	Palka 2006
		2004	15,053	0.78	21	Garrison *et al.* 2010
		2004	5,426	0.54	22	Palka 2006
		2004	20,479	0.59	21+22	Estimate summed from north and south surveys
		2006	14,408	0.38	23	
		2011	15,197	0.55	40+41	Palka 2012
		2011	3,053	0.44	42	
		2011	**18,250**	**0.46**	**40+41+42**	Estimate summed from north and south surveys
Pilot Whale	Western North Atlantic	1951	50,000			Derived from catch data from 1951-1961 drive fishery (Mitchell 1974)
		1975	43,000-96,000			Derived from population models (Mercer 1975)
		1982	11,120	0.29	1	CETAP 1982
		1991	3,636	0.36	7	Waring *et al.*1992:1998

		1991	3,368	0.28	5	
		1991	5,377	0.53	6	
		1993	668	0.55	9	
		1995	8,176	0.65	12	Palka 1996
		1995	9,776	0.55	12+16	Sum of US (#12) and Canadian (#16) surveys
		1998	1,600	0.65	16	
		1998	9,800	0.34	17	
		1998	5,109	0.41	15	
		2002	5,408	0.56	18	Palka 2006
		2004	15,728	0.34	22	Palka 2006
		2004	15,411	0.43	21	Garrison *et al.* 2010
		2004	31,139	0.27	21+22	Estimate summed from north and south surveys
		2006	26,535	0.35	23	Estimate summed from north and south surveys
		2007	16,058	0.79	25	Lawson and Gosselin 2009; long-finned pilot whales
		2011	**5,636**	**0.63**	**40+41**	**long-finned pilot whales**
		2011	11,865	0.57	40+41	unidentified pilot whales
		2011	4,569	0.57	40+41	short-finned pilot whales
		2011	16,946	0.43	42	short-finned pilot whales
		2011	**21,515**	**0.37**	**40+41+42**	**Best estimate for short-finned pilot whales alone; Estimate summed from north and south surveys**
Atlantic white-sided Dolphin	Western North Atlantic	1982	28,600	0.21	1	
		1992	20,400	0.63	2+7	
		1993	729	0.47	9	
		1995	27,200	0.43	12	Palka 1996
		1995	11,750	0.47	11	
		1996	560	0.89	13	
		1999	51,640	0.38	17	
		2002	109,141	0.3	18	Palka 2006
		2004	2,330	0.8	22	Palka 2006
		2006	17,594	0.3	23	
		2006	63,368	0.27	(18+23)/2	average of #18 and #23
		2007	5,796	0.43	25	Lawson and Gosselin 2009
		2011	**48,819**	**0.61**	**40+41**	Palka 2012
White-beaked Dolphin	Western North Atlantic	1982	573	0.69	1	CETAP 1982
			5,500			(Alling and Whitehead 1987)
		1982	3,486	0.22		(Alling and Whitehead 1987)
		2006	**2,003**	**0.94**	**23**	
		2007	11,842		25	
		2008			26	
Common Dolphin	Western North Atlantic	1982	29,610	0.39	1	
		1991	22,215	0.4	7	Waring *et al.*1992:1998

		1993	1,645	0.47	9	
		1995	6,741	0.69	12	Palka 1996
		1998	30,768	0.32	17	
		1998	0		15	
		2002	6,460	0.74	18	
		2004	90,547	0.24	22	Palka 2006
		2004	30,196	0.54	21	Garrison *et al.* 2010
		2004	120,743	0.23	21+22	Estimate summed from north and south surveys
		2006	84,000	0.36	24	
		2007	**173,486**	**0.55**	**25**	Lawson and Gosselin 2009
		2011	67,191	0.29	40+41	Palka 2012
		2011	2,993	0.87	42	
		2011	70,184	0.28	40+41+42	Estimate summed from north and south surveys
Atlantic Spotted Dolphin	Western North Atlantic	1982	6,107	0.27	1	CETAP 1982
		1995	4,772	1.27	12	Palka 1996
		1998	32,043	1.39	16	
		1998	14,438	0.63	14	Mullin and Fulling 2003
		2004	3,578	0.48	22	Palka 2006
		2004	47,400	0.45	21	Garrison *et al.* 2010
		2004	50,978	0.42	21+22	Estimate summed from north and south surveys
		2011	26,798	0.66	40+41	Palka 2012
		2011	17,917	0.42	42	
		2011	**44,715**	**0.43**	**40+41+42**	Estimate summed from north and south surveys
Pantropical Spotted Dolphin	Western North Atlantic	1982	6,107	0.27	1	CETAP 1982
		1995	4,772	1.27	12	Palka 1996
		1998	343	1.03	16	
		1998	12,747	0.56	14	Mullin and Fulling 2003
		2004	0		22	Palka 2006
		2004	4,439	0.49	21	Garrison *et al.* 2010
		2004	4,439	0.49	21+22	Estimate summed from north and south surveys
		2011	0	0	40+41	Palka 2012
		2011	3,333	0.91	42	
		2011	**3,333**	**0.91**	**40+41+42**	**Estimate summed from north and south surveys**
Striped Dolphin	Western North Atlantic	1982	36,780	0.27	1	
		1995	31,669	0.73	12	Palka 1996
		1998	39,720	0.45	16	
		1998	10,225	0.91	14	Mullin and Fulling 2003
		2004	52,055	0.57	22	

		2004	42,407	0.53	21	Garrison *et al.* 2010
		2004	94,462	0.4	21+22	Estimate summed from north and south surveys
		2011	46,882	0.33	40+41	Palka 2012
		2011	7,925	0.66	42	
		2011	**54,807**	**0.3**	**40+41+42**	**Estimate summed from north and south surveys**
Rough-toothed Dolphin	Western North Atlantic	2011	0	0	40+41	Palka 2012
		2011	271	1	42	
		2011	**271**	**1**	**40+41+42**	**Estimate summed from north and south surveys**
Bottlenose Dolphin	Western North Atlantic Offshore	1998	16,689	0.32	16	
		1998	13,085	0.4	14	Mullin and Fulling 2003
		2002	26,849	0.19	20	
		2002	5,100	0.41	18	Palka 2006
		2004	9,786	0.56	22	Palka 2006
		2004	44,953	0.26	21	Garrison *et al.* 2010
		2006	2,989	1.11	23	
		2011	26,766	0.52	40+41	Palka 2012
		2011	50,766	0.55	42	
		2011	77,532	0.4	**40+41+42**	**Estimate summed from north and south surveys**
Harbor Porpoise	Gulf of Maine/Bay of Fundy	1991	37,500	0.29	3	Palka 1995
		1992	67,500	0.23	8	Smith *et al.* 1993
		1995	74,000	0.2	12	Palka 1996
		1995	12,100	0.26	11	
		1996	21,700	0.38	14	Mullin and Fulling 2003
		1999	89,700	0.22	17	Palka 2006; survey discovered portions of the range not previously surveyed
		2002	64,047	0.48	21	Palka 2006
		2004	51,520	0.65	23	Palka 2006
		2006	89,054	0.47	24	
		2007	4,862	0.31	25	Lawson and Gosselin 2009
		2011	**79,883**	**0.32**	**40+41**	Palka 2012
Harbor Seal	Western North Atlantic	2001	99,340	0.097	27	Gilbert *et al.* 2005
						Waring *et al.* 2015
		2012	70,142	0.29	43	
Gray Seal	Western North Atlantic	1999	5,611		28	Barlas 1999
		2001	1,731		27	Gilbert *et al.* 2005
		2004	52,500	0.15	37	Gulf of St Lawrence and Nova Scotia Eastern Shore
			208,720	0.14		
			216,490	0.11		
		2004	223,220	0.08	36	Sable Island
				95% CI		

				263,000-		
		2012	331,000	458,000		DFO 2013
Bryde's Whale	Northern Gulf of Mexico	1991-1994	35	1.1	30	Hansen *et al.* 1995
		1996-2001	40	0.61	33	Mullin and Fulling 2004
		2003-2004	15	1.98	35	
		2009	**33**	**1.07**	**38**	
Sperm Whale	Northern Gulf of Mexico	1991-1994	530	0.31	30	Hansen *et al.* 1995
		1996-2001	1,349	0.23	33	Mullin and Fulling 2004
		2003-2004	1,665	0.2	35	
		2009	**763**	**0.38**	**38**	
Kogia spp.	Northern Gulf of Mexico	1991-1994	547	0.28	30	Hansen *et al.* 1995
		1996-2001	742	0.29	33	Mullin and Fulling 2004
		2003-2004	453	0.35	35	
		2009	**186**	**1.04**	**38**	
Cuvier's Beaked Whale	Northern Gulf of Mexico	1991-1994	30	0.5	30	Hansen *et al.* 1995
		1996-2001	95	0.47	33	Mullin and Fulling 2004
		2003-2004	65	0.67	35	
		2009	**74**	**1.04**	**38**	
Mesoplodon spp.	Northern Gulf of Mexico	1996-2001	106	0.41	33	Mullin and Fulling 2004
		2003-2004	57	1.4	35	
		2009	**149**	**0.91**	**38**	
Killer Whale	Northern Gulf of Mexico	1991-1994	277	0.42	30	Hansen *et al.* 1995
		1996-2001	133	0.49	33	Mullin and Fulling 2004
		2003-2004	49	0.77	35	
		2009	**28**	**1.02**	**38**	
False killer Whale	Northern Gulf of Mexico	1991-1994	381	0.62	30	Hansen *et al.* 1995
		1996-2001	1,038	0.71	33	Mullin and Fulling 2004
		2003-2004	777	0.56	35	
Short-finned Pilot Whale	Northern Gulf of Mexico	1991-1994	353	0.89	30	Hansen *et al.* 1995
		1996-2001	2,388	0.48	33	Mullin and Fulling 2004
		2003-2004	716	0.34	35	
		2009	**2,415**	**0.66**	**38**	
Melon-headed Whale	Northern Gulf of Mexico	1991-1994	3,965	0.39	30	Hansen *et al.* 1995
		1996-2001	3,451	0.55	33	
		2003-2004	2,283	0.76	35	
		2009	**2,235**	**0.75**	**38**	
Pygmy Killer Whale	Northern Gulf of Mexico	1991-1994	518	0.81	30	Hansen *et al.* 1995
		1996-2001	408	0.6	33	Mullin and Fulling 2004
		2003-2004	323	0.6	35	
		2009	**152**	**1.02**	**38**	
Risso's Dolphin	Northern Gulf of Mexico	1991-1994	2,749	0.27	30	Hansen *et al.* 1995
		1996-2001	2,169	0.32	33	Mullin and Fulling 2004
		2003-2004	1,589	0.27	35	

		2009	**2,442**	**0.57**	**38**	
Pantropical Spotted Dolphin	Northern Gulf of Mexico	1991-1994	31,320	0.2	30	Hansen *et al*. 1995
		1996-2001	91,321	0.16	33	Mullin and Fulling 2004
		2003-2004	34,067	0.18	35	
		2009	**50,880**	**0.27**	**38**	
Striped Dolphin	Northern Gulf of Mexico	1991-1994	4,858	0.44	30	Hansen *et al*. 1995
		1996-2001	6,505	0.43	33	Mullin and Fulling 2004
		2003-2004	3,325	0.48	35	
		2009	**1,849**	**0.77**	**38**	
Spinner Dolphin	Northern Gulf of Mexico	1991-1994	6,316	0.43	30	Hansen *et al*. 1995
		1996-2001	11,971	0.71	33	Mullin and Fulling 2004
		2003-2004	1,989	0.48	35	
		2009	**11,441**	**0.83**	**38**	
Clymene Dolphin	Northern Gulf of Mexico	1991-1994	5,571	0.37	30	Hansen *et al*. 1995
		1996-2001	17,355	0.65	33	Mullin and Fulling 2004
		2003-2004	6,575	0.36	35	
		2009	**129**	**1**	**38**	
Atlantic Spotted Dolphin	Northern Gulf of Mexico	1991-1994 oceanic	3,213	0.44	30	Hansen *et al*. 1995
		1996-2001 oceanic	175	0.84	33	Mullin and Fulling 2004
		1998-2001 OCS	37,611	0.28	34	This abundance estimate is from 2000-2001 surveys only (from Fulling *et al.* 2003). Current best population size estimate is unknown because data from the continental shelf portion of this species' range are more than 8 years old.
		2003-2004 oceanic	0	-	35	
		2009	2968	0.67	38	
Fraser's Dolphin	Northern Gulf of Mexico	1991-1994	127	0.9	30	Hansen *et al*. 1995
		1996-2001	726	0.7	33	
		2003-2004	0	-	35	
		2009	0	-	38	Current best population size estimate is unknown.
Rough-toothed Dolphin	Northern Gulf of Mexico	1991-1994 oceanic	852	0.31	30	
		1996-2001 oceanic	985	0.44	33	Mullin and Fulling 2004
		1998-2001 OCS	1,145	0.83	34	This abundance estimate is from 2000-2001 surveys only (from Fulling *et al.* 2003). Current best population size estimate is unknown because data from the continental shelf portion of this species' range are more than 8 years old.
		2003-2004 oceanic	1,508	0.39	35	
		2009	624	0.99	0.05	

Bottlenose Dolphin	Northern Gulf of Mexico Oceanic					Mullin and Fulling 2004
		1996-2001	2,239	0.41	33	
		2003-2004	3,708	0.42	35	
		2009	**5,806**	**0.39**	**38**	
Bottlenose Dolphin	Northern Gulf of Mexico Continental Shelf	1998-2001	17,777	0.32	34	This abundance estimate is from 2000-2001 surveys only (from Fulling *et al.* 2003). Current best population size estimate is unknown because data from the continental shelf are more than 8 years old.
Bottlenose Dolphin	Northern Gulf of Mexico Coastal (3 stocks)	Eastern 1994	9,912	0.12	32	
		Eastern 2007	**7,702**	**0.19**	**39**	
		Northern 1993	4,191	0.21	31	Blaylock and Hoggard 1994; Current best population size estimate for this stock is unknown because data are more than 8 years old.
		Northern 2007	**2,473**	**0.25**	**39**	
		Western 1992	3,499	0.21	31	Blaylock and Hoggard 1994; Current best population size estimate for this stock is unknown because data are more than 8 years old.
Bottlenose Dolphin	Northern Gulf of Mexico Bay, Sound and Estuarine (33 stocks)	Choctawhatchee Bay, 2007	179	0.04		Conn *et al.* 2011
		St. Joseph Bay, 2005-2007	146	0.18		Balmer *et al.* 2008
		St. Vincent Sound, Apalachicola Bay, St. George Sound, 2008	439	0.14		Tyson *et al.* 2011
		Sarasota Bay, Little Sarasota Bay, 2007	160	-		Direct count; Wells 2009.
		Mississippi River Delta, 2011-12	332	.93		
		Mississippi Sound/ Lake Borgne, Bay Boudreau	901	0.63		

		Pine Island Sound, Charlotte Harbor, Gasparilla Sound, Lemon Bay (2006)	826	0.09		Bassos-Hull *et al.* 2013
		Remaining 27 stocks	unknown	undetermined	31	Blaylock and Hoggard 1994; Current best population size estimate for each of these 27 stocks is unknown because data are more than 8 years old.

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Northeast Sink Gillnet

	Harbor Porpoise		Bottlenose Dolphin, Atlantic Offshore Stock		White-Sided Dolphin		Common Dolphin		Risso's Dolphin		Long-finned Pilot Whale		Harbor Seal		Gray Seal		Harp Seal	
Year	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV
1990	2900	0.32	0	0	0	0	0	0	0	0	0	0	602	0.68	0	0	0	0
1991	2000	0.35	0	0	49	0.46	0	0	0	0	0	0	231	0.22	0	0	0	0
1992	1200	0.21	0	0	154	0.35	0	0	0	0	0	0	373	0.23	0	0	0	0
1993	1400	0.18	0	0	205	0.31	0	0	0	0	0	0	698	0.19	0	0	0	0
1994	2100	0.18	0	0	240	0.51	0	0	0	0	0	0	1330	0.25	19	0.95	861	0.58
1995	1400	0.27	0	0	80	1.16	0	0	0	0	0	0	1179	0.21	117	0.42	694	0.27
1996	1200	0.25	0	0	114	0.61	63	1.39	0	0	0	0	911	0.27	49	0.49	89	0.55
1997	782	0.22	0	0	140	0.61	0	0	0	0	0	0	598	0.26	131	0.5	269	0.5
1998	332	0.46	0	0	34	0.92	0	0	0	0	0	0	332	0.33	61	0.98	78	0.48
1999	270	0.28	0	0	69	0.7	146	0.97	0	0	0	0	1446	0.34	155	0.51	81	0.78
2000	507	0.37	132	1.16	26	1	0	0	15	1.06	0	0	917	0.43	193	0.55	24	1.57
2001	53	0.97	0	0	26	1	0	0	0	0	0	0	1471	0.38	117	0.59	26	1.04
2002	444	0.37	0	0	30	0.74	0	0	0	0	0	0	787	0.32	0	0	0	0
2003	592	0.33	0	0	31	0.93	0	0	0	0	0	0	542	0.28	242	0.47	0	0
2004	654	0.36	1[a]	na	7	0.98	0	0	0	0	0	0	792	0.34	504	0.34	303	0.3
2005	630	0.23	0	0	59	0.49	5	0.8	15	0.93	0	0	719	0.2	574	0.44	35	0.68
2006	514	0.31	0	0	41	0.71	20	1.05	0	0	0	0	87	0.58	248	0.47	65	0.66
2007	395	0.37	0	0	0	0	11	0.94	0	0	0	0	92	0.49	886	0.24	119	0.35
2008	666	0.48	0	0	81	0.57	34	0.77	0	0	0	0	242	0.41	618	0.23	238	0.38
2009	591	0.23	0	0	0	0	43	0.77	0	0	0	0	513	0.28	1063	0.26	415	0.27
2010	387	0.27	0	0	66	0.9	42	0.81	0	0	3	0.82	540	0.25	1155	0.28	253	0.61
2011	273	0.2	0	0	18	0.43	64	0.71	0	0	0	0	343	0.19	1491	0.22	14	0.46
2012	277.3	0.59	0	0	9	0.92	95	0.4	6	0.87	0	0	252	0.26	542	0.19	0	0
2013	399	0.33	27	5	4	1.03	104	0.47	23	0.97	0	0	147	0.3	1127	0.2	22	0.75
2014	128	0.27	0	0	10	0.66	111	0.46	0	0	0	0	390	0.39	917	0.14	17	0.53

Note: this table only includes observed bycatch. For a complete list of marine mamal species interactions with this fishery please see http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/ne_sink_gillnet.html

[a] Unextrapolated mortalities

[b] Due to uncertainty in stock identification both minimum and maximum estimates are provide with associated CV's. As a result of uncertainty in stock identification, minimum and maximum mortality estimates are not additive across the Atlantic coastal and estuarine bottlenose dolphin stocks.

na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

Mid-Atlantic Sink Gillnet

Year	Harbor Porpoise		Bottlenose Dolphin, Atlantic Offshore Stock		Bottlenose Dolphin, Northern Migratory Coastal Stock		Bottlenose Dolphin, Southern Migratory Coastal Stock		Bottlenose Dolphin, Northern NC Estuarine Stock		Bottlenose Dolphin, Southern NC Estuarine Stock		White-Sided Dolphin		Common Dolphin		Risso's Dolphin		Pilot Whale, Unidentified		Harbor Seal		Gray Seal		Harp Seal	
	SI&M_est	CV	SI&M_est	CV	SI&M_est (min-max)[b]	CV[b]	SI&M_est (min-max)[b]	CV[b]	SI&M_est (min-max)[b]	CV[b]	SI&M_est (min-max)[b]	CV[b]	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV
1994	0	0	0	0	na	na	na	na	na	na	na	na	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	103	0.57	56	1.66	na	na	na	na	na	na	na	na	0	0	7.4	0.69	0	0	0	0	0	0	0	0	0	0
1996	311	0.31	64	0.83	na	na	na	na	na	na	na	na	0	0	43	0.79	0	0	0	0	0	0	0	0	0	0
1997	572	0.35	0	0	na	na	na	na	na	na	na	na	45	0.82	0	0	0	0	0	0	0	0	0	0	0	0
1998	446	0.36	63	0.94	na	na	na	na	na	na	na	na	0	0	0	0	0	0	7	0	11	0.77	0	0	17	1.02
1999	53	0.49	0	0	na	na	na	na	na	na	na	na	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	21	0.76	0	0	na	na	na	na	na	na	na	na	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	26	0.95	na	na	na	na	na	na	na	na	na	na	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	unk	na	0	0	8.25-9.29	0.34-0.33	11.96-30.68	0.79-0.52	5.21-24.38	0.63-0.53	0.59-1.45	0.35-0.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	76	1.13	0	0	3.92-6.66	0.36-0.30	15.71-41.55	0.51-0.62	3.68-27.17	0.58-0.59	1.04-1.57	0.42-0.34	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	137	0.91	0	0	4.86-7.28	0.35-0.33	33.50-40.10	0.79-0.51	4.03-18.96	0.62-0.49	0.92-2.17	0.43-0.36	0	0	0	0	0	0	0	0	15	0.86	69	0.92	0	0
2005	470	0.51	1[a]	na	4.89-6.52	0.39-0.32	69.40-80.30	0.60-0.64	3.95-15.20	0.60-0.49	0.48-0.78	0.41-0.30	0	0	0	0	0	0	0	0	63	0.67	0	0	0	0
2006	511	0.32	0	0	4.64-5.19	0.33-0.33	4.00-79.50	0.48-0.53	2.16-35.55	0.35-0.49	0.75-1.05	0.51-0.37	0	0	0	0	0	0	0	0	26	0.98	0	0	0	0
2007	58	1.03	0	0	0.00-3.18	0.00-1.08	0.00-6.00	0.00-0.97	0.00-9.69	0.00-0.95	0.00-0.00	0.00-0.00	0	0	0	0	34	0.73	0	0	0	0	0	0	38	0.9
2008	350	0.75	0	0	0.00-3.05	0.00-1.08	0.00-5.27	0.00-0.97	0.00-8.08	0.00-0.95	0.00-0.00	0.00-0.00	0	0	0	0	0	0	0	0	88	0.74	0	0	176	0.74
2009	201	0.55	0	0	0.00-23.86	0.00-0.83	0.00-37.61	0.00-0.86	0.00-46.79	0.00-0.82	0.00-0.00	0.00-0.00	0	0	0	0	0	0	0	0	47	0.68	0	0	0	0
2010	259	0.88	0	0	0.00-2.62	0.00-1.08	0.00-4.11	0.00-0.97	0.00-6.96	0.00-0.95	0.00-0.00	0.00-0.00	0	0	30	0.48	0	0	0	0	89	0.39	267	0.75	0	0
2011	123	0.41	0	0	0.00-2.98	0.00-1.08	0.00-4.33	0.00-0.97	0.00-8.38	0.00-0.95	0.00-0.00	0.00-0.00	0	0	29	0.53	0	0	0	0	21	0.67	19	0.6	0	0
2012	63.41	0.83	0	0	tbd	tbd	tbd	tbd	tbd	tbd	tbd	tbd	0	0	15	0.93	0	0	0	0	0	0	14	0.98	0	0

2013	19	1.06	26	0.95	tbd	tbd	tbd	tbd	tbd	tbd	tbd	tbd	0	0	62	0.67	0	0	0	0	0	0	0	0	0	0
2014	22	1.03	0	0									0	0	17	0.86	0	0	0	0	19	1.06	22	1.09	0	0

Note: this table only includes observed bycatch. For a complete list of marine mamal species interactions with this fishery please seehttp://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/midatl_ gillnet.html

[a] Unextrapolated mortalities

[b] Due to uncertainty in stock identification both minimum and maximum estimates are provide with associated CV's. As a result of uncertainty in stock identification, minimum and maximum mortality estimates are not additive across the Atlantic coastal and estuarine bottlenose dolphin stocks.

na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

New England/North Atlantic Bottom Trawl

Year	Harbor Porpoise		Bottlenose Dolphin, Atlantic Offshore Stock		White-Sided Dolphin		Common Dolphin		Risso's Dolphin-Atlantic		Pilot Whale, Unidentified		Long-finned Pilot Whale		Harbor Seal		Gray Seal		Harp Seal		Minke whale	
	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	91	0.97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	110	0.97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	182	0.71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	142	0.77	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	93	1.06	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	137	0.34	27	0.29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	161	0.34	30	0.3	0	0	21	0.27	0	0	0	0	0	0	49	1.1	0	0
2002	0	0	0	0	70	0.32	26	0.29	0	0	22	0.26	0	0	0	0	0	0	0	0	0	0
2003	*	*	0	0	216	0.27	26	0.29	0	0	20	0.26	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	200	0.3	26	0.29	0	0	15	0.29	0	0	0	0	0	0	0	0	0	0
2005	7.2	0.48	0	0	213	0.28	32	0.28	0	0	15	0.3	0	0	0	0	unk	unk	unk	unk	0	0
2006	6.5	0.49	0	0	40	0.5	25	0.28	0	0	14	0.28	0	0	0	0	0	0	0	0	0	0
2007	5.6	0.46	48	0.95	29	0.66	24	0.28	3	0.52	0	0	0	0	0	0	unk	unk	0	0	0	0
2008	5.6	0.97	19	0.88	13	0.57	6	0.99	2	0.56	0	0	21	0.51	0	0	16	0.52	0	0	7.8	0.69
2009	0	0	18	0.92	171	0.28	24	0.6	3	0.53	0	0	13	0.7	0	0	22	0.46	5	1.02	0	0
2010	0	0	4	0.53	37	0.32	114	0.32	2	0.55	0	0	30	0.43	0	0	30	0.34	0	0	0	0
2011	5.9	0.71	10	0.84	141	0.24	72	0.37	3	0.55	0	0	55	0.18	9	0.58	58	0.25	3	1.02	0	0
2012	0	0	0	0	27	0.47	40	0.54	0	0	0	0	33	0.32	3	1	37	0.49	0	0	0	0
2013	7	0.98	0	0	33	0.31	17	0.54	0	0	0	0	16	0.42	4	0.89	20	0.37	0	0	0	0
2014	5.5	0.86	0	0	16	0.5	17	0.53	4.2	0.91	0	0	25	0.44	11	0.63	19	0.45			0	0

Note: this table only includes observed bycatch. For a complete list of marine mamal species interactions with this fishery please see http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/ne_bottom_trawl.html [a] Unextrapolated mortalities

[b] Due to uncertainty in stock identification both minimum and maximum estimates are provide with associated CV's. As a result of uncertainty in stock identification, minimum and maximum mortality estimates are not additive across the Atlantic coastal and estuarine bottlenose dolphin stocks.

na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

Mid-Atlantic Bottom Trawl

	Harbor Porpoise		Bottlenose Dolphin, Atlantic Offshore Stock		White-Sided Dolphin		Common Dolphin		Risso's Dolphin-Atlantic		Pilot Whale, Unidentified		Long-finned Pilot Whale		Harbor Seal		Gray Seal	
Year	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV
1997	0	0	0	0	161	1.58	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	228	1.03	0	0	0	0	0	0
2000	0	0	0	0	27	0.17	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	27	0.19	103	0.27	0	0	39	0.3	0	0	0	0	0	0
2002	0	0	0	0	25	0.17	87	0.27	0	0	38	0.36	0	0	0	0	0	0
2003	0	0	0	0	31	0.25	99	0.28	0	0	31	0.31	0	0	0	0	0	0
2004	0	0	0	0	26	0.2	159	0.3	0	0	35	0.33	0	0	0	0	0	0
2005	0	0	0	0	38	0.29	141	0.29	0	0	31	0.31	0	0	0	0	0	0
2006	0	0	0	0	3	0.53	131	0.28	0	0	37	0.34	0	0	0	0	0	0
2007	0	0	11	0.42	2	1.03	66	0.27	33	0.34	0	0	0	0	0	0	0	0
2008	0	0	16	0.36	0	0	23	1	39	0.69	0	0	0	0	0	0	0	0
2009	0	0	21	0.45	0	0	167	0.46	23	0.5	0	0	0	0	24	0.92	38	0.7
2010	0	0	20	0.34	0	0	21	0.96	54	0.74	0	0	0	0	11	1.1	0	0
2011	0	0	34	0.31	0	0	271	0.25	62	0.56	0	0	0	0	0	0	25	0.57
2012	0	0	16	1.00	0	0	323	0.26	8	1	0	0	0	0	23	1	30	1.1
2013	0	0	0	0	0	0	269	0.29	46	0.71	0	0	0	0	11	0.96	29	0.67
2014	0	0	25	0.66	9.7	0.94	329	0.29	21	0.93	0	0	0	0	10	0.95	7	0.96

Note: this table only includes observed bycatch. For a complete list of marine mamal species interactions with this fishery please see http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/ma_bottom_trawl.html

[a] Unextrapolated mortalities

[b] Due to uncertainty in stock identification both minimum and maximum estimates are provide with associated CV's. As a result of uncertainty in stock identification, minimum and maximum mortality estimates are not additive across the Atlantic coastal and estuarine bottlenose dolphin stocks.

na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

Northeast Mid-Water Trawl

	Harbor Porpoise		Bottlenose Dolphin, Atlantic Offshore Stock		White-Sided Dolphin		Common Dolphin		Risso's Dolphin-Atlantic		Pilot Whale, Unidentified		Long-finned Pilot Whale		Harbor Seal		Gray Seal	
Year	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	4.6	0.74	0	0	0	0	0	0
2001	0	0	0	0	unk	na	0	0	0	0	11	0.74	0	0	0	0	0	0
2002	0	0	0	0	unk	na	0	0	0	0	8.9	0.74	0	0	0	0	0	0
2003	0	0	0	0	22	0.97	0	0	0	0	14	0.56	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	5.8	0.58	0	0	0	0	0	0
2005	0	0	0	0	9.4	1.03	0	0	0	0	1.1	0.68	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	16	0.61	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0.81	0	0
2010	0	0	0	0	0	0	1[a]	na	0	0	0	0	0	0	2[a]	na	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
2012	0	0	0	0	0	0	1[a]	na	0	0	0	0	1	0	1[a]	na	1[a]	na
2013	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1[a]	na
2014	0	0	0	0	0	0	0	0	0	0	0	0	4	na	1[a]	na	0	0

Note: this table only includes observed bycatch. For a complete list of marine mamal species interactions with this fishery please see http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/ne_mw_trawl.html

[a] Unextrapolated mortalities

[b] Due to uncertainty in stock identification both minimum and maximum estimates are provide with associated CV's. As a result of uncertainty in stock identification, minimum and maximum mortality estimates are not additive across the Atlantic coastal and estuarine bottlenose dolphin stocks.

na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

Mid-Atlantic Mid-Water Trawl

	White-Sided Dolphin		Common Dolphin		Risso's Dolphin-Atlantic		Pilot Whale, Unidentified		Long-finned Pilot Whale		Harbor Seal		Gray Seal	
Year	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	unk	na	0	0	0	0	0	0	0	0	0	0	0	0
2002	unk	na	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	22	0.99	0	0	0	0	0	0	0	0	0	0	0	0
2005	58	1.02	0	0	0	0	0	0	0	0	0	0	0	0
2006	29	0.74	0	0	0	0	0	0	0	0	0	0	0	0
2007	12	0.98	3.2	0.7	0	0	0	0	0	0	0	0	0	0
2008	15	0.73	0	0	1[a]	na	0	0	0	0	0	0	0	0
2009	4	0.92	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	1[a]	na	1[a]	na
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: this table only includes observed bycatch. For a complete list of marine mamal species interactions with this fishery please see http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/ma_mw_trawl.html

[a] Unextrapolated mortalities

[b] Due to uncertainty in stock identification both minimum and maximum estimates are provide with associated CV's. As a result of uncertainty in stock identification, minimum and maximum mortality estimates are not additive across the Atlantic coastal and estuarine bottlenose dolphin stocks.

na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

Pelagic Longline

	Pantropical Spotted dolphin - GMex		Bottlenose Dolphin, Atlantic Offshore Stock		Common Dolphin		Risso's Dolphin - Atlantic		Risso's Dolphin - Gmex		Pilot Whale, Unidentified - Atl.		Short-finned Pilot Whale - Atlantic		Beaked whale, Unidentified	
Year	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV
1992	0	0	0	0	0	0	0	0	0	0	22	0.23	0	0	0	0
1993	0	0	0	0	0	0	13	0.19	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	7	1	0	0	137	0.44	0	0	0	0
1995	0	0	0	0	0	0	103	0.68	0	0	345	0.51	0	0	0	0
1996	0	0	0	0	0	0	99	1	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	57	1	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	22	1	0	0	381	0.79	0	0	0	0
2000	0	0	0	0	0	0	64	1	0	0	133	0.88	0	0	0	0
2001	0	0	0	0	0	0	69	0.57	0	0	79	0.48	0	0	0	0
2002	0	0	0	0	0	0	28	0.86	0	0	54	0.46	0	0	0	0
2003	0	0	0	0	0	0	40	0.63	0	0	21	0.77	0	0	5.3	1
2004	0	0	0	0	0	0	28	0.72	0	0	74	0.42	0	0	0	0
2005	0	0	0	0	0	0	3	1	0	0	212	0.21	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	185	0.47	0	0	0	0
2007	0	0	0	0	0	0	9	0.65	0	0	57	0.65	0	0	0	0
2008	0	0	0	0	0	0	16.8	0.732	8.3	0.63	0	0	80	0.42	0	0
2009	16	0.69	8.8	1	8.5	1	11.8	0.711	0	0	0	0	17	0.7	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	127	0.78	0	0
2011	0	0	0	0	0	0	11.8	0.699	1.5	1	0	0	305	0.29	0	0
2012	1	0	61.8	0.68	0	0	15.1	1	29.8	1	0	0	170.1	0.33	0	0
2013	0	0	0	0	0	0	1.9	1	0	0	0	0	124	0.32	0	0
2014	0	0	0	0	0	0	7.7	1	0	0	0	0	233	0.24	0	0

Note: this table only includes observed bycatch. For a complete list of marine mamal species interactions with this fishery please see http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/ao_car_gmex_pelagics_longline.html[a] Unextrapolated mortalities
[b] Due to uncertainty in stock identification both minimum and maximum estimates are provide with associated CV's. As a result of uncertainty in stock identification, minimum and maximum mortality estimates are not additive across the Atlantic coastal and estuarine bottlenose dolphin stocks.
na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

Pelagic Drift Gillnet

	White-Sided Dolphin		Common Dolphin		Risso's Dolphin-Atlantic		Pilot Whale, Unidentified		Long-finned Pilot Whale		Bottlenose Dolphin, Atlantic Offshore Stock		Beaked whale, Unidentified		Sowerby's beaked whales		Harbor porpoise	
Year	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV
1989	4.4	0.71	0	0	87	0.52	0	0	0	0	72	0.18	60	0.21	0	0	0.7	7
1990	6.8	0.71	0	0	144	0.46	0	0	0	0	115	0.18	76	0.26	0	0	1.7	2.65
1991	0.9	0.71	223	0.12	21	0.55	30	0.26	0	0	26	0.15	13	0.21	0	0	0.7	1
1992	0.8	0.71	227	0.09	31	0.27	33	0.16	0	0	28	0.1	9.7	0.24	0	0	0.4	1
1993	2.7	0.17	238	0.08	14	0.42	31	0.19	0	0	22	0.13	12	0.16	0	0	1.5	0.34
1994	0	0.71	163	0.02	1.5	0.16	20	0.06	0	0	14	0.04	0	0	3	0.09	0	0
1995	0	0	83	0	6	0	9.1	0	0	0	5	0	3	0	6	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	2	0.25	9	0.12	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	9	0	0	0	0	0	3	0	7	0	2	0	0	0
1999	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0

Note: this table only includes observed bycatch.

[a] Unextrapolated mortalities

[b] Due to uncertainty in stock identification both minimum and maximum estimates are provide with associated CV's. As a result of uncertainty in stock identification, minimum and maximum mortality estimates are not additive across the Atlantic coastal and estuarine bottlenose dolphin stocks.

na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

Pelagic Pair Trawl

	White-Sided Dolphin		Common Dolphin		Risso's Dolphin-Atlantic		Pilot Whale, Unidentified		Long-finned Pilot Whale		Bottlenose dolphin-Atlantic offshore	
Year	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV
1989	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0.6	1	0	0	0	0	13	0.52
1992	0	0	0	0	4.3	0.76	0	0	0	0	73	0.49
1993	0	0	0	0	3.2	1	0	0	0	0	85	0.41
1994	0	0	0	0	0	0	2	0.49	0	0	4	0.4
1995	0	0	0	0	3.7	0.45	22	0.33	0	0	17	0.26
1996	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0

Note: this table only includes observed bycatch.
[a] Unextrapolated mortalities
[b] Due to uncertainty in stock identification both minimum and maximum estimates are provide with associated CV's. As a result of uncertainty in stock identification, minimum and maximum mortality estimates are not additive across the Atlantic coastal and estuarine bottlenose dolphin stocks.
na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

Gulf of Mexico Shrimp Otter Trawl

	Atlantic Spotted Dolphin		Bottlenose dolphin, Continental Shelf Stock		Bottlenose dolphin, Western Coastal Stock		Bottlenose dolphin, Northern Coastal Stock		Bottlenose dolphin, Eastern Coastal Stock		Bottlenose dolphin, TX BSE Stocks		Bottlenose dolphin, LA BSE Stocks		Bottlenose dolphin, AL/MS BSE Stocks		Bottlenose dolphin, FL BSE Stocks	
Year	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV
1997	128	0.44	172	0.42	217	0.84	13	0.80	18	0.99	0	-	29	1.00	37	0.82	3	0.99
1998	146	0.44	180	0.43	148	0.80	20	0.95	23	0.99	0	-	31	0.99	37	0.83	2	0.99
1999	120	0.44	159	0.42	289	0.91	31	0.72	11	0.99	0	-	38	0.89	52	0.85	3	0.99
2000	105	0.44	156	0.43	242	0.86	15	0.72	15	0.99	0	-	21	0.86	47	0.77	8	0.99
2001	115	0.45	169	0.42	291	0.85	15	0.79	11	0.99	0	-	28	0.99	55	0.74	6	0.99
2002	128	0.44	166	0.42	223	0.80	29	0.84	12	0.99	0	-	118	0.98	69	0.84	6	0.99
2003	75	0.45	122	0.43	133	0.79	15	0.71	5	0.99	0	-	72	1.00	52	0.82	5	0.99
2004	84	0.46	132	0.43	111	0.80	14	0.88	5	0.99	0	-	77	0.90	26	0.90	2	0.99
2005	55	0.49	94	0.43	66	0.84	11	0.64	1	0.99	0	-	57	0.96	15	0.72	3	0.99
2006	49	0.44	77	0.43	105	0.89	16	0.67	6	0.99	0	-	55	0.97	17	0.64	3	0.99
2007	43	0.45	60	0.43	81	0.85	20	0.67	3	0.99	0	-	47	0.90	26	0.77	1	0.99
2008	37	0.53	46	0.44	56	0.80	22	0.77	1	0.99	0	-	61	1.00	28	0.76	1	0.99
2009	49	0.50	56	0.43	77	0.89	35	0.67	3	0.99	0	-	116	1.02	45	0.73	6	0.99
2010	44	0.42	57	0.40	57	0.83	17	0.64	3	0.99	0	-	113	1.09	58	0.64	6	0.99
2011	35	0.48	63	0.44	67	0.91	13	0.65	1	0.99	0	-	104	0.98	47	0.64	3	0.99

Note: this table only includes observed bycatch. For a complete list of marine mammal species interactions with this fishery please see http://www.nmfs.noaa.gov/pr/interactions/fisheries/table2/segom_shrimp_trawl.html

[a] Unextrapolated mortalities

[b] Due to uncertainty in stock identification both minimum and maximum estimates are provide with associated CV's. As a result of uncertainty in stock identification, minimum and maximum mortality estimates are not additive across the Atlantic coastal and estuarine bottlenose dolphin stocks.

na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

Harbor Porpoise

	Mid-Atlantic Gillnet		North Atlantic Bottom Trawl		NE Sink Gilllnet		Pelagic Drift Gillnet	
Year	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV
1990	na	na	0	0	2900	0.32	1.7	2.65
1991	na	na	0	0	2000	0.35	0.7	1
1992	na	na	0	0	1200	0.21	0.4	1
1993	na	na	0	0	1400	0.18	1.5	0.34
1994	na	na	0	0	2100	0.18		
1995	103	0.57	0	0	1400	0.27		
1996	311	0.31	0	0	1200	0.25		
1997	572	0.35	0	0	782	0.22		
1998	446	0.36	0	0	332	0.46		
1999	53	0.49	0	0	270	0.28		
2000	21	0.76	0	0	507	0.37		
2001	26	0.95	0	0	53	0.97		
2002	unk	na	0	0	444	0.37		
2003	76	1.13	*	*	592	0.33		
2004	137	0.91	0	0	654	0.36		
2005	470	0.51	7.2	0.48	630	0.23		
2006	511	0.32	6.5	0.49	514	0.31		
2007	58	1.03	5.6	0.46	395	0.37		
2008	350	0.75	5.6	0.97	666	0.48		
2009	201	0.55	0	0	591	0.23		
2010	259	0.88	0	0	387	0.27		
2011	123	0.41	5.9	0.71	273	0.2		
2012	63.41	0.83	0	0	277.3	0.59		
2013	19	1.06	7	0.98	399	0.33		
2014	22	1.03	5.5	0.86	128	0.27		

Note: this table only includes observed bycatch. [a] Unextrapolated mortalities
na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

Common Bottlenose Dolphin, Atlantic Offshore Stock

	Mid-Atlantic Bottom Trawl		Mid-Atlantic Gillnet		North Atlantic Bottom Trawl		NE Sink Gilllnet		Pelagic Drift Gillnet		Pelagic Longline	
Year	**SI&M_est**	**CV**	**SI&M_est**	**CV**	**SI&M_est**	**CV**	**SI&M_est**	**CV**	**SI&M_est**	**CV**	**SI&M_est**	**CV**
1991	na	na	na	na	91	0.97	0	0	26	0.15	0	0
1992	na	na	na	na	0	0	0	0	28	0.1	0	0
1993	na	na	na	na	0	0	0	0	22	0.13	0	0
1994	na	na	na	na	0	0	0	0	14	0.04	0	0
1995	na	na	56	1.66	0	0	0	0	5	0	0	0
1996	na	na	64	0.83	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0			0	0
1998	0	0	63	0.94	0	0	0	0			0	0
1999	0	0	0	0	0	0	0	0			0	0
2000	0	0	0	0	0	0	132	1.16			0	0
2001	0	0	na	na	0	0	0	0			0	0
2002	0	0	0	0	0	0	0	0			0	0
2003	0	0	0	0	0	0	0	0			0	0
2004	0	0	0	0	0	0	1[a]	na			0	0
2005	0	0	1[a]	na	0	0	0	0			0	0
2006	0	0	0	0	0	0	0	0			0	0
2007	11	0.42	0	0	48	.95	0	0			0	0
2008	16	0.36	0	0	19	0.88	0	0			0	0
2009	21	0.45	0	0	18	0.92	0	0			8.8	1
2010	20	0.34	0	0	4	0.53	0	0			0	0
2011	34	0.31	0	0	10	0.84	0	0			0	0
2012	16	1	0	0	0	0	0	0			61.8	0.68
2013	0	0	0	0	0	0	27	0.95			0	0
2014	25	0.66	0	0	0	0	0	0			0	0

Note: this table only includes observed bycatch. [a] Unextrapolated mortalities
na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

White-sided Dolphin

	Mid-Atlantic Bottom Trawl		Mid-Atlantic Gillnet		Mid-Atlantic Midwater Trawl		North Atlantic Bottom Trawl		NE Sink Gilllnet		Northeast Midwater Trawl		Pelagic Drift Gillnet	
Year	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV
1990	na	na	na	na	na	na	0	0	0	0	na	na		
1991	na	na	na	na	na	na	0	0	49	0.46	na	na	0	0
1992	na	na	na	na	na	na	110	0.97	154	0.35	na	na	110	0.97
1993	na	na	na	na	na	na	0	0	205	0.31	na	na	0	0
1994	na	na	0	0	na	na	182	0.71	240	0.51	na	na	182	0.71
1995	na	na	0	0	na	na	0	0	80	1.16	na	na	0	0
1996	na	na	0	0	na	na	0	0	114	0.61	na	na		
1997	161	1.58	45	0.82	na	na	0	0	140	0.61	na	na		
1998	0	0	0	0	na	na	0	0	34	0.92	na	na		
1999	0	0	0	0	0	0	0	0	69	0.7	0	0		
2000	27	0.17	0	0	0	0	137	0.34	26	1	0	0		
2001	27	0.19	0	0	unk	na	161	0.34	26	1	unk	na		
2002	25	0.17	0	0	unk	na	70	0.32	30	0.74	unk	na		
2003	31	0.25	0	0	0	0	216	0.27	31	0.93	22	0.97		
2004	26	0.2	0	0	22	0.99	200	0.3	7	0.98	0	0		
2005	38	0.29	0	0	58	1.02	213	0.28	59	0.49	9.4	1.03		
2006	3	0.53	0	0	29	0.74	40	0.5	41	0.71	0	0		
2007	2	1.03	0	0	12	0.98	29	0.66	0	0	0	0		
2008	0	0	0	0	15	0.73	13	0.57	81	0.57	0	0		
2009	0	0	0	0	4	0.92	171	0.28	0	0	0	0		
2010	0	0	0	0	0	0	37	0.32	66	0.9	0	0		
2011	0	0	0	0	0	0	141	0.24	18	0.43	0	0		
2012	0	0	0	0	0	0	27	0.47	9	0.92	0	0		
2013	0	0	0	0	0	0	33	0.31	4	1.03	0	0		
2014	9.7	0.94	0	0	0	0	16	0.50	10	0.66	0	0		

Note: this table only includes observed bycatch. [a] Unextrapolated mortalities

na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

Risso's Dolphin, Western North Atlantic Stock

	Mid-Atlantic Bottom Trawl		Mid-Atlantic Gillnet		North Atlantic Bottom Trawl		NE Sink Gilllnet		Pelagic Longline	
Year	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV
1996	0	0	0	0	0	0	0	0	99	1
1997	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	57	1
1999	0	0	0	0	0	0	0	0	22	1
2000	0	0	0	0	0	0	15	1.06	64	1
2001	0	0	0	0	0	0	0	0	69	0.57
2002	0	0	0	0	0	0	0	0	28	0.86
2003	0	0	0	0	0	0	0	0	40	0.63
2004	0	0	0	0	0	0	0	0	28	0.72
2005	0	0	0	0	0	0	15	0.93	3	1
2006	0	0	0	0	0	0	0	0	0	0
2007	33	0.34	34	0.73	3	0.52	0	0	9	0.65
2008	39	0.69	0	0	2	0.56	0	0	16.8	0.732
2009	23	0.5	0	0	3	0.53	0	0	11.8	0.711
2010	54	0.74	0	0	2	0.55	0	0	0	0
2011	62	0.56	0	0	3	0.55	0	0	11.8	0.699
2012	8	1	0	0	0	0	6	0.87	15.1	1
2013	46	0.71	0	0	0	0	23	0.97	1.9	1
2014	21	0.93	0	0	4.2	0.91	0	0	7.7	1.0

Note: this table only includes observed bycatch. [a] Unextrapolated mortalities

na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

Long-finned Pilot Whale, Western North Atlantic Stock

	Mid-Atlantic Bottom Trawl		Mid-Atlantic Midwater Trawl		North Atlantic Bottom Trawl		NE Sink Gilllnet		Northeast Midwater Trawl		Pelagic Longline	
Year	**SI&M_est**	**CV**	**SI&M_est**	**CV**	**SI&M_est**	**CV**	**SI&M_est**	**CV**	**SI&M_est**	**CV**	**SI&M_est**	**CV**
2008	0	0	0	0	21	0.51	0	0	16	0.61	na	na
2009	0	0	0	0	13	0.7	0	0	0	0	na	na
2010	0	0	0	0	30	0.43	3	0.82	0	0	na	na
2011	0	0	0	0	55	0.18	0	0	1	0	na	na
2012	0	0	0	0	33	0.32	0	0	1	0	na	na
2013	0	0	0	0	16	0.42	0	0	3	0	na	na
2014	0	0	0	0	32	0.44	0	0	4	na	9.6	

Note: this table only includes observed bycatch. [a] Unextrapolated mortalities
na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

Short-finned Pilot Whale, Western North Atlantic Stock

	PLL	
Year	**SI&M_est**	**CV**
2008	80	0.42
2009	17	0.7
2010	127	0.78
2011	305	0.29
2012	170	0.33
2013	124	0.32
2014	233	0.24

Note: this table only includes observed bycatch. [a] Unextrapolated mortalities
na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

Common Dolphin, Western North Atlantic Stock

	Mid-Atlantic Bottom Trawl		Mid-Atlantic Gillnet		North Atlantic Bottom Trawl		NE Sink Gilllnet		Northeast Midwater Trawl		Pelagic Drift Gillnet		Pelagic Longline	
Year	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV	SI&M_est	CV
1990	na	na	na	na	0	0	0	0	na	na			na	na
1991	na	na	na	na	0	0	0	0	na	na	223	0.12	na	na
1992	na	na	na	na	0	0	0	0	na	na	227	0.09	0	0
1993	na	na	na	na	0	0	0	0	na	na	238	0.08	0	0
1994	na	na	0	0	0	0	0	0	na	na	163	0.02	0	0
1995	na	na	7.4	0.69	142	0.77	0	0	na	na	83	0	0	0
1996	na	na	43	0.79	0	0	63	1.39	na	na			0	0
1997	0	0	0	0	93	1.06	0	0	na	na			0	0
1998	0	0	0	0	0	0	0	0	na	na			0	0
1999	0	0	0	0	0	0	146	0.97	0	0			0	0
2000	0	0	0	0	27	0.29	0	0	0	0			0	0
2001	103	0.27	0	0	30	0.3	0	0	0	0			0	0
2002	87	0.27	0	0	26	0.29	0	0	0	0			0	0
2003	99	0.28	0	0	26	0.29	0	0	0	0			0	0
2004	159	0.3	0	0	26	0.29	0	0	0	0			0	0
2005	141	0.29	0	0	32	0.28	5	0.8	0	0			0	0
2006	131	0.28	0	0	25	0.28	20	1.05	0	0			0	0
2007	66	0.27	0	0	24	0.28	11	0.94	0	0			0	0
2008	23	1	0	0	6	0.99	34	0.77	0	0			0	0
2009	167	0.46	0	0	24	0.6	43	0.77	0	0			8.8	1
2010	21	0.96	30	0.48	114	0.32	42	0.81	1[a]	na			0	0
2011	271	0.25	29	0.53	72	0.37	64	0.71	0	0			0	0
2012	323	0.26	15	0.93	40	0.54	95	0.4	1[a]	0			61.8	.68
2013	269	0.29	62	0.67	17	0.54	104	0.46	0	0			0	0
2014	17	0.53	17	0.86	17	0.53	111	0.47	0	0			0	0

Note: this table only includes observed bycatch. [a] Unextrapolated mortalities
na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

Harbor Seal

	Herring Purse Seine		Mid-Atlantic Bottom Trawl		Mid-Atlantic Gillnet		Mid-Atlantic Midwater Trawl		Northeast Bottom Trawl		NE Sink Gilllnet		Northeast Midwater Trawl	
Year	**SI&M_est**	**CV**	**SI&M_est**	**CV**	**SI&M_est**	**CV**	**SI&M_est**	**CV**	**SI&M_est**	**CV**	**SI&M_est**	**CV**	**SI&M_est**	**CV**
1990	na	na	na	na	na	na	na	na	0	0	602	0.68	na	na
1991	na	na	na	na	na	na	na	na	0	0	231	0.22	na	na
1992	na	na	na	na	na	na	na	na	0	0	373	0.23	na	na
1993	na	na	na	na	na	na	na	na	0	0	698	0.19	na	na
1994	na	na	na	na	na	na	na	na	0	0	1330	0.25	na	na
1995	na	na	na	na	0	0	na	na	0	0	1179	0.21	na	na
1996	na	na	na	na	0	0	na	na	0	0	911	0.27	na	na
1997	na	na	0	0	0	0	na	na	0	0	598	0.26	na	na
1998	na	na	0	0	11	0.77	na	na	0	0	332	0.33	na	na
1999	na	na	0	0	0	0	na	na	0	0	1446	0.34	0	0
2000	na	na	0	0	0	0	0	0	0	0	917	0.43	0	0
2001	na	na	0	0	0	0	0	0	0	0	1471	0.38	0	0
2002	na	na	0	0	0	0	0	0	0	0	787	0.32	0	0
2003	0	0	0	0	0	0	0	0	0	0	542	0.28	0	0
2004	0	0	0	0	15	0.86	0	0	0	0	792	0.34	0	0
2005	0	0	0	0	63	0.67	0	0	0	0	719	0.2	0	0
2006	na	na	0	0	26	0.98	0	0	0	0	87	0.58	0	0
2007	0	0	0	0	0	0	0	0	0	0	92	0.49	0	0
2008	0	0	0	0	88	0.74	0	0	0	0	242	0.41	0	0
2009	0	0	24	0.92	47	0.68	0	0	0	0	513	0.28	1.3	0.81
2010	0	0	11	1.1	89	0.39	1[a]	0	0	0	540	0.25	2	0
2011	1[a]	0	0	0	21	0.67	0	0	9	0.58	343	0.19	0	0
2012	0	0	23	1	0	0	0	0	3	1	252	0.26	1	0
2013	0	0	11	0.96	0	0	0	0	4	0.89	147	0.3	0	0
2014	0	0	10	0.95	19	1.06	0	0	11	0.63	390	0.39	na	ma

Note: this table only includes observed bycatch. [a] Unextrapolated mortalities
na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

Gray Seal

	Herring Purse Seine		Mid-Atlantic Bottom Trawl		Mid-Atlantic Gillnet		Mid-Atlantic Midwater Trawl		Northeast Bottom Trawl		NE Sink Gilllnet		Northeast Midwater Trawl	
Year	**SI&M_est**	**CV**	**SI&M_est**	**CV**	**SI&M_est**	**CV**	**SI&M_est**	**CV**	**SI&M_est**	**CV**	**SI&M_est**	**CV**	**SI&M_est**	**CV**
1994	na	na	na	na	0	0	0	0	0	0	19	0.95	0	0
1995	na	na	na	na	0	0	0	0	0	0	117	0.42	0	0
1996	na	na	na	na	0	0	0	0	0	0	49	0.49	0	0
1997	na	na	0	0	0	0	0	0	0	0	131	0.5	0	0
1998	na	na	0	0	0	0	0	0	0	0	61	0.98	0	0
1999	na	na	0	0	0	0	0	0	0	0	155	0.51	0	0
2000	na	na	0	0	0	0	0	0	0	0	193	0.55	0	0
2001	na	na	0	0	0	0	0	0	0	0	117	0.59	0	0
2002	na	na	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	242	0.47	0	0
2004	0	0	0	0	69	0.92	0	0	0	0	504	0.34	0	0
2005	0	0	0	0	0	0	0	0	unk	unk	574	0.44	0	0
2006	na	na	0	0	0	0	0	0	0	0	248	0.47	0	0
2007	0	0	0	0	0	0	0	0	unk	unk	886	0.24	0	0
2008	0	0	0	0	0	0	0	0	16	0.52	618	0.23	0	0
2009	0	0	38	0.7	0	0	0	0	22	0.46	1063	0.26	0	0
2010	0	0	0	0	267	0.75	1[a]	0	30	0.34	1155	0.28	0	0
2011	0	0	25	0.57	19	0.6	0	0	58	0.25	1491	0.22	0	0
2012	0	0	30	1.1	14	0.98	0	0	37	0.49	542	0.19	1[a]	na
2013	0	0	29	0.67	0	0	0	0	20	0.37	1127	0.2	1[a]	na
2014	0	0	7	0.96	22	1.09	0	0	19	0.45	917	0.14	0	0

Note: this table only includes observed bycatch. [a] Unextrapolated mortalities
na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

Harp Seal

	Mid-Atlantic Gillnet		Northeast Bottom Trawl		NE Sink Gilllnet	
Year	**SI&M_est**	**CV**	**SI&M_est**	**CV**	**SI&M_est**	**CV**
1994	0	0	0	0	861	0.58
1995	0	0	0	0	694	0.27
1996	0	0	0	0	89	0.55
1997	0	0	0	0	269	0.5
1998	17	1.02	0	0	78	0.48
1999	0	0	0	0	81	0.78
2000	0	0	0	0	24	1.57
2001	0	0	49	1.1	26	1.04
2002	0	0	0	0	0	0
2003	0	0	*	*	0	0
2004	0	0	0	0	303	0.3
2005	0	0	0	0	35	0.68
2006	0	0	0	0	65	0.66
2007	38	0.9	0	0	119	0.35
2008	176	0.74	0	0	238	0.38
2009	0	0	5	1.02	415	0.27
2010	0	0	0	0	253	0.61
2011	0	0	3	1.02	14	0.46
2012	0	0	0	0	0	0
2013	0	0	0	0	22	0.75
2014	0	0	0	0	57	0.42

Note: this table only includes observed bycatch. [a] Unextrapolated mortalities
na=not applicable; unk= observer coverage was absent or too low to detect bycatch, or no estimate generated; tbd= to be determined

APPENDIX VI: Reports not updated in 2016

Species	Stock	Updated
Blue whale	Western North Atlantic	2010
Sperm whale	North Atlantic	2014
Killer whale	Western North Atlantic	2014
Pygmy killer whale	Western North Atlantic	2007
False killer whale	Western North Atlantic	2014
Northern bottlenose whale	Western North Atlantic	2014
Sowerby's beaked whale	Western North Atlantic	2014
Cuvier's beaked whale	Western North Atlantic	2013
Blainville's beaked whale	Western North Atlantic	2013
Gervais' beaked whale	Western North Atlantic	2013
True's beaked whale	Western North Atlantic	2013
Melon-headed whale	Western North Atlantic	2007
White-beaked dolphin	Western North Atlantic	2007
Atlantic spotted dolphin	Western North Atlantic	2013
Pantropical spotted dolphin	Western North Atlantic	2013
Striped dolphin	Western North Atlantic	2013
Fraser's dolphin	Western North Atlantic	2007
Rough-toothed dolphin	Western North Atlantic	2013
Clymene dolphin	Western North Atlantic	2013
Spinner dolphin	Western North Atlantic	2013
Common bottlenose dolphin	Western North Atlantic, northern migratory coastal	2015
Common bottlenose dolphin	Western North Atlantic, southern migratory coastal	2015
Common bottlenose dolphin	Western North Atlantic, S. Carolina/Georgia coastal	2015
Common bottlenose dolphin	Western North Atlantic, northern Florida coastal	2015
Common bottlenose dolphin	Western North Atlantic, central Florida coastal	2015
Common bottlenose dolphin	Northern North Carolina Estuarine System	2015
Common bottlenose dolphin	Southern North Carolina Estuarine System	2015
Common bottlenose dolphin	Northern South Carolina Estuarine System	2015
Common bottlenose dolphin	Charleston Estuarine System	2015
Common bottlenose dolphin	Northern GA/ Southern South Carolina Estuarine System	2015
Common bottlenose dolphin	Central Georgia Estuarine System	2015
Common bottlenose dolphin	Southern Georgia Estuarine System	2015
Common bottlenose dolphin	Jacksonville Estuarine System	2015
Common bottlenose dolphin	Indian River Lagoon Estuarine System	2015
Common bottlenose dolphin	Biscayne Bay	2013
Common bottlenose dolphin	Florida Bay	2013
Harp seal	Western North Atlantic	2013
Hooded seal	Western North Atlantic	2007
Bryde's whale	Gulf of Mexico	2015
Cuvier's beaked whale	Gulf of Mexico Oceanic	2012
Blainville's beaked whale	Gulf of Mexico Oceanic	2012
Gervais' beaked whale	Gulf of Mexico Oceanic	2012
Common bottlenose dolphin	Gulf of Mexico Oceanic	2014

Common bottlenose dolphin	Gulf of Mexico, Continental shelf	2015
Common bottlenose dolphin	Gulf of Mexico, eastern coastal	2015
Common bottlenose dolphin	Gulf of Mexico, northern coastal	2015
Common bottlenose dolphin	Gulf of Mexico, western coastal	2015
Common bottlenose dolphin	Gulf of Mexico, Oceanic	2015
Common bottlenose dolphin	Gulf of Mexico, bay, sound and estuary (27 stocks)	2015
Common bottlenose dolphin	Barataria Bay	2015
Common bottlenose dolphin	Mississippi Sound, Lake Borgne, Bay Boudreau	2015
Common bottlenose dolphin	St. Joseph Bay	2015
Common bottlenose dolphin	Choctawhatchee Bay	2015
Atlantic spotted dolphin	Gulf of Mexico	2015
Pantropical spotted dolphin	Gulf of Mexico	2015
Rough-toothed dolphin	Gulf of Mexico (Outer continental shelf and Oceanic)	2012
Clymene dolphin	Gulf of Mexico Oceanic	2012
Fraser's dolphin	Gulf of Mexico Oceanic	2012
Killer whale	Gulf of Mexico Oceanic	2012
False killer whale	Gulf of Mexico Oceanic	2012
Pygmy killer whale	Gulf of Mexico Oceanic	2012
Dwarf sperm whale	Gulf of Mexico Oceanic	2012
Pygmy sperm whale	Gulf of Mexico Oceanic	2012
Melon-headed whale	Gulf of Mexico Oceanic	2012
Risso’s dolphin	Gulf of Mexico	2015
Pilot whale, short-finned	Gulf of Mexico	2015
Sperm whale	Gulf of Mexico	2015
Sperm whale	Puerto Rico and US Virgin Islands stock	2010
Common bottlenose dolphin	Puerto Rico and US Virgin Islands stock	2011
Cuvier's beaked whale	Puerto Rico and US Virgin Islands stock	2011
Pilot whale, short-finned	Puerto Rico and US Virgin Islands stock	2011
Spinner dolphin	Puerto Rico and US Virgin Islands stock	2011
Atlantic spotted dolphin	Puerto Rico and US Virgin Islands stock	2011

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WILDLIFE MONOGRAPHS

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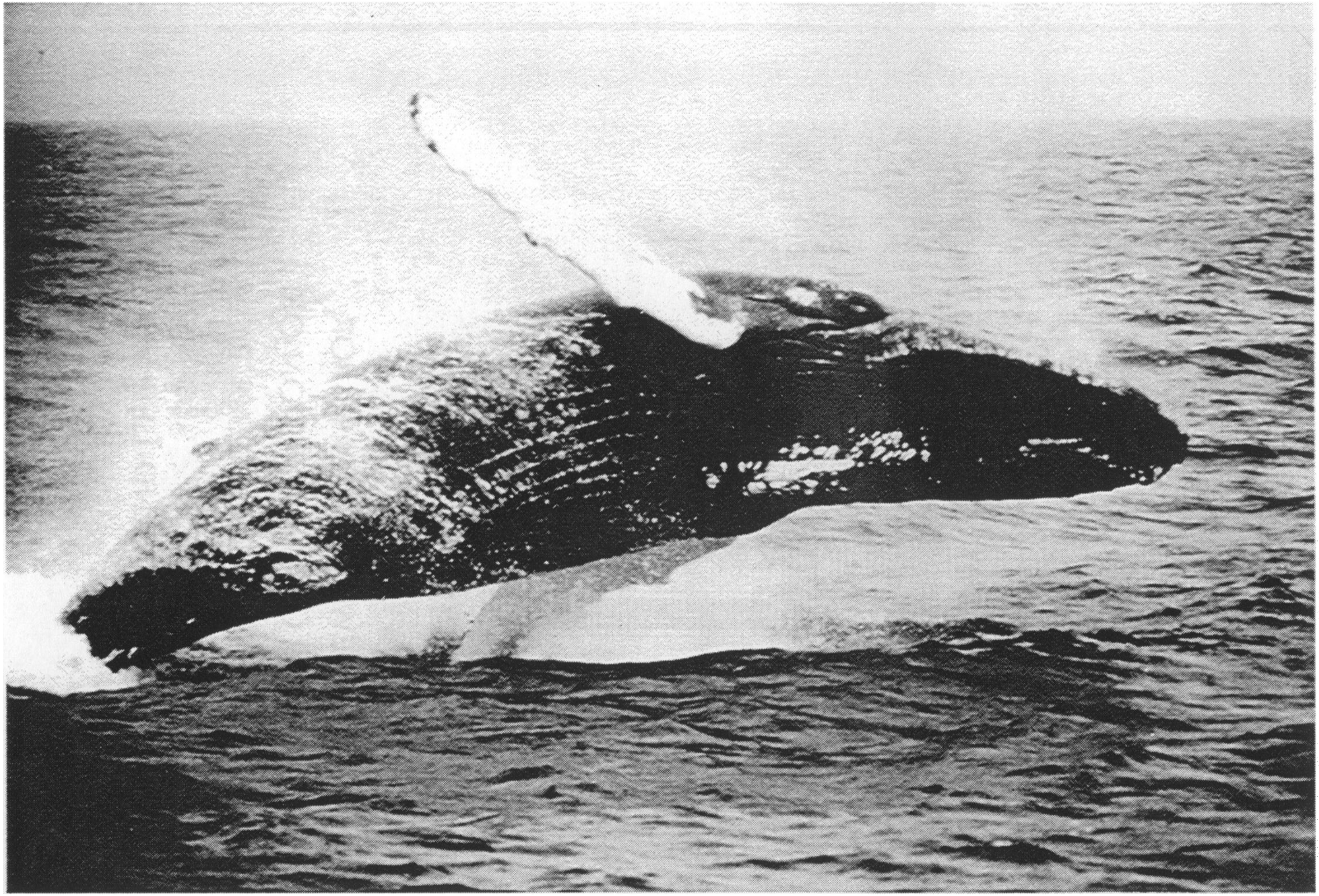
NEW PRINCIPLES FOR THE CONSERVATION OF WILD LIVING RESOURCES

by

SIDNEY J. HOLT AND LEE M. TALBOT

APRIL 1978 NO. 59



FRONTISPIECE. Humpback whale, Pacific Ocean off Hawaii. Protected for periods ranging from 12 years in the northern Pacific Ocean to 23 years in the northwestern Atlantic Ocean. The remaining humpback whale stocks are roughly estimated at about 10 percent of their original populations, with no clear evidence of recovery. Whales represent the classic case of mismanagement of wild living resources, one with stock after stock overharvested to commercial, and occasionally, biological extinction. However, the International Whaling Commission has now adopted most of the new principles for management that this paper recommends. (Credit: John Dominis, Time-Life Inc.)

NEW PRINCIPLES FOR THE CONSERVATION OF WILD LIVING RESOURCES

Sidney J. Holt[1] *and Lee M. Talbot*[2]

CONTENTS

[1] United Nations Food and Agriculture Organization, Rome, Italy.
[2] President's Council on Environmental Quality, Washington, D.C. 20006.

PREFACE

There is growing international concern with the depletion of stocks of many wild animal resources—fishes, marine mammals, reptiles, invertebrates, and terrestrial wildlife—in the face of increasing demands on those resources for food and other values. That concern led to development of a program to critically examine the basis for management of those resources and to prepare appropriate recommendations for improvement in their management. The program was sponsored by the President's Council on Environmental Quality, the World Wildlife Fund–U.S., the Ecological Society of America, the Smithsonian Institution, and the International Union for the Conservation of Nature and Natural Resources.

The financial support for the program and publication of this monograph was provided by the World Wildlife Fund–U.S., and very considerable secretarial and other staff assistance was furnished by the Washington Office of the Fund and the Council on Environmental Quality. The program was organized by Lee M. Talbot.

Preliminary consultations and meetings were held in 1974, followed by two workshops at Airlie House, Virginia, in February and April 1975. This report is the final result.

The participants in the workshops first critically reviewed the scientific basis of existing goals of conservation. They examined both the theory and the practice of aquatic and terrestrial wildlife management, insofar as it is directed to sustaining the values of resources for future realization on a continuing basis. They concluded that a new statement of principles was urgently needed to meet modern needs in the light of current knowledge, particularly of ecology. They prepared such a statement, redefining the primary goal of renewable resource management and formulating four general principles for its implementation.

The participants in the workshops also prepared a detailed interpretation of the new principles, with respect to marine resources now under consideration by the United Nations Conference on the Law of the Sea (Appendix 4). Lastly, they suggested that resource management institutions—international, national, state, and local—should incorporate the new principles in their charters, and further, that those institutions should be evaluated with respect to their capacities to implement and achieve the basic goal as defined.

The participants (Appendix 1) were invited on the basis of outstanding expertise and experience in research and management of wild terrestrial or aquatic living resources. They were drawn from a broad spectrum of disciplines and all had focussed on the theory or practice of conservation and exploitation of the resources involved.

The objective of the meetings and workshops was to produce a written report intended to present the "state of the art" as perceived by the participants. The procedure followed was to start with individual working papers, and carry them through successive reviews, revisions, and redrafts. The text is the final report of the workshops, assembled and edited by Sidney Holt and Lee Talbot. To assure that it accurately reflected the participants' views, the final draft was circulated to all participants for correction and approval.

INTRODUCTION

Man is making ever-increasing demands on the world's wild living resources—fishes, aquatic invertebrates, reptiles, marine and terrestrial mammals, and birds—for food, other animal products, and other values. The United Nations Conference on the Human Environment in 1972, the World Conferences on Food and on Population in 1974, and the fisheries aspects of current Law of the Sea negotiations, attest to the growing international recognition of the problems thereby created. At the same time, it is clear that past attempts to manage those resources, or the failure to manage their exploitation on a rational basis, have allowed gross depletion of many of them, rather than assuring sustained or improved yields and values.

The absence of rational management policy, or the application of a policy that results in overutilization or other abuse of a resource, results in the loss of the full range of benefits to both present and future generations. Effective management policy, on the other hand, can result in an equitable distribution of benefits between present and future users of the resource.

Considering the world as a whole, we can say that most exploitation of wild living resources has not been managed in the strict or scientific sense of the word. Where management has been attempted, the concept of maximum sustainable yield (MSY) or some related single species approach most often has been adopted as the basic concept (Appendix 3). A number of other factors have been involved in past failures to achieve rational management of wild living resources. In view of the significance of those resources to human welfare, it is timely to redefine the scientific principles that should underlie their conservation and management.

The term "conservation" has been used with such a variety of meanings, and often without definition, that it is tempting to avoid using it here. Yet it does have the specific meaning we need of "wise use," involving "keeping for future use," for which concept there is no better word in the English language. Therefore we have retained it (Appendix 2).

The maintenance of resource systems in desirable states is an essential part of scientific, ecologically sound management, and should be the *primary goal* of conservation policy. Such states can provide continuing social benefits and cultural values. Benefits and values may be tangible or intangible, realized or potential. A resource system in a desirable state would have the capacity to accomodate changing human values and to persist in the face of changing environmental conditions. Of particular importance is the need to avoid irreversible changes in the system as a result of human actions.

Effective management and successful conservation requires the existence of legal and institutional arrangements to implement scientifically based principles. While different resource users may have widely differing objectives, those objectives, and the corresponding legal and institutional arrangements to attain them are not the main concern of this report. However, the above *primary goal* is consistent with the aims of most national and international institutions concerned with the management of living resources. To achieve our primary goal requires a sophisticated approach to conservation that takes into account the ecosystem as well as the selected species or stocks considered to have special value at some particular time. Ecologically simplistic concepts such as maximum sustainable yield are not adequate for that purpose. More comprehensive concepts and procedures are suggested below.

THE CHALLENGE

The approaches to conservation measures, to secure future values, have varied from one situation to another. One approach is an *ad hoc* one—simply to try to find agreement on a collective action that enhances future values for all present participants. To achieve this, some inequities usually must be accepted; some users will have greater potential benefit than others and that can lead, and has sometimes led, to the failure of such an approach.

Another approach has been to define a specific goal of conservation. The most usual goal has been the maintenance of the resource in such condition that it is capable of supplying a maximum sustainable yield, and that has been the basis for regulating the exploitation of many wild species (Appendix 3). Strictly, maximum

FIG. 1. Pribilof fur seals (bulls, cows, and pups), St. Paul Islands, Alaska. Brought back from a seriously depleted population to the point where they have provided an annual harvest of tens of thousands of animals, the Pribilof fur seals were long regarded as the classic example of the success of single species management according to the concept of maximum sustainable yield. However, in recent years there has been a decrease in productivity of the population, and it is clear that there are factors involved other than direct harvest. Those factors probably include competition for food (pollock) from commercial fishing operations, deaths caused by seals becoming entangled in discarded fish nets and binding materials, physiological impact from pesticides and heavy metals, and possibly changes in social structure when the seals are ashore on the islands. (Credit: National Oceanic and Atmospheric Administration)

sustainable yield has applied only to some consumptive uses of the resource, but by referring to "values" instead of "yields," the concept could be generalized. The apparent simplicity of the maximum sustainable yield approach has appealed to legislators. It has been incorporated in many international instruments as well as in national and local legislation to regulate fish and game harvest. The concept has sometimes been advocated so forcefully as to imply that a maximum yield not only *could* be taken but *should* be taken; a policy of so-called "full utilization" leads to the view that a resource is in some ways being "wasted" if a maximum sustainable yield is not being taken. Such a view can be grossly misleading.

Where maximum sustainable yield has been applied, it has ensured recognition of the renewable nature of the resource as well as its vulnerability, and undoubtedly has sometimes served the purpose of restraining exploitation. Some failures in maximum sustainable yield management must be ascribed more to failures in application than to weakness in the concept. On the other hand, such a simplistic concept has a number of deficiencies and problems (Fig. 1). For example, it:

— focuses attention on the dynamics of particular species or stocks without explicit regard to the interactions between those species or stocks and other components of the ecosystem;
— concerns only the quantity and not the quality of potential yield or other value from the resource;
— depends on a degree of stability and resilience of the resource that may not exist;
— focuses attention on the output from resource use, without regard to the input of energy, of other natural resources, and of human skill and labor required to secure the output;
— may admit, and even encourage, overexploitation.

There are, of course, certain fundamental differences in conservation objectives when a resource is managed for commercial exploitation rather than for recreational use. Those differences are particularly evident when we compare the problems associated with managing some terrestrial vertebrate resources with those of marine fisheries. The maximum sustainable yield concept has not often been the explicit basis for the former. Small game management often is based on the annual production of a seasonal surplus being harvested down to a threshold density that will maintain what is believed to be a reproductive population in a steady state. Some avian species with high potentials for increase have been managed successfully on that basis in favorable localities with good habitat conditions. Allowable harvests of large ungulates (Fig. 2), on the other hand, are conceptually based more on the concept of limited carrying capacity of the environment, as presumably determined by the impact of the species on the vegetation in its habitat. In theory, surveys are made of vegetational conditions as an index of population pressure and the annual harvest is adjusted accordingly. In practice, other considerations often prevail. In the case of waterfowl (Fig. 3), harvest limits are set on the basis of surveys of aquatic conditions, breeding pairs, and indexes of production of young, with the objective of maintaining an adequate breeding population for the following year. Successful management of terrestrial vertebrates has often relied on habitat protection and restrictions on harvest methods.

In terrestrial situations, detailed observations of behavior, ecological relationships, and habitat response are often possible (Figs. 2, 4), whereas those factors usually are inferred indirectly from samples in aquatic situations. Terrestrial species provide greater opportunity than aquatic ones for rapid detection of response to management mistakes and to natural changes, and for control of harvest by species, sex, and age. Most of the harvested terrestrial species are herbivores so that the relationship between abundance of the species and its food supply not only can be observed directly, but is usually fairly simple and well understood. On the other hand, the bulk of the harvested aquatic species are carnivorous, so that the relationship between harvested species and food supply is not only much more difficult to observe, but is also likely to be quite complex.

Such differences do not mean that maximum sustainable yield is necessarily a more useful concept in the management of terristrial wildlife than in marine fisheries—it is not (Fig. 5). They do illustrate the particular difficulty in obtaining accurate data for the effective management of aquatic resources, and emphasize the need for more sophisticated procedures. Present procedures usually consider only the effects of exploiting an individual species or group of species in isolation, and fail to recognize any need for predicting the effects on other components of the ecosystem or reciprocal relationships between the species and its environment. Those effects may include changes (1) in the populations of competing or symbiotic species within the functional group of the exploited species,

FIG. 2. Aerial survey of pronghorns, Sheldon Antelope Refuge, California. In management of such terrestrial species, direct observations of numbers, behavior, ecological relationships, and habitat condition are often possible, whereas those factors usually must be inferred from samples in aquatic situations. (Credit: U.S. Fish and Wildlife Service)

FIG. 3. Trapping and banding waterfowl (Canada geese and mallards) at the Blackwater National Wildlife Refuge, Maryland, in the course of studies on the population dynamics and migration routes. The resulting information is basic to management of this resource for both consumptive and nonconsumptive purposes. (Credit: U.S. Fish and Wildlife Service)

(2) in the vegetational structure and carnivore populations where the exploited species is a herbivore, and (3) in prey numbers where the exploited species is a carnivore. These are only first-order responses, and consequent changes in more remote parts of the system are probable.

No species exists in isolation. Exploitation of one species has some impact on other components of the ecosystem (Fig. 6), and valid principles for conservation would take due account of that fact. A truly ecological approach will, however, go further. Just as it is necessary, especially under conditions of intensifying use, to

FIG. 4. African elephants, Tanzania, Africa. The herd matriarch comes forward to protect her family, and often is the first shot. Elephant studies have shown the necessity of considering the social and behavioral factors in any management program. (Credit: Iaian and Oria Douglas-Hamilton, World Wildlife Fund)

view the species and stocks of immediate interest to man in the context of the ecosystems as a whole, so now those natural systems are seen in the context of their relationships with human institutions. Historically, many renewable resource stocks—especially marine animals—were exploited as common property resources, with little or no form of effective regulation (Fig. 7). Such exploitation often resulted in the depletion of stocks, not only economically but also biologically. Such depletion—or the threat of it—has led to the establishment of institutions that have attempted to control exploitation. In practice, such institutions occasionally have been successful in controlling biological depletion at least temporarily, but much less successful in reducing economic overexploitation. One factor cited is that under such conditions, resource rents may have remained at a low level, and the corresponding overcapacity of industry has often led to continuing difficulties even in controlling biological overexploitation.

A more sophisticated management approach might attempt explicitly to achieve economic efficiency in resource exploitation in the long run. One theory postulates that such regulation could generate economic rents that could in turn be utilized—reinvested—so as further to improve the effectiveness of management. Unfortunately, that approach has not been attempted at the international level, in part at least because of a continuing failure to recognize the magnitude of the potential benefits, and in part, because of the problems of distribution of benefits to new participants or nations in a fishery. The failure to apply effective management results in the loss of the values that could be realized from the resource.

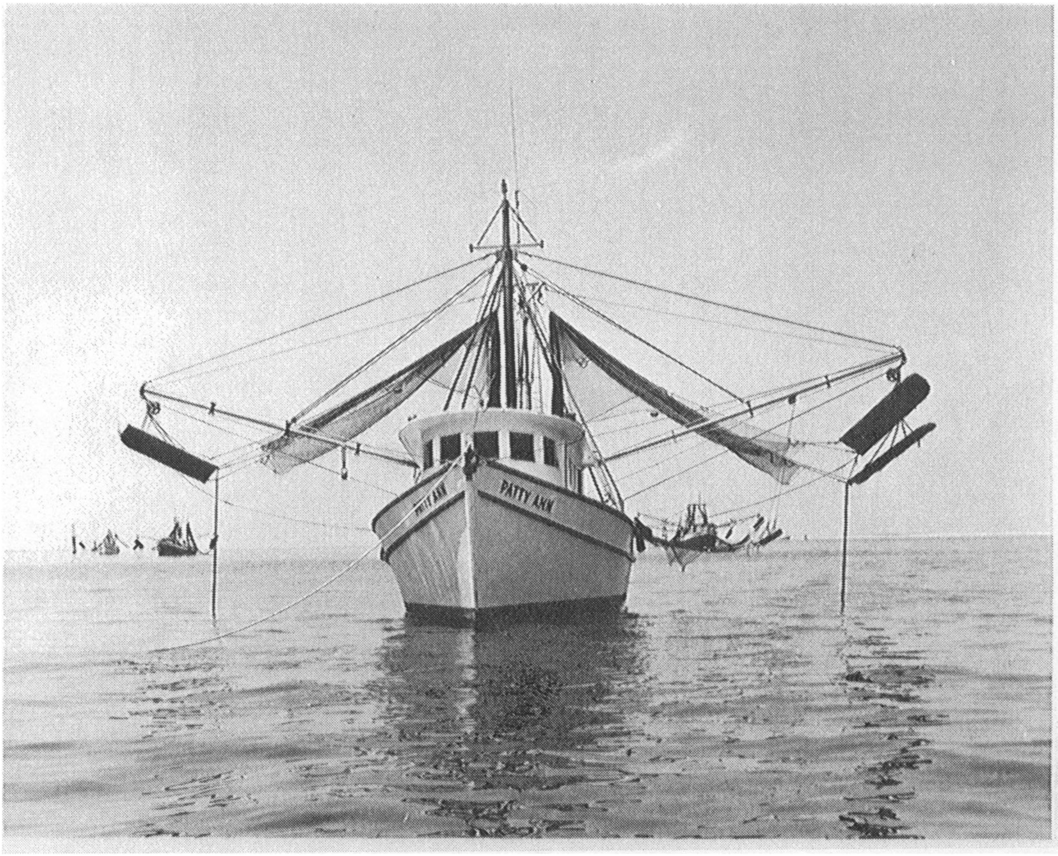


FIG. 5. Shrimp fleet at Galveston, Texas. The principles for conservation of wild living resources apply as much to invertebrates as to vertebrates. (Credit: National Oceanic and Atmospheric Administration)

Newly defined principles of conservation need to be applied in such a way as to facilitate securing and sustaining such benefits.

THE PRINCIPLES OF CONSERVATION

The embodiment of simplistic formulations in legislation has reinforced a belief that hypotheses, such as that the size of a stock essentially determines the yield it can sustain in perpetuity, have in fact been validated, and that the desirable state of a resource system can be exactly specified in terms of a single criterion. That belief does not survive scrutiny, and attempts to apply simple criteria can hinder attempts to use renewable resources wisely. At the same time, man's uses of natural resources are continually intensifying and becoming more widespread, and as a result more demands are put on our ability to understand and predict the consequences of such uses. Although present and near-future needs for increased food supplies might partially and temporarily be met by increased exploitation, conservation for the long term must take precedence in defining new guiding principles to meet the criticisms described in the previous section.

The particular patterns of resource use will, of course, vary from place to place and time to time, but this means only that the new general principles would be applied in a different style, and with differ-

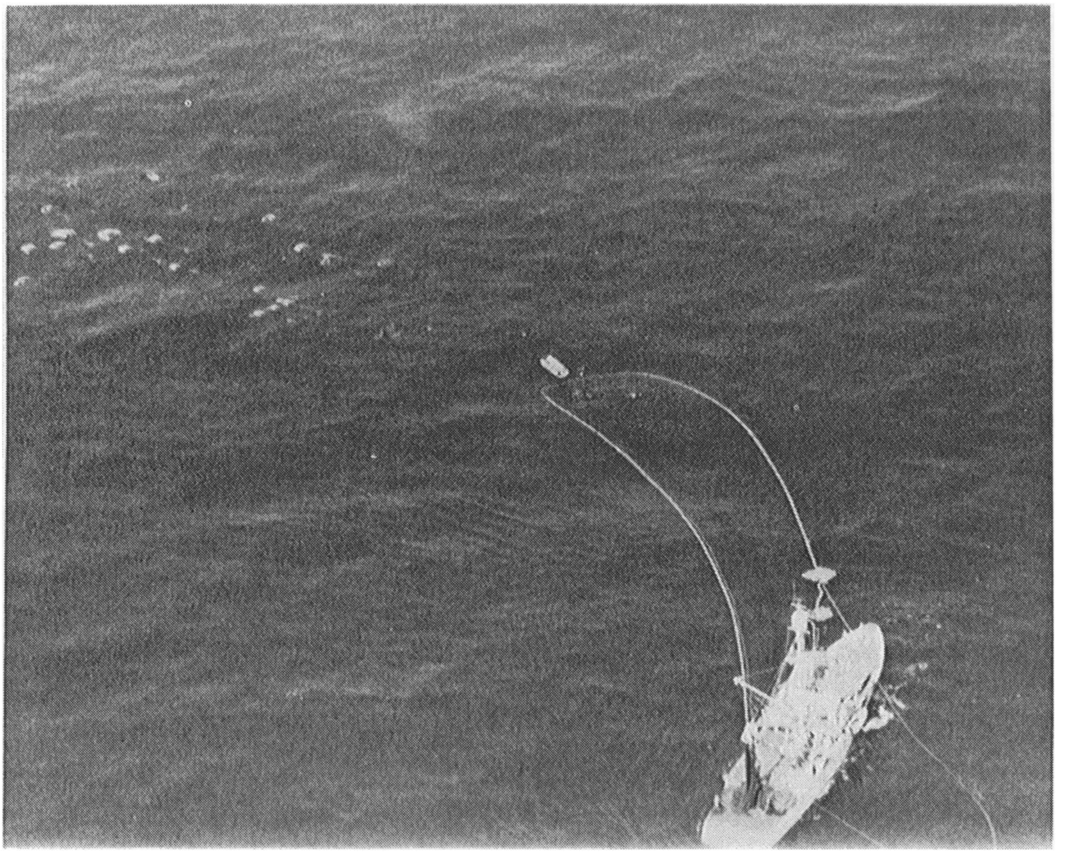


FIG. 6. Purse seiner in the eastern tropical Pacific Ocean fishing "on porpoise" for yellowfin tuna. The net is deployed around a school of porpoise because the tuna are often found in association with them. Unless care is taken when the seine net is pursed, the porpoises may be drowned. Such "incidental take" has represented a gross waste of living resources, ranging from around a quarter of a million to well over a half million dolphins per year. Regulations under the Marine Mammal Protection Act of 1972, enforced for the first time in 1977, reduced that loss to about 24,000 animals. In the photograph, porpoises may be seen escaping from the seine, assisted by fishermen in the skiff. (Credit: Naval Undersea Center)

ing emphasis, from one situation to another. Since there is a growing appreciation of the fact that effective conservation, even of a particular species, must take into account interactions between that species and its living and nonliving environment, the formulation of principles here includes the ecosystem within which the species exists.

The consequences of resource utilization and the implementation of principles of resource conservation are the responsibility of the parties having jurisdiction over the resource or, in the absence of clear jurisdiction, with those having jurisdiction over the users of the resource. The privilege of utilizing a resource carries with it the obligation to adhere to the following four general principles:

1. The ecosystem should be maintained in a desirable state such that
   a. consumptive and nonconsumptive values could be maximized on a continuing basis,
   b. present and future options are ensured, and
   c. risk of irreversible change or long-term adverse effects as a result of use is minimized.

FIG. 7. Japanese trawler, Bering Sea, bringing in the catch. Starting in the mid-1950s, the Japanese, and subsequently Soviet, distant water fleets rapidly increased their harvest of ground fish, reaching annual levels of more than two million metric tons from 1971 through 1974. The impacts of that technology extend far beyond the target species. For example, the trawlers catch accidentally, then usually discard, immature halibut, most of which die. Annually, the weight of that incidental, wasted "harvest" is significantly greater than that of the adult halibut in the intentional halibut fishery. The trawlers' incidental take contributed to the crash of the halibut fishery in the 1960s, and has precluded its recovery since then. The trawlers may also compete with the Pribilof fur seals for pollock, reducing the potential seal harvest. (Credit: National Oceanic and Atmospheric Administration)

2. Management decisions should include a safety factor to allow for the facts that knowledge is limited and institutions are imperfect.
3. Measures to conserve a wild living resource should be formulated and applied so as to avoid wasteful use of other resources.
4. Survey or monitoring, analysis, and assessment should precede planned use and accompany actual use of wild living resources. The results should be made available promptly for critical public review.

Principle 1 recognizes the necessity of maintaining each of the world's ecosystems in a desirable state in which potential users of resources within a system may realize a diversity of values in perpetuity. The three criteria of Principle 1, taken together, cover the main features of the desirable size and structure of the living resource, its natural change in time, and its relation with the varying physical environment. Criterion 1a is a more ecologically valid development from the maximum sustainable yield concept since it specifies a wider range of benefits to be maximized rather than simply specifying a particular maximum yield as a primary goal. Options should be kept open (Criterion 1b) since values are diverse and can be expected to change. Further, advances in scientific knowledge and the ensuing technology will provide new uses and new perceptions that may well call for different treatments of living resources. Our understanding of diversity, organization, and dynamics of ecosystems, as well as of the genetic basis and evolutionary development of various forms of life, can be expected to improve. We must thus strive to maintain any given ecosystem in a state that permits changing values to be appreciated and new knowledge to be applied.

Adjustments to changing values and needs, and correction for the results of previous actions, may also require the capacity to reverse the outcomes of previous actions (Criterion 1c). Thus, it is desirable to avoid those actions that alter ecosystems in such a way that the return of the system to its previous state is impossible or unlikely. The extinction of a species and destruction of habitat are examples of irreversible outcomes. Often, the outcomes of proposed actions cannot be adequately predicted, and in such cases the apparent relative potential of actions to lead to undesirable effects may serve as a basis for their selection or rejection. Actions that are spatially or temporally limited are less likely to lead to large-scale irreversible outcomes than similar actions that are widespread or persistent.

The several criteria for a desirable state may not always appear to be wholly compatible, and defining the desirable state will then involve compromises. In applying Principle 1, fulfillment of its Criteria 1b and 1c may, strictly, involve acceptance of somewhat less than the maximum of a particular single yield that could possibly be realized on a continuing basis as provided in Criterion 1a. Such "sacrifice" will, however, be relatively small and will be compensated for in other ways. Specifically, it will contribute to safety (Principle 2) and to the avoidance of waste of other resources (Principle 3). It may also increase the net benefits to each user in realizing consumptive values. Further, it should be recognized that Criterion 1a refers to *values*, not simply to *yields*. Value, in this context, implies more than economic yield.

Ideally, resource conservation measures should be based on a thorough understanding of the biological characteristics of the resource and its environment. Principle 2 recognizes that both our knowledge and our arrangements for applying that knowledge will always have shortcomings, and that they should be allowed for so present management does not inadvertently prejudice future values.

In practice, our knowledge is often seriously inadequate, and predictions are uncertain. Uncertainty may arise from ignorance of such things as biological growth rates, interactions with other species, effects of the species on its habitat, and unpredictable environmental events. Similarly, the imperfection of institutional arrangements can lead to errors and delays in the implementation of policy decisions. To reduce the risk of irreversible changes or other long-term adverse effects, an appropriate safety factor should be included in all conservation measures. The magnitude of the safety factor should be proportional to the magnitude of the risk. The greater our ignorance of the resource—particularly of its capacity to respond to changed conditions—and/or the weaker the management institutions, the greater the safety factor must be.

Any use of a living resource must involve use of other resources, such as capital and energy. It is well known that the conduct of many fisheries, including some supposedly managed on the maximum sustainable yield principle, has involved an overcommitment of resources such as capital, labor, and fuel (Fig. 8). Specific measures for conserving a particular resource should be chosen and applied in such a way that they do not encourage undesired and unnecessary waste

FIG. 8. Soviet stern trawler under surveillance by U.S. Coast Guard aircraft. Sophisticated and efficient distant water fisheries of such nations as Japan and the Soviet Union are a major factor in harvest of living resources from the world's oceans. (Credit: National Oceanic and Atmospheric Administration)

or misuse of other natural resources. The conservation of other resources will nearly always require utilization at a level appreciably less than the supposed maximum sustainable yield. The safety factor will thus often result in a net economic gain in both the short and long term. This should not be taken to imply that consideration should not be given to noneconomic values. Where recreational or nonconsumptive values are of primary concern, consideration of economic efficiency may be inapplicable. A further waste to be avoided or minimized may occur through incidental destruction of "nontarget species," i.e., species other than those primarily valued and sought, such as porpoises in the yellowfin tuna fishery (Fig. 6).

Principle 4 concerns the needs and duties of information gathering, interpreting and explaining, that are an essential part of resource management. Timely and accurate scientific information is an essential component of a conservation program (Fig. 9). The amount of investment in such assessment should be related to the intensity of use, the complexity of the problem, and the vulnerability of the system to adverse impact.

Data collection—in principle by all those who exercise or claim a right to use a resource—is itself extremely important, but of equal importance is continual improvement in our understanding of processes in ecosystems and of methods to measure and predict the directions and rates of those processes. Such improved

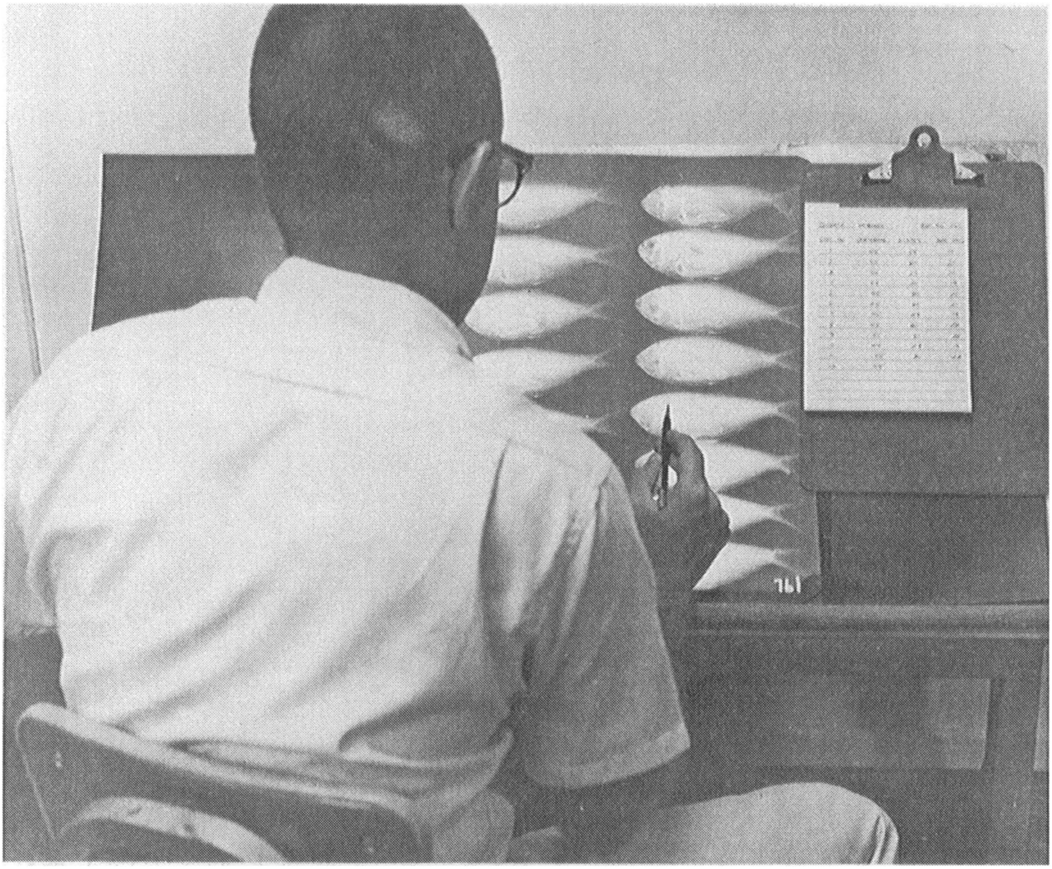


FIG. 9. Government scientists using radiograph for counting vertebrae and fin rays in population studies of menhaden. Improvement of the scientific information base, and the development of new technologies and methodologies is essential to effective management of living resources (Credit: National Oceanic and Atmospheric Administration)

information is necessary to improve and correct management approaches and to adjust them to changing conditions. Critical public review is necessary both to provide for accountability for data and decisions, and to ensure the opportunity for normal scientific peer review. Thus, Principle 4 implies both strengthening and some reorientation of research and research procedures.

APPLICATIONS

Obviously, it will not be easy to develop the techniques needed to put the four proposed principles into effect. It will take much time and considerable effort. If, as is hoped, the principles are widely accepted, high priority should be given to working out interpretations of them for particular cases, and suitable procedures for their implementation.

Clearly, the complexity of the problems involved is now being more widely appreciated. This is attested by the attempts to understand ecosystems as functioning units, as in the Biome Projects of the International Biological Program. In the management of aquatic and terrestrial resources, several institutions already have acknowledged the need to move beyond management based on the maximum sustainable yield concept toward broader goals. Some have considered certain aspects of the general principles outlined in this document.

The need to limit the rate of development of fisheries on newly exploited species in order to permit adequate assessment of the effects of fishing has been recognized and applied by the International Commission for the Northwest Atlantic Fisheries (ICNAF). Also, the concept of including interspecific effects has been incorporated by setting limits on the total harvest of all species from an area. The protocol of the International Commission for the Northwest Atlantic Fisheries stipulates that regulations may be proposed on the basis of scientific, economic, and technical considerations.

Available reports about the anchoveta fishery in Peru now reflect consideration not only of conventional and improved stock production models, but also determinations of the optimal number of fishing boats, the best capacity for processing plants, discussion of social effects of modifying the labor costs, and the phasing of some of the overcapacity into new fishing endeavors.

Some experimental management studies of warmwater recreational fisheries in the United States have recognized the importance of maintaining satisfactory age and size structures of fish populations in order to sustain fishing quality. Conservation and sustained benefits can be accomplished by programs that maintain the satisfactory qualities of ecosystems—both habitat and community structure.

In the International Whaling Commission (IWC), most of the principles are beginning to play a role in the establishment of harvest quotas. At its 1974 meeting, the Commission agreed that management of whale stocks should eventually be based on some "optimum" rather than simple numerical maximum sustainable yield, the Scientific Advisory Committee of the International Whaling Commission having recommended that "Scientific advice for management of whale stocks should be based not only on the concept of sustainable yield and numbers, but should also include considerations such as total whale weight rather than numbers, interactions within the marine ecosystem, and the health of the ecosystem as this concept is quantified." The "New Management Procedures" now in effect, provide for a safety factor, and the scientific analysis and assessments have been much improved, with publication required.

In the management of fur seals in South Africa, attention is now being given to the balance between the fur seal and the pilchard populations on which they prey, both species being of economic value in their own right.

There are examples of harvesting of wild ungluate populations in African nations where management policies emphasize balanced harvesting of several species simultaneously in the context of the condition of the environment.

The Marine Mammal Protection Act of 1972 is the first national legislation to place maintenance of the health of the ecosystem as the primary objective of management. Its declaration of policy states that:

"Species and population stocks should not be permitted to diminish beyond the point at which they cease to be a significant functional element of the ecosystem of which they are a part . . . . The primary objective of their management should be to maintain the health and stability of the marine ecosystem. Wherever consistent with the primary objective, it should be the goal to obtain an optimum sustainable population, keeping in mind the optimum carrying capacity of the habitat."

These examples serve to demonstrate how the need for new approaches has already brought some institutions to adopt certain aspects of the principles defined here. The following steps are now needed:

(1) The charters of resource management institutions should be amended as necessary to embody the four general principles, and

(2) The institutions should be evaluat-

ed with respect to their capacities to implement the principles.

APPENDIX 1

List of participants

P - Attended planning meetings
1 - Attended first Workshop
2 - Attended second Workshop

(All attendances at Workshops were in personal capacity.)

D. L. Alverson (P)
Northwest Fisheries Center,
National Marine Fisheries Service,
Seattle, Washington

David R. Anderson (P,1,2)
U.S. Fish and Wildlife Service,
Patuxent Research Center,
Laurel, Maryland

Richard O. Anderson (2)
Missouri Cooperative Fishery Research Unit,
University of Missouri,
Columbia, Missouri

William Aron (P,1,2)
Office of Ecology and Environmental Conservation,
NOAA,
Washington, D.C.

David A. Bella (2)
Department of Civil Engineering,
Oregon State University,
Corvallis, Oregon

Gerard Bertrand (P,1,2)
University of Wisconsin,
Madison, Wisconsin

L. J. Bledsoe (2)
Center for Quantitative Science,
University of Washington,
Seattle, Washington

Kenneth P. Burnham (2)
U. S. Fish and Wildlife Service,
Laurel, Maryland

Archie Carr (2)
Department of Zoology, University of Florida,
Gainesville, Florida

Douglas G. Chapman (P,2)
College of Fisheries,
University of Washington,
Seattle, Washington

Colin Clark (1,2)
Department of Mathematics,
University of British Columbia,
Vancouver, Canada

L. Lee Eberhardt (2)
Ecosystems Department,
Battelle-Northwest,
Richland, Washington

John Gottschalk (2)
International Association of Fish and Wildlife Agencies,
Washington, D.C.

John Grandy (P,1,2)
Defenders of Wildlife,
Washington, D.C.

J. A. Gulland (1)
Fishery Resources and Environment Division
Rome, Italy

Richard C. Hennemuth (P,1,2)
National Marine Fisheries Service,
Woods Hole, Massachusetts

Sidney J. Holt (1,2)
Fishery Resources and Environmental Division,
FAO, Rome, Italy, and Royal University of Malta

Laurence R. Jahn (P,1,2)
Wildlife Management Institute,
Washington, D.C.

Thomas E. Lovejoy (P,1,2)
World Wildlife Fund,
Washington, D.C.

Bill Massmann (2)
Division of Federal Aid,
U.S. Fish and Wildlife Service,
Washington, D.C.

R. S. Miller (P,1)
School of Forestry and Environmental Studies,
Yale University,
New Haven, Connecticut

W. Scott Overton (2)
Department of Forest Management,
Oregon State University,
Corvallis, Oregon

Henry A. Regier (P,1,2)
Department of Zoology,
University of Toronto,
Toronto, Canada

James J. Reisa (2)
Council on Environmental Quality,
Washington, D.C.

Godfrey A. Rockefeller (2)
World Wildlife Fund,
Washington, D.C.

Brian J. Rothschild (1,2)
Southwest Fisheries Center,
National Marine Fisheries Service,
La Jolla, California

Donald B. Siniff (2)
310 Biological Science Center,
University of Minnesota,
St. Paul, Minnesota

Tim Smith (2)
Southwest Fisheries Center,
National Marine Fisheries Service,
La Jolla, California

Robert B. Symthe (2)
Council on Environmental Quality,
Washington, D.C.

Lee M. Talbot (P,1,2)
Council on Environmental Quality,
Washington, D.C.

Scott Riviere (1,2)
World Wildlife Fund,
Washington, D.C.

F. H. Wagner (P,1)
College of Natural Resources,
Utah State University,
Logan, Utah

George Waring (P)
Marine Mammal Commission,
Washington, D.C.

George Woodwell (P)
Marine Biological Laboratory,
Woods Hole, Massachusetts

APPENDIX 2

Conservation

The term "conservation" has been used with the meaning of "wise use" involving among other things, "keeping for future use." In its broad definition, it includes management measures, and means the collection and application of biological information for the purposes of increasing and maintaining the number of animals within species and populations at some optimum level with respect to their habitat. Used in this way, conservation refers to the entire scope of activities that constitute a modern scientific resource program, including but not limited to research, census, law enforcement, and habitat acquisition and improvement, and periodic or total protection as well as regulated taking.

Conservation may refer to a set of measures intended to maintain a resource in a desirable state, or to designate the process of attaining such a state. In a narrow context, conservation can refer to the application of measures that in some way restrain the otherwise free use of a resource in order to ensure that it retains certain desirable natural properties. Used in this way, conservation can be considered as one facet of rational resource management, which may also cover activities intended to improve the resource or ameliorate damage resulting from previous misuse of it. (Of course, in its broader context, conservation includes all those activities.)

The need for conservation arises from a combination of two conditions:

(1) that the use of the resource is sufficiently intensive to significantly affect it, and

(2) that the pressure of present use is such that unless restrained or otherwise regulated it will prejudice future uses and values.

The development of technology and the increase of human populations now ensure that practically all wild living resources are accessible to, and vulnerable to change—sometimes drastic change—by human agency. The second condition might, in theory, apply to an individual man, owning and subsisting on a wild resource who decides to limit his hunting now so that he has food for next year and the year after. Noncompetitive groups may also impose restraints on themselves in the expectation of providing better for the future of their members and their kin. In practice, however, in the modern world, the need for conservation measures arises essentially because any group of users usually will give relatively greater weight to present values with respect to future values, than does the larger group of which the user group is a part. Conservation measures are the means to correct such an imbalance by adding more weight to future values than would be accorded to them by the separate users of the resource.

Each resource user's relatively short-term view is enhanced by his uncertainty of future benefit. This arises from the expected behavior of contemporary competitors and insecurity of his future access to the resource. Societies, therefore, often seek to establish a longer-term view by eliminating or reducing the risks of exclusion and detrimental competition. Thus, indefinite or long-term rights of use may be granted, competition regulated through allocations, and conflicts in different kinds of use of the same resource resolved by applying some formula. Such actions are not considered to be included among the conservation measures to which attention is here directed, but they are complementary to them. Experience has shown the need for both types of social action at all levels—from the control of individual users by local authorities to the self-regulation of national activities through international mechanisms.

APPENDIX 3

The Concept of Maximum Sustainable Yield

The maximum sustainable yield (MSY) is the greatest harvest that can be taken from a self-regenerating stock of animals year after year while still maintaining a constant average size of the stock. It is derived from the hypothesis—supported to a certain extent by observations—that a population of animals, in growing from an initial small number, at first increases more or less geometrically (exponentially) but that the rate of increase slows down as the population gets larger. The graph of population size against time is thus an S-shaped curve that eventually approaches or reaches a "final" size, that reflects the *carrying capacity* of the habitat of the population (Fig. 10). At that level, the death rate is balanced by recruitment, and a "steady state" is attained. The simple theory then postulates that the final size is actually the *initial* size of the renewable resource before man begins exploitation, and that when he begins to take an annual harvest the stock is reduced. According to the theory, the potential of the stock for increase is assumed to be determined by its size, and it presumably can be held steady at a certain size by removing each year a catch equal to that potential rate of increase; this is a "sustainable yield." So if the population growth curve is S-shaped, the greatest yield can be sustained from a stock of intermediate size, corresponding with the turning point (inflection) of the population growth curve. Study of such curves suggests that the intermediate stock level to be expected in many cases would be between about 40 and 60 percent of the level at "carrying capacity," although for some species the level may be higher.

The simple conceptual model outlined above, and also some more complex mathematical models, exhibit the property of a single maximum yield as a function of stock size. According to certain commonly used theoretical models of population growth, maximum sustainable yield should be obtainable from a stock level about half the level at "carrying capacity" (Fig. 11). Such models involve a number of assumptions, the most important of which may be summarized as follows:

- the stock is more or less self-contained;
- the stock has attained, before exploitation began, a steady state, at the carrying capacity;
- there are no significant trends in carrying capacity during the period of exploitation;
- the nature of the implied density de-

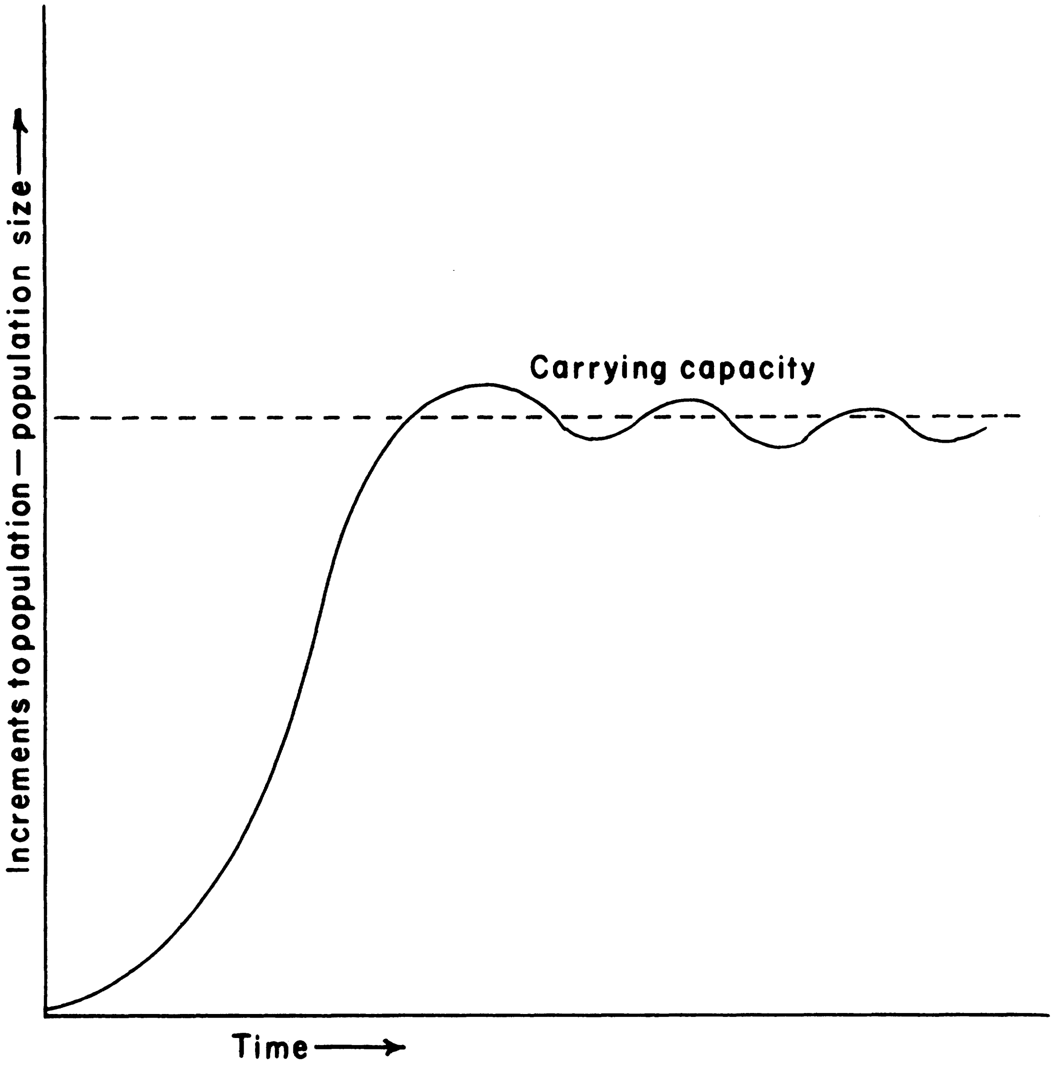


FIG. 10. The population curve is S-shaped because increments to the population are slow when the population is at a low level, with few individuals reproducing; the increments increase steeply when the population is higher and all individuals are reproducing at maximum rate; and the increments level off when the carrying capacity of the environment is reached, and mortality or other loss balances recruitment.

pendence of reproduction, growth and/or natural mortality, and in particular, any time lags in the response of the stock to exploitation, are not such as to cause fluctuations of large amplitude in the stock; and

— the process of reducing the "initial" stock by exploitation is reversible.

It is in practice usually very difficult to test any of those assumptions. Stocks have occasionally been reduced to less than half their initial size, and then recovered under full or partial protection (as in the case of the North Pacific halibut). In other cases, severely reduced stocks have never recovered, in spite of receiving total protection (such as the

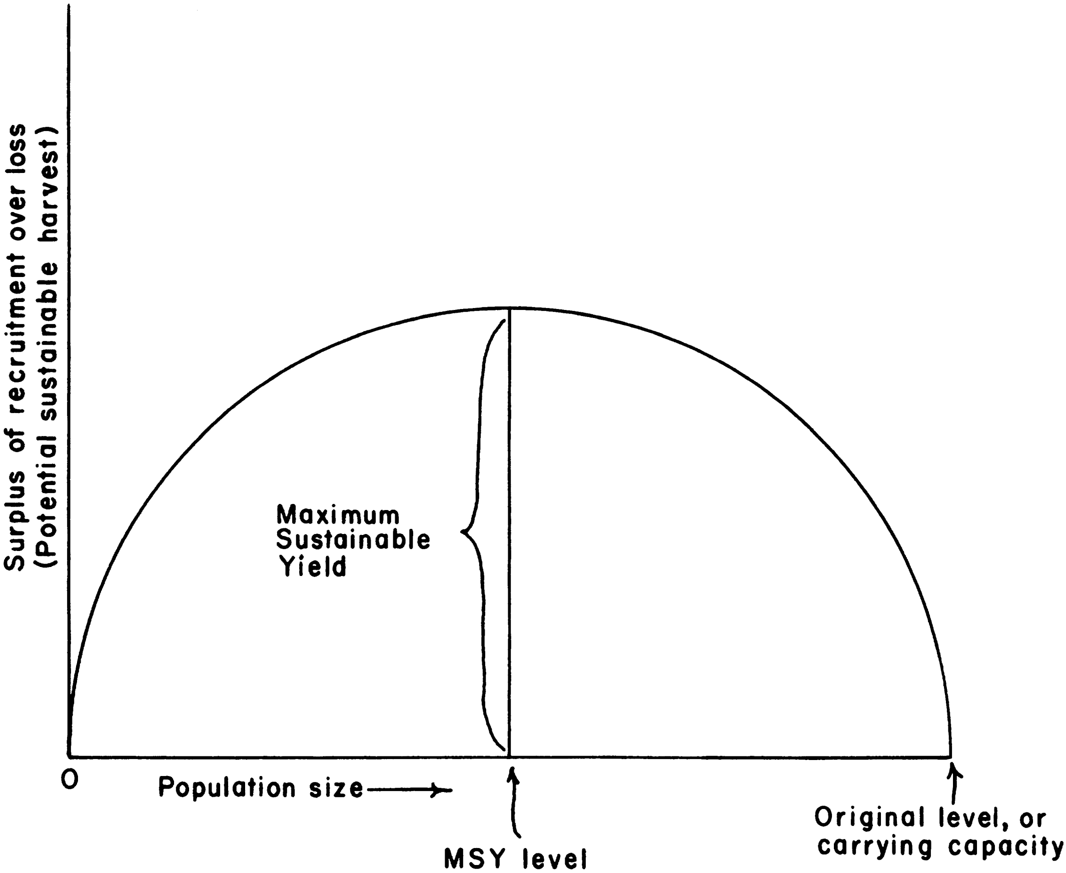


FIG. 11. The maximum sustainable yield concept is based on the assumption that an unexploited population exists at an equilibrium density, maintained by density dependent factors—i.e., it is at the carrying capacity. When the population is reduced and the density lowered, recruitment rates increase and exceed rates of loss. The difference between the recruitment and loss represents the number of animals that can be removed through exploitation, without reducing the population further, and if that number is removed annually, it is assumed that the population will be stabilized at the new, artificially induced equilibrium density. Under a strict abstract logistic curve condition, the population density producing the greatest harvestable surplus—the maximum sustainable yield—is one-half the "original level."

blue whale). In some cases, reduction of one species has led to the increase of another, unexploited species, and a change in the composition of the ecosystem (such as in the case of the California sardine and anchovy). We have as yet no sure means of predicting such consequences. Although a number of methods have been devised and used to estimate the parameters of the models described, they all depend on assumptions that are both overly simplistic and unproven. For example, the effect of exploitation on the age composition of a population has often been ignored, or it has been assumed that a reduction of the proportion of old individuals will result in an increase in reproduction. Under exploitation, the age composition usually is truncated, with the younger age groups comprising a higher proportion of the total. This occurs where exploitation is nonselective as well as where there is selection for larger—usually older—individuals. If, in a given species, the older age groups have higher reproductive rates—and particularly if the youngest several age groups constitute a prereproductive stage in the life history—an exploited population with truncated age structure will have a lower relative reproductive rate than would a population in which all individuals had an equivalent reproductive potential.

The social organization of the wild population is another factor to which far too little attention has been given in development of the concept of maximum sustainable yield. Dominance patterns, involving the supremacy of one or a few males that accomplish all or most of the breeding, exist in many species. Those patterns may rather delicately control the reproduction of a population, and if the patterns are destroyed, that control can be upset, in some cases, reducing the reproductive rate. Another aspect of concern is the effect that loss of group leaders experienced in foraging or migration, may have on group survival (Fig. 4).

From an ecological point of view, the major problems associated with maximum sustainable yield involve its concentration on the stock involved to the exclusion of factors such as:

— relationships within a trophic level (e.g., competition);
— relationships between trophic levels;
— impacts on symbiotic or commensal relationships; and
— changes in carrying capacity due to factors such as climate, pollution, and other human influences.

In sum, the concept of maximum sustainable yield as a simple function of stock size was developed to provide a generalized approximate description of the response of a stock or species to exploitation. It has served a useful evolutionary function, as a means of generalized description, and as an elementary teaching aid for students and for administrators. It has provided a preliminary conservation goal where it has been used to try to avoid or correct overexploitation. It has played a significant role in the evolution of understanding of wild populations. However, like some other simplified concepts, maximum sustainable yield has become institutionalized in a more absolute and precise role than intended by the biologists who were responsible for its original formulation. It is being expected to perform functions for which it was never intended, serving for example, as the sole conceptual basis for or goal of management in some cases. Once a concept has been adopted and institutionalized, it is difficult to change it. In this case, because of its institutionalization, the concept of maximum sustainable yield is now an obstacle to the acceptance of concepts that derive from present ecological knowledge, and that would provide a more adequate basis for management. A more adequate basis is especially necessary at this time when the overall impact of man on the biosphere is increasing and diversifying as never before.

APPENDIX 4

Application to the Law of the Sea

Summary

The Workshop prepared a statement of principles for the conservation of wild living resources that could meet modern needs. The statement redefines the primary goal of renewable resource management and the conditions for effective application of the principles. In this Appendix to the report of the workshops the statement is adapted to specific problems concerning the living resources of the sea, particularly, but not exclusively, those that are or may be internationally managed. The document explains the reasoning behind this endeavor, and annexed to it is a form of words that it is suggested might usefully be included in the text of instruments now being prepared by the United Nations Conference on the Law of the Sea.

Text

Man is making ever-increasing demands on renewable natural resources, for food and for other products and values. The United Nations Conference on the Human Environment in 1972, the United Nations Conferences on Population and Food in 1974, and the current United Nations Conference on the Law of the Sea (UNCLOS) all attest to rising international awareness of the global problems created thereby. With respect to the wild living resources, including fishes and other marine organisms, it is evident that although much progress has been made in the past three decades, some attempts to manage those resources have nevertheless permitted gross depletion of several of them, rather than assuring continuing, high and improved yields. Absence of an effective policy for rational management, or the application of a policy that results in overutilization or other abuse of a resource, results in the loss of potential benefits to both present and future generations. Losses with respect to marine resources have been estimated roughly in the order of several hundreds of millions of dollars annually. Such losses will increase unless appropriate policies are implemented soon. An effective policy would, on the other hand, secure great benefits and ensure that they are distributed equitably both among nations and existing users, and between present and future generations.

The United Nations Conference on the Law of the Sea has concentrated on the equitable distribution of fisheries resources among states, and hence of potential benefits from their use, rather than on the problem of balancing present and future uses. Proposals submitted to the Conference to date address more the question of rights, access, and jurisdictional limits than the formulation of overall long-term objectives. This is understandable, in view of the urgent need to resolve existing and potential conflicts among nations and among different users of the ocean. The two questions are, however, linked. The task of the Workshops was limited to close examination of the latter and to suggest new approaches to its solution. It is hoped that the suggestions made will be useful to those persons engaged in preparing new legislation covering those matters.

Management failures are attributable at least as much to institutional weaknesses as to shortcomings in the formulation of objectives. Those aspects are, however, also linked; in particular, attempts to apply unsound objectives lead to the sharpening of conflicts and to stress and failure in management institutions, and hence to less than optimal use of resources.

If management as a whole is concerned primarily with the allocation of values among interested parties who use or may use a resource, conservation is that component of management which regulates the relationship between current and potential values (Appendixes 1 and 2). The primary goal of conservation policy is the maintenance of resource systems in desirable states. Such a goal is consistent with the perceived evolutionary direction of international institutions.

The Workshops agreed on a set of Principles for the conservation of wild living resources. Those Principles provide guidelines for achieving the primary goal; they represent, inter alia, an attempt to specify what are desirable states in this context. In addition, a number of criteria were agreed that should be met in applying the Principles. For this, a sophisticated approach to management is necessary, taking into account the basic characteristics of ecosystems as well as the properties of selected species and resource stocks that may be of interest to certain users at particular times. Simplistic goals of conservation, including the widely adopted one of assuring "maximum sustainable yield," prove to be inadequate.

The desirable state of a resource system is defined as one that fulfills the following three conditions:

(1) physical yields, or other derived values, could be maximized on a continuing basis;

(2) diversity of present and future options in using it are ensured; and

(3) risk of irreversible change or of long-term adverse effects resulting from use is minimized.

These three conditions do not contradict each other, but they are not always wholly compatible. Where the desired state is some compromise between them, Conditions 2 and 3 may be fulfilled by foregoing some of the continuing yield the potential for which Condition 1 seeks to maximize. Such sacrifice will, however, be relatively small, and compensated for by other benefits to present and future users.

The set of Principles prepared by the Workshop are generally applicable to terrestrial, marine, and freshwater situations. With respect specifically to the marine environment, it is suggested that the instruments to be prepared by the United Nations Conference on the Law of the Sea should refer explicitly to those Principles and to the necessary conditions for their application in various circumstances. This might best be done by including an appropriate definition of "conservation" and specification of the main conditions. Accordingly, an annotated draft text is offered in the Annex to this Appendix. It includes valid ideas expressed in existing texts but reflects the better understanding of the nature of marine resources we now possess, as well as being responsive to modern fishing conditions.

The draft is divided into three paragraphs. These could, if necessary, be used separately, in articles, in a preamble, or in a Conference resolution, depending on the eventual form of the instruments now being prepared. They might serve to specify the general criteria for international management of fisheries in waters beyond national jurisdictions, and as guidelines to coastal states in exercising their authority in waters falling within their jurisdictions. Similar wording might be used to define the conditions for exercise of authority entrusted to any state, group of states, or international machinery.

"Conservation" is defined in Paragraph A of the Annex. The introductory words, and Subparagraph 1, are identical in form with, and similar in content to, Article 2 of the 1958 Geneva Convention on Fishing and Conservation of the Living Resources of the High Seas. Similar wording has been included in a number of draft articles submitted by states to the United Nations Conference on the Law of the Sea, several of which acknowledge the need for more effective conservation programs and would impose a conservation obligation on coastal states as well as on international organizations established to manage fishery resources. Two small, but nevertheless significant, additions have been made here. Firstly, the definition refers both to the resources themselves and to their environment, which together constitute the marine ecosystem. Secondly, Subparagraph 1 indicates the need for supplies of food to be stable as well as maximal; the population levels of many stocks of fish and other marine animals are naturally variable, but under intensive use that variability can be increased, to the detriment of the fishing industry and, in some cases, endangering the survival of the stock. The intention of Subparagraph 1 is to ensure that stocks will generally be maintained at levels not lower, and possibly substantially higher, than the levels required to meet the definition in the 1958 convention, insofar as such levels can be determined.

Subparagraphs 2 and 3 introduce new principles. These are called for by changes in the nature of fisheries that have occurred in the 20 years since a United Nations Technical Conference prepared the earlier definition. Marine fisheries have, in that time, expanded greatly. They have diversified, and many more nations are participating in them. Although the world catch has continued to increase, the rate of increase has slowed—despite continuing increase in fishing effort—and occasionally in recent years the total annual catch has declined. Some of the resources on which large and valuable fisheries were based have proved unable to withstand the intensity of fishing to which they have been subjected, resulting in considerable distress to some fishing industries, social disruption, and financial losses. Although no species are known yet to have become totally extinct as a result of this fishing pressure, the adverse effects will in some cases endure for many years and some may be irreversible. Over the same period, shifts in the nature of interest in the marine resources have reminded us that values can and do change, often unpredictably. Thus, wise use of resources involves regulating the impact of current exploitation so as to provide for continuation of current types of use but at the same time not to foreclose use of the resource for other purposes in the future. This is particularly desirable for a resource the exploitation of which is regulated internationally, because those who use it in the future may not always be the descendents of those who use it now. Application of Subparagraph 2 is a necessary—but not in itself sufficient—action to preserve options. This will be achieved generally by limiting the impact of fishing, and probably more effectively by encouraging a pattern of resource utilization such that a given total yield is secured as a balanced mixture of species from various trophic levels[1] in the ecosystem, rather than comprising one or a few species taken mainly or entirely from one trophic level.

As pointed out earlier, simultaneous fulfillment of all criteria laid down in the three subparagraphs may in practice involve some compromise, but should by its nature give compensatory benefits. In particular, by taking yields on a continuing basis at levels somewhat less than the maximum possible, some unintended wasteful expenditure of other natural resources used by fishery industries (e.g., fuel used to obtain the catch or materials and energy used in constructing excess vessels and gear), will be avoided, and the net benefits accruing to each participant in the fishery will often be increased. The problem of wasteful use of other resources is addressed in Subparagraph 1 of Paragraph B in the Annex. It has long been recognized that the benefits of conservation may lie as much in avoiding excessive fishing effort, as in enhancing the value of sustained catches. Application of the Principles embodied in the definition of conservation would of course restrain effort, but it is not alone sufficient; there are numerous cases where the benefits from conservation measures have been largely dissipated through intensified competition among participants for shares of the regulated catches. At a time when it is becoming widely accepted that there are overall limits to natural resources, it seems appropriate that the instruments of the United Nations Conference on the Law of the Sea should be explicit on this matter by recognizing that the conservation of living marine resources while having special aspects, is nevertheless a part of the general problem of resource husbandry.

Subparagraph 2 may be read to cover also the need to act, in the process of applying conservation measures, so as to ensure that catches of fishes and other animals that may be taken incidentally with those most prized, are not wasted.

While some ecological concepts are rather well founded and generally accepted by the scientific community, there are weaknesses in current theory, data, models, and analytical and computational procedures. Furthermore, as fishing continues to intensify and diversify, the nature of its impact is changing so that, notwithstanding scientific advances of the past two decades, we are still far from

[1] This biological term describes the feeding relationships of organisms. Some—the green plants, including phytoplankton—are primary producers, constructing living material from inorganic nutrients in the sea by photosynthesis; others are herbivorous; primary carnivores feed on the herbivores, and they in turn form the diet of secondary carnivores. These several categories (producers, herbivores, primary carnivors, etc.) constitute trophic levels.

being able to predict in detail, or at long-range, changes in marine ecosystems—particularly qualitative changes—that may profoundly affect man's use of those resources. Furthermore, although the machinery for decision making may be improved; there will always be some delay in implementing decisions, some likelihood of mistakes having significant consequences, and perhaps some shortcomings in enforcement of regulations. Good management calls for appropriate allowance for these inevitabilities. Again, natural changes in many characteristics of living systems and of their physical environment cannot yet be predicted, and some may never be predictable. These facts all call for the inclusion of safety factors in conservation measures, the margin of safety provided being based on reasonable assessments of the degree of uncertainty and the magnitude of the risk. This is provided for in Paragraph B, Subparagraph 2.

The wording of Subparagraph 3 is taken straight from the 1958 Convention. It favors a priority of resource use that is now even more relevant than it was in 1958, or than in 1966 when that convention came into force. The wording does not, in our interpretation, exclude products for indirect human consumption, but would nevertheless tend to favor direct use where possible. Since that time, some other aspects of "product quality" have also been recognized as important, such as the presence of heavy metals, pesticides, and other contaminants in marine organisms. This is in part covered by other draft articles before the United Nations Conference on the Law of the Sea that deal with pollution of the sea, but perhaps calls for explicit cross-reference in the articles on conservation and allocation of fisheries resources.

The 1958 Convention provides for conservation measures to be based on scientific evidence. This is a necessary, but not a sufficient, provision for successful application of new international law. Data must not only be adequate, but they and the derived results must be promptly disseminated so that critical review of them is possible. The application of conservation measures should be constantly modulated by feedback of data, and their effects continuously monitored. Furthermore, pertinent environmental properties need to be monitored concurrently, and the observed or anticipated effects of changes in them—whether natural or caused by man—taken into account through appropriate changes in the conservation measures.

A most important need is to locate unambiguously the responsibility for collecting and analyzing data, and generally for conducting research and monitoring. Practical considerations dictate that specific duties must be firmly, though not necessarily exclusively, assigned to those entities that have the right to utilize the resources, and particularly to those that exercise that right. Not only can they benefit economically from their right, but much of the data essential for the formulation of conservation measures comes from the catches and the records of fishing operations. Those who utilize a resource are, further, likely to be the ones with the means, or access to the means, to conduct the necessary research, and also with the possibilities, under international law, of conducting certain kinds of research—whether from commercial or research vessels or from other platforms—in areas over which jurisdiction is exercised. One of the main causes of past failures has been that data have not been promptly available, nor contributed by all participants in the fisheries, and have not always been of adequate scope. Furthermore, the means to analyze and interpret the data and materials that have been collected have frequently been inadequate, and the results have not been promptly disseminated. The provisions of Paragraph B are intended to correct those faults.

ANNEX

(a) A. "Conservation of the living resources of the sea is that aggregate of measures required to maintain those resources and their environment in a state such that

(b) (1) a maximum and stable supply of food and other marine products may be taken from them on a continuing basis;

(c) (2) there is minimal likelihood
(d)(e) of irreversible or long-term adverse effects of exploitation on particular resources or on the marine ecosystem as a whole; and

(3) a wide diversity of options for future use is ensured."

B. "Conservation measures shall be formulated with a view to

(f) (1) avoiding wasteful use of other natural resources expended to secure the supply of food and other marine products;

(2) providing a margin of safety to allow for unpredicted variations and characteristics of marine resources and their environment, and for the fact that the application of measures may be subject to delay or be otherwise imperfect; and

(3) securing in the first place a supply of food for human consumption."

C. "The party or parties having jurisdiction over a living marine resource shall ensure that such continuing scientific research is conducted, and that such data are regularly collected and analyzed and results promptly disseminated, as are necessary for the formulation of conservation measures and for monitoring the effects of their application. The scope of the necessary research and data is such as to reveal the state and dynamics of the stocks being or to be exploited, the effects of exploitation on them, their interactions with other elements of the marine ecosystem to which they belong, and their dependence on environmental processes."

"In meeting this responsibility the party having jurisdiction shall ensure that entities acting under its authority collect the necessary data, including information about the utilized and the discarded
(g) catches, and about the fishing op-
(h) erations."

Notes

(a) The 1958 Geneva Convention on Fishing and Conservation of the Living Resources of the High Seas refers in its Article 1, Paragraph 2, to "conservation" as the process of reaching a defined state of the resources. Article 2, on the other hand, defines "conservation" as "the aggregate of measures" required for attainment of such a state. Here, the latter approach is followed, for convenience.

(b) We would have preferred not to use the technical term "maximum" in such a text but recognize that it has found acceptance in many international treaties as a legal term [see (e) below].

(c) Values may be attached to properties of living marine resources other than their ability to yield "food and products"; examples are the recreational value of sport fishing, and aesthetic, ecological, and scientific values. Under present conditions, these other values pertain more to resources that are, or may become, under the exclusive jurisdiction of certain coastal states than to resources of international interest; for the latter, that are the primary concern of the draft here offered, we retain the overriding interest in "products," noting that possible shifts of interests are taken care of in Subparagraph 3.

(d) Irreversible effects include the extinction of species, tribes, or races of plants or animals, or the reduction of them to levels from which they may not recover their former order of abundance even if exploitation of them were to cease entirely. The term also includes any irreversible consequences of such a reduction to other components of the ecosystem. This criterion can strictly only be expressed in terms of a change in a probability. There are now available (as there were not in 1958) case histories and some biological models relevant to this criterion, adoption of which would ensure that the danger was recognized and due caution exercised.

(e) Whereas the concept of maximum sustainable yield in the 1958 Convention was formulated as a sufficient criterion of conservation, a cohesive set of criteria is now required. The 1958 formulation becomes, as amended, one of the set. Different elements of such a set may be only partially compatible. From the scientific point of view, several interconnected variables cannot, in general, simultaneously be maximized or minimized. Such incongruity is, however, not uncommon in legal documents, and the practice has been followed here, rather than attempting to define precisely the mathematical conditions for singular states.

(f) The set of desirable qualities to be maintained in the resource can be expanded to meet economic and social criteria other than those recognized explicitly in the definition of conservation. Not all of them will necessarily be fully compatible with the three contained in the definition. They concern, inter alia, the relations of input to output of the industry and its continuity and stability; and the nature and quality of the products. Input–output relations can be expressed formally in the language of economic theory, but for the present purposes, especially in an international context, a more general reference to the ways of using some natural resources to secure values from others seems more appropriate. (Subparagraph 1). This consideration might also be taken into account in the application of the provision of Subparagraph 3.

(g) Data concerning quantities, composition, and other characteristics of catches are among the most important information required for resource assessment. Most catches are retained and utilized, but frequently parts of the catches are discarded. Such discards may include unwanted catches of valued species—undersized ones, for example—or other species of lower market value or for which there is no market. It is always desirable and sometimes essential, to have information about them, for monitoring the effect of certain conservation measures, for assessing the overall impact of fishing, for studying how resource waste might be avoided, and because in the future species now discarded may be valued more highly than now.

(h) Notwithstanding the recent development of some independent methods of assessing marine fishery resources, measures of "fishing effort" remain essential for this purpose. In any case, appropriate conservation resources can neither be formulated nor their effects adequately monitored without a rather detailed knowledge of the intensity, efficiency, and deployment of fishing operations. Data needed include the distribution of different kinds of fishing effort in time and space, and information about technical, environmental, and other factors that determine the level of performance of fishing units.

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[illegible]

STOCK CLASSIFICATIONS

[illegible]

CATCHES

[illegible]

ABORIGINAL SUBSISTENCE CATCHES

[illegible]

INFRACTIONS

[illegible]

SCIENTIFIC RESEARCH

[illegible]

[illegible]

wondered why an increase in catch from the numbers taken from 1848 to 1993 was needed. Argentina had a similar reservation.

The proposal, as an amendment to paragraph 13(b)(1) of the Schedule shown in Appendix 21, was nevertheless adopted unanimously. Australia asked that the strike carryover element should be reviewed next year when it was clarified that there was no limit to the number that could be carried forward from any season.

10.3.3 North Pacific eastern stock of gray whales

The Russian Federation referred to its document setting out the basis of the claim for a reduced catch limit of 140 gray whales per year. Discussion of this request demonstrated broad support within the Technical Committee for such a quota but it was noted that some discussions may still occur on replacement of whale meat from other food sources.

In the Plenary, the Russian Federation asked for support for its proposal, which was given by the USA and Spain. Australia spoke of its close and critical examination of issues of need and stock levels arising from its dedication to concern for traditional cultures and peoples, and in this context also agreed to this particular quota. France, Denmark, Sweden and Germany also voiced their support, and the Commission agreed to amend Schedule paragraph 13(b)(ii)(1) and Table 1 to set the catch limit for this stock for each of the three years 1995, 1996 and 1997 at 140 whales, as shown in Appendix 21.

10.3.4 Greenland stocks of fin and minke whales

Denmark spoke of the need recognised by the IWC for 670 tonnes of whale meat which has been supported by much documentation in recent years. It proposed that for the years 1995, 1996 and 1997 the East Greenland minke whale catch should remain at 12 animals a year; the West Greenland catch of fin whales should be maintained at 21 animals a year; but that the West Greenland minke whale quota should be increased to 165 whales struck a year with a total of 450 in the three year period.

This proposal received a measure of support within the Technical Committee, but a number of delegations wished to see the proposal in writing before they could commit themselves to the increase in the West Greenland minke whale catch proposed.

In the Plenary, Denmark introduced a revised proposal to take account of the comments it had received. This reduced the West Greenland fin whale figure to 19, and increased the West Greenland minke whale three year total to 465 with a limit of 165 a year. The East Greenland minke whale quota remains unchanged at 12 for the new three year period.

Support for this amended proposal was given by Spain, Sweden, Finland, St Vincent and The Grenadines, France, Brazil, Germany, Republic of Korea and the USA, and it was then agreed by consensus. The resulting amendments to the Schedule Table 1, the footnotes and paragraph 13(b)(iii) are given in Appendix 21.

11. COMPREHENSIVE ASSESSMENT OF WHALE STOCKS

11.1 Report of the Scientific Committee

The Chairman of the Scientific Committee presented the relevant parts of the report of his Committee to the Technical Committee, as summarised below.

11.1.1 Revised Management Procedure

The Scientific Committee noted the report of an independent panel appointed by the USA to review the RMP, considered the issues arising where appropriate and concluded they had been adequately addressed.

The Scientific Committee considered a number of matters directly related to the calculation of catch limits, including the documentation of RMP-related computer programs, questions of process error and the progress on standard analysis programs for estimating absolute abundance.

In considering further trials of the *CLA*, the Scientific Committee agreed that the *CLA* was robust to a wide range of uncertainty, including the question of multi-species effects and performance in the presence of environmental degradation.

There was discussion of the presentation of the trial results, the effects of under-reporting of historical catches and documentary performance in combination trials.

Matters not directly related to the calculation of catch limits included monitoring and data requirements, and consideration of six principles concerning the role of science in resource management. The Scientific Committee agreed that these principles had all been taken into account in developing the RMP, with great weight being given to taking account of uncertainty.

The Scientific Committee reiterated its recommendation of last year that the Commission adopt the specifications of the RMP and endorse the annotations, including the minor amendments proposed this year and adopt the guidelines for conducting surveys and analysing data within the RMS. In addition, it recommended adoption of the guidelines for data collection and analysis under the RMS other than those required as direct input for the *CLA*.

Methodology – Estimation of g(0)

The Scientific Committee reviewed in detail the sources of differences in the estimation of $g(0)$ – the probability of sighting a whale on the trackline – in northeastern Atlantic minke whale sighting surveys. A new estimate of 0.587 (CV 0.063) based on a sub-set of the data had been presented; this compared with 0.36 (CV 0.079) used previously by the Committee. It identified five potential factors which contribute to the differences. The underlying causes raise a number of important issues which will be fully addressed at next year's meeting.

In the Technical Committee, the Netherlands asked whether this problem would have an effect on the existing estimates of North Atlantic and Southern Hemisphere minke whales. In response the Chairman of the Scientific Committee clarified that in the case of North Atlantic minke whales this may indeed have consequences for the estimate. If $g(0)$ is re-estimated for Southern Hemisphere and North Pacific minke whales, where at present it is assumed that $g(0)=1$, then, the estimated $g(0)$ shall be <1. Upon a question from Norway the Chairman of the Scientific Committee pointed out that no new estimates of abundance had been suggested in the Scientific Committee for the northeastern Atlantic minke whale stock. The USA emphasised the importance of the $g(0)$ issue.

The Scientific Committee also commented on its recognition of the problems of investigating avoidance or attraction behaviour which could bias shipboard line transect estimates for North Atlantic minke whales.

In the Plenary, there was extensive questioning of the Chairman of the Scientific Committee by the Commissioners on the details of the $g(0)$ issue and its implications for the assessment of the northeast Atlantic minke whale stock. Ireland sought clarification of the Report of the Scientific Committee, while the Netherlands refuted the claim by Norway that the estimate made at the Glasgow meeting in 1992 is still valid, believing that the questions over $g(0)$ mean that there is no generally accepted abundance estimate. The UK associated itself with these remarks. Germany noted that a special working group will address the problem and received confirmation that until the Scientific Committee has resolved the issue, the exact status of the stock is not known. Spain also noted the uncertainty involved. Ireland received confirmation that if the alternative value of $g(0)$ is correct, the estimate of numbers would be dramatically reduced.

Norway expressed surprise at these questions, pointing to the statements that the Scientific Committee had no business to discuss on this stock and no new estimate of abundance had been suggested. The Chairman of the Scientific Committee reiterated that there is an estimate of $g(0)$ from two years ago, and a new analysis and estimate this year. It was not possible to resolve the cause of the difference this year and it was not deemed appropriate to take the next step to make a new estimate of abundance while there is uncertainty over the value of $g(0)$ to use. The Netherlands repeated its intervention, concluding that the most important issue was the consequential effect on the abundance estimate, which could result in very different catch limits if the RMP is applied, possibly even zero if the revised estimate of $g(0)$ is nearer the new value calculated. Norway maintained that the original abundance estimate has not been challenged in the Scientific Committee and still stands until a different result is produced, but Ireland understood that additional data and analysis now indicates uncertainty about $g(0)$.

11.1.2 Southern Hemisphere baleen whales

The Scientific Committee has as its priority species the humpback whale. It reviewed genetic information on stock identity, possible sex-segregated migration and estimates of abundance. The best estimates from the IDCR cruise data south of 60°S were 4,500 (CV 0.23) for the 1978/79–1983/84 surveys and 5,600 (CV 0.28) for the 1985/86–1990/91 surveys. These estimates pertain to only part of the range of humpback whales at the time of the surveys. The Scientific Committee was not in a position to attempt to carry out assessments at this meeting.

The Scientific Committee reviewed the implications of the catch history revisions of past USSR whaling records now available. It noted that it only uses estimates of current abundance based on direct methods such as sightings surveys or other methods that do not depend on catch data, so revisions to past records have no effect on its estimates of current abundance.

The level of depletion of stocks will be underestimated if catches are under-reported and the reverse for over-reporting, which both occur in the USSR records. Under-reported catches may be sufficient to explain an apparent failure of a stock/species to recover when protected.

The RMP uses estimates of recent abundance together with a time series of recorded or estimated historic catches to determine the appropriate catch limits. It is robust to underestimations of total historic catches by up to 50% and implementation is only being considered for minke whales where the level of misreporting is small and certainly less than 50%.

Estimates of abundance for other species than minke and humpback whales based on the first thirteen IDCR cruises (1978/79–1990/91) south of 60°S represented only partial stock estimates, except for blue whales. This was reported to the Plenary under Item 16.

11.1.3 North Pacific minke whales

The Scientific Committee considered the preparations for implementation of the RMS for North Pacific minke whales.

11.1.4 North Atlantic minke whales

The Scientific Committee had no business to discuss under this item.

11.1.5 Southern Hemisphere minke whales

Sighting data and genetic information were considered by the Scientific Committee.

11.1.6 North Pacific Bryde's whales

The Scientific Committee agreed that it should begin the Comprehensive Assessment process for North Pacific Bryde's whales at its next meeting.

11.1.7 Other stocks

Time did not permit review by the Scientific Committee of abundance estimates for eastern North Atlantic fin whales, eastern tropical Pacific humpback whales and North Pacific minke whales.

11.1.8 Future work plans

The Scientific Committee identified six specific topics that should be considered for discussion at the 47th Annual Meeting.

11.2 Review of Schedule paragraph 10(e) and other related paragraphs

This item was referred directly to the Plenary.

In the Plenary, the UK observed that one Contracting Government has resumed commercial whaling, taking 157 minke whales in the northeast Atlantic. It deplored Norway's action which in its view weakens the credibility and reputation of the IWC and urged it to reconsider its decision to exercise its objection to the IWC's moratorium on commercial whaling. This statement was supported by the Netherlands, New Zealand, Ireland, Germany, France, Brazil, Australia, Argentina and Spain.

11.3 Proposed new system of supervision and control

Norway suggested the establishment of an *ad hoc* Working Group to consider questions of supervision and control of whaling operations as proposed in the paper it had submitted. The USA and Japan expressed their support and the USA expected that NGOs could attend this Working Group. The Working Group was therefore established to report directly to Plenary on this Item.

The Plenary subsequently received the report of the Working Group on Supervision and Control, chaired by Mr E. Lemche (Denmark). The Technical Committee had decided that observers would be admitted to the Working Group, but it was unclear whether this meant that the normal rules for observers' participation would apply, or if all observers would automatically participate. This question was referred to the Commission.

The Working Group took as a starting point that their discussions should be governed by the 1992 Resolution on the Revised Management Scheme, which noted that the additional steps required to complete the RMS included agreement upon a fully effective inspection and observation programme. Norway had presented a proposal on an inspection and observation programme, but a number of delegations felt that this, while a useful starting point, was not nearly comprehensive enough.

Some delegations preferred terms of reference worked out and an agenda agreed upon at the outset, and had produced a list to this end. The Chairman stated that terms of reference would have to be given by a higher body, i.e. the Technical Committee and in the absence of an agenda he produced a list of talking points which was accepted by the Working Group as a starting point for its work.

The Working Group agreed that the work on the inspection and observation programme is based on the assumption that IWC rules will be as amended by the adoption of the RMP/RMS and noted that any future changes to the RMS may require further changes to the inspection and observation programme.

Despite the difficulties of embarking on these discussions, the following points were addressed.

Aim of programme of Inspection and Observation

There was agreement that the objective of the Working Group should be to develop a fully effective inspection and observation programme which would ensure that whaling operations under jurisdiction of Member Governments comply with IWC rules (Convention and Schedule).

Furthermore, there was agreement that the Working Group should focus its work to an inspection and observation programme for commercial whaling in accordance with the Commission's priority of work on Management Procedures for commercial and aboriginal subsistence whaling.

The UK referred to the 1992 Resolution which states that among the additional steps required to complete the Revised Management Scheme are '... arrangements to ensure that total catch limits over time are within the limits set under the Revised Management Scheme ...'. In view of this there would need to be a linkage between enforcement under inspection and observation of commercial whaling and scientific whaling programmes.

Discussion took place over the possible application of an agreed scheme for observation and inspection to scientific research under a special permit. There was consensus that such research was a sovereign right of Contracting Governments, guaranteed by Article VIII of the Convention. Such research by member countries would have to comply with IWC rules.

Focus of work

Some delegations held the view that this Working Group should concentrate on the international rules, i.e IWC rules, noting that member governments may have to transform IWC-rules into national law. The rules to be complied with should be the international rules.

Some delegations underlined that the international inspection and observation programme of the IWC will be the regulations as adopted in the Schedule. In addition national regulations for implementing the IWC rules, should be examined to ensure their effectiveness.

There was agreement that the Working Group should aim at a system that will be generally applicable, but would concentrate on such whaling operations which might be permitted by the IWC in the foreseeable future.

Some delegations stated that international observers may not have enforcement jurisdiction. Other delegations held the view that certain enforcement powers might be given to international observers by agreement with the flag or coastal state.

Inspection and observation programmes in other international agreements

Delegates and observers present provided information on a number of observer programmes operating under other treaties. These included the Observer Programme in the South Pacific, Inter-American Tropical Tuna Commission and European Community Inspectors in fisheries conducted by member states.

It was proposed that other IWC member countries may bring forward information on other programmes of this nature. The Working Group agreed to propose that the Commission through the Secretariat ask member countries to provide such information.

Role of inspectors and observers, etc.

NATIONAL INSPECTORS

Norway presented the roles and duties of national inspectors as proposed in its paper. Some delegations held the view that more enforcement powers ought to be given to the national inspector.

There was agreement that it is the duty of member governments to impose penalties for infractions. National inspectors should be given enforcement powers. If prosecution or legal actions would be required, that would be the responsibility of national judicial or administrative systems.

There was disagreement over whether the possibility of IWC sanctions should be considered or multilateral agreements in respect of sanctions along IATTC lines.

INTERNATIONAL OBSERVERS

Norway presented the roles and duties of international observers as proposed in its paper. Observers shall observe the whaling activity to ensure transparency, be it on board or on shore, and report to the IWC.

The Working Group concluded that observers should report on the whaling activity, including possible infractions and give copies of the reports to the captain of the vessel, the national inspector and the IWC. The Working Group also reached agreement on a number of points such as that the report should be sent to national authorities whose whaling operations were being observed, as the observers will also report on the efficiency of the national system on inspection and control.

There was agreement in the Working Group that the observers duties represented at least the above mentioned points. Some delegations stated that the list of duties for the observers would have to be more extensive.

There were divergent views in the Working Group as to the necessity and advantage of providing real time reporting.

Some delegations held the view that if vessels could not accommodate both national inspectors and international observers, the national inspector should yield to the international observer. Other delegations could not accept that enforcement of jurisdiction be transferred to international observers.

A discussion also took place on the possible role of international inspectors.

It was noted that the IWC can only set catch limits for a species in an area and this may represent a problem to be addressed when more than one member state is involved in catching in that area.

Further items

Because of time limitation, inspector and observer coverage, the administration aspects and Schedule provisions relating to penalties were not discussed, although consideration of them is essential in drawing up a new observation and control system.

The Working Group also compiled a list of additional points. It was agreed that all these points should be discussed, but not necessarily have implications for the inspection and observation programme.

Proposed terms of reference for Working Group on Supervision and Control

The Working Group agreed to recommend the following terms of reference for future work:

The Working Group shall provide advice to the Commission on a comprehensive inspection and observation programme for adoption as a component of the Revised Management Scheme for commercial whaling. The purpose of the programme is to ensure that whaling operations under the jurisdiction of Contracting Governments comply with IWC regulations and national rules implementing such regulations.

In providing that advice, the Working Group will take into account, as necessary, relevant international and national observer systems, and the potential usefulness of elements of those systems to the inspection and observation programme.

The Working Group shall provide draft text for Schedule amendments and may, within a general framework, propose different rules for different forms of whaling to which the programme would apply.

Possible timetable

The Working Group agreed that it should continue its work and expected such work to be a time consuming 3–4 days.

The Working Group agreed that it should meet in the week(s) preceding the 47th Annual Meeting, either coinciding with the Scientific Committee, or the Working Groups and sub-committees immediately before the 47th Annual Meeting. Some delegations noted the importance of NGO participation in meetings on this topic.

Some delegations proposed an intersessional meeting of the Working Group well in advance of the 47th Annual Meeting. Norway offered to host such a meeting. Other delegations foresaw difficulties as to participation in such an intersessional meeting.

11.4 Adoption of the Revised Management Procedure

11.5 Proposed data standards

11.6 Proposed survey guidelines

Norway suggested that these items should be referred directly to the Plenary, since the text of the Norwegian proposals on these agenda items was taken directly from the Scientific Committee report. This was agreed. In the Plenary, Norway proposed to reintroduce its proposals next year, given that some items are also covered in a Resolution on the RMS.

11.7 Action arising

The Technical Committee and the Commission endorsed the internal recommendations of the Scientific Committee concerning future studies, research activities and analyses. Concerning the RMP, the Technical Committee took note of the specific recommendations and passed them on to the Plenary for action.

11.7.1 Revised Management Scheme

Australia introduced a Resolution co-sponsored by Finland, Germany, Netherlands, South Africa, Spain and the USA on the Revised Management Scheme. Sweden also wished to co-sponsor what it regarded as an important step forward. Similarly Switzerland wished to be listed as a co-sponsor, noting the view that the RMP is the most rigorously tested management procedure for a resource yet designed and which it believed should be adopted and not just accepted together with finalising the RMS.

The USA recalled that the Scientific Committee had again unanimously recommended that the Commission adopt the specification of the RMP and endorse the annotations. It also recommended adopting the guidelines for conducting surveys and analysing data, provided advice on minimum standards for data and recommended guidelines for data collection. The USA believed it premature to adopt the RMP into the Schedule until the entire RMS can be adopted as a package. It is committed to science-based solutions to international environmental problems. There are still difficult issues to resolve which this Resolution does not address, including unauthorised whaling, illicit trade in whale products, under-reporting of catch data, the effects of environmental degradation and humane killing concerns. The Resolution does not give approval to any activity contrary to the moratorium or the sanctuaries established and the USA does not support a resumption of commercial whaling.

The Netherlands shared these views and accepted the Scientific Committee's advice on the RMP.

France associated itself in the appreciation of the work of the Scientific Committee in achieving the RMP and identified features in the text of the Resolution which led to its support, including the exclusion of any possibility of lifting the moratorium in the light of present knowledge. The UK generally associated itself with the remarks of the USA and France, but was not listed as a sponsor of the Resolution because there is no reference to humane killing which it regards as an issue of great importance and of relevance to some aspects of the RMS.

Ireland identified a series of concerns which it considered must be satisfied, including the question of *Catch-cascading*, small populations, the need for reliable data on catches, the $g(0)$ issue and problems with the *Catch Limit Algorithm*. Mexico considered the *CLA* unclear, and India shared the concerns of Ireland and Mexico.

Denmark saw no problem in taking a step forward by adopting the RMP, neither did St Vincent and The Grenadines, Chile regarded this as a matter of priority and New Zealand accepted the consensus of the complete package.

The Resolution (Appendix 5) was then adopted, Norway noting its existing objection to Schedule paragraph 10(e).

New Zealand introduced a Resolution (Appendix 6) on behalf of Australia, Netherlands, UK and the USA concerning the unreliability of past whaling data, which was also adopted by consensus.

A Resolution on international trade in whale meat and products sponsored by Argentina, Australia, Brazil, India, Monaco, New Zealand and the USA was then considered.

Japan reminded the meeting of its reservations in CITES and commented on operative paragraph 4. The USA noted the discussion in the Infractions sub-committee on whale meat from Taiwan, recalled the 1978 Resolutions on this subject and non-member whaling, and considered that the IWC must take an active role on the question. New

There is some preliminary evidence for fin whales that whales in different regions of the North Atlantic have different vocal patterns. For example, fin whales recorded off Bermuda or the West Indies sound different to those recorded in the Norwegian Sea. These differences might eventually be of value for discriminating between different populations. Differences have also been observed between fin whale vocalisations from the North Pacific and North Atlantic Oceans.

Minke whales are primarily detected in the southern part of the western North Atlantic during the autumn, winter and spring. There are some preliminary detections of minke whales off the British Isles, but they are rarely, if ever, detected in the Norwegian Sea region. Fig. 5 illustrates the seasonal trend in the flow of whales through the western North Atlantic. Whales appear to move through the West Indies region from the northeast to the west during the autumn to mid-winter period and then westward and northward during the mid-winter through spring period. Fig. 6 shows monthly levels of detection from one of the array sights (array 2) depicted in Fig. 5.

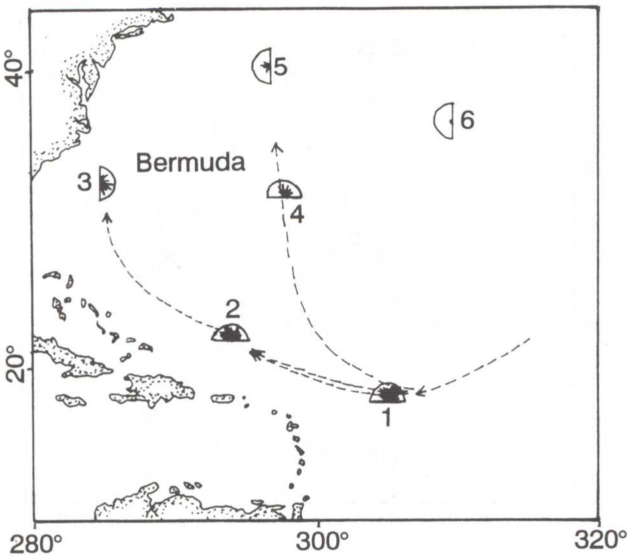

Fig. 5. Flow of whales through West Indies region.

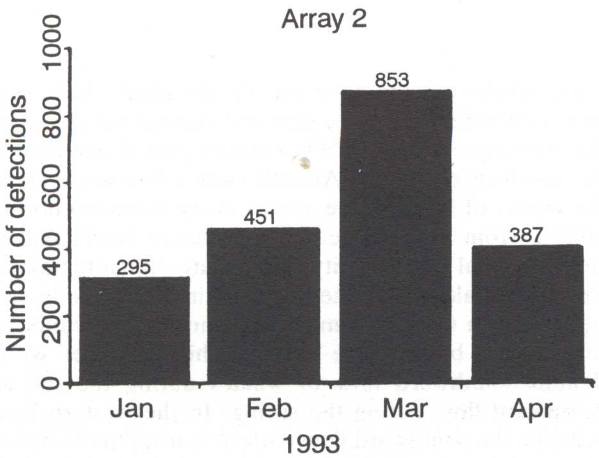

Fig. 6. Monthly detections from Array 2 (see Fig. 5).

Humpback whales, like minke whales, are vocally active seasonally and regionally. This is especially true in the western North Atlantic. This was not well documented in the eastern North Atlantic, primarily because of the limited effort on the part of the *Whales '93* team in that part of the ocean. However, there were definite detections of singing humpback whales off the British Isles. During the winter months in the North Pacific, they have been recorded singing in the Gulf of Alaska and off the Northwest US coast, well north of the wintering grounds where singing is traditionally reported. Also, throughout the entire West Indies region, singing whales were consistently detected during the winter in deep water, 50–100 miles offshore of the islands.

It was not possible to follow the humpback migration southward through the western North Atlantic as originally planned. This was surprising given the relatively small area involved (in geographical terms) and the relatively good acoustic array coverage. The primary reason for this inability to systematically follow the humpback migration is most probably due to the fact that the song is not very loud (*ca* 165 dB re 1 microPascal 1m) and is composed of mostly high-frequency notes (>100Hz). Consequently, humpback whale song is usually only detectable out to ranges of <50 miles, although there was one occasion when a singer was detected at almost 100 miles range.

There is much more variability in the vocal repertoires for all three balaenopterids than has been previously reported. None of the existing literature adequately describes the variability (individual, geographic, species) observed. It is evident that all these species are acoustically prolific in the deep ocean, and that sound production and perception are critical for their survival.

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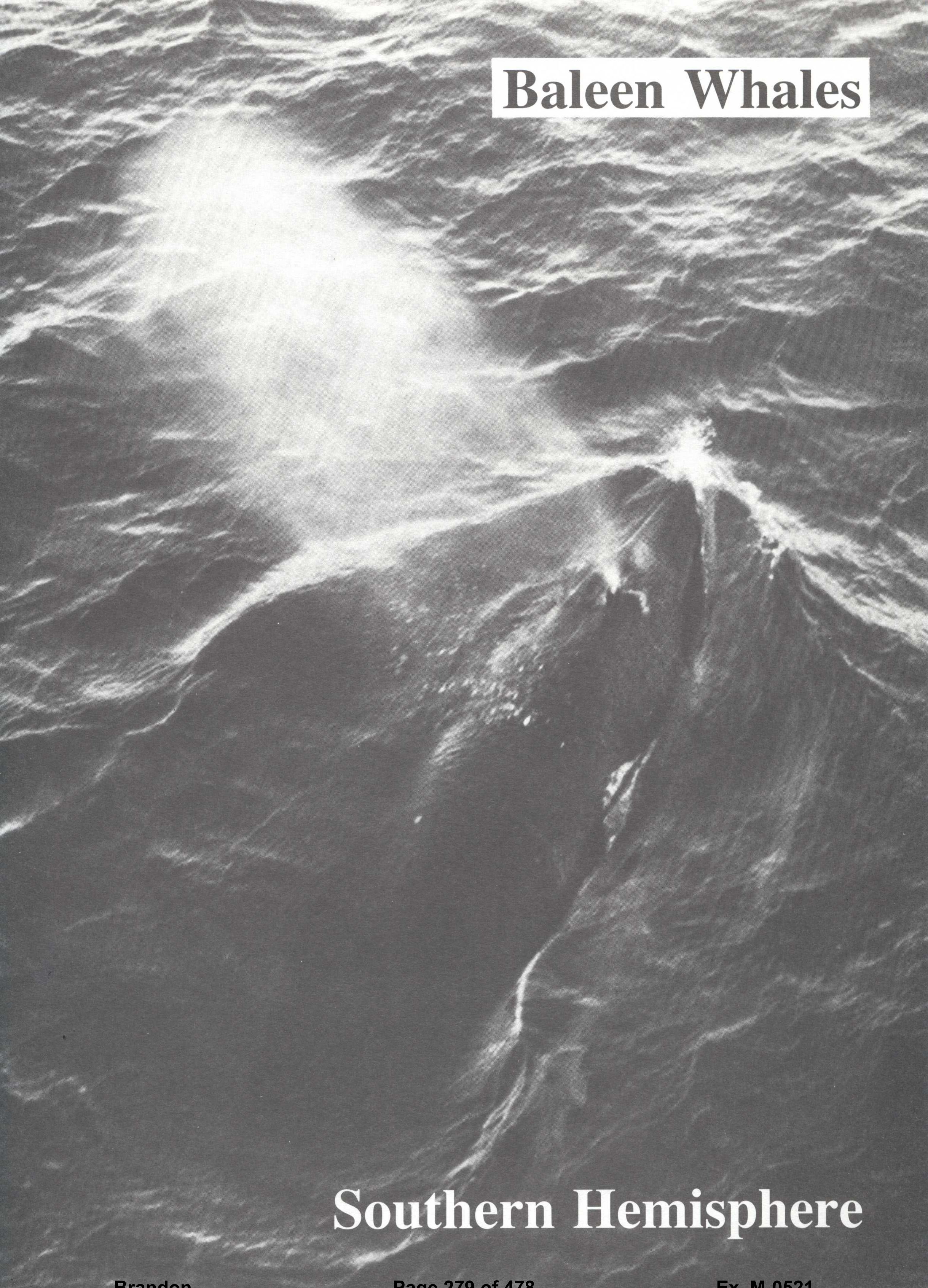


Baleen Whales

Southern Hemisphere

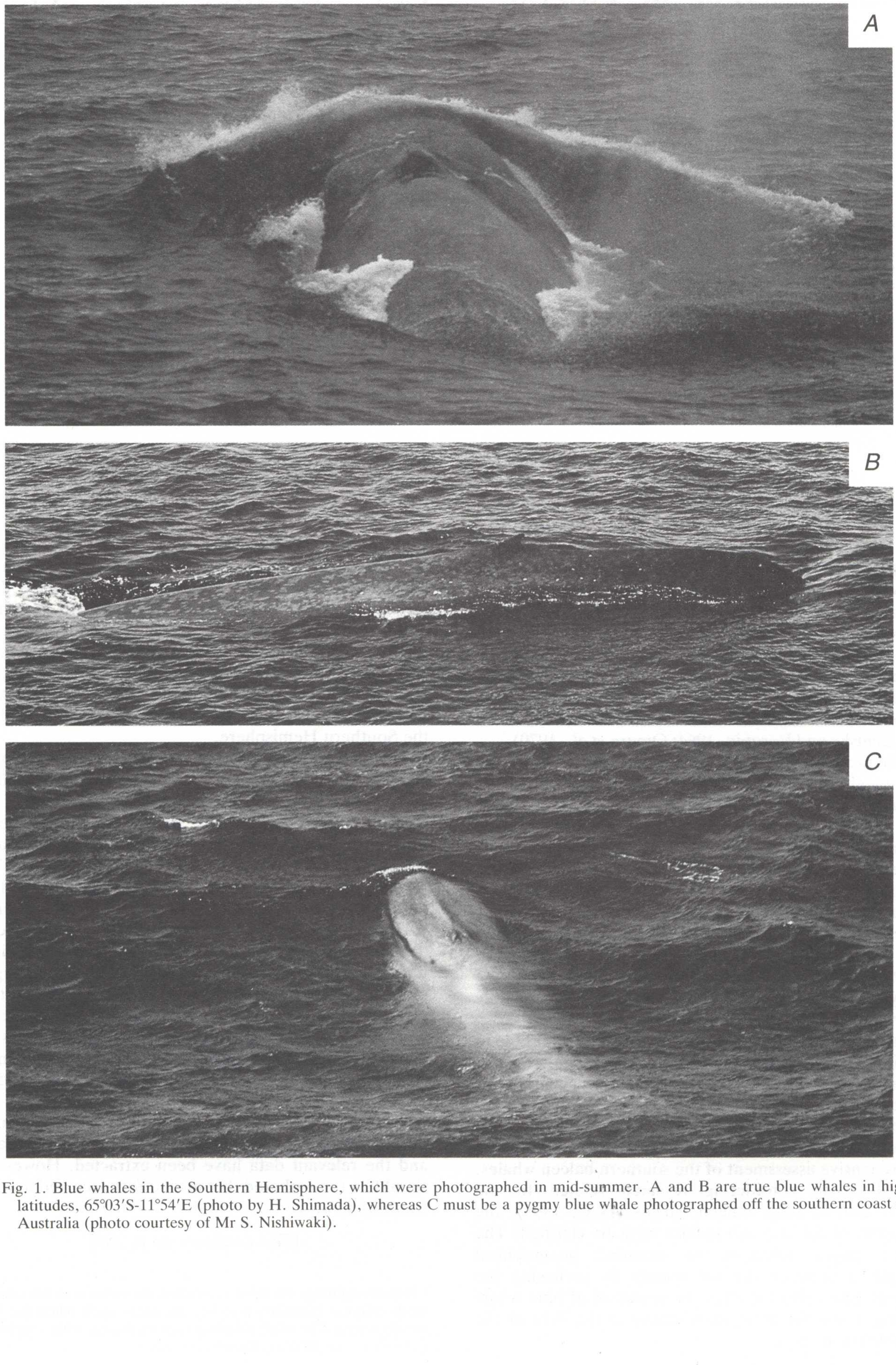
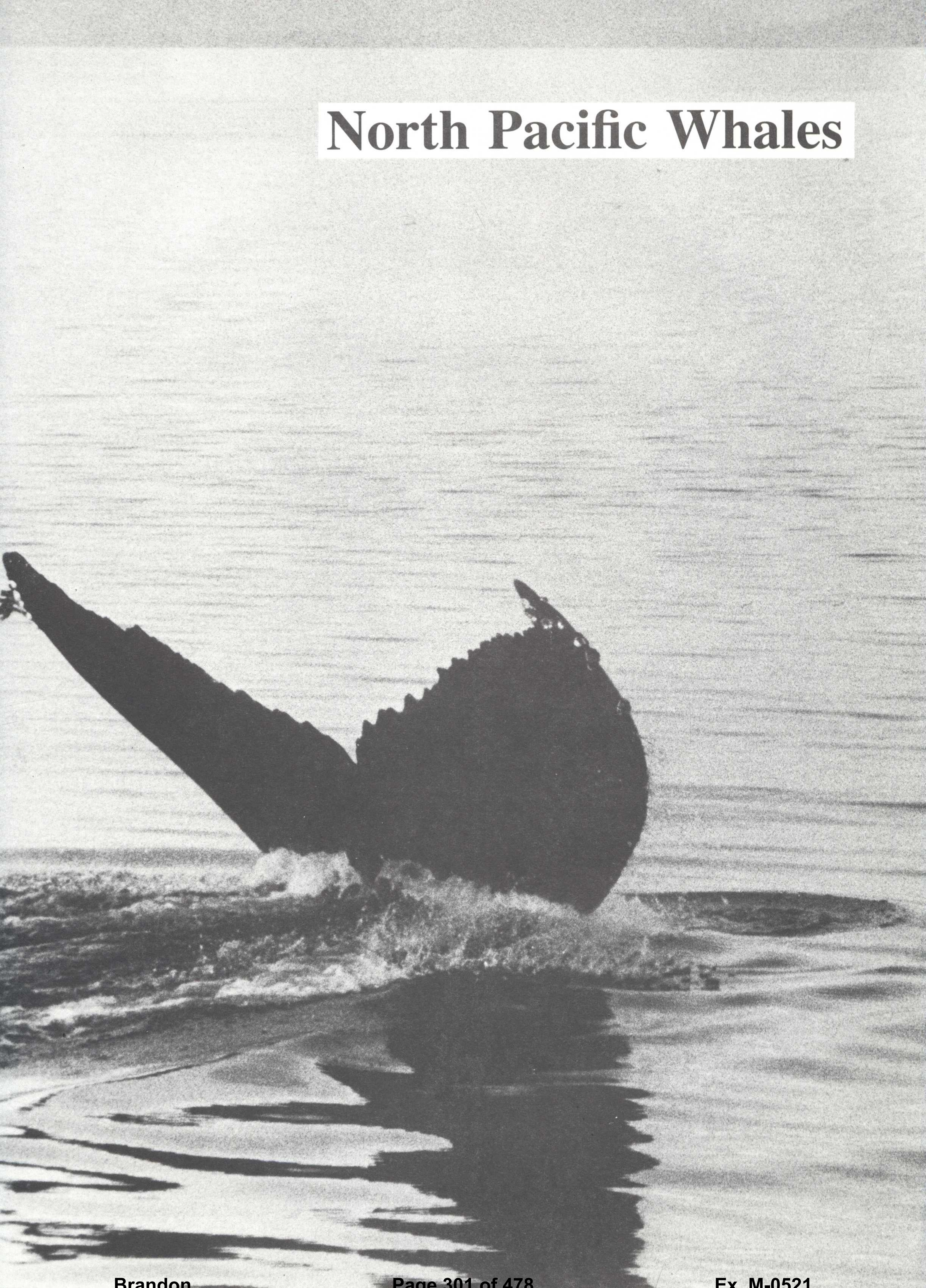


Fig. 1. Blue whales in the Southern Hemisphere, which were photographed in mid-summer. A and B are true blue whales in high latitudes, 65°03′S-11°54′E (photo by H. Shimada), whereas C must be a pygmy blue whale photographed off the southern coast of Australia (photo courtesy of Mr S. Nishiwaki).

North Atlantic Whales

North Pacific Whales



Aboriginal Subsistence Whaling

no additional information about $MSYL_{(mat)}$. Investigations of de la Mare (1990) have previously demonstrated very flat marginal likelihoods for MSYL given diverse modeling assumptions. Our analysis is also unable to provide a precise estimate of a.

The pre– and post-model distributions of P_{1993} also do not differ. This means that the combined information does not refine our knowledge of P_{1993}. However, P_{1993} itself is quite informative about other parameters; see Section 6.

Fig. 14 shows the ratio of the post-model variance to the pre-model variance for model inputs and outputs. This shows about which quantities the model is most informative. A value close to 1 means that the model does not provide much additional information, while a value much smaller than 1 indicates the model is substantially reducing uncertainty. Fig. 14 shows that the model is most informative about s, P_0, $MSYR_{(mat)}$, % calves, ROI and MCM, as is also evident from Figs 10–13.

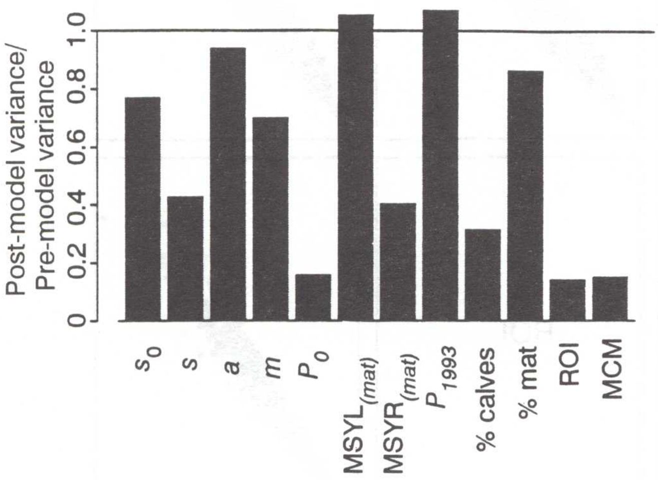


Fig. 14. Ratio of post- to pre-model distribution variance for model inputs and outputs.

Figs 10–13 allow us to perform an informal sensitivity analysis to the pre-model specifications; see Section 6 and Givens *et al.* (1994) for a more thorough discussion. These figures suggest no incompatibilities between the pre-model and post-model distributions; hence the BALEEN II PDM is capable of accommodating all the available evidence without conflict. Further, changing the pre-model distribution of any input or output so as to assign less weight to values with weight in the pre-model distribution but virtually no weight in the post-model distribution would have little effect on the results. For example, changing the pre-model distribution so as to exclude values of P_0 between 25,000 and 35,000 would have virtually no effect on the results given above and the conclusions drawn from them concerning quantities of interest.

Fig. 15 shows the post-model pointwise median trajectory for the total population size with a pointwise 95% confidence band. The limits of this band at each time point indicate a 95% post-model probability interval for the population size at that time point. The 15 most likely trajectories are shown in Fig. 16. Notice that these trajectories are qualitatively similar and they all agree with existing beliefs and with the pre-model evidence.

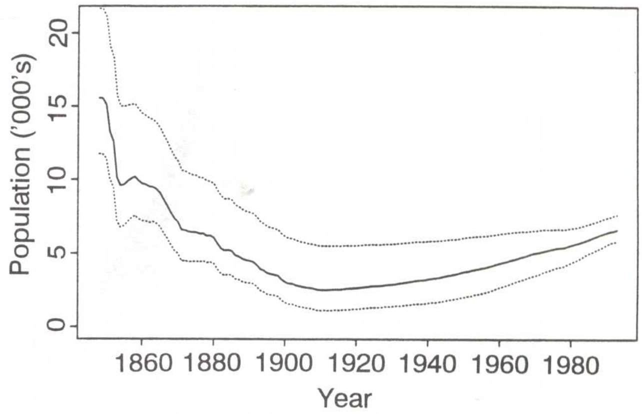


Fig. 15. Post-model pointwise median trajectory and 95% confidence band.

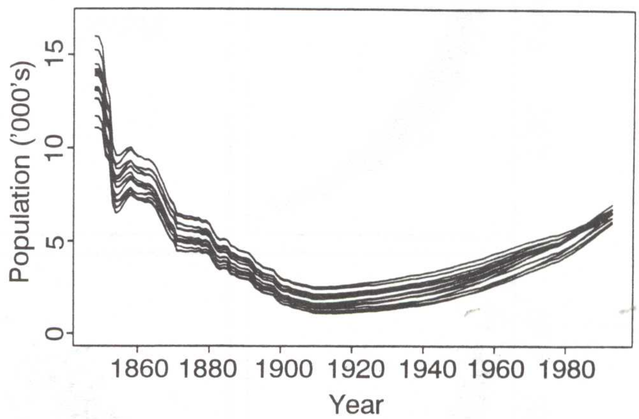


Fig. 16. The fifteen most likely total population trajectories drawn from the post-model distribution. These 15 trajectories (1.7% of the unique ones in the final sample) account for 13.3% of the probability.

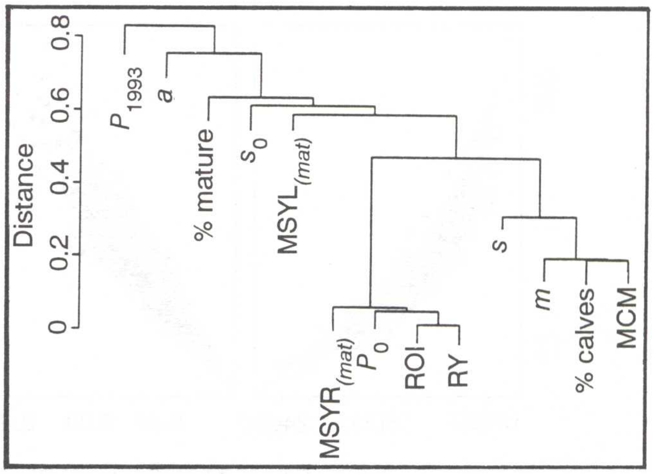
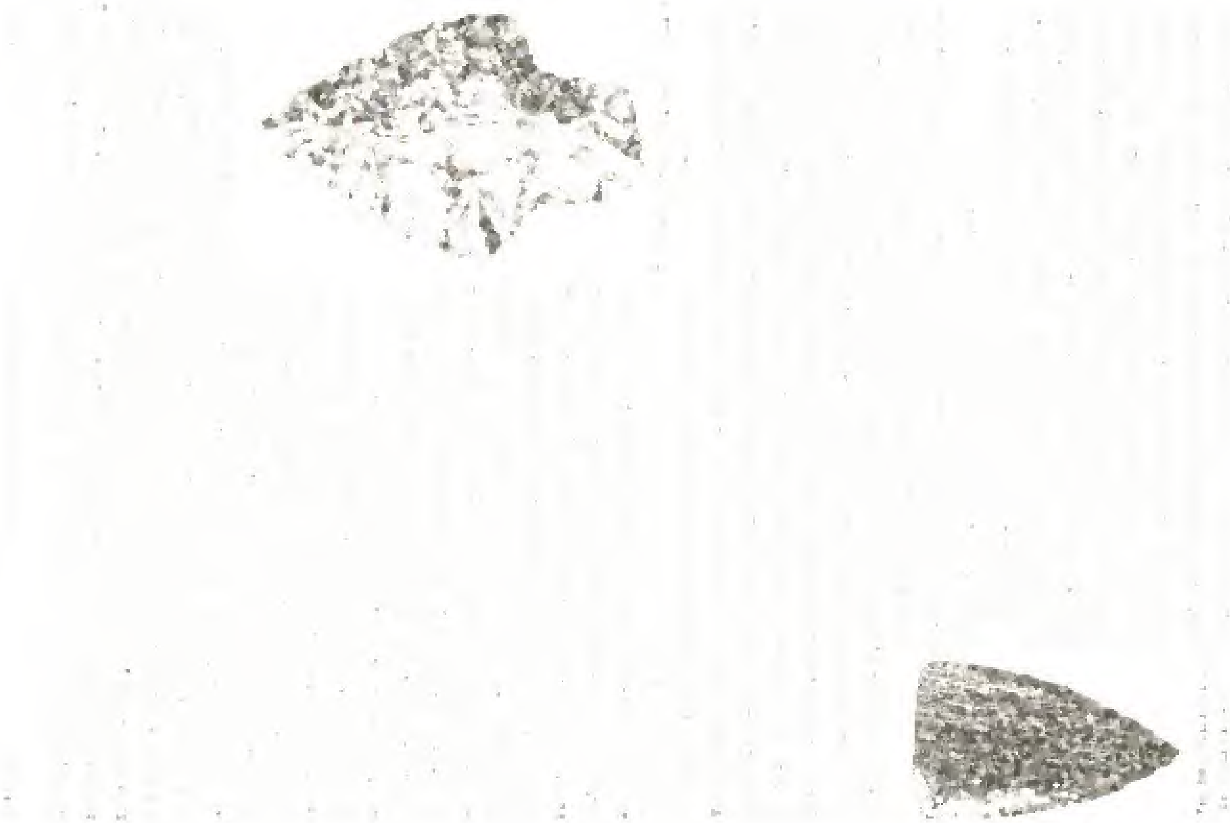
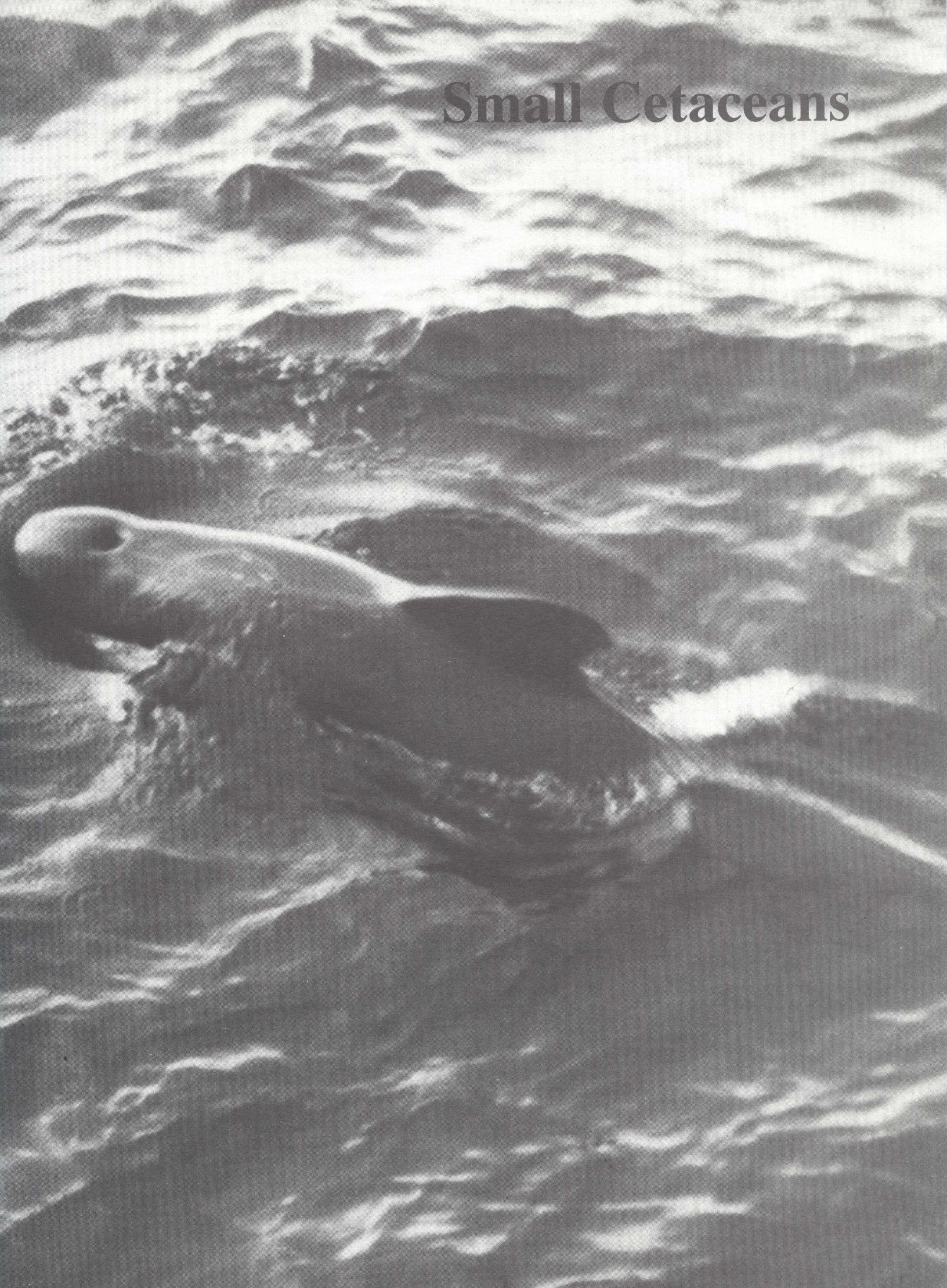


Fig. 17. Connected hierarchical clustering of variables, where distance between clusters is one minus the maximum absolute post-model correlation between members of each cluster.

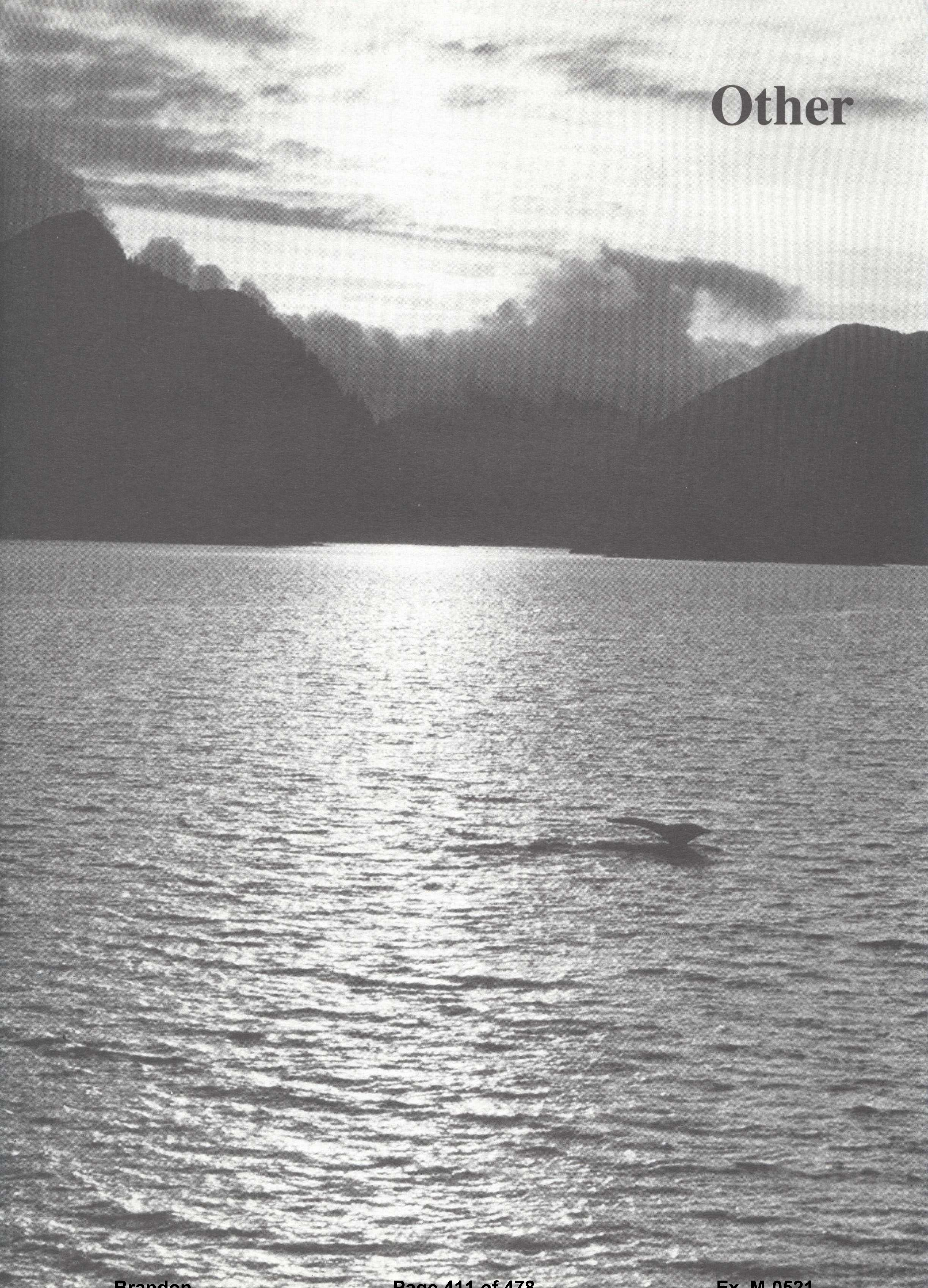
Fig. 17 shows the results of a cluster analysis on the quantities of interest using the connected hierarchical clustering method (Everitt, 1980), where the distance measure is chosen to be one minus the absolute post-model



Small Cetaceans



Other



(unpublished) worked on a simple stereophotographic system that did not rely on precisely controlled camera alignment, but on measuring alignment each time the cameras were mounted by taking photographs of very distant objects. However, despite initial promise, further investigations revealed substantial measurement errors and the system was not developed further (Lovell, pers. comm.). Here we present details of a stereophotographic method for measuring sperm whales. This method is broadly similar to that of Lovell *et al.*, but camera alignment is controlled. The system is economical to implement and is usable from small boats.

METHODS

Design

The general design of our system broadly resembled that used by Major and Dill (1978) to quantify the 3-dimensional structure of bird flocks. Two standard 35mm cameras (*Pentax* MX) were mounted on an aluminium bar of rectangular section (50 x 40mm; wall thickness 2.5mm) so that the centres of their lenses were 2.401m apart. The limit on bar length (2.65m) was imposed by the space available on the aft deck of our 6.5m research vessel. The cameras butt against plates to the front and side. Screw-in plates on the rear locate the camera bodies firmly against these butt plates (Fig. 1). This system facilitated consistent alignment and invariant base length.

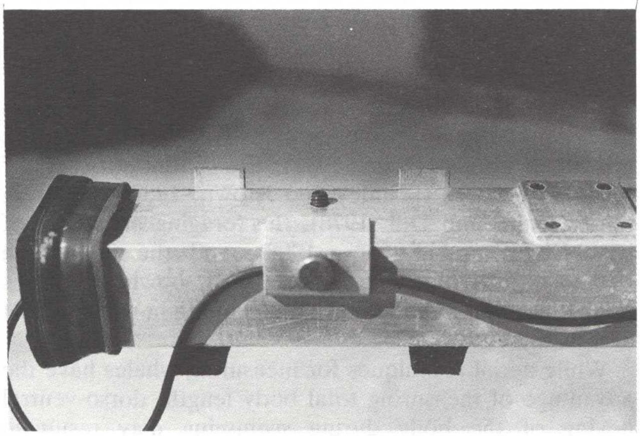


Fig. 1a. Photograph showing mounting system with butt plates controlling camers position and alignment.

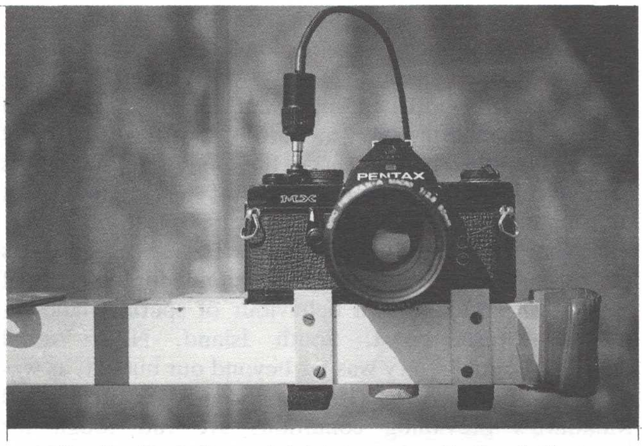


Fig. 1b. View of one of the cameras mounted on the bar.

The bar was held at eye-height atop a short, adjustable mast on the aft deck (Fig. 2). The mast was supported by three, easily detachable, wire stays. A rubber universal joint from a windsurfer connects the bar and mast allowing the bar to turn and tilt independently of the boat. Lines with hooks secured the bar amidships when the boat moved at speed. The vessel used was a 6.5m '*Neptune* Offshore' centre console rigged-hulled inflatable boat, powered by a 90hp *Yamaha* outboard.

Fig. 2. The stereophotogrammetric system in use.

As we had access to *Pentax* 50mm f2.8 macro and *Pentax* 50mm f4.0 macro lenses we used them, but there is no reason why macro lenses should be preferred. Lens focussing rings were taped on the infinity focus setting during calibrations and measurements of whales. To standardise the effect of distortions inherent in each lens and camera body, each lens was always used with the same camera body and each camera body permanently assigned to one end of the bar. To minimise unsharpness caused by movement of the whale and the boat, camera shutters were set at 1/1000s. Camera shutters were triggered simultaneously using paired air-releases with a common bulb. Film was advanced manually, although motor drives may be added in the future. *Kodak* TMAX 100 and TMAX 400 films were used.

Calibration

Ideally, pairs of stereo images contain points of known distance apart, so that each pair is essentially self-calibrating. This is known as 'affine scaling', one of the 'control' methods used in photogrammetry (see Rüther, 1983). While this can be easily achieved in typical survey applications and even in some biological ones (e.g. Rüther, 1983), it would be difficult to achieve in our application. Providing that camera alignment remains undamaged and synchrony of exposure maintained, such control is not absolutely necessary if the system is initially calibrated and carefully set up for each use. Our calibrations consisted of determining the focal lengths of the lenses (at infinity focus) and determining the measurement errors with range, angle and mounting/remounting of the cameras to the bar.

Calculation of focal length of the lenses

For accurate stereophotogrammetry in the absence of control, the focal lengths of the lenses must be known precisely. Using an optical bench we measured the position of the external nodal point of each lens. In a nearby sports

Résumé Section

This section includes Résumés of those papers presented to the Scientific Committee but not published in this volume. They are provided for information only and do not constitute publication; and as such should not be cited in papers without consultation with authors. Copies of the full papers are available at cost price from the IWC Secretariat.

Annex E

Report of the Standing Working Group (SWG) on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP)

Members: Donovan (Chair), Allison, Brandão, Bravington, Breiwick, Butterworth, Clarke, C., Cooke, George, Dereksdottir, Givens, Johnston, Kell, Kingsley, Magnusson, Mate, Matsuda, O'Hara, Okamura, Oosthuisen, Punt, Rademeyer, Skaug, Suydam, Tanaka, Wade, Witting, Zeh.

1. INTRODUCTORY ITEMS

1.1 Convenor's opening remarks
Donovan welcomed the participants. He reminded the members that the primary task for the SWG this meeting was to work towards the selection of preferred candidate *SLA*(s) for the Bering-Chukchi-Beaufort (B-C-B) Seas stock of bowhead whales. He drew attention to the remarkable quantity of work undertaken by developers and Allison during the period since the last meeting. Before considering the results of the trials and determining the preferred candidate(s), he wished to congratulate and thank all of the developers for their work during recent years. Progress has only been possible because developers have shared their thoughts, approaches and code – equally important lessons have been learned from approaches that have not succeeded as well as those that have. Whichever procedure is finally chosen, it will owe a considerable debt to the other developers and members of the SWG who have worked in a spirit of cooperation and collaboration throughout.

1.2 Election of Chair
Donovan was elected Chair.

1.3 Appointment of rapporteurs
Givens and Punt acted as rapporteurs, with assistance from the Chair.

1.4 Adoption of agenda
The adopted agenda is given as Appendix 1.

1.5 Review of documents
The documents available to the SWG were SC/53/AWMP1-8, SC/53/O2 and SC/53/Rep1, the Report of the Third Workshop on the Development of an Aboriginal Subsistence Whaling Management Procedure (published in this volume). That report contains the latest details of trial scenarios, statistics and assumptions.

For ease of reading, unless another reference is given, 'Last meeting' refers to SC/53/Rep1. A glossary of terms is given as Appendix 2.

2. PROGRESS SINCE SEATTLE

2.1 Computing tasks
The Common Control Program is the computer code used to run the *Evaluation*, *Robustness* and *Cross-validation trials*. This program also calculates the performance statistics and the information needed to compare the performance of candidate *SLA*s. The only portion of code that an AWMP developer needs to supply is that implementing their candidate *SLA*.

Allison reported she had updated the Common Control Program to implement the modifications to the *Evaluation* and *Robustness trials* agreed at the last meeting. A version of the program was distributed to the developers in January to allow them to finalise their *SLA*s. Allison reported that she had received code implementing the five *SLA*s (and their variants) described under Item 3, and that she had been able to replicate the results for the *Evaluation trials* obtained by the developers. She reported that she had applied all *SLA*s to the 26 *Evaluation trials*, and had applied the 'central' version of each *SLA* to 101 of the 103 *Robustness trials* and the five *Cross-validation trials*. In addition, she had written the software to produce the graphical summaries developed at the last meeting. Trials for the eastern North Pacific gray whales were nearing completion but some of the specifications were incomplete and advice would be needed from the SWG. Allison expressed thanks to Punt for the assistance and advice he had given during the year and also to David Poole who had conducted the conditioning for some of the trials. The SWG thanked Allison for her diligent and timely work on these matters, without which the progress made would have been impossible.

2.2 Other
Givens reported that the SWG web site (*http://www.stat.colostate.edu/~geof/iwcawmp.html*) had been updated intersessionally. It includes reference information and subject- and date-indexed archives of all correspondence of the AWMP intersessional e-mail group. The SWG thanked Givens for the upkeep of the web site. The SWG noted that the AWMP intersessional e-mail group had once again provided a valuable means of communication among members of the SWG. It **recommended** that this e-mail group continue to coordinate the intersessional activities of the SWG.

3. DESCRIPTION OF POTENTIAL PROCEDURES FOR BOWHEAD WHALES

Potential *Strike Limit Algorithms* developed by four groups of Scientific Committee members were considered by the SWG. Non-technical descriptions of the procedures *written by the developers themselves* are given below.

3.1 The Dereksdottir-Magnússon (D-M) *SLA*

The procedure is described in detail in SC/53/AWMP7 and Dereksdóttir and Magnússon (2001). It centres on the 'Kalman filter', a tool widely used in engineering to estimate the state of a stochastic system with noisy observations, i.e. a system with both 'process' noise and observation noise. In order to apply the Kalman filter, mathematical models of the dynamics and the relationship between the observations and the true state are required. In what is called the Adaptive Kalman Filter Strike Limit Algorithm (AKF-SLA), a simple Pella-Tomlinson population model without age structure and without a delay in the dynamics, is used to describe the stock dynamics. A linear relationship between observed stock size and true stock size is assumed. The noise is taken to be additive and Gaussian after a log-transformation of the variables (i.e. stock size).

The way the Kalman filter works is that the most recent stock estimate is projected forward in time (a prediction) until a new observation is available. The prediction is then compared to the observation and an updated estimate of the state calculated. If we call the updated estimate x_{new}, the prediction x_{old} and the observation z, the updating formula is:

$$x_{\text{new}} = x_{\text{old}} + \tilde{K}(z - x_{\text{old}})$$

where the time-dependent coefficient $\tilde{K}$ is known as the Kalman gain. This updating of the most recent stock estimate is carried out whenever a new observation of the stock size (a survey estimate) is made.

The term in brackets in the updating formula is the difference between the actual observation (the survey estimate in this case) and the prediction from the model based on past history. Thus, a large difference between the predicted observation and the actual observation will result in a large update whilst a small difference results in a correspondingly small update. The Kalman gain depends on the magnitude of the measurement noise and the 'process' noise. The gain decreases (giving a small update) with increasing measurement noise (low confidence in the measurement) and increases (giving a large update) with increasing process noise (high confidence in the observations relative to model prediction).

The stock dynamics model and the observation model contain a number of unknown parameters. In the version of the AKF-SLA that is applied to the B-C-B stock of bowhead whales, two of the parameters (i.e. *MSYL* and natural mortality) are fixed. The remaining parameters (i.e. *MSYR*, *K* carrying capacity and *B* observation bias) are estimated by Bayesian methods. Each of the three parameters (*MSYR*, *K*, *B*) range over a sequence of discrete values that thus gives a three-dimensional grid of parameter values. A prior probability distribution is given to the parameter combinations in the grid and a Kalman filter is associated with each combination.

The probability associated with each parameter combination is updated by Bayesian methods each time a new survey estimate becomes available. The estimate of the state associated with each of the combinations is updated at the same time by the corresponding Kalman filter. For each (*MSYR*, *K*, *B*) combination in the grid, there corresponds therefore a posterior probability for the particular combination and an estimate of the state (i.e. stock size) given this particular parameter combination. This combination of Kalman filtering and Bayesian methodology is known as Adaptive Kalman Filtering (AKF). The overall estimate of the present state (stock size) is then obtained by summing all the stock estimates corresponding to the different parameter combinations, weighted by the respective probabilities.

When a catch control law is specified, a strike limit can be calculated - conditional on the values of three parameters (*MSYR*, *K*, *B*) and the corresponding stock estimate. Associated with each conditional strike limit is the most recent posterior probability of the particular parameter combination.

The catch control law used in the present version of the AKF-SLA is the minimum of pre-specified aboriginal need and the strike limit given by the *H*-rule (IWC, 2001a). Thus, when all the Kalman filters corresponding to each of the parameter combinations have been applied, a sequence of strike limits (the same number as the number of parameter combinations) and associated probabilities are available. Arranging all the strike limits in an increasing sequence, the associated probability distribution makes it possible to construct the cumulative probability distribution for the strike limit. Setting a percentile of this distribution gives the eventual strike limit. This percentile is the tuning parameter of the *SLA*; the higher the percentile, the higher the final strike limit. In the basic version of the procedure applied to the B-C-B bowhead stock, the bias factor is taken to be unity (i.e. no bias) in all the filters so that a two-dimensional grid of (*MSYR*, *K*) values is used.

The AKF strike limit algorithm is based on well-established methodologies, i.e. Kalman filtering techniques and Bayesian methods, and therefore stands on sound theoretical ground.

The results of the *Evaluation trials* are good with regard to final depletion and need satisfaction for most of the trials (value of tuning parameter = 70%). However, the stock is under-utilised in trial BE04 due to a negative bias in the stock estimate (this can be improved by including bias filters) and the final depletion is too low in trials BE09, BE12, BE13 and BE16, especially BE12. The depletion in some of these low productivity trials can be improved somewhat but only by compromising need satisfaction in the higher *MSYR* trials. Strong points of the *SLA* are the ability to fully satisfy need in the first 20 years of management, catch variability is generally low, and the *SLA* is fairly stable in the sense that there is a small spread in strike limit trajectories. A weak point of the *SLA* is the inability to cope satisfactorily with situations with low *MSYR*, historical survey bias and future positive bias (trial BE12). Although performance in low productivity trials without future positive bias (BE09) can be improved somewhat by choosing a more conservative tuning, BE12 can be improved only slightly.

3.2 The Givens *SLA* 1 (G-G)

This *SLA* (see SC/53/AWMP3 for technical details) was designed for conservative management, ensuring vigilant protection for the stock while fulfilling moderate subsistence need.

The strike limits are calculated from a linear model fit using a strategy known to provide Bayes rule optimality as described by Givens (1999). Like the procedure adopted for use in the *RMP*, this *SLA* places greater weight on ensuring at least moderate catch in all cases where this is appropriate, rather than trying to obtain a high but unreliable or even risky catch in some cases. Furthermore, it places greater priority on the satisfaction of subsistence need in the first 50 years of management than it does for high need in years 75-100. In fact, it gives complete need satisfaction in the first 20 years on every deterministic bowhead *Evaluation trial.*

The *SLA* was designed to place conservation as the highest goal. For example, on trial pairs where need is high and *MSYR* is either high or low, the *SLA* guarantees stock protection in the low *MSYR* trial, at the expense of some catch in the high *MSYR* trial. It rejects the reverse strategy of fully satisfying need in the high *MSYR* trial at the expense of depletion risk in the low *MSYR* trial. Conservatism is achieved by controlling for 5^{th} percentile - rather than median - depletion performance, and by giving the most risky trials heavier weighting in the tuning. The tuning also reflects the goal that after 100 years of management, the stock should show at least some recovery, even in the 5^{th} percentile performance.

The *SLA* produces extremely stable strike limits. This was a design goal reflecting the concern that highly variable limits are disruptive to subsistence hunters and may even serve to reduce the operational feasibility of satisfying need.

Finally, the *SLA* produces relatively narrow ranges of performance (both depletion and need satisfaction) on most trials. The appeal of this feature is that it enables one to set (via tuning) *SLA* performance closer to desired levels with better control against poor performance. For example, if the main goal is good median risk, a target level can be met while better controlling against poor 5^{th} percentile risk or poor need satisfaction performance.

Subject to the conservation and recovery of the stock, subsistence need is met to the greatest extent possible.

The strike limit calculation proceeds as follows. Given survey abundance data, the model and estimation procedure of SC/53/AWMP5 are used to estimate five quantities: carrying capacity, next year's yield (truncated) given a current-year catch of 120, current stock size, the default SC/53/AWMP5 strike limit, and a sort of trailing mean estimated stock size. The raw strike limit in years 0-34 is a linear function of the first three of these and the ratio of yield to carrying capacity. From year 35 onwards, the slope with respect to yield is modified. The coefficients of these linear functions are determined to achieve a Bayes rule optimality.

The raw strike limit is bounded above by need and bounded below by 90% of the previous limit. To this raw strike limit, several adjustments are made.

(1) If three or more consecutive strike limits each equal 90% of their predecessor, the raw strike limit is averaged with 75% of the default SC/53/AWMP5 strike limit (see Item 3.4).
(2) The strike limit must not be less than 90% of the previous limit, nor exceed the previous limit by the maximum of 15 whales/year or 15%.
(3) If the strike limit would satisfy at least 95% of need, it is raised to 100% of need.
(4) From year 35 onwards, if the trailing mean stock size is less than 6,700, the strike limit is reduced by 30%; if it is less than 6,000 in year 50 or later, the strike limit is reduced by 50%. In any year, if the estimated total stock abundance based on all available past data is less than 2,000, then the strike limit is set to zero.

This results in a strike limit algorithm with the following general behaviour: strike limits increase as estimated stock size or yield increases, and decrease as carrying capacity increases. For a stock near *MSYL*, the strike limit is essentially a linear function of carrying capacity, replacement yield, current stock size and *MSYR*.

The *SLA* can be tuned using several tuning parameters, and/or by re-optimisation using alternative Bayesian priors and loss functions. Sensitivity to tuning seems to be low for the former approach, and moderate for the latter. To match the extent of risk associated with candidate *SLA*s, a much more risk-tolerant tuning of this *SLA* was developed; it is described in SC/53/AWMP8. It has the strengths mentioned above plus it fulfils more needed strikes in scenarios where need is very high.

3.3 The Givens *SLA* 2 - (G-M)

This *SLA* (see SC/53/AWMP4 for technical details) is a simple merging of the *SLA*s described in SC/53/AWMP1 (Punt) and SC/53/AWMP5 (Johnston-Butterworth). It combines the better short-term performance of the former with the better long-term performance of the latter (see Items 3.4 and 3.5 below).

The strike limit calculation depends on the strike limits output from these two *SLA*s, omitting their quota variability dampening and phase-out features. For years 0-20, the raw strike limit is set equal to the corresponding result from the SC/53/AWMP1 *SLA*. Thereafter, the raw strike limit is set equal to the maximum of the output of the SC/53/AWMP5 *SLA* and a weighted average of the outputs of the two *SLA*s. This weighting is parameterised by a single tuning parameter. The weighted average equals the SC/53/AWMP1 output when the tuning parameter is 1 and the SC/53/AWMP5 output when the tuning parameter is 0. For tuning values between 0 and 1, the weighting shifts linearly.

Two adjustments are made to the raw strike limit. First, the strike limit is not allowed to be less than 90% of the previous limit. Second, when the strike limit would satisfy at least 95% of needed strikes, then the limit is raised to 100% of needed strikes.

The performance of this *SLA* can be adjusted through the choice of the tuning parameter, or by changing the tuning of the two individual *SLA*s.

One appeal of this *SLA* is its simplicity. For example, with the tuning parameter set to zero, this *SLA* essentially uses the SC/53/AWMP1 strike limits for the first 20 years and the SC/53/AWMP5 strike limits thereafter.

This merging approach generally provides superior need satisfaction - especially over the 20-year time span and at the 5^{th} percentile at any time span - while maintaining risk to the stock at a level between the individual *SLA*s.

3.4 The Johnston-Butterworth (J-B) *SLA*

This *SLA* (see SC/53/AWMP5 for technical details) is based upon the same simple population model as the *CLA* of the *RMP*. This model is fit to the available data by a penalised maximum-likelihood method, rather than adopting a Bayes-like approach as in the *CLA*. The rationale for this is that although Bayesian estimation is appealing in its presentational simplicity, in practice the development of computer code for its accurate implementation is a lengthy and expensive process. A maximisation instead of an integration process is simple to implement numerically.

A penalty function is added to the log-likelihood for two reasons: (1) to stabilise estimates of model parameters; and (2) to 'bias' initial model estimates in a manner that reduces the risk of unintended depletion while nevertheless not causing strikes to drop too much below need levels. The *SLA* sets strike limits equal to need unless the model both estimates the population to be below *MSYL* and not to be achieving a specified rate of increase.

This *SLA* incorporates an option to constrain the inter-5-year strike variation levels. The base-case (and both tunings) of the J-B *SLA* use a 15% downwards only inter-5-year strike constraint without restricting increases. This assists in reducing variability in need satisfaction without compromising conservation objectives.

The J-B *SLA* has three tuning parameters. A preferred *SLA* is selected by the authors, as well as two alternative tunings. The one tuning improves on need satisfaction, whilst the other tuning improves on resource recovery.

The strengths of the preferred J-B *SLA* include:

(1) simple and relatively easy to explain to both managers and whalers;
(2) easily 'tuned' to improve on either need satisfaction or resource recovery; and
(3) reasonable performance on most trials.

The weakness of this preferred *SLA* include:

(1) higher variability in need satisfaction over the full management period;
(2) largish reductions in strike limits for some 'difficult' trials;
(3) poor resource recovery when need is high and $MSYR_{1+} = 1\%$; and
(4) poor need satisfaction when future surveys are negatively biased.

3.5 The Punt (A-P) *SLA*

This *SLA* (see SC/53/AWMP1 for technical details) determines the strike limit as the greatest future catch which, if continued over the next 20 years, is consistent with either the population in 20 years exceeding *MSYL* with a pre-specified probability, or the population in 20 years exceeding a target fraction of the current population size with a pre-specified probability. The strike limit for a 5-year block is constrained not to differ by more than 20% from that for the previous 5-year block. The calculation of these probabilities is based on a Bayesian-like estimation approach where a prior is placed on *MSYR*, and the only data included in the likelihood function are the estimates of abundance from surveys (assumed to be unbiased). The coefficients of variation assigned to these estimates of abundance are downweighted to give less weight to less recent abundance estimates. The population dynamics model used is that which underlies the *CLA* of the *RMP*. This *SLA* explicitly includes precaution when setting strike limits by using a prior for *MSYR* which assigns highest probability to values for $MSYR \leq 0.01$. This *SLA* includes the phase-out rule presently included in the *RMP*.

The A-P *SLA* has eight tuning parameters. These parameters determine the relative prior probability for $MSYR \leq 0.01$, *MSYL*, the extent to the which historical survey estimates are downweighted, the target value for the ratio of the population size in 20 years to that at present, the probability of being above *MSYL* in 20 years, the probability that the population size in 20 years relative to that at present exceeds the target value, and the extent by which strike limits for a future block may differ from that for the previous block. The values for these parameters are selected to achieve a desired balance between need satisfaction, risk avoidance and stability of strike limits. Three tunings of this *SLA* are available (low, high and central). These tunings were selected to achieve a range of risk-need satisfaction trade-offs for trial BE12.

The design criteria for this *SLA* include being as generic as possible (so that the *SLA* can be tailored straightforwardly to additional aboriginal whaling operations), to be as similar to the *CLA* of the *RMP* as possible (to avoid the introduction of a completely new algorithm for managing whale populations), to include Bayesian features (so that greater uncertainty implies lower strike limits), and to be consistent with the spirit of paragraph 13(a) of the Schedule. The current version of the A-P *SLA* is reasonably generic and is based roughly on paragraph 13(a). In principle, the only modification needed to apply it to an additional aboriginal whaling operation would be to select the values for the eight control parameters to achieve the desired risk-need satisfaction balance. In contrast, the *SLA* does not include a formal Bayesian estimation framework (although it does include a Bayesian-like framework that achieves essentially the same outcome), and the only features of the *CLA* of the *RMP* included in this *SLA* are its population dynamics model and phase-out rule.

The performance of the central tuning of this *SLA* is generally adequate in terms of allowing populations to recover to above their present sizes and satisfying need when this is possible. The most notable exception to this in terms of risk avoidance occurs when *MSYR* is low (1% of the total population size at *MSYL*) and the data are poor, when the lower 5th percentile of the 1+ population size in 100 years expressed relative to that at present is only 77%. Performance, in terms of need satisfaction, is poorest when future survey estimates are negatively biased. This *SLA* (particularly its 'low' tuning) also leads to relatively wide distributions for the performance statistics.

4. PRINCIPLES OF SELECTION OF *SLA*S

The IWC's objectives for aboriginal whaling management given by the Commission are:

(1) ensure that the risks of extinction to individual stocks are not seriously increased by subsistence whaling;
(2) enable aboriginal people to harvest whales in perpetuity at levels appropriate to their cultural and nutritional requirements, subject to the other objectives; and
(3) maintain the status of stocks at or above the level giving the highest net recruitment and ensure that stocks below that level are moved towards it, so far as the environment permits.

The first objective has been accorded highest priority by the Commission.

The SWG agreed that consideration of the results of the *Evaluation trials* (table 3 on p.20 of this volume) would play the primary role in the selection of preferred *SLA*(s). The purpose of the *Robustness* and *Cross-validation trials* (tables 4 and 5 on p.21 of this volume) is respectively to examine *SLA* performance for the full range of plausible scenarios and to examine performance for scenarios not available to the developers.

The SWG noted its discussions on this matter during previous meetings. It then agreed that the first phase of the selection process would involve identifying the *SLA*s that meet the Commission objectives satisfactorily and that the second phase would involve choosing amongst those.

Equivalence tuning is a way to provide *SLA* developers with the opportunity to adjust their *SLA*s to strive towards a pre-specified balance of risk, satisfaction of need and recovery. The tuning criterion agreed at the last meeting (matching the (1+) median final depletion achieved by *H* for trial BE14 to within 0.005) was not, in fact, appropriate for the purposes of equivalence tuning. At the present meeting, the SWG reconsidered the merits of *equivalence tuning* in this case. It was noted that performance differs markedly across trials and performance statistics, even when equivalence tuning is achieved. Given this, the SWG agreed to group the 13 *SLA* variants into three categories based on a rough evaluation of the emphasis each *SLA* placed on risk avoidance. The SWG noted that *equivalence tuning* was different from *performance tuning* which involves evaluating the risk-need satisfaction trade-off achieved by a single *SLA*.

In the context of Commission objective (2), the SWG has placed emphasis on consultation with hunters via the Commission's Aboriginal Subsistence Whaling Sub-Committee. Issues covered have included the importance of catch stability and need satisfaction in the shorter term versus that in the longer term. In addition, this year the SWG noted comments made by the Alaska Eskimo Whaling Commission (AEWC) provided in SC/53/AWMP3. The AEWC emphasised the high importance they attach to satisfying need in the near future compared with the relatively low importance to attempting to satisfy large increases in need in the distant future (50-100 years from now). They also indicated that emphasis should be placed on 'realistic' levels of future need (rather than the upper limits of the need envelope[1]). They further stressed that *SLA* performance was extremely important and that they would not be concerned if the Commission adopted a 'complicated' *SLA* in order to ensure the best performance. Finally, they indicated that they saw no urgency for the adoption of a new *SLA* for the B-C-B bowhead whales since the existing management process seemed to be working well.

The SWG considered whether to assign relative weights to each of the *Evaluation trials*. The SWG agreed that weights could be assigned to trials based on their biological plausibility (e.g. *MSY* rate, time-trend in survey bias) and on the realism of the need trajectory. Weights could also be based on the ability of the trial to distinguish *SLA* performance, i.e. whether the trial provides a challenge in terms of need satisfaction or risk avoidance. Based on the comments by the AEWC and earlier comments by the Commission, the SWG agreed that the trials with final need levels of 201 should be assigned a lower weight than those with final need levels of 67 and 134 (especially with respect to need satisfaction) and that if two *SLA*(s) perform similarly, satisfaction of need for the first 20 years of the 100-year projection period would be given emphasis when selecting a preferred *SLA*.

Apart from these general considerations, the SWG did not *a priori* assign weights to each *Equivalence trial* although it acknowledged that each member of the SWG would assign their own weights to each trial during the selection process. It agreed that a more formal weighting of trials may be necessary once the number of candidate *SLA*s is reduced. If the number of trials on which performance differs is small, the number of trials that would need to be weighted would be reduced from the current 26.

The SWG noted its earlier comment that, performance being equal, a substantially simpler *SLA* might be preferred if, for example it greatly reduced future computational requirements and eased the process of validating the computer code for the preferred *SLA*. The SWG **agreed** however, that all candidates identified in Item 5.2 may be sufficiently complex as to render complexity differences between them irrelevant, at least with respect to explaining them to the Commission or hunters.

[1] The need envelope sets bounds on the situations that an *SLA* has to be able to cope with in the AWMP simulations.

5. REVIEW RESULTS OF THE BOWHEAD WHALE TRIALS

5.1 Graphical presentation and performance statistics

Allison provided the SWG with examples of the tables and plots it developed at the last meeting. The SWG reviewed these example plots and refined them to simplify interpretation of the results. The SWG agreed that the full suite of tables and graphs will be available in a Master Summary. The SWG agreed that following seven graphical summaries (see Appendix 3 for examples) would be included in the Master Summary:

(1) **Plot 1**: Time-trajectories of total (1+) population size for *H* by simulation and trial, pointwise median time-trajectories of total (1+) population size by *SLA* and trial, and time-trajectories of total (1+) population for simulations 1-5 by *SLA* and trial.
(2) **Plot 2**: Time-trajectories of total (1+) population size for *H* and each of the *SLA*s by simulation and trial.
(3) **Plot 3**: Time-trajectories of strike limit against time for *H* and each of the *SLA*s by trial.
(4) **Plot 4**: Pointwise median strike limits and time-trajectories of strike limit for simulations 1 – 5 by *SLA* and trial.
(5) **Plot 5**: Box plots summarising the distributions for the mandatory statistics for each trial and candidate *SLA*.
(6) **Plot 6**: Need satisfaction (N9) versus final depletion (D1; 1+ population component) for 13 variants of the base-case trial that span a range for $MSYR_{1+}$ from 1 to 4% in steps of 0.0025 for each *SLA*. The historical survey bias changes linearly from 0.67 to 1.00 as $MSYR_{1+}$ changes from 0.01 to 0.025 so that the trial with $MSYR_{1+} = 0.01$ matches trial BE01. $MSYL_{1+}$ ranges linearly from 0.6 to 0.8 for $0.025 \leq MSYR_{1+} \leq 0.04$ so the trials with $MSYR_{1+} = 0.025$ and 0.04 are the same as trials BE01 and BE10. Need doubles over 100 years in every trial, and each trial was conditioned to provide appropriate biological parameter sets. The dots show actual outcomes for each trial and *SLA*; the lines merely connect the dots. The top set of lines connects medians, and the bottom set the lower 5th percentiles. The hash marks on the x-axis indicate the 5th percentile D1 values for trials where $MSYR_{1+} < 0.025$.
(7) **Plot 7**: Scatter plots for each *SLA* of the median final depletion (1+ population component) expressed relative to that achieved by *H* versus the average need satisfaction (N9) expressed relative to that achieved by *H* (median performance) and of the lines joining the joint 5% and 95% points for the final depletion expressed relative to that achieved by *H* and for the average need satisfaction expressed relative to that achieved by *H* (boundary performance).

Tabular summaries available to the SWG included lists of the values of the performance statistics (5th, 50th and 95th percentiles) for each *SLA*.

The SWG agreed that the process of selecting preferred candidate *SLA*(s) would be divided into two stages. The first stage involved examining the results for the *Evaluation trials* in tabular form and using the plots 3, 5, 6 and 7, from which it would eliminate any unsuitable candidates.

5.2 Initial consideration of preferred candidate(s)

The SWG agreed that the task of summarising the performance statistics and hence selecting preferred *SLA*(s) would be considerably simplified if the number of candidates could be reduced from 13. The SWG therefore considered plots 2 and 4 and the tabular results for some of the trials, and agreed that it was possible to reduce the number of candidate *SLA*s from 13 to 4. Nine candidate *SLA*s were eliminated from further consideration for the following reasons.

A-P(L) and J-B(L): Poor performance in terms of satisfying need over the first twenty years of the 100-year management period for trials (such as BE01) in which need can be fully satisfied.

D-M(H): This *SLA* drives the resource to low levels in some trials (e.g. BE12) and its performance is, in any case, not very different from those for D-M(L) and D-M for most trials.

A-P(H) and J-B(H): Very poor performance in terms of resource conservation for trial BE12. The time-trajectories of population size for these *SLA*s drop monotonically over the 100-year period for this very difficult trial.

G-M and G-M(H): Performance of these *SLA*s tends to be worse than that for the G-G and G-G(H) *SLA*s on several performance statistics for several trials.

A-P and J-B: These *SLA*s are far more variable than the two D-M and two G-G *SLA*s.

During the review, Cooke commented that in some cases the performance of the *SLA*s was poorer than simply setting the *strike limit* equal to need (i.e. those trials for which need can be fully satisfied). In addition, for several of the trials in which need cannot be satisfied, the *SLA*s nevertheless still lead to upper 95th percentiles for the total need satisfaction (N9) statistic very close to 1. In order to investigate this further, the SWG therefore compared the performances of the 13 *SLA*s with that of the (hypothetical) *Strike Limit Algorithm* that involves always setting the *strike limit* equal to need. This 'catch = need' *Strike Limit Algorithm* performs perfectly (as expected) for many of the 'easy' trials but leaves the resource at unacceptably low levels for *Evaluation trials* in which $MSYR_{1+} = 0.01$ (for example, trials BE09, BE12 and BE16), and in many of the *Robustness trials*.

The SWG therefore **agreed** to proceed by considering only the following variants: D-M, D-M(L), G-G, G-G(H). The Chair drew attention to his earlier comments regarding the invaluable contributions made to the overall process by all developers (Item 1.1).

5.3 Comparison of *SLA*s using the *Evaluation trials*

The SWG contrasted the performance statistics for the D-M, D-M(L), G-G and G-G(H) *SLA*s for each of the 26 *Evaluation trials.* The aim of this comparison was to identify differences and similarities in the performance for these four *SLA*s. The intention was not to produce a mechanical scoring system from which automatically to choose the *SLA* with most points. The ultimate decision would be made via a composite view of all of the factors discussed in Item 4. During the examination of the *Evaluation trials*, the basis and method of comparing performance evolved and expanded as the SWG learnt more about how to interpret and summarise trial results. It also recognised that the various statistics all provided insight into the performance of the *SLA*s and that in any one trial it was possible for individual statistics to imply different relative performance inferences.

The SWG noted that performance on the lower 5th percentile statistics reflected the 'guaranteed' performance of an *SLA* while performance on the median statistics reflected its 'expected' performance. Final evaluation requires human integration over a number of factors including the assignation of relative weights to performance in terms of 'guaranteed' versus 'expected' performance, overall plausibility of trials and the magnitude of any observed differences. Given these provisos, the SWG examined each of the trials and attempted to identify the 'best' *SLA*s for each trial as detailed below. Trials indicated by asterisks are trials for which setting the strike limit equal to need performs perfectly and those indicated by ampersands involve need increasing to 201 over the 100-year period – such trials are considered less plausible than the trials in which need is constant or increases to 134. The comments on each trial below were based on an initial examination by the full SWG and finalised by a small group comprising Allison, Punt and Witting.

BE01,BE01-SE*. This is the baseline trial. The G-G(H) *SLA* performs best in terms of the lower 5th percentile of the N9(100 years) statistic. This *SLA* also outperformed the other *SLA*s in terms of the fraction of years in which the strike limit equals need.

BE02*. The four *SLA*s perform equally well for this trial.

BE03,BE03-SE*. The G-G and G-G(H) *SLA*s perform best as they achieve the greatest need satisfaction over the last 80 years.

BE04*. All four *SLA*s fail to satisfy need for this trial. The D-M *SLA* outperforms the other three *SLA*s given its performance in terms of satisfying need over the last 80 years.

BE05*. The D-M *SLA* performs best as a result of its higher lower 5th percentile of the N9(100 years) statistic.

BE07*. The D-M and G-G(H) *SLA*s perform best as they are better able to satisfy need over the last 80 years.

BE08*. The G-G(H) *SLA* performs best as it achieves the highest lower 5th percentile of the N9(100 years) statistic.

BE09. This is a trial in which need cannot be fully satisfied so performance is measured in terms of risk avoidance. The G-G and D-M(L) *SLA*s perform equally well in terms of preventing further declines in population size (D10; lower 5th percentile). The D-M(L) *SLA* achieves the highest lower 5th percentile of the final depletion distribution for this trial and is therefore considered to perform best.

BE10*. The G-G(H) *SLA* performs best as it achieves a higher lower 5th percentile of the N9(100 years) statistic and because most of the time-trajectories for the annual strike limit are close to need.

BE11*. The G-G and G-G(H) *SLA*s set the strike limit equal to need for all but a few years so perform best for this trial.

BE12. This trial is the most difficult from the viewpoint of resource conservation. Performance is not particularly good for any of the *SLA*s for this trial (they reduce the resource well below its initial level in many of the simulations) although it is considered to be only marginally plausible. The G-G *SLA* performs best for this trial because it achieves the highest values for the lower 5th percentile for the final depletion (D1) and relative increase (D10) statistics.

BE13. There is little to choose among the four *SLA*s for this trial. The G-G and G-G(H) *SLA*s perform better in terms of avoiding low final depletions while the D-M and D-M(L)

*SLA*s allow some recovery and achieve greater need satisfaction.

BE14*&. The D-M *SLA* performs best overall for this trial as it achieves the greatest level of need satisfaction over the last 80 years. The G-G and G-G(H) outperform the D-M and D-M(L) *SLA*s in satisfying need over the first 20 years.

BE16&. Need cannot be fully satisfied in this trial so the key aspect of performance relates to risk avoidance. The G-G *SLA* performs best for this trial by achieving full need satisfaction over the first 20 years and the highest lower 5th percentile of the final depletion distribution for the N9(100 years) statistic.

BE20*&. The D-M *SLA* performs best in terms of median need satisfaction over the last 80 years while the G-G(H) *SLA* achieves the highest lower 5th percentile of need satisfaction. The G-G *SLA* outperforms the D-M(L) *SLA* in terms of the lower 5th percentile and median need satisfaction for this trial.

BE21*. The G-G(H) *SLA* outperforms the other *SLA*s in terms of satisfying need over the last 80 years.

BE22. All four *SLA*s perform equally well for the deterministic version of this trial. The performances of the two G-G(H) *SLA*s are marginally better than those of the two D-M *SLA*s in terms of need satisfaction when allowance is made for stochastic dynamics,

BE23*&. The D-M *SLA* outperforms the other three *SLA*s in terms of median need satisfaction and the G-G(H) *SLA* achieves the highest lower 5th percentile of the need satisfaction distribution (100 years). The G-G and G-G(H) *SLA*s better satisfy need over the first 20 years.

BE24. This trial is difficult to interpret. All four *SLA*s allow substantial recovery of the resource. The G-G(H) *SLA* appeared to perform best as it achieved the highest need satisfaction over the 100-year period.

5.4 General features of the D-M and G-G *SLA*s

Examination of the results of the *Evaluation trials* and the technical specifications of the *SLA*s led to some preliminary observations regarding the four *SLA*s.

The G-G and G-G(H) *SLA*s perform better at satisfying need over the first 20 years of the 100-year period than the D-M and D-M(L) *SLA*s although the difference in performance is often insubstantial (the largest difference is 5% but most differences are less than 1%) and some of these differences may be due to the 'snap-to-need' feature that forms part of the G-G and G-G(H) *SLA*s. Over the entire set of *Evaluation trials*, 95% of the strike limits set by the G-G and G-G(H) SLAs were between 67 and 129; 95% were between 67 and 132 for the D-M and D-M(L) *SLA*s.

Upon inspection of the time trajectories of strike limits for *Evaluation trials*, the SWG noted that there were instances where each *SLA* provided strike limits that became more variable as time progressed, even though both procedures generally satisfied need well in the first 20 years.

In response to queries from the SWG, both developers noted that their *SLA*s were easily *performance tuned*, and in both cases tunings to increase risk avoidance were easier to achieve than tuning to increase need satisfaction. The D-M *SLA* has one explicit tuning parameter, but it was noted that in order to achieve a wider range for the need satisfaction-risk avoidance trade-off, it might be necessary to add additional tuning parameters. The G-G *SLA* has several tuning parameters, and can also be tuned through a revised *H-optimisation* step.

It was noted that both the G-G and D-M *SLA*s employed a protection level below which harvest could be limited. In both cases, the estimated stock size based on all available data must be above 2,000 to avoid the possibility of a zero strike limit. It was noted that these protection levels had never been invoked by either *SLA* in any of the bowhead *Evaluation trials*, and that the location and severity of such protection levels could be easily adjusted or removed with no effect on *Evaluation trial* results and probably limited effect on *Robustness trials*. It was also noted that such a protection level was broadly consistent with the current management scheme expressed in sub-Paragraph 13(a) of the Schedule i.e. there is some minimum population level below which catches should not be taken.

The preliminary calculations of advisable catch used by the G-G *SLA* are a piecewise linear function of time, and the final strike limits are subject to two intermediate protection levels that are invoked only after 35 years of management. Many members believed that the performance gains produced by this strategy were not sufficient to warrant reliance on an *SLA* that produced strike limits that were not guaranteed to be a continuous function of time. Small changes in the abundance data could have disproportionately large impacts on strike limits. It was noted that the SWG had previously agreed to place no limitations on the use of the time variable in *SLA*s. However, some uses of time-dependence are less desirable than others. This aspect of the G-G *SLA* is one that might be improved with future work.

It was noted that both *SLA*s included design aspects that the SWG believed could be improved with further opportunity for development, but it was unclear whether these changes would result in substantial improvements in performance.

In order to observe how the *SLAs* react to a sharp decline in abundance, the SWG **agreed** that an exploratory trial should be conducted in which the population size drops to 2,000 in the first year of the projection period. This is not because the SWG believes that such a scenario is even remotely plausible (and thus it is neither an *Evaluation* nor a *Robustness trial*) but it will provide information that can be used to assess the relative speed at which the *SLA*s react to large changes in population size. However, the SWG noted that such a trial would be difficult to interpret since there are both positive and negative aspects of reacting quickly to such a change. The SWG believed that large changes in population size approaching this magnitude would lead to an *Implementation Review*; the *SLA* would not be applied blindly for 100 years even though the survey estimates dropped markedly.

5.5 Comparison of *SLA*s using the *Robustness* and *Cross-validation trials*

The purpose of the *Robustness trials* is to examine whether a preferred *SLA* performs as expected when it is used to manage scenarios that are plausible but (occasionally much) less likely than those that underlie the *Evaluation trials.* They may also be used as a method of selecting between two *SLA*s that are 'tied' after examination of performance on the *Evaluation trials*.

The SWG considered the performance of the four *SLA*s on the *Robustness trials*. All four *SLA*s perform well for the *Robustness trials*. The BR12-9^S and BR06-12^S trials were most notable in terms of distinguishing among the *SLA*s. The G-G and G-G(H) *SLAs* achieve better risk avoidance than the D-M and D-M(L) *SLA*s for these trials. The SWG did not have the full set of results for trials BR16E-9^S (large and temporally correlated environmental variability) and

BR-11a (reductions in natural mortality). The results for the modified versions of these trials should be examined at the proposed intersessional workshop.

The SWG reviewed the current *Robustness trials* and **agreed** to modify them as follows:

(1) Delete trials BR01-10 and BR08a-20 as they lead to unrealistic time-trajectories of population size.
(2) Delete all *Robustness trials* based on a constant need of 67 and $MSYR_{1+} = 2.5\%$ as these trials are not informative.
(3) Delete trials BR05a-1, BR05b-1, BR12-10, BR12-10^S, BR14-10 and BR17-9 as these trials are not informative.
(4) Delete trials BR07b-1 and BR08a-16 as their stochastic variants are more challenging.
(5) Recondition trial BR06b-1 in hope of eliminating several highly atypical trajectories produced by the currently conditioned parameter sets.
(6) Improve the interpretability of the plots that show time-trajectories of population size for all *Robustness trials* in which carrying capacity changes with time. The plots would be clearer if there was a dotted line showing the pointwise median time-trajectory of population size under zero catch for comparison with the simulated trajectories.
(7) Reduce the extent to which natural mortality increases over time for the BR11a trials so that the population can avoid extinction under zero catch.

Cross-validation trials are case-specific trials to be held aside from *SLA* development so that resulting *SLAs* can be subjected to a subsequent independent test. Cross validation is an informal check for whether the selected *SLA*s perform roughly as expected. The *Cross-validation trials* conducted intersessionally examine whether unpredictable behaviour occurs within the interior of a tested region of parameter space due to over-fitting.

No evidence for over-fitting is evident from the results of the five *Cross-validation trials*, which are interpolative, nor from the *Robustness trials* which examine behaviour for scenarios beyond the *Evaluation trials*. The SWG **agreed** to increase the number of *Cross-validation trials* from five to 10 to better sample the distributions for the model parameters considered in the *Cross-validation trials*. It also **agreed** to increase the range for the estimated survey *CV* from 0.1-0.25 to 0.1-0.4 so that the value that forms the central value for the *Evaluation trials* is also the central value for the *Cross-validation trials*.

5.6 Selection of preferred *SLA*(s)

The SWG considered an enormous quantity of tabular and graphical material at this meeting as part of the evaluation and selection process. It was clear from this that it had two excellent procedures available (four variants) which exhibited very similar performance. Given the similarity, selection of a single procedure from the vast array of results is not a trivial task, even if more time was available. In addition, the SWG had identified a number of issues that it wished to consider in more detail, in terms of further plots for some of the *Robustness trials*, modifications to certain *Robustness trials*, additional *Cross-validation trials* and further work on certain issues concerning each of the procedures (see Item 13). The SWG **agreed** that given the importance of the decision, the complexity of integrating the performance results before it and the additional work identified, it preferred to postpone a final decision.

In the 'ideal' workplan given in SC/53/Rep1, the SWG had stated that it would 'examine trial results and determine 'preferred' candidate(s)'. Given the importance of the decision, the SWG **agreed** that it would still be able to meet its 'ideal' timetable if it did not choose a single candidate for presentation at the present meeting. It therefore **recommends** that the work identified in Item 13 be undertaken and that the results be examined at an intersessional workshop. The SWG **agreed** that this would enable it to make a recommendation for an *SLA* for the Bering-Chukchi-Beaufort Seas stock of bowhead whales to the Committee at the 2002 Annual Meeting.

6. REVIEW OF GRAY WHALE TRIALS

There was insufficient time to consider the further development of gray whale trials at this meeting, and no new *SLA*s for this fishery were presented. SC/53/AWMP6, in an application to gray whales, further elucidated the features of the inertial dynamics model whose development was encouraged by the SWG in recent years. Although the SWG did not have time to review this document, it was discussed in some detail in Annex F. It was **agreed** to informally consider aspects of gray whale trial development after the close of the SWG meeting and via the intersessional working group.

7. PROGRESS ON DEVELOPMENT OF POTENTIAL *SLA*S FOR GREENLANDIC FISHERIES AND THE GREENLAND RESEARCH PROGRAMME

As noted in previous years, little progress is envisioned in this regard until results from the Greenland Research Programme become available. The SWG considered the Greenland Research Programme (e.g. see SC/53/Rep1) in the context of possible data needs for a management procedure for Greenlandic whaling. It builds upon previous discussions (e.g. IWC, 2001b). It was **agreed** to focus on West Greenland, since catches off East Greenland are few.

7.1 The fisheries

Currently exploited species are fin and minke whales. Basic information on the geographic and seasonal distribution of fin and minke catches is given in Witting (2000). Catches of minke whales are now mainly inshore within the West Greenland archipelago.

7.2 Stock structure, range, movement

A major problem is the lack of information on the identity and range of the stocks from which the catches are taken (see IWC, 2001b). Witting *et al.* (2000) and SC/53/O2 reported on feasibility studies of biopsy sampling of minke whales in this area. Despite certain problems with the design and execution of these feasibility studies (e.g. see IWC, 2001b and SC/53/Rep1), the SWG concluded that it is unlikely to be possible to biopsy sufficient animals for the stock structure studies proposed last year.

SC/53/O2 reported on a fin whale that was satellite-tagged on 30 September 2000 in coastal West Greenland (68°42'N 52°50'W). It remained in the area until at least 13 October. On 16 and 17 October it was found further south, about 175 km off the coast of West Greenland. On 20 October it had moved approximately 250km southeast to another inshore area. It moved another 100km south along the coast and up to 50km off the coast until 2 November, then appeared back in the area it was located at on 20 October. The last position received was on 16 December and contact was lost on 20 December after 81 days. The tracking data shows a clear connection between inshore and offshore fin whales in West Greenland and indicates that the potential area of distribution of fin whales to be included in an abundance survey for West Greenland is larger than that covered in previous surveys.

The SWG noted that although satellite tagging was no easier, the technique is more promising because useful information on movements of animals in the hunted stock can be obtained from a smaller sample size than that required for a biopsy programme.

7.3 Abundance and trends

Inshore surveys within the archipelago are relatively feasible due to the more favourable weather conditions. Witting indicated that an annual shipborne survey of the inshore area might more readily get support, given that the survey could record other wildlife in addition to cetaceans. The surveys could sample an area in which approximately 80% of the catches occur, and could thus provide an index of abundance directly related to the stock components being exploited. Since a relative abundance series first becomes useful after about 10 annual data points have been collected, it is a long-term project that should preferably be conducted within the means available within Greenland for research.

The usual data collection protocols for shipborne line transect surveys, including dual platforms, could be followed. Survey designs within the archipelago will be constrained by navigational conditions, so it not certain that sighting rates could be expanded to abundance estimates. In any case, such a study area presumably represents only a small part of the summer range of the stocks. A fixed-track design, repeating the same track each year, would be the best approach for producing an abundance index. The surveys should be conducted in late summer in the period of maximum minke whale abundance. One would also expect greater inter-annual consistency at this time, given that the time of the arrival of whales early in summer can vary considerably.

The SWG recognised that an abundance index alone would probably not provide a sufficient basis for a management procedure, and would need to be supplemented with surveys covering a larger area for which absolute abundance should be estimated. A large-scale survey at *ca* 10-15 year intervals may be realistic, but would require external funding. The logistics of offshore surveys are less favourable than inshore surveys, with much time lost to poor weather.

Satellite tracking data, even of a limited number of individuals, is important for determining the summer range of whales from the hunted stock, and hence the area that should be surveyed. Satellite tagging could be conducted from survey vessels, but would require dedicated time during which ordinary survey mode is suspended.

7.4 Preliminary consideration of management procedures

Work done during the development of the RMP indicated: (1) absolute abundance surveys conducted at 10-year intervals were nearly as useful as five-yearly surveys; (2) annual indices of relative abundance can provide a valuable supplement to the absolute abundance estimates, provided the indices are reasonably valid, albeit not linearly proportional to abundance.

The SWG **agreed** that preliminary trials of simple management procedures using an annual inshore abundance index coupled with 10-yearly surveys be conducted before the next Annual Meeting. These must cover cases where there is inter-annual variability in the index. The results of these would help determine the utility of proceeding with the annual series of inshore surveys starting in late summer 2002.

A problem with a relative abundance index is that it could decline for reasons possibly unrelated to exploitation. In such circumstances, it might be necessary to bring forward the next absolute abundance survey of the larger area.

The group recognised that sightings of fin whales in the annual inshore surveys would be few in number, such that it might not be possible to obtain a useful index for this species. Given the poor prospects for obtaining substantial information on this species in the area, due to its low numbers and other factors, it might be appropriate, at some future time, to consider management approaches in which the specified need (640 tonnes of meat annually) is met without any hunting of fin whales.

7.5 Biological data

Greenland intends to collect tissue samples from as many caught animals as possible. These should be analysed on an ongoing basis and compared with samples from other countries (e.g. Iceland, Canada, USA), with a view to determining possible relationships of West Greenland minke whales to those in other areas based on haplotype frequencies. It may be possible to have this work undertaken at no cost to Greenland or the IWC, by geneticists who have a scientific interest in the material.

7.6 Recommendations

7.6.1 Annual inshore surveys

Planning should proceed for an annual series of inshore surveys starting in late summer 2002, with a view to producing a relative abundance index, preferably within the research resources available within Greenland. Survey design should take account of the available information on the distribution of the target species. Detailed survey plans and methodology should be developed during the intersessional period and presented to the AWMP group for review. Funding for such surveys should be considered the responsibility of the Greenland Home Rule Government.

7.6.2 Exploratory simulation studies

Preliminary simulation studies of management procedures should be conducted utilising a combination of an annual relative index and infrequent absolute abundance estimates. Witting, Magnússon, Dereksdottír and Cooke agreed to cooperate on this issue and present results to the 2002 Annual Meeting. It was **agreed** that this would be a suitable case for funding from the AWMP Developers' Fund. Results from this preliminary work may or may not indicate modification of the plans for the inshore index surveys.

7.6.3 Satellite tagging

An annual programme of satellite tagging in conjunction with the inshore surveys should be started in 2002, with the aim of gradually building up records of animal movements, based on a target of four informative tracks per year. IWC funding should be provided to cover the tags themselves, equipment, personnel and some ship time from the surveys for the tagging. It was **agreed** that the remaining £36,000 from the funds allocated to the Greenland Research programme last year should be spent on this work, over the next two years as follows:

Summer 2002: personnel £4,000, travel £1,000, 4 tags £8,000, 5 days ship time £5,000 (Total £18,000).

Summer 2003: personnel £4,000, travel £1,000, 4 tags £8,000, 5 days ship time £5,000 (Total £18,000).

7.6.4 Planning for a large-scale survey

Based on the results of the first few years of satellite tagging, which are used to determine the area to be surveyed, plans should be drawn up for a large-scale survey to be held in about five years time. The intention is that subsequent surveys would be conducted at infrequent (10-15 year) intervals, with the area to be covered to be based on the state of knowledge on stock range at the time.

8. PROGRESS ON CONSIDERATION OF FISHERY TYPE 3

The SWG has defined a type 3 fishery to be characterised by a small total population size (of the order of 300 animals) where demographic and environmental stochasticity may have potentially critical effects on the survival of the stock and aboriginal harvest of even a few whales would be a matter for very careful scrutiny.

The SWG regretted that it did not have time to consider the interesting and important work described in SC/53/AWMP2 submitted for consideration under this item. It urged Punt and Breiwick to resubmit this paper at the next opportunity because the SWG was enthusiastic about studying its implications for the management of a type 3 fishery.

9. SCIENTIFIC ASPECTS OF AN ABORIGINAL SUBSISTENCE WHALING SCHEME

The SWG **agreed** that it was premature to consider the appropriateness of developing detailed specifications for the AWMP at the level that now exists for the RMP (IWC, 1999a) and its associated guidelines with respect to surveys and data.

However, there are a number of issues the SWG wished to draw to the Commission's attention.

9.1 'Rules'

9.1.1 Carry-over

Last year, the Committee presented the Commission with the following illustration:

> For the purposes of illustration only, it is assumed that the block is 5 years, that the total strike limit over the 5 year period is 500 and that an inter-annual carryover allowance of 50% is permitted. The block length and the percentage inter-annual carryover allowance are numbers for which explicit advice is required from the Commission. The total block quota is then divided by the number of years to provide an average annual quota. The strike limit set for any one year should normally be allowed to exceed this average annual quota by 50%, provided that the total strikes allowed during a block do not exceed the block limit (plus any carryover brought into the block). The same 50% allowance may be carried over between the last year of one block and the first year of the next block; it does not impact the overall block limit.

In response the Commission agreed:

> that blocks of five years with an inter-annual variation of fifty per cent were satisfactory in terms of allowing for the likely variability in hunting conditions. It therefore agreed that these values are appropriate for use in trials. It was recognised that this does not commit the Commission to these values in any final aboriginal whaling management procedure.

In order to allow the Commission to consider this further, the SWG notes that if under a recommended *SLA*, current need is met (and there is no indication from the present results that this will not be the case), then a revised *Schedule* paragraph might look something like that below:

For the years **[2003-2007**] inclusive, the total number of strikes shall not exceed [**330].** The *Strike Limit* in any one year shall not exceed [**100**].

9.1.2 Phase-out (and survey interval)

Weather and ice conditions often prevent the completion of a successful bowhead abundance survey even when all best efforts are made. Since 1988, three successful censuses have been made (1988, 1993 and 2001) in six attempts.

Phase-out is the process by which annual strike limits should be gradually decreased to zero in the absence of a new abundance estimate. The SWG **recommends** that phase-out should begin in the 10^{th} year after the year of the most recent abundance estimate. Since it might require several attempts to obtain a successful abundance estimate, this could mean that an attempt to undertake a census might begin after about seven years from the most recent success. This will probably result in a survey interval of about 7-10 years in practice. The SWG draws attention to the fact that the risk and need satisfaction performance of the G-G and D-M *SLA*s was not diminished in *Evaluation trials* when surveys occurred at 10-year rather than 5-year intervals.

The SWG also discussed the appropriate length and abruptness of the phase-out itself. One phase-out method might be to reduce the strike limit by 20% for each year starting in the 10^{th} year after the most recent abundance estimate. This would be in line with the rule in the RMP. However, in the limited time available for discussion, the SWG noted that there are several other potentially useful approaches to phase-out that require further consideration. It **agreed** that it would consider this issue further during the coming year.

Finally, the SWG considered the issue of the quantity to which any phase-out rule would be applied. *SLAs* generally estimate a maximal allowable catch, which is then reduced to the need level if it exceeds need. If the phase-out rule was applied to the maximal allowable catch before comparison with the need level, this could eliminate the gradualness of the phase-out and delay its invocation. If instead the phase-out rule was applied to the strike limit after it was bounded by the need level, this could provide an inducement for the hunters to seek increases in the need level to soften the potential effects of phase-out.

The SWG requested that the Commission review its progress on survey interval and phase-out to confirm that the introduction of phase-out in the 10^{th} year after the most recent abundance estimate would be an approach compatible with its management goals. Furthermore, the SWG asked the Commission to indicate if it wished to impose any constraints on: (1) the type of phase-out rule employed; (2) the maximum length of time it would take for phase-out to reach zero strikes; and (3) the quantity to which phase-out should be applied.

9.2 Guidelines for surveys

The SWG considered three issues related to abundance estimates for use in an *SLA*. It restricted itself at this stage to considering *SLA*s that require an absolute abundance estimate. This is the case for the *SLA*s for bowhead whales currently under consideration.

Table 1
Proposed work plan.

Time	Ideal (bowhead)	Scheme	Ideal but unlikely (gray)
Post 2001 Meeting	Incorporate feedback from Commission; run any necessary additional or revised trials.	Incorporate feedback from Commission.	Finalise specifications of all *Trials*.
Workshop	Review intersessional work; select preferred candidate and advise on tuning options for presentation to the Commission.		Candidate *SLA(*s) coded and sent to Secretariat; *Evaluation Trials* coded, run and results circulated.
2002 Meeting	Finalise all aspects for presentation to Commission.		*Robustness Trials* run and results available at meeting; examine trial results and determine 'preferred' candidate(s); revise *Cross-Validation Trials* if necessary.

The SWG **agreed** to the principles below.

9.2.1 Survey/census methodology and design

The SWG **agreed** that plans for undertaking a survey/census should be submitted to the Scientific Committee in advance of their being carried out, although prior approval by the Committee is not a requirement. This should normally be at the Annual Meeting before the survey/census is being carried out. Sufficient detail should be provided to allow the Committee to review the field and estimation methodology. Considerably more detail would be expected if novel methods are planned.

9.2.2 Committee oversight

The SWG **agreed** that it was appropriate that should it desire, the Scientific Committee could nominate one of its members to observe the survey/census to ensure that proposed methods were adequately followed. This would be more important if novel methods were being used.

9.2.3 Data analysis

The SWG **agreed** that it was appropriate that all data to be used in the estimation of abundance were made available to the Scientific Committee suitably in advance of the Annual Meeting at which an estimate was to be presented. If new estimation methods are used, the Committee may require that computer programs (including documentation to allow such programs to be validated) shall be provided to the Secretariat for eventual validation by them.

9.3 Guidelines for data/sample collection

The SWG **agreed** that data from each harvested animal should be collected and made available to the IWC. The following information should normally be provided for each whale: species, number of animals, sex, season, position of catch (to the nearest village), length of catch (to 0.1m). It further requested that information/samples on reproductive status and samples for genetic studies be collected where possible.

10. PRESENTATION TO THE COMMISSION

The Committee reiterated the importance it attached to continuing dialogue with the Commission and hunters throughout the development process. It referred to Item 9 above and **recommends**, as in previous years: (1) a presentation by the Chairman of the SWG of its report and a less technical Chairman's discussion paper; and (2) informal discussions among the SWG Chairman and interested Commissioners.

11. MANAGEMENT ADVICE FOR MINKE AND FIN WHALES OFF GREENLAND

The SWG noted that in 2000, 142 minke whales (102 females, 36 males, 4 unknown) were taken off West Greenland and three were struck-and-lost. In the same year, 10 minke whales (2 males and 8 females) were taken off East Greenland and 6 fin whales (3 males and 3 females plus 1 struck-and-lost animal) were taken off West Greenland.

The SWG recalled that the Committee has never been able to provide satisfactory scientific advice on either the fin or minke whales off Greenland. It reflects the lack of data relating to both stock structure and abundance and is the reason the Committee first called for a Greenland Research Programme to be established in 1998 (IWC, 1999b). This inability to provide advice is a matter of great concern, particularly in the case of fin whales where the best available abundance estimate is from 1987/88 and is only 1,096 (95%CI 520-2,106), and the SWG **urges** continued funding of the research discussed under Item 7 above at the requisite levels, by both Greenland and the IWC. It reminds the Commission that without such information it may be many years before it is able to provide satisfactory scientific advice on these stocks. Even with the success of the programme, it is difficult to envisage that the SWG will be able to develop a suitable *SLA* (or *SLA*s) for the Greenlandic fisheries before 2006.

12. WORK PLAN

The SWG **agreed** that a small working group chaired by Donovan would continue to meet after the close of the SWGs business to: (1) develop a detailed work plan related to the work necessary to be completed on the D-M and G-G *SLA*s including deadlines for both developers and for computing tasks; (2) to determine the timing, costs and venue of an intersessional workshop; and (3) to refine the work needed to move towards final specification of *Robustness trials* and *Cross-validation trials* for the gray whale. Item 1 is reported in Appendix 4.

The SWG **recommended** the continuation of the AWMP developers' fund at the level of £8,000. Donovan noted that this fund had been critical to the SWG's rapid AWMP development pace and to the excellent quality and quantity of *SLA*s submitted for consideration thus far.

13. ADOPTION OF REPORT

The SWG congratulated Allison for completing the many tasks requested of her during this year's meeting and during the last meeting. The report was adopted at 9:00am on July 14, 2001.

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Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 1:61-116.
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Witting, L. 2000. Seasonal and geographical distribution of catches of minke and fin whales in West Greenland, 1988-99. Paper SC/52/AS2 presented to the IWC Scientific Committee, June 2000, in Adelaide, Australia (unpublished). [Paper available from the Office of this Journal].
Witting, L., Villum, V., Dueck, L., Numminem, L. and Heide-Jorgensen, M.P. 2000. A feasibility study on tagging and biopsy sampling of West Greenland minke and fin whales. Paper SC/D2K/AWMP5 presented to the Third Workshop on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP), December 2000, Seattle (unpublished). [Paper available from the Office of this Journal].

Appendix 1

AGENDA

1. Introductory items
   1.1 Convenor's opening remarks
   1.2 Election of Chair
   1.3 Appointment of rapporteurs
   1.4 Adoption of agenda
   1.5 Review of documents

2. Progress since Seattle
   2.1 Computing tasks
   2.2 Other

3. Description of potential procedures for bowhead whales
   3.1 The Dereksdottir-Magnusson (D-M) *SLA*
   3.2 The Givens *SLA* 1(G-G)
   3.3 The Givens *SLA* 2(G-M)
   3.4 The Johnston-Butterworth (J-B)
   3.5 The Punt (A-P) *SLA*

4. Principles of selection of *SLA*s

5. Review results of bowhead whale trials
   5.1 Graphical presentation and performance statistics
   5.2 Initial consideration of preferred candidate(s)
   5.3 Comparison of *SLA*s using the *Evaluation trials*
   5.4 General features of the D-M and G-G *SLA*s
   5.5 Comparison of *SLA*s using the *Cross-validation* and *Robustness Trials*
   5.6 Selection of preferred candidate *SLA*(s)

6. Review of gray whale trials

7. Progress on development of potential *SLA*s for Greenlandic fisheries and the Greenland Research Programme
   7.1 The fisheries
   7.2 Stock structure, range, movement
   7.3 Abundance and trends
   7.4 Preliminary consideration of management procedures
   7.5 Biological data
   7.6 Recommendations
      7.6.1 Annual inshore surveys
      7.6.2 Exploratory simulation studies
      7.6.3 Satellite tagging
      7.6.4 Planning for a large-scale survey

8. Progress on consideration of Fishery type 3

9. Scientific aspects of an Aboriginal Subsistence Whaling Scheme
   9.1 'Rules'
      9.1.1 Carryover
      9.1.2 Phase-out (and survey interval)
   9.2 Guidelines for surveys
      9.2.1 Surveys/census methodology and design
      9.2.2 Committee oversight
      9.2.3 Data analysis
   9.3 Guidelines for data/sample collection

10. Presentation to the Commission

11. Management advice for minke and fin whales off Greenland

12. Work plan

13. Adoption of report

Appendix 2

TERMINOLOGY

The following table contains working definitions agreed in order to ensure consistency in the terminology used during the development of the AWMP. No attempt was made to change the definitions of terms currently used by the Committee, but rather it was considered important to be consistent in the use of terminology in describing the process by which the AWMS will be developed. This table is viewed as a living document whose contents may change to reflect AWMP development progress.

PROCEDURES (Schemes, Procedures and Algorithms)	
AWMP	Aboriginal Subsistence Whaling Management Procedure.
AWMS	Aboriginal Subsistence Whaling Scheme.
SLA	*Strike Limit Algorithm*: an algorithm that produces limits on strikes for a management stock (note: for some hunts all strikes may not result in a mortality).
OBJECTIVES	
Biological stock	Biological population.
Block limit	Limit on strikes, where applicable with a time period > 1yr.
Management stock	Management unit for which a limit on strikes is set and where the area must be specified on a case-by-case basis.
Minimum stock level	(See Paragraph 13(a) of the Schedule - note: acceptable risk level not defined).
Need	Specified by the Commission.
DEVELOPMENT (Trials, Evaluations and Tuning)	
Additional variance	The extent by which variability of successive abundance estimates exceeds the estimated variability of the estimates. This is implemented as the difference between the CV provided to the *SLA* (CV_{est}) and the true CV used when generating the abundance estimate (CV_{true}).
Carryover strikes	Unused strikes that can be added to the strike limit for the subsequent year or group of years.
Case-specific trial	A trial in which the population size and other input parameters are customised to represent a specific application.
Common Control Program	The computer code which is used by developers to conduct *Initial Exploration Trials* and calculate performance statistics.
Conditioning	The process of selecting specifications/parameter values for case-specific trials to ensure that they are not inconsistent with already existing data.
Cross-validation Trials	Case-specific trials to be held aside from *SLA* development so that resulting *SLAs* can be subjected to a subsequent independent test.
Design criterion	A way to evaluate an *SLA*, expressed in terms of what an *SLA* should look like, conceptually or structurally; any criterion that is not a performance criterion.
Demographic stochasticity	Taking account of random variability in the number of births and deaths each year.
Equivalence tuning	A way to provide *SLA* developers with the opportunity to adjust their *SLA*s to strive towards a pre-specified balance of risk, satisfaction of need and recovery.
Evaluation Trials	Trials used for formal comparisons of candidate *SLA*s. Their number would be limited, compared to the number of *Robustness Trials*. *Evaluation trials* would be initiated prior to *Robustness Trials*.
Generic trial	A trial in which the population size or the other input parameters are not customised to represent a specific application.
H:	An *SLA*, which represents a particular balance among risk, need satisfaction and recovery and which operates in the idealised case when the parameters of the Common Control Program are known exactly.
H-optimisation	A method for improving performance of *SLA*s, singly or merged, by minimising the Bayes risk (i.e. weighted expected loss) of its strike limits relative to those of an idealised *SLA, H*.
Implementation Trials	The final set of trials upon which a *SLA* for a specific stock is recommended to the Commission.
Implementation Review	A major review of information carried out before calculation of a new block of quotas or in response to significant new information in the middle of a block if it is thought it might result in a significant change to a catch limit.
Initial Exploration Trial	Case-specific simulation trials for assessing the merits of performance statistics and to provide a framework for developers in the AWMP.
Merging of *SLA*s	Any method for combining *SLA*s that produces a new *SLA* which provides strike limits depending on the limits given by the component *SLA*s.
Need Envelope	Sets bounds on the situations that an AWMP will have to be able to cope with, at least with respect to the objective to fulfil 'need' requirements - used for the purposes of simulations only.
Performance criterion	A way to evaluate an *SLA*, expressed in terms of a performance statistic.
Performance statistic	A statistic used to evaluate how well a specific *SLA* achieves some or all of the objectives for the AWMP.
Performance tuning	A way to change the behaviour of an *SLA* to reflect management objectives.
Retrofitting	*Post-hoc* adjustment of the output of an *SLA* to optimally resemble a different *SLA* or set of management objectives.
Replacement yield	The catch during year *t* that will keep the recruited population size at the start of year *t*+1 the same as that at the start of year *t*.
Robustness Trials	Trials to examine *SLA* performance for a full range of plausible scenarios. These would be applied to a restricted set of *SLA*s found to perform well in *Evaluation trials*. The number of these trials would be potentially large.
Type 1 fishery	A case where there is relatively little available information and stock identity problems and where the Committee has had considerable problems providing advice under Para. 13(a).
Type 2 fishery	A case where there is relatively large amount of information and Para. 13(a) has largely been met (e.g. Bering-Chukchi-Beaufort bowhead whales).
Type 3 fishery	A case where there is relatively little available information, small population size and stock identity problems (e.g. West Greenland fin whales) and where the Committee has had, or would have, considerable problems providing advice under Para. 13(a).
Sustainable yield	For a given stock size, the catch that would result if the population remained at that stock size indefinitely – the long-term value for replacement yield.
U-optimisation	A method for calibrating performance of an *SLA* so that its strike limits optimally match an explicitly defined measure of risk.
REVISED MANAGEMENT PROCEDURE (RMP) The RMP is described in detail in IWC (1994, pp.145-52).	
CLA	*Catch Limit Algorithm*, the process described in IWC (1994, pp.147-8) that is used in the RMP to calculate a catch limit for a *Management Area*.
Implementation/ Simulation Trials	Involve identifying the range of plausible hypotheses relevant to recommending an *Implementation* or *Implementation Review* for the RMP and formulating simulation models which conform with these hypotheses.

Appendix 3

EXAMPLES OF THE GRAPHICAL SUMMARY PLOTS FOR THE *EVALUATION* AND *ROBUSTNESS* TRIALS

Table 1

The *Evaluation Trials* for the Bering-Chukchi-Beaufort Seas stock of bowhead whales.
(Parameter values that differ from base-case values are highlighted in bold.)

Trial no.	Description	Model	$MSYR_{1+}$	$MSYL_{1+}$	Final need	Historical survey bias	Future survey bias	Survey CV (true, est)	Age data	Other
BE01*	Base case	D, S_E	2.5%	0.6	134	1	1	0.25, 0.25	Good	
BE02	Constant need	D	2.5%	0.6	**67**	1	1	0.25, 0.25	Good	
BE03	Future +ve bias	D, S_E	2.5%	0.6	134	1	**1→1.5 in yr 25**	0.25, 0.25	Good	
BE04	Future –ve bias	D	2.5%	0.6	134	1	**1→.67 in yr 25**	0.25, 0.25	Good	
BE05	Underestimated *CV*s	D	2.5%	0.6	134	1	1	**0.25, 0.10**	Good	
~~BE06~~	Deleted SC2000									
BE07*	$MSYL_{1+}$ = 0.8	D, S_E	2.5%	**0.8**	134	1	1	0.25, 0.25	Good	
BE08	10 yr surveys	D	2.5%	0.6	134	1	1	0.25, 0.25	Good	10 year surveys
BE09*	$MSYR_{1+}$ = 1%	D, S_E	**1%**	0.6	134	**0.67 → 1**	1	0.25, 0.25	Good	
BE10*	$MSYR_{1+}$ = 4%	D	**4%**	**0.8**	134	1	1	0.25, 0.25	Good	
BE11	Bad data	D	2.5%	0.6	134	1	**1→1.5 in yr 25**	**0.25, 0.10**	Poor	
BE12*	Difficult 1%	D, S_E	**1%**	0.6	134	**1 → 1.5**	**1.5**	**0.25, 0.10**	Poor	
BE13	Difficult 1%; constant need	D	**1%**	0.6	**67**	**1 → 1.5**	**1.5**	**0.25, 0.10**	Poor	
BE14	Need increases to 201	D	2.5%	0.6	**201**	1	1	0.25, 0.25	Good	
~~BE15~~	~~Future +ve bias; 201 need~~	~~D~~	~~2.5%~~	~~0.6~~	~~**201**~~	~~1~~	~~**1→1.5 in yr 25**~~	~~0.25, 0.25~~	~~Good~~	
BE16	$MSYR_{1+}$ = 1%; 201 need	D, S_E	**1%**	0.6	**201**	**0.67 → 1**	1	0.25, 0.25	Good	
~~BE17~~	Demoted to BR04 SC2000									
~~BE18~~	Demoted to BR04 SC2000									
~~BE19~~	Demoted to BR04 SC2000									
BE20*	$MSYR_{1+}$ = 4%; 201 need	D	**4%**	**0.8**	**201**	1	1	0.25, 0.25	Good	
BE21*	Integrated	D	**U[1,4%]**	**U[.4-.8]**	134	1	1	0.25, 0.25	Good	
BE22*	Time lag in density dependence	D, S_E	2.5%	0.6	134	1	1	0.25, 0.25	Good	20 year lag
BE23	Strategic surveys; 201 need	D	2.5%	0.6	**201**	1	1	0.25, 0.25	Good	Strategic surveys
BE24*	Inertia Model (A_i/A=0.5)	D	**Selected from 0.1 – 2%**[§]	0.6	134	1	1	0.25, 0.25	Good	Inertia model

* Requires conditioning. **§** $MSYR_{1+}$ here refers to MSYR in the absence of inertia dynamics.

Table 2

The *Robustness Trials*. The trials indicated with asterisks were deleted during the meeting.

Trial	Factor	Basic trials (see Table 2)	Factor Level
BR01	A: Density-dependence	1, 1^S, 9, 9^S,10*	Density-dependence on mature (BE trials use 1+)
BR02	B: Stochastic dynamics	2^{S}*, 8^{S}, 13^{S}	Stochastic dynamics (with serially-correlated environmental variation)
~~BR03~~	~~D: Form of need time dependence~~	~~1, 9, 9^S, 10~~	~~Step function in year 2053~~
BR04	E: Survey frequency	9, 13, 14, 16, 20	15 years
		16, 20	10 years
BR05	F: Strategic surveys	1*, 9	Yes + CV = (0.25, 0.25)
		1*, 9	Yes + CV = (0.34, 0.25)
BR06	G: Survey bias time dependence	1	Historic bias: 1.5 constant; Future bias: decreasing (1.5→1)
		1	Historic bias: 0.67 constant; Future bias: increasing (0.67→1)
		9, 9^S	Future bias: sinusoidal from base value in yr 0 to maximum of 150% in eayr 40
		12, 12^S	Future bias: decreases (1.5→1)
		14	Future bias: increases from 1→1.5 in year 25 and constant thereafter (formerly BE15)
BR07	H: Future survey *CV*	1	CV = (0.1, 0.1)
		1*, 1^S	CV = (0.34, 0.25)
		9	(0.1, 0.1) + sinusoidal survey bias (factor G)
BR08	I: Historic catch bias	14, 16*, 16^S,20*	0.5
		14, 16, 16^S	1.5
BR09	K: Time dependence in *K*	1, 2*, 9, 10	*K* halves linearly over 100 years
		1, 2*, 9, 10	*K* doubles linearly over 100 years
		1	*K* varies sinusoidally from base value in year 0 to maximum of 150% in year 40
		1, 21	Tent *K: K* doubles linearly between years -50 to 0 and halves between years 0 to 50
		1, 9	*K* halves linearly over 100 years + strategic surveys
BR10	L: Time dependence in *MSYR*	10	*MSYR* halves linearly over 100 years
		9	*MSYR* doubles linearly over 100 years
		1, 2*, 8	Step *MSYR* 2½%→1%→2½% every 33 years (alone)
		1, 2*, 8	Step *MSYR* 2½%→1%→2½% every 33 years in sync with *M* (compute *MSYR* first) – if it is practical (halve *M* for each age class)
		1	*K* and *MSYR* halve linearly over 100 years
		1, 21	*K* and *MSYR* vary as tent *K* (see BR09)
BR11	M: Time dependence in *M*	1, 2*, 9, 10	*M* halves linearly over 100 years
		1, 2*, 9, 10	*M* doubles linearly over 100 years
BR12	N: Episodic events	1, 1^S, 2*, 9, 9^S, 10*, 10^S*	Two events in which 20% of animals die occur between years 1-50
BR13	O: Integrated.	1, 11, 14	$MSYR_{1+}$~U[0.01, 0.04]; fixed $MSYL_{1+}$=0.6
		11, 14	$MSYR_{1+}$~U[0.01, 0.04]; $MSYL_{1+}$~U[0.4, 0.8]
		1, 1^S, 2*, 11, 11^S, 14	$MSYR_{1+}$~U[0.01, 0.04]; $MSYL_{1+}$~U[0.4, 0.8]; historical catch bias ~U[0.5, 1.5]; Serial correlation ~ U[0.47, 0.95]
		1^S, 11^S	$MSYR_{1+}$~U[0.01, 0.04]; $MSYL_{1+}$~U[0.4, 0.8]; historical catch bias ~U[0.5, 1.5]; Serial correlation ~ U[0.47, 0.95]; time delay in density dependence ~U[0, 30]
BR14	P: Initial year of population projection	1, 9, 10*	1940 (reference or base case level is 1848)
BR15	Q: $MSYL_{1+}=0.9$	1, 9, 10	
BR16	R: Different stochastic parameters	1^S	Correlation in recruitment ρ = *-0.75*
		1^S	Correlation in recruitment ρ = *0.9*
		1^S, 9^S, 10^S	Correlation in recruitment ρ = *0.9;* + episodic events
		1^S	Change s_e^2 to give 3* variation in population size at equilibrium
		1^S, 9^S	Serial correlation = *0.9* + change s_e^2 to give 3* equilibrium variation +episodic events
BR17	S: Time lag in density dependence	9*	20 year time lag

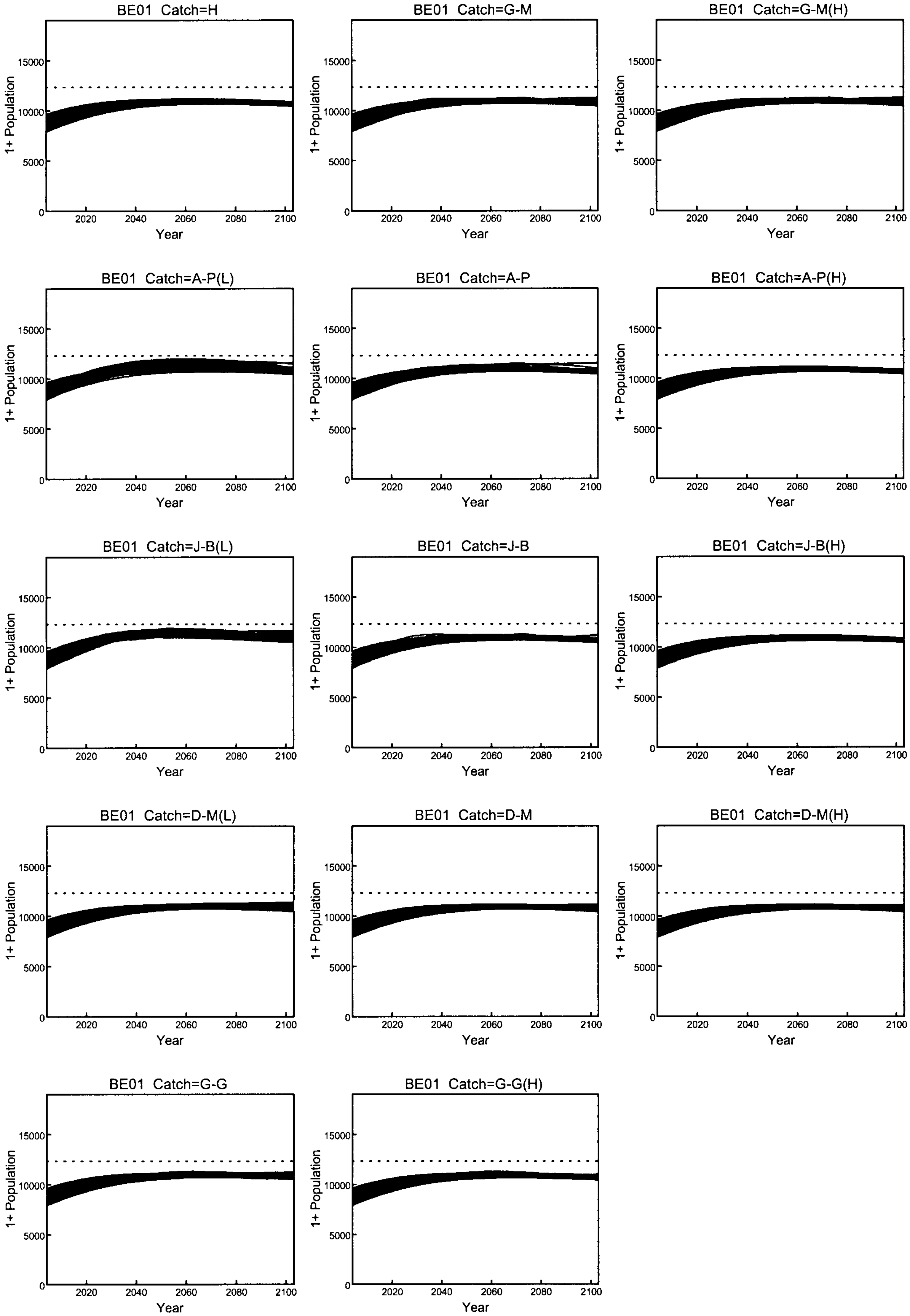
Table 3

Factors and ranges for constructing the *Cross-validation Trial*s.

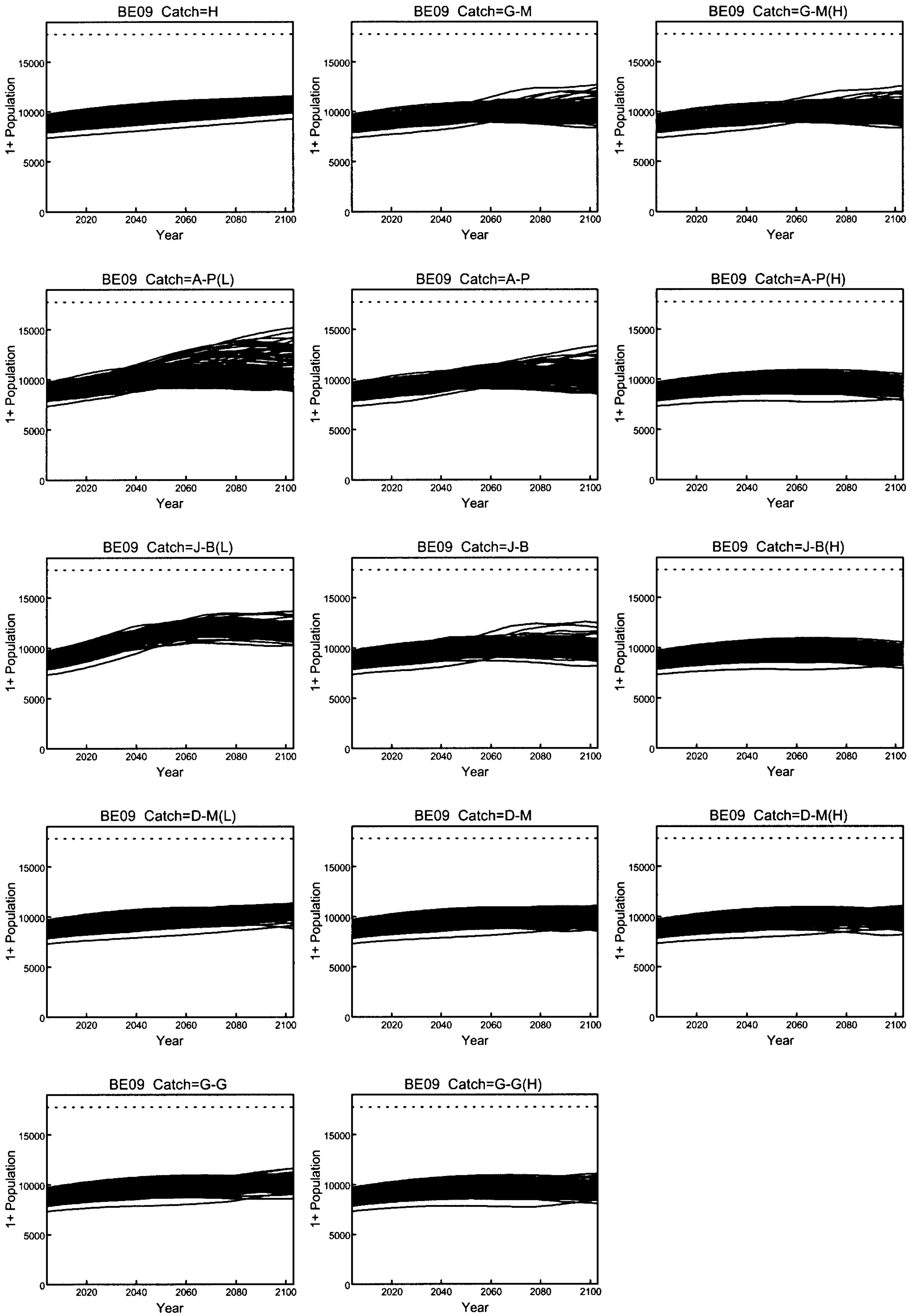
Factor	Range
$MSYR_{1+}$	1 – 4%
$MSYL_{1+}$	0.4 – 0.8
Final need	67 – 201
Survey bias in future year 25	0.67 – 1.5
Estimated survey CV	0.1 – 0.4*
Time-lag	0 – 20

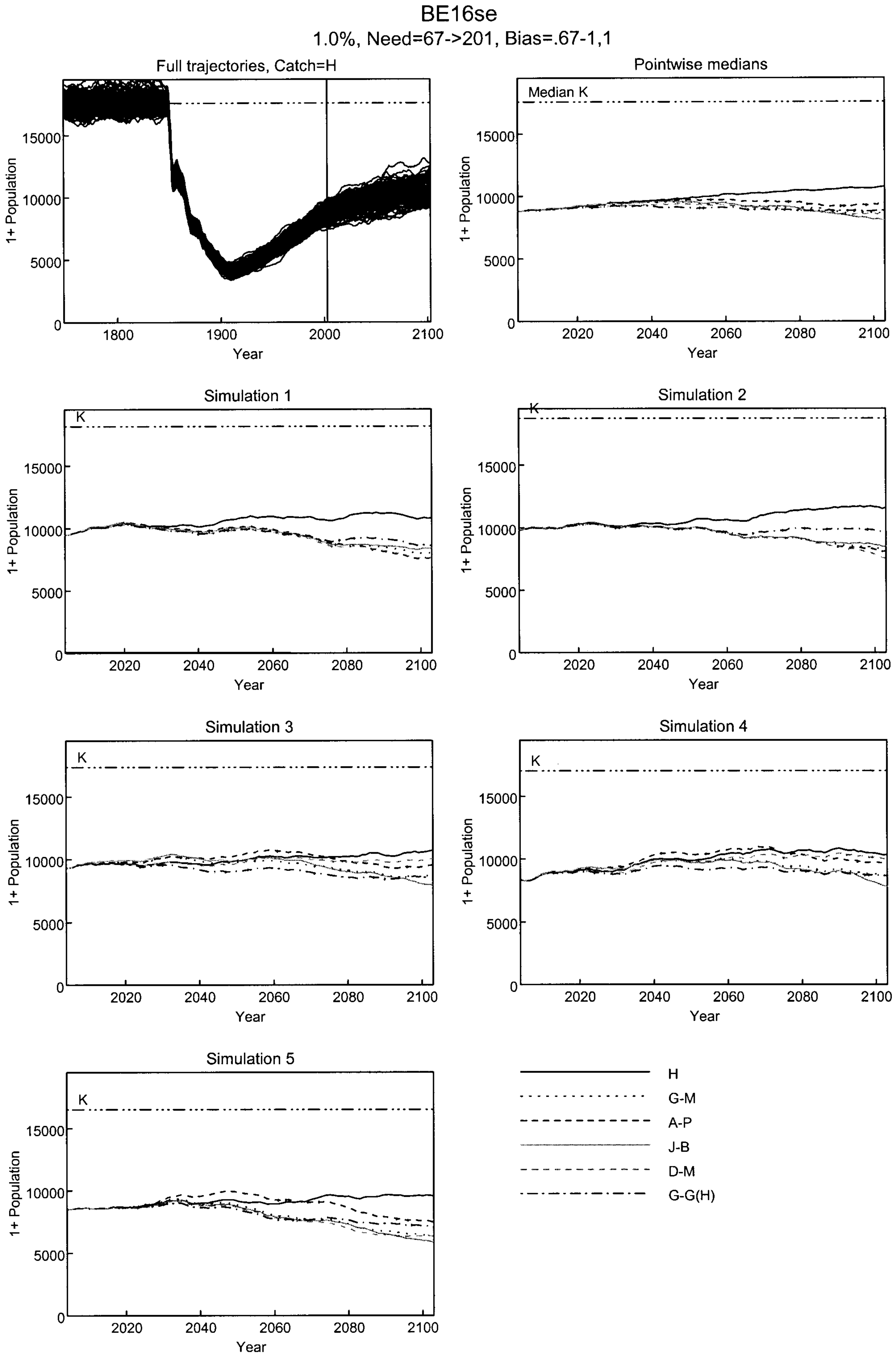
* Modified from 0.25 agreed at the last meeting.

BE01 Base Case: 2.5%, Need=67->134

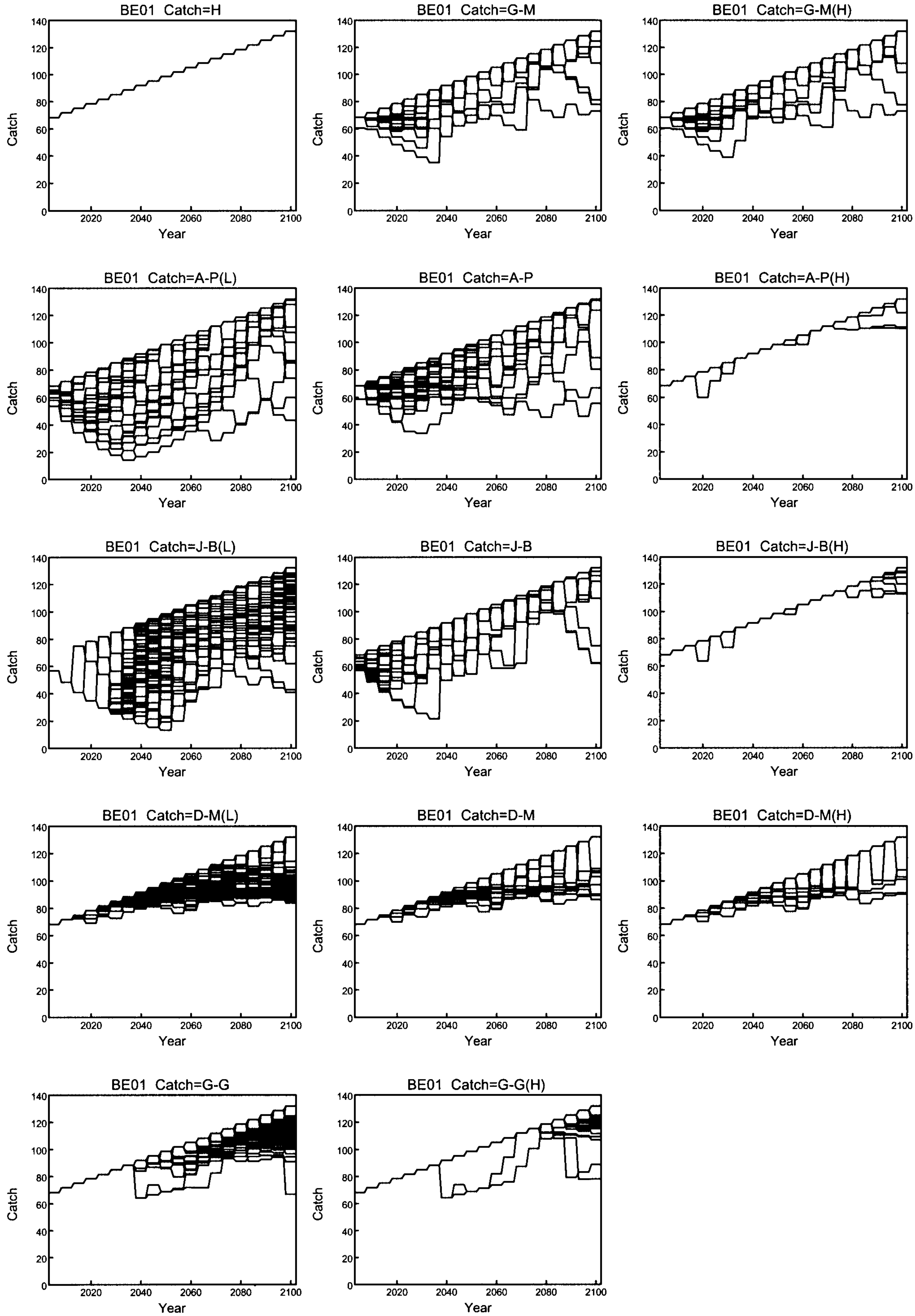


BE09 1.0%, Need=67->134, Bias=.67-1,1

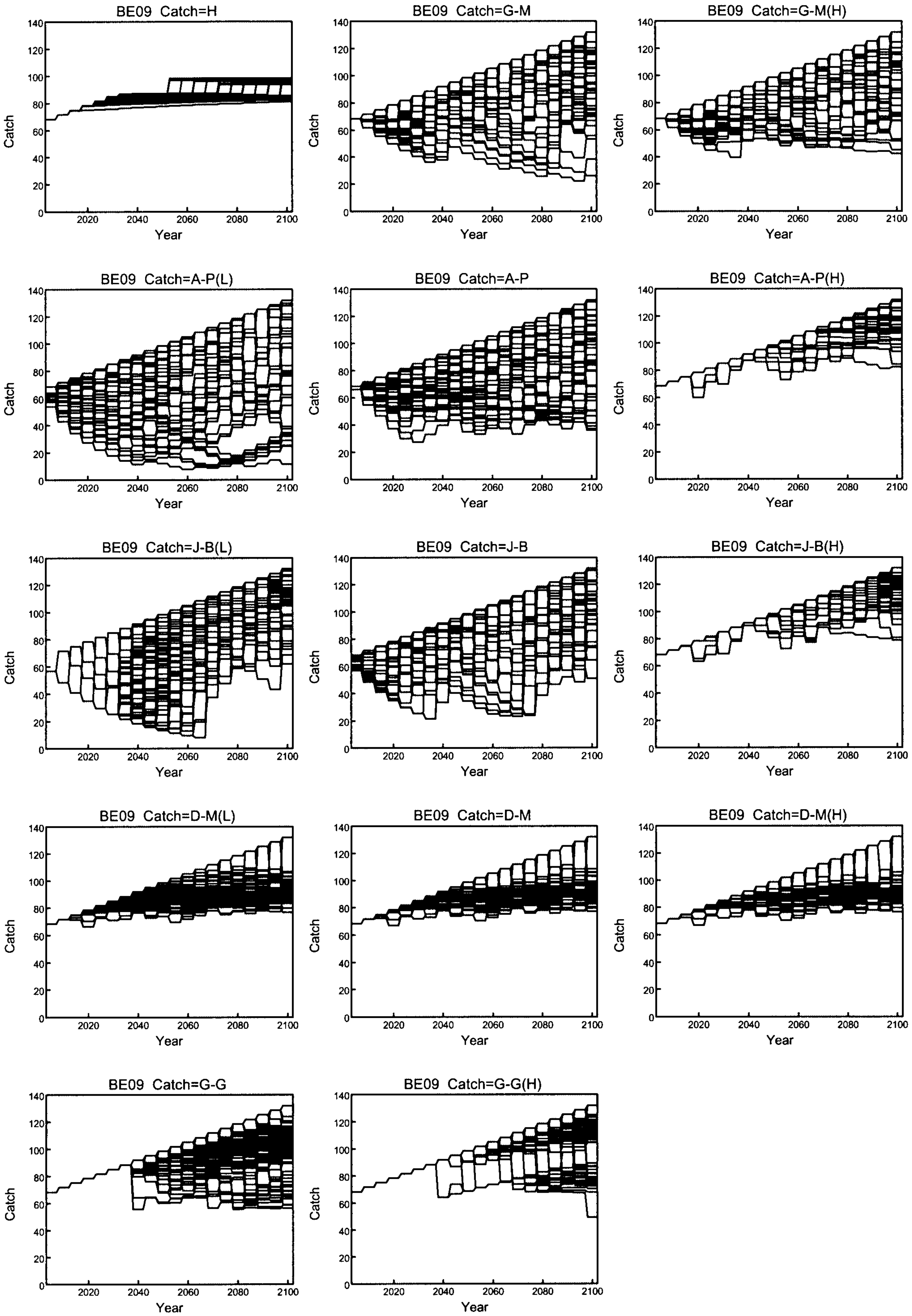



BE16se
1.0%, Need=67->201, Bias=.67-1,1
Full trajectories, Catch=H
Pointwise medians
Median K
Simulation 1
Simulation 2
Simulation 3
Simulation 4
Simulation 5
K
1+ Population
Year
0
5000
10000
15000
1800
1900
2000
2100
2020
2040
2060
2080
H
G-M
A-P
J-B
D-M
G-G(H)

BE01 Base Case: 2.5%, Need=67->134

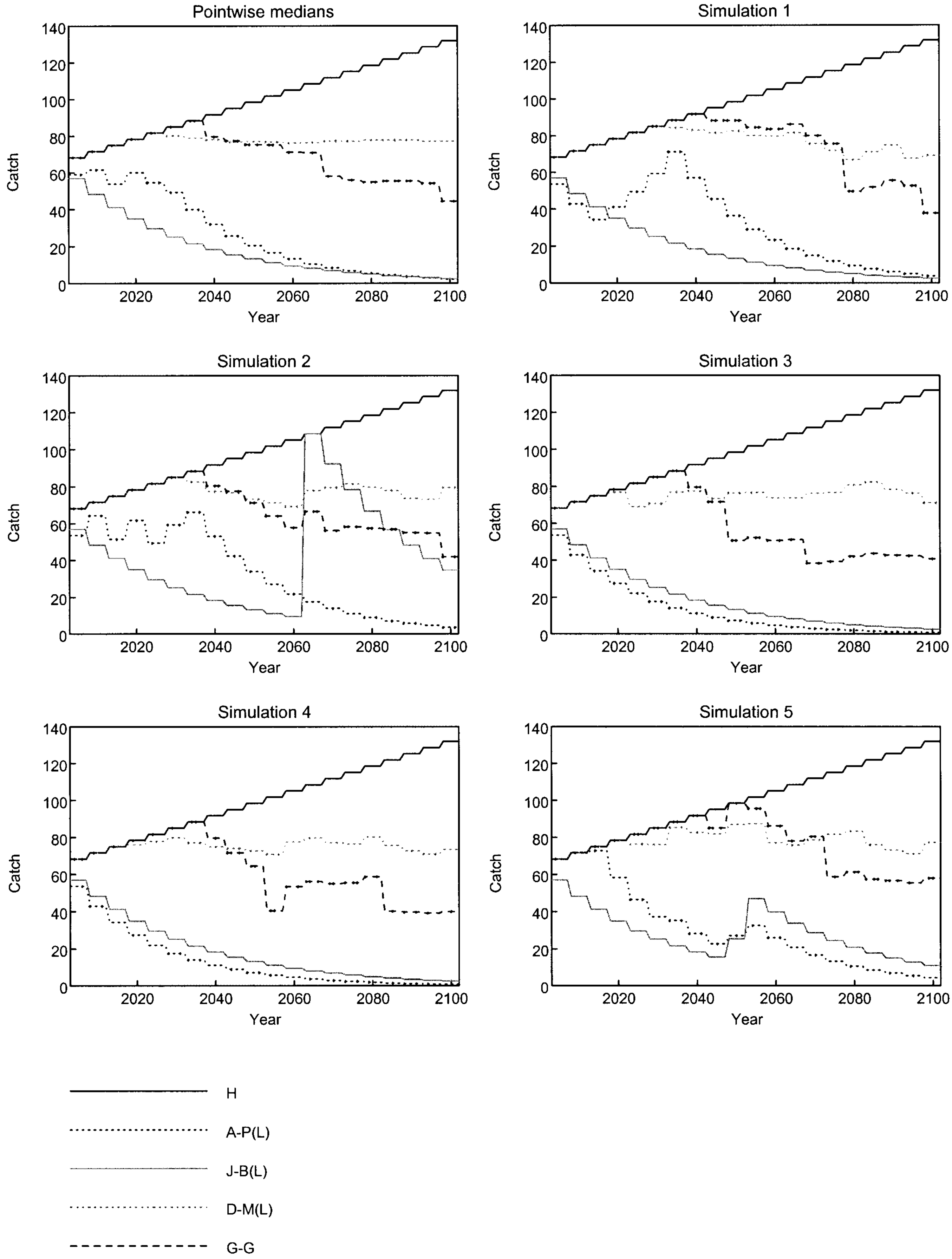


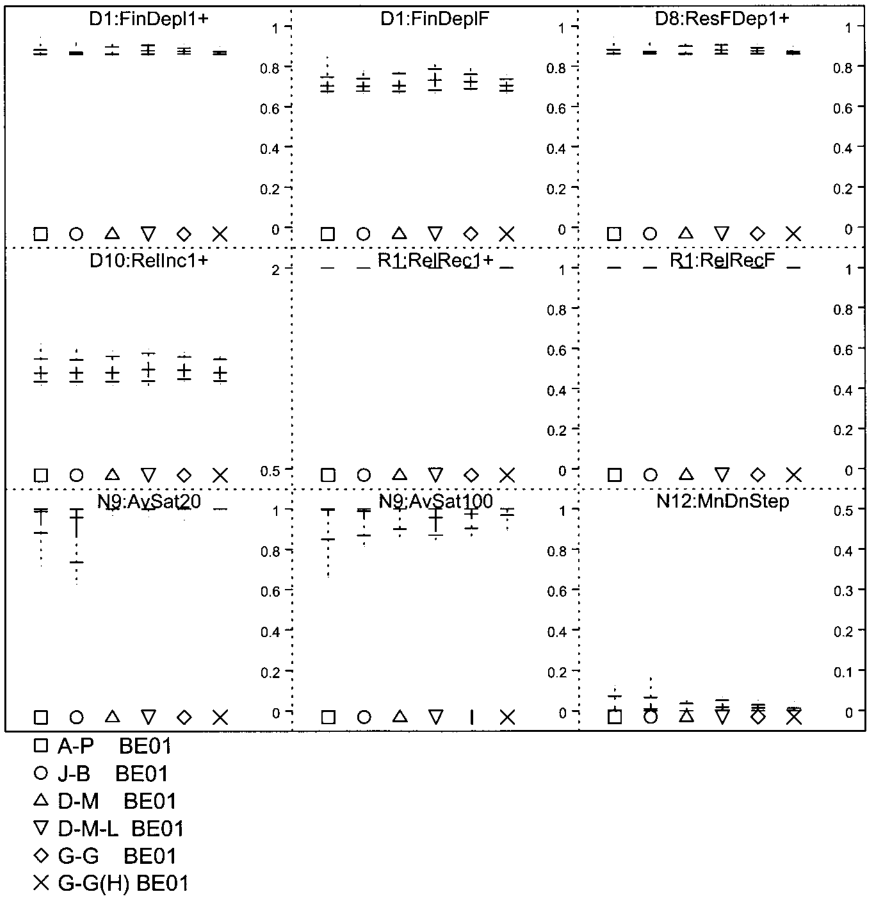
BE09 1.0%, Need=67->134, Bias=.67-1,1

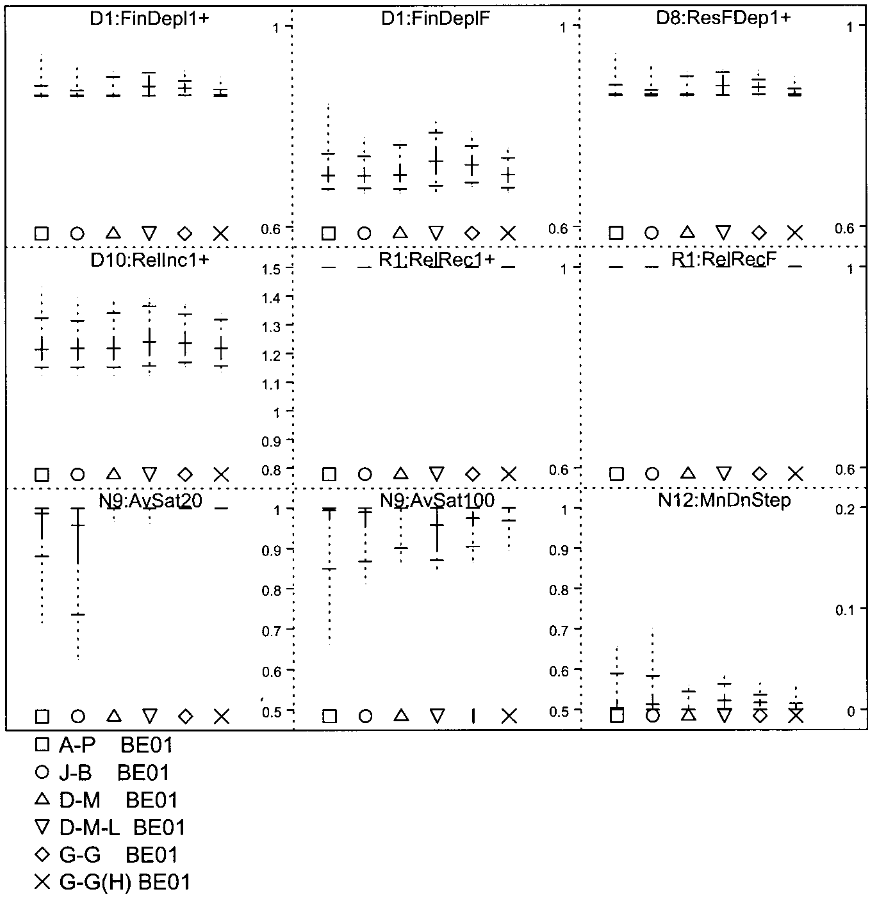


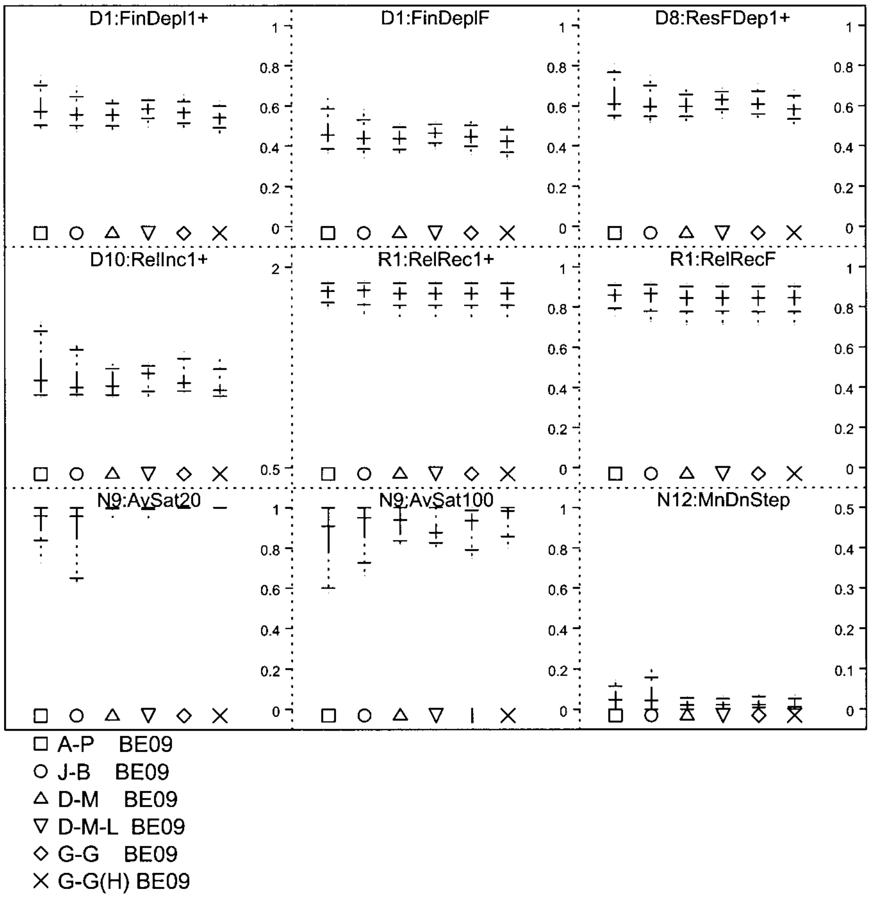
BE04

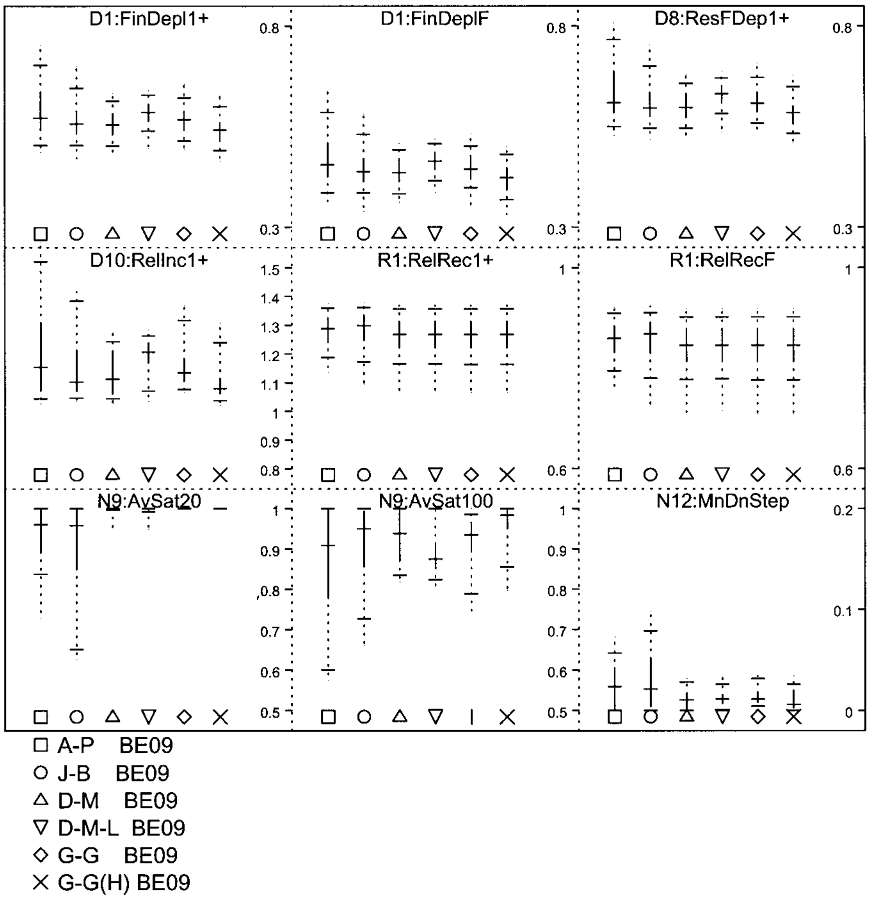
2.5%, Need=67->134, Bias=1,0.67

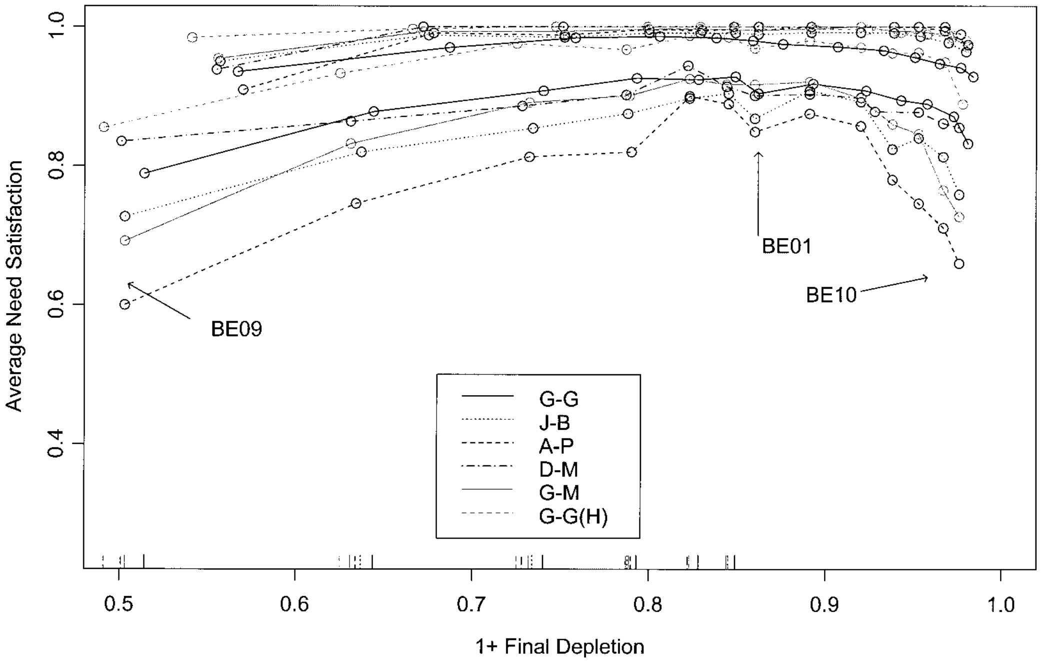



D1:FinDepl1+
D1:FinDeplF
D8:ResFDep1+
D10:RelInc1+
R1:RelRec1+
R1:RelRecF
N9:AvSat20
N9:AvSat100
N12:MnDnStep
A-P BE01
J-B BE01
D-M BE01
D-M-L BE01
G-G BE01
G-G(H) BE01

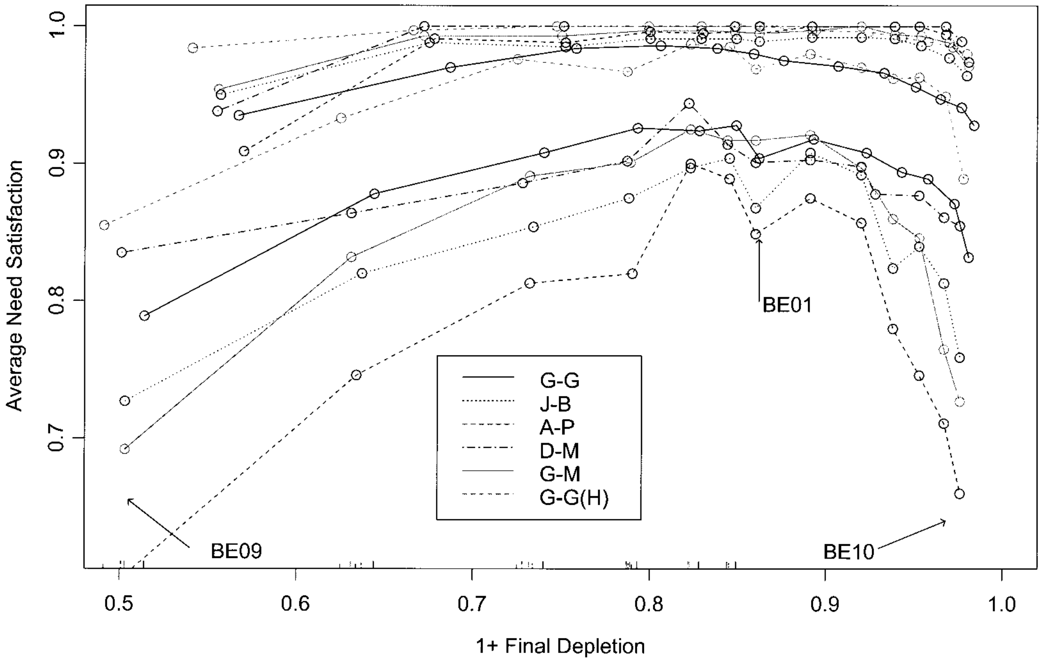

D1:FinDepl1+
D1:FinDeplF
D8:ResFDep1+
D10:RelInc1+
R1:RelRec1+
R1:RelRecF
N9:AvSat20
N9:AvSat100
N12:MnDnStep
A-P BE01
J-B BE01
D-M BE01
D-M-L BE01
G-G BE01
G-G(H) BE01


D1:FinDepl1+
D1:FinDeplF
D8:ResFDep1+
D10:RelInc1+
R1:RelRec1+
R1:RelRecF
N9:AvSat20
N9:AvSat100
N12:MnDnStep
□ A-P BE09
○ J-B BE09
△ D-M BE09
▽ D-M-L BE09
◇ G-G BE09
✕ G-G(H) BE09

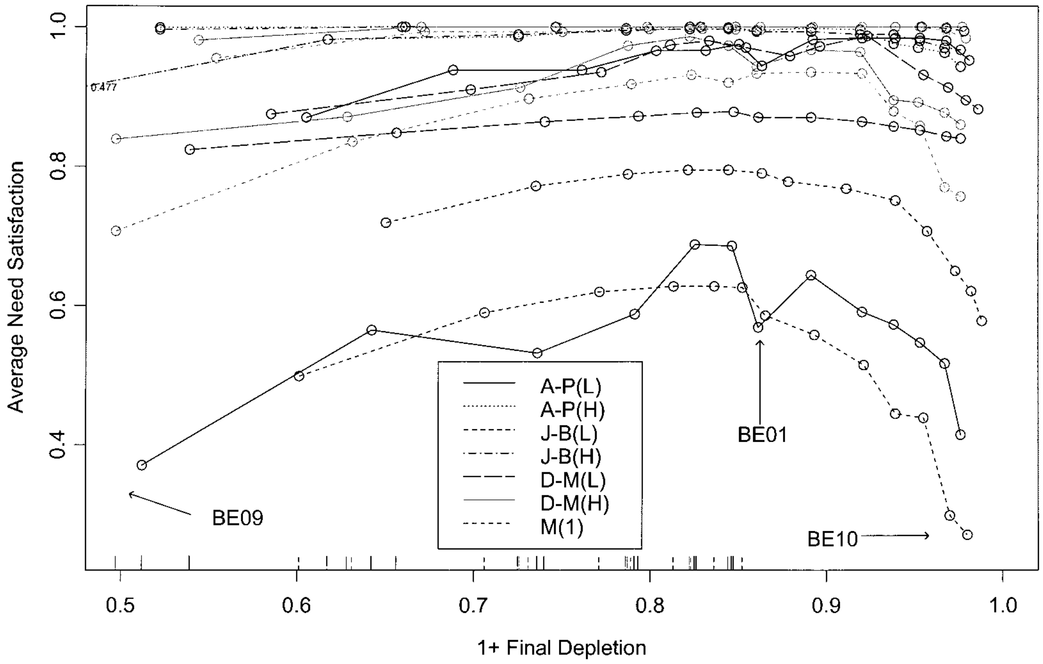

D1:FinDepl1+
D1:FinDeplF
D8:ResFDep1+
D10:RelInc1+
R1:RelRec1+
R1:RelRecF
N9:AvSat20
N9:AvSat100
N12:MnDnStep
□ A-P BE09
○ J-B BE09
△ D-M BE09
▽ D-M-L BE09
◇ G-G BE09
✕ G-G(H) BE09



Average Need Satisfaction
1.0
0.8
0.6
0.4
BE01
BE10
BE09
G-G
J-B
A-P
D-M
G-M
G-G(H)
0.5
0.6
0.7
0.8
0.9
1.0
1+ Final Depletion

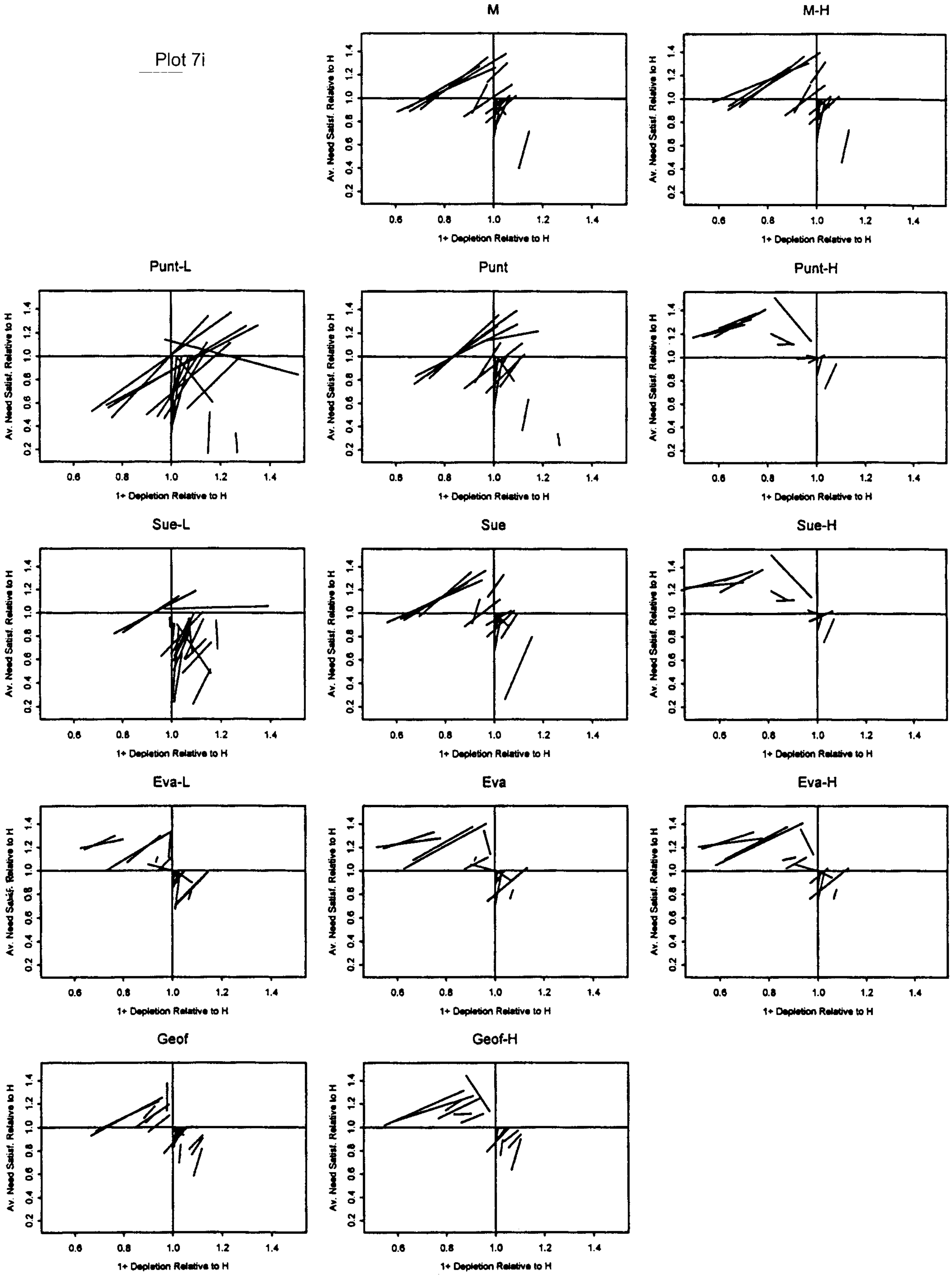


Average Need Satisfaction
1.0
0.9
0.8
0.7
BE01
BE09
BE10
G-G
J-B
A-P
D-M
G-M
G-G(H)
0.5
0.6
0.7
0.8
0.9
1.0
1+ Final Depletion



Average Need Satisfaction
1.0
0.8
0.6
0.4
0.477
BE01
BE09
BE10
A-P(L)
A-P(H)
J-B(L)
J-B(H)
D-M(L)
D-M(H)
M(1)
0.5
0.6
0.7
0.8
0.9
1.0
1+ Final Depletion

Plot 7i


M
M-H
Punt-L
Punt
Punt-H
Sue-L
Sue
Sue-H
Eva-L
Eva
Eva-H
Geof
Geof-H
Av. Need Satisf. Relative to H
1+ Depletion Relative to H
0.2
0.4
0.6
0.8
1.0
1.2
1.4

Plot 7ii

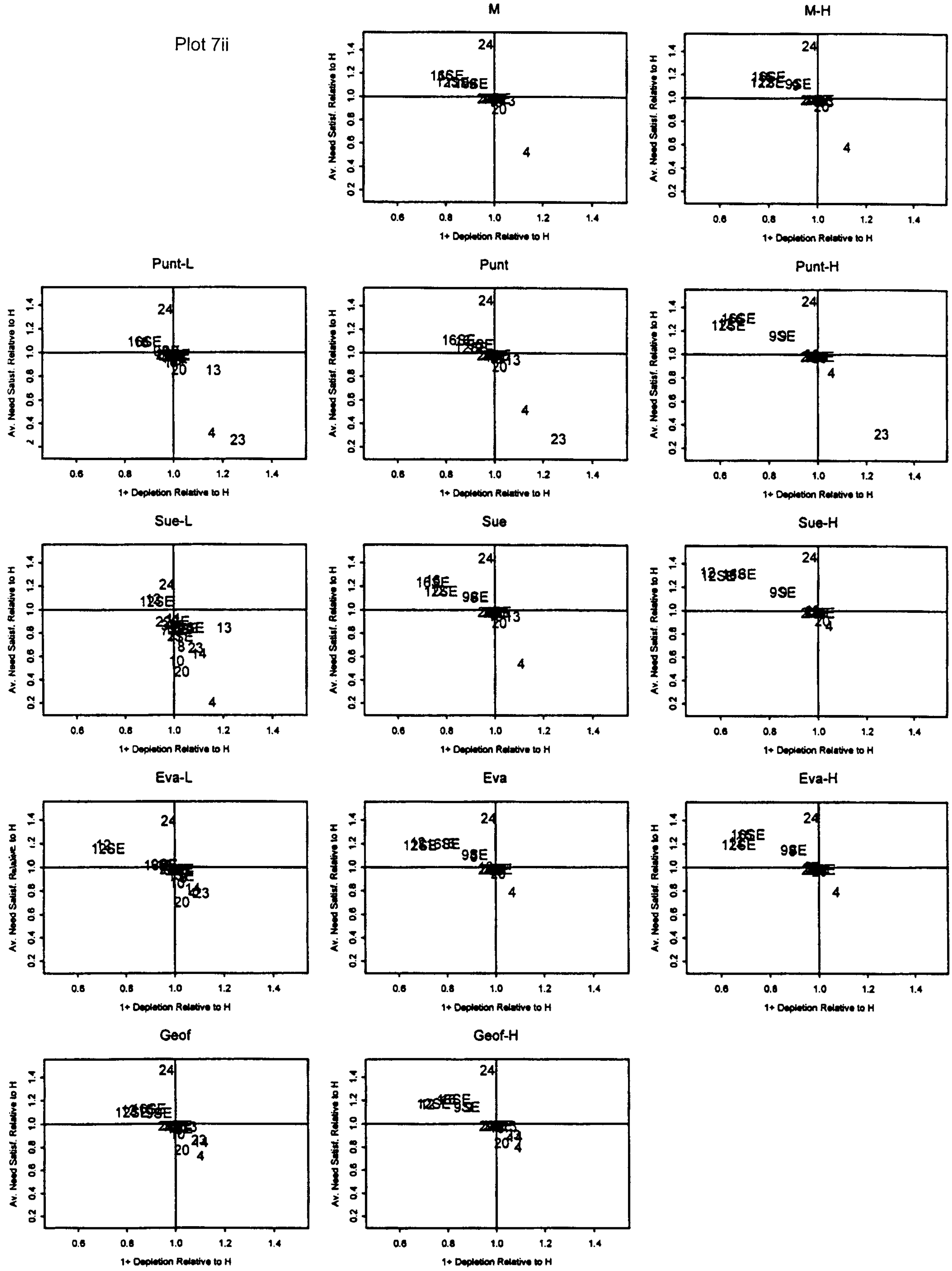

M
M-H
Punt-L
Punt
Punt-H
Sue-L
Sue
Sue-H
Eva-L
Eva
Eva-H
Geof
Geof-H
Av. Need Satisf. Relative to H
1+ Depletion Relative to H

Table of Statistics Example 1
BE01 Base Case: 2.5%, Need=67->134

Risk & Recovery Statistics (1+ population / Mature females) — **Need Statistics** (20yr horizon / 100yr horizon)

D1: Final depletion

	1+ population 5%	Med	96%	Mature females 5%	Med	96%
H	.860	.862	.863	.675	.699	.731
G-M	.860	.862	.875	.676	.701	.736
G-M(H)	.860	.862	.875	.675	.701	.736
A-P(L)	.861	.863	.900	.677	.706	.780
A-P	.860	.862	.881	.675	.702	.745
A-P(H)	.860	.862	.863	.675	.699	.731
J-B(L)	.865	.878	.923	.688	.733	.820
J-B	.860	.862	.871	.677	.701	.739
J-B(H)	.860	.862	.865	.675	.699	.731
D-M(L)	.861	.879	.906	.681	.730	.787
D-M	.860	.862	.898	.675	.703	.763
D-M(H)	.860	.862	.879	.675	.701	.736
G-G	.862	.876	.891	.687	.722	.760
G-G(H)	.860	.863	.873	.678	.703	.736

N1: Total need satisfaction

	20yr horizon 5%	Med	96%	100yr horizon 5%	Med	96%
H	1.000	1.000	1.000	1.000	1.000	1.000
G-M	.897	1.000	1.000	.932	.996	1.000
G-M(H)	.897	1.000	1.000	.943	.996	1.000
A-P(L)	.539	.824	1.000	.587	.959	1.000
A-P	.877	.989	1.000	.852	.996	1.000
A-P(H)	1.000	1.000	1.000	.995	1.000	1.000
J-B(L)	.618	.618	.618	.595	.807	.879
J-B	.734	.961	1.000	.896	.991	1.000
J-B(H)	1.000	1.000	1.000	.993	1.000	1.000
D-M(L)	.999	1.000	1.000	.851	.953	1.000
D-M	1.000	1.000	1.000	.885	1.000	1.000
D-M(H)	1.000	1.000	1.000	.941	1.000	1.000
G-G	1.000	1.000	1.000	.895	.968	1.000
G-G(H)	1.000	1.000	1.000	.961	1.000	1.000

D2: Lowest depletion

	5%	Med	96%
H	.405	.466	.530
G-M	.405	.466	.530
G-M(H)	.405	.466	.530
A-P(L)	.405	.466	.530
A-P	.405	.466	.530
A-P(H)	.405	.466	.530
J-B(L)	.405	.466	.530
J-B	.405	.466	.530
J-B(H)	.405	.466	.530
D-M(L)	.405	.466	.530
D-M	.405	.466	.530
D-M(H)	.405	.466	.530
G-G	.405	.466	.530
G-G(H)	.405	.466	.530

N4:Fraction of years in which catch=quota

	20yr horizon 5%	Med	96%	100yr horizon 5%	Med	96%
H	1.00	1.00	1.00	1.00	1.00	1.00
G-M	.25	1.00	1.00	.65	.95	1.00
G-M(H)	.25	1.00	1.00	.60	.95	1.00
A-P(L)	.00	.25	1.00	.05	.75	1.00
A-P	.25	.75	1.00	.30	.95	1.00
A-P(H)	1.00	1.00	1.00	.95	1.00	1.00
J-B(L)	.00	.00	.00	.05	.35	.60
J-B	.00	.75	1.00	.60	.90	1.00
J-B(H)	1.00	1.00	1.00	.90	1.00	1.00
D-M(L)	.75	1.00	1.00	.20	.62	1.00
D-M	1.00	1.00	1.00	.30	1.00	1.00
D-M(H)	1.00	1.00	1.00	.55	1.00	1.00
G-G	1.00	1.00	1.00	.45	.77	1.00
G-G(H)	1.00	1.00	1.00	.75	1.00	1.00

D9: Minimum population level

	1+ population 5%	Med	96%	Mature females 5%	Med	96%
H	**8061**	**8770**	**9244**	**1969**	**2248**	**2554**
G-M	**8061**	**8770**	**9244**	**1969**	**2248**	**2554**
G-M(H)	8061	8770	9244	1969	2248	2554
A-P(L)	8061	8770	9244	1969	2248	2554
A-P	8061	8770	9244	1969	2248	2554
A-P(H)	8061	8770	9244	1969	2248	2554
J-B(L)	8061	8770	9244	1969	2248	2554
J-B	8061	8770	9244	1969	2248	2554
J-B(H)	8061	8770	9244	1969	2248	2554
D-M(L)	8061	8770	9244	1969	2248	2554
D-M	8061	8770	9244	1969	2248	2554
D-M(H)	8061	8770	9244	1969	2248	2554
G-G	8061	8770	9244	1969	2248	2554
G-G(H)	8061	8770	9244	1969	2248	2554

N9: Average need satisfaction

	20yr horizon 5%	Med	96%	100yr horizon 5%	Med	96%
H	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
G-M	**.901**	**1.000**	**1.000**	**.917**	**.995**	**1.000**
G-M(H)	.901	1.000	1.000	.933	.995	1.000
A-P(L)	.547	.832	1.000	.569	.944	1.000
A-P	.881	.988	1.000	.849	.995	1.000
A-P(H)	1.000	1.000	1.000	.995	1.000	1.000
J-B(L)	.626	.626	.626	.586	.778	.851
J-B	.737	.958	1.000	.868	.989	1.000
J-B(H)	1.000	1.000	1.000	.993	1.000	1.000
D-M(L)	.999	1.000	1.000	.870	.958	1.000
D-M	1.000	1.000	1.000	.901	1.000	1.000
D-M(H)	1.000	1.000	1.000	.943	1.000	1.000
G-G	1.000	1.000	1.000	.904	.975	1.000
G-G(H)	1.000	1.000	1.000	.969	1.000	1.000

D10: Relative increase

	1+ population 5%	Med	96%	Mature females 5%	Med	96%
H	1.152	1.212	1.310	1.361	1.489	1.696
G-M	1.152	1.219	1.316	1.361	1.490	1.712
G-M(H)	1.152	1.215	1.316	1.361	1.490	1.712
A-P(L)	1.152	1.220	1.342	1.361	1.504	1.835
A-P	1.152	1.215	1.323	1.361	1.490	1.744
A-P(H)	1.152	1.215	1.313	1.361	1.489	1.697
J-B(L)	1.166	1.248	1.367	1.393	1.560	1.878
J-B	1.152	1.219	1.315	1.361	1.490	1.711
J-B(H)	1.152	1.216	1.313	1.361	1.489	1.697
D-M(L)	1.157	1.241	1.365	1.378	1.544	1.837
D-M	1.152	1.219	1.341	1.361	1.493	1.809
D-M(H)	1.152	1.215	1.317	1.361	1.489	1.712
G-G	1.170	1.237	1.338	1.395	1.548	1.757
G-G(H)	1.157	1.219	1.319	1.361	1.505	1.711

N12: Mean Downstep or modified AAV

	20yr horizon 5%	Med	96%	100yr horizon 5%	Med	96%
H	.000	.000	.000	.000	.000	.000
G-M	.000	.000	.045	.000	.002	.021
G-M(H)	.000	.000	.045	.000	.001	.021
A-P(L)	.000	.094	.200	.000	.013	.062
A-P	.000	.000	.054	.000	.001	.036
A-P(H)	.000	.000	.000	.000	.000	.002
J-B(L)	.150	.150	.150	.026	.049	.097
J-B	.000	.037	.114	.000	.005	.033
J-B(H)	.000	.000	.000	.000	.000	.004
D-M(L)	.000	.000	.000	.000	.009	.026
D-M	.000	.000	.000	.000	.000	.018
D-M(H)	.000	.000	.000	.000	.000	.018
G-G	.000	.000	.000	.000	.007	.014
G-G(H)	.000	.000	.000	.000	.000	.006

R1: Relative recovery

	1+ population 5%	Med	96%	Mature females 5%	Med	96%
H	1.000	1.000	1.000	1.000	1.000	1.000
G-M	1.000	1.000	1.000	1.000	1.000	1.000
G-M(H)	1.000	1.000	1.000	1.000	1.000	1.000
A-P(L)	1.000	1.000	1.000	1.000	1.000	1.000
A-P	1.000	1.000	1.000	1.000	1.000	1.000
A-P(H)	1.000	1.000	1.000	1.000	1.000	1.000
J-B(L)	1.000	1.000	1.000	1.000	1.000	1.000
J-B	1.000	1.000	1.000	1.000	1.000	1.000
J-B(H)	1.000	1.000	1.000	1.000	1.000	1.000
D-M(L)	1.000	1.000	1.000	1.000	1.000	1.000
D-M	1.000	1.000	1.000	1.000	1.000	1.000
D-M(H)	1.000	1.000	1.000	1.000	1.000	1.000
G-G	1.000	1.000	1.000	1.000	1.000	1.000
G-G(H)	1.000	1.000	1.000	1.000	1.000	1.000

R3: Time frequency in recovered state

	20yr horizon 5%	Med	96%	100yr horizon 5%	Med	96%
H	1.000	1.000	1.000	1.000	1.000	1.000
G-M	1.000	1.000	1.000	1.000	1.000	1.000
G-M(H)	1.000	1.000	1.000	1.000	1.000	1.000
A-P(L)	1.000	1.000	1.000	1.000	1.000	1.000
A-P	1.000	1.000	1.000	1.000	1.000	1.000
A-P(H)	1.000	1.000	1.000	1.000	1.000	1.000
J-B(L)	1.000	1.000	1.000	1.000	1.000	1.000
J-B	1.000	1.000	1.000	1.000	1.000	1.000
J-B(H)	1.000	1.000	1.000	1.000	1.000	1.000
D-M(L)	1.000	1.000	1.000	1.000	1.000	1.000
D-M	1.000	1.000	1.000	1.000	1.000	1.000
D-M(H)	1.000	1.000	1.000	1.000	1.000	1.000
G-G	1.000	1.000	1.000	1.000	1.000	1.000
G-G(H)	1.000	1.000	1.000	1.000	1.000	1.000

BE01 contd.

D8: Rescaled final depletion

	5%	Med	96%	5%	Med	96%
H	.860	.862	.863	.676	.699	.732
G-M	.860	.862	.876	.677	.701	.736
G-M(H)	.860	.862	.876	.676	.701	.736
A-P(L)	.861	.863	.900	.678	.706	.781
A-P	.861	.862	.881	.676	.703	.746
A-P(H)	.860	.862	.863	.676	.700	.732
J-B(L)	.865	.878	.923	.689	.733	.820
J-B	.860	.862	.871	.678	.702	.740
J-B(H)	.860	.862	.865	.676	.700	.732
D-M(L)	.861	.879	.906	.682	.731	.788
D-M	.860	.862	.898	.676	.704	.764
D-M(H)	.860	.862	.879	.676	.702	.736
G-G	.862	.876	.891	.688	.723	.761
G-G(H)	.860	.863	.873	.679	.704	.737

N2: Length of shortfall

	5%	Med	96%	5%	Med	96%
H	.000	.000	.000	.000	.000	.000
M	-0.750	.000	.000	-0.300	-0.050	.000
G-M(H)	-0.750	.000	.000	-0.300	-0.050	.000
A-P(L)	-1.000	-0.620	.000	-0.950	-0.250	.000
A-P	-0.750	-0.250	.000	-0.550	-0.050	.000
A-P(H)	.000	.000	.000	-0.050	.000	.000
J-B(L)	-1.000	-1.000	-1.000	-0.900	-0.450	-0.250
J-B	-1.000	-0.250	.000	-0.300	-0.050	.000
J-B(H)	.000	.000	.000	-0.100	.000	.000
D-M(L)	-0.250	.000	.000	-0.800	-0.250	.000
D-M	.000	.000	.000	-0.600	.000	.000
D-M(H)	.000	.000	.000	-0.300	.000	.000
G-G	.000	.000	.000	-0.500	-0.200	.000
G-G(H)	.000	.000	.000	-0.250	.000	.000

R4: Relative time to recovery

	5%	Med	96%	5%	Med	96%
H	1.000	1.000	1.000	1.000	1.000	1.000
G-M	1.000	1.000	1.000	1.000	1.000	1.000
G-M(H)	1.000	1.000	1.000	1.000	1.000	1.000
A-P(L)	1.000	1.000	1.000	1.000	1.000	1.000
A-P	1.000	1.000	1.000	1.000	1.000	1.000
A-P(H)	1.000	1.000	1.000	1.000	1.000	1.000
J-B(L)	1.000	1.000	1.000	1.000	1.000	1.000
J-B	1.000	1.000	1.000	1.000	1.000	1.000
J-B(H)	1.000	1.000	1.000	1.000	1.000	1.000
D-M(L)	1.000	1.000	1.000	1.000	1.000	1.000
D-M	1.000	1.000	1.000	1.000	1.000	1.000
D-M(H)	1.000	1.000	1.000	1.000	1.000	1.000
G-G	1.000	1.000	1.000	1.000	1.000	1.000
G-G(H)	1.000	1.000	1.000	1.000	1.000	1.000

N10: AAV

	5%	Med	96%	5%	Med	96%
H	.040	.040	.040	.034	.034	.034
G-M	.040	.040	.095	.034	.037	.074
G-M(H)	.040	.040	.095	.034	.037	.069
A-P(L)	.040	.147	.200	.034	.061	.172
A-P	.033	.040	.113	.034	.037	.108
A-P(H)	.040	.040	.040	.034	.034	.034
J-B(L)	.150	.150	.150	.091	.130	.203
J-B	.040	.108	.269	.034	.044	.102
J-B(H)	.040	.040	.040	.034	.034	.034
D-M(L)	.040	.040	.040	.030	.041	.071
D-M	.040	.040	.040	.034	.034	.063
D-M(H)	.040	.040	.040	.034	.034	.069
G-G	.040	.040	.040	.032	.037	.052
G-G(H)	.040	.040	.040	.032	.034	.037

N11: Anti-curvature

	5%	Med	96%	5%	Med	96%
H	.001	.001	.001	.001	.001	.001
G-M	.001	.001	.012	.001	.011	.052
G-M(H)	.001	.001	.012	.001	.009	.049
A-P(L)	.001	.012	.023	.001	.016	.061
A-P	.001	.003	.017	.001	.009	.063
A-P(H)	.001	.001	.001	.001	.001	.006
J-B(L)	.002	.002	.002	.044	.077	.129
J-B	.001	.012	.024	.001	.015	.084
J-B(H)	.001	.001	.001	.001	.001	.007
D-M(L)	.001	.001	.001	.001	.019	.040
D-M	.001	.001	.001	.001	.001	.036
D-M(H)	.001	.001	.001	.001	.001	.043
G-G	.001	.001	.001	.001	.008	.025
G-G(H)	.001	.001	.001	.001	.001	.008

Table of Statistics Example 2
BE09 1%, Need=67->134, Bias=.67-1,1

Risk & Recovery Statistics

D1: Final depletion

	1+ population 5%	Med	96%	Mature females 5%	Med	96%
H	.571	.610	.630	.443	.486	.523
G-M	.503	.556	.677	.385	.437	.544
G-M(H)	.497	.554	.651	.385	.435	.535
A-P(L)	.514	.592	.781	.394	.472	.678
A-P	.503	.570	.703	.386	.455	.585
A-P(H)	.479	.522	.571	.357	.408	.460
J-B(L)	.601	.650	.710	.478	.531	.611
J-B	.503	.557	.645	.386	.438	.531
J-B(H)	.477	.522	.571	.360	.408	.460
D-M(L)	.539	.585	.628	.415	.465	.507
D-M	.501	.555	.613	.383	.435	.492
D-M(H)	.497	.544	.600	.378	.429	.485
G-G	.514	.567	.621	.398	.445	.502
G-G(H)	.491	.541	.599	.368	.423	.481

D2: Lowest depletion

	5%	Med	96%
H	.335	.376	.420
G-M	.335	.376	.420
G-M(H)	.335	.376	.420
A-P(L)	.335	.376	.420
A-P	.335	.376	.420
A-P(H)	.335	.376	.420
J-B(L)	.335	.376	.420
J-B	.335	.376	.420
J-B(H)	.335	.376	.420
D-M(L)	.335	.376	.420
D-M	.335	.376	.420
D-M(H)	.335	.376	.420
G-G	.335	.376	.420
G-G(H)	.335	.376	.420

D9: Minimum population level

	5%	Med	96%	5%	Med	96%
H	7960	8696	9461	1705	1968	2213
G-M	7960	8696	9461	1705	1968	2213
G-M(H)	7960	8696	9461	1705	1968	2213
A-P(L)	7960	8696	9461	1705	1968	2213
A-P	7960	8696	9461	1705	1968	2213
A-P(H)	7960	8696	9461	1705	1968	2213
J-B(L)	7960	8696	9461	1705	1968	2213
J-B	7960	8696	9461	1705	1968	2213
J-B(H)	7960	8696	9461	1705	1968	2213
D-M(L)	7960	8696	9461	1705	1968	2213
D-M	7960	8696	9461	1705	1968	2213
D-M(H)	7960	8696	9461	1705	1968	2213
G-G	7960	8696	9461	1705	1968	2213
G-G(H)	7960	8696	9461	1705	1968	2213

D10: Relative increase

	5%	Med	96%	5%	Med	96%
H	1.194	1.244	1.263	1.241	1.298	1.318
G-M	1.050	1.098	1.408	1.060	1.119	1.509
G-M(H)	1.043	1.095	1.408	1.054	1.115	1.490
A-P(L)	1.057	1.176	1.676	1.071	1.220	1.890
A-P	1.043	1.154	1.521	1.054	1.184	1.659
A-P(H)	1.026	1.065	1.133	1.037	1.076	1.156
J-B(L)	1.193	1.320	1.554	1.244	1.414	1.732
J-B	1.047	1.102	1.385	1.057	1.125	1.461
J-B(H)	1.030	1.065	1.138	1.038	1.078	1.164
D-M(L)	1.071	1.206	1.263	1.082	1.247	1.316
D-M	1.043	1.112	1.242	1.051	1.135	1.295
D-M(H)	1.035	1.080	1.236	1.048	1.097	1.286
G-G	1.076	1.133	1.317	1.096	1.161	1.380
G-G(H)	1.037	1.079	1.239	1.045	1.095	1.294

R1: Relative recovery

	5%	Med	96%	5%	Med	96%
H	.810	.867	.918	.779	.846	.902
G-M	.818	.877	.919	.783	.857	.909
G-M(H)	.818	.877	.919	.783	.857	.909
A-P(L)	.832	.900	.936	.805	.884	.924
A-P	.822	.879	.920	.794	.859	.909
A-P(H)	.808	.867	.918	.776	.846	.902
J-B(L)	.896	.917	.942	.875	.902	.931
J-B	.813	.885	.921	.780	.868	.910
J-B(H)	.808	.867	.918	.776	.846	.902
D-M(L)	.808	.867	.918	.779	.846	.902
D-M	.808	.867	.918	.777	.846	.902
D-M(H)	.808	.867	.918	.777	.846	.902
G-G	.808	.867	.918	.776	.846	.902
G-G(H)	.808	.867	.918	.776	.846	.902

Need Statistics

N1: Total need satisfaction

	20yr horizon 5%	Med	96%	100yr horizon 5%	Med	96%
H	1.000	1.000	1.000	.797	.825	.881
G-M	.853	.967	1.000	.670	.956	1.000
G-M(H)	.853	.967	1.000	.687	.960	1.000
A-P(L)	.539	.843	1.000	.378	.888	1.000
A-P	.831	.960	1.000	.570	.912	1.000
A-P(H)	1.000	1.000	1.000	.902	.999	1.000
J-B(L)	.618	.618	.766	.519	.748	.870
J-B	.644	.961	1.000	.709	.955	1.000
J-B(H)	1.000	1.000	1.000	.901	.995	1.000
D-M(L)	.993	1.000	1.000	.802	.855	1.000
D-M	.997	1.000	1.000	.814	.929	1.000
D-M(H)	.998	1.000	1.000	.817	.978	1.000
G-G	1.000	1.000	1.000	.751	.921	.982
G-G(H)	1.000	1.000	1.000	.826	.980	1.000

N4:Fraction of years in which catch=quota

	5%	Med	96%	5%	Med	96%
H	1.00	1.00	1.00	.20	.25	.30
G-M	.25	.75	1.00	.25	.70	1.00
G-M(H)	.25	.75	1.00	.15	.73	1.00
A-P(L)	.00	.25	1.00	.05	.52	1.00
A-P	.25	.75	1.00	.10	.60	1.00
A-P(H)	1.00	1.00	1.00	.45	.98	1.00
J-B(L)	.00	.00	.25	.05	.30	.60
J-B	.00	.75	1.00	.25	.75	1.00
J-B(H)	1.00	1.00	1.00	.45	.95	1.00
D-M(L)	.75	1.00	1.00	.15	.30	1.00
D-M	.75	1.00	1.00	.20	.70	1.00
D-M(H)	.75	1.00	1.00	.25	.90	1.00
G-G	1.00	1.00	1.00	.35	.60	.90
G-G(H)	1.00	1.00	1.00	.50	.85	1.00

N9: Average need satisfaction

	5%	Med	96%	5%	Med	96%
H	1.000	1.000	1.000	.822	.848	.897
G-M	.859	.967	1.000	.692	.954	1.000
G-M(H)	.859	.967	1.000	.707	.955	1.000
A-P(L)	.547	.845	1.000	.412	.870	1.000
A-P	.838	.960	1.000	.600	.909	1.000
A-P(H)	1.000	1.000	1.000	.914	.999	1.000
J-B(L)	.626	.626	.764	.499	.719	.844
J-B	.651	.958	1.000	.727	.950	1.000
J-B(H)	1.000	1.000	1.000	.913	.996	1.000
D-M(L)	.993	1.000	1.000	.824	.875	1.000
D-M	.997	1.000	1.000	.835	.938	1.000
D-M(H)	.998	1.000	1.000	.839	.981	1.000
G-G	1.000	1.000	1.000	.789	.935	.986
G-G(H)	1.000	1.000	1.000	.855	.984	1.000

N12: Mean Downstep or modified AAV

	5%	Med	96%	5%	Med	96%
H	.000	.000	.000	.000	.000	.000
G-M	.000	.017	.053	.000	.018	.060
G-M(H)	.000	.017	.053	.000	.016	.049
A-P(L)	.000	.072	.200	.000	.028	.103
A-P	.000	.013	.077	.000	.024	.057
A-P(H)	.000	.000	.000	.000	.000	.014
J-B(L)	.121	.150	.150	.026	.050	.100
J-B	.000	.037	.139	.000	.021	.079
J-B(H)	.000	.000	.000	.000	.002	.021
D-M(L)	.000	.000	.000	.000	.011	.026
D-M	.000	.000	.000	.000	.010	.028
D-M(H)	.000	.000	.000	.000	.009	.036
G-G	.000	.000	.000	.004	.011	.032
G-G(H)	.000	.000	.000	.000	.006	.026

R3: Time frequency in recovered state

	5%	Med	96%	5%	Med	96%
H	1.000	1.000	1.000	1.000	1.000	1.000
G-M	1.000	1.000	1.000	1.000	1.000	1.000
G-M(H)	1.000	1.000	1.000	1.000	1.000	1.000
A-P(L)	1.000	1.000	1.000	1.000	1.000	1.000
A-P	1.000	1.000	1.000	1.000	1.000	1.000
A-P(H)	1.000	1.000	1.000	1.000	1.000	1.000
J-B(L)	1.000	1.000	1.000	1.000	1.000	1.000
J-B	1.000	1.000	1.000	1.000	1.000	1.000
J-B(H)	1.000	1.000	1.000	1.000	1.000	1.000
D-M(L)	1.000	1.000	1.000	1.000	1.000	1.000
D-M	1.000	1.000	1.000	1.000	1.000	1.000
D-M(H)	1.000	1.000	1.000	1.000	1.000	1.000
G-G	1.000	1.000	1.000	1.000	1.000	1.000
G-G(H)	1.000	1.000	1.000	1.000	1.000	1.000

BE09 contd.

D8: Rescaled final depletion

	5%	Med	96%	5%	Med	96%
H	.625	.658	.671	.528	.559	.582
G-M	.543	.594	.733	.446	.496	.637
G-M(H)	.540	.593	.717	.445	.495	.627
A-P(L)	.560	.635	.851	.455	.538	.783
A-P	.550	.608	.767	.453	.518	.675
A-P(H)	.522	.562	.606	.427	.468	.512
J-B(L)	.650	.698	.779	.556	.608	.706
J-B	.546	.596	.699	.446	.500	.613
J-B(H)	.522	.563	.607	.429	.469	.515
D-M(L)	.581	.631	.670	.480	.534	.577
D-M	.545	.596	.656	.447	.502	.565
D-M(H)	.538	.586	.645	.442	.490	.551
G-G	.558	.608	.671	.470	.509	.579
G-G(H)	.533	.583	.649	.438	.485	.541

N2: Length of shortfall

	5%	Med	96%	5%	Med	96%
H	.000	.000	.000	-0.800	-0.750	-0.700
M	-0.750	-0.250	.000	-0.600	-0.150	.000
G-M(H)	-0.750	-0.250	.000	-0.650	-0.150	.000
A-P(L)	-1.000	-0.750	.000	-0.950	-0.400	.000
A-P	-0.750	-0.250	.000	-0.900	-0.300	.000
A-P(H)	.000	.000	.000	-0.550	-0.030	.000
J-B(L)	-1.000	-1.000	-0.750	-0.950	-0.500	-0.250
J-B	-1.000	-0.250	.000	-0.500	-0.150	.000
J-B(H)	.000	.000	.000	-0.450	-0.050	.000
D-M(L)	-0.250	.000	.000	-0.850	-0.700	.000
D-M	-0.250	.000	.000	-0.800	-0.200	.000
D-M(H)	-0.250	.000	.000	-0.750	-0.100	.000
G-G	.000	.000	.000	-0.650	-0.350	-0.100
G-G(H)	.000	.000	.000	-0.500	-0.150	.000

R4: Relative time to recovery

	5%	Med	96%	5%	Med	96%
H	.220	.310	.590	.220	.330	.600
G-M	.050	.090	.650	.050	.100	.710
G-M(H)	.040	.090	.660	.050	.100	.690
A-P(L)	.060	.570	.900	.060	.600	.900
A-P	.040	.140	.770	.050	.165	.770
A-P(H)	.030	.060	.140	.030	.070	.140
J-B(L)	.760	.880	.900	.760	.880	.910
J-B	.050	.100	.750	.050	.110	.760
J-B(H)	.030	.060	.130	.040	.070	.140
D-M(L)	.070	.200	.510	.070	.200	.560
D-M	.040	.105	.400	.050	.120	.420
D-M(H)	.040	.080	.380	.040	.080	.390
G-G	.070	.120	.460	.080	.135	.540
G-G(H)	.040	.080	.280	.040	.080	.360

N10: AAV

	5%	Med	96%	5%	Med	96%
H	.040	.040	.040	.010	.017	.018
G-M	.040	.049	.096	.034	.060	.134
G-M(H)	.040	.049	.096	.034	.058	.122
A-P(L)	.040	.148	.200	.034	.089	.182
A-P	.040	.049	.115	.034	.076	.122
A-P(H)	.040	.040	.040	.029	.034	.050
J-B(L)	.150	.150	.174	.093	.141	.227
J-B	.040	.116	.227	.034	.074	.181
J-B(H)	.040	.040	.040	.032	.034	.067
D-M(L)	.037	.040	.040	.027	.038	.062
D-M	.040	.040	.040	.032	.037	.068
D-M(H)	.040	.040	.040	.034	.036	.086
G-G	.040	.040	.040	.034	.042	.068
G-G(H)	.040	.040	.040	.032	.036	.059

N11: Anti-curvature

	5%	Med	96%	5%	Med	96%
H	.001	.001	.001	.002	.005	.008
G-M	.001	.005	.012	.001	.031	.090
G-M(H)	.001	.005	.012	.001	.030	.086
A-P(L)	.001	.012	.023	.001	.030	.072
A-P	.001	.006	.016	.001	.033	.072
A-P(H)	.001	.001	.001	.001	.001	.026
J-B(L)	.002	.002	.020	.041	.091	.148
J-B	.001	.011	.023	.001	.045	.126
J-B(H)	.001	.001	.001	.001	.003	.036
D-M(L)	.001	.001	.002	.001	.022	.036
D-M	.001	.001	.001	.001	.020	.040
D-M(H)	.001	.001	.001	.001	.015	.051
G-G	.001	.001	.001	.004	.016	.044
G-G(H)	.001	.001	.001	.001	.006	.034

Annual Report of the International Whaling Commission 2004

Covering the 2003-2004 financial year and the 56th Annual Meeting held in Sorrento in 2004

Annual Report
of the
International Whaling Commission
2004

THE INTERNATIONAL WHALING COMMISSION WAS CONSTITUTED UNDER THE INTERNATIONAL CONVENTION FOR THE REGULATION OF WHALING SIGNED AT WASHINGTON ON 2 DECEMBER 1946

International Whaling Commission
The Red House, 135 Station Road, Impington, Cambridge, UK, CB4 9NP
Tel: +44 (0)1223 233971
Fax: +44 (0)1223 232876
E-mail: *iwcoffice@iwcoffice.org*

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List of Members of the Commission

Contracting Government	*Adherence*	*Commissioner*	*Appointment*
Antigua & Barbuda	21.07.82	Mr A. Liverpool	02.07.04
Argentina	18.05.60	Ambassador E.H. Iglesias	08.02.02
Australia	10.11.48	Mr C. O'Connell	29.08.01
Austria	20.05.94	Dr A. Nouak	09.08.96
Belgium	15.07.04	Mr A. de Lichtervelde	14.07.04
Belize	17.06.03	The Hon I. Cal	01.04.04
Benin	26.04.02	Mr Bantole Yaba	06.05.02
Brazil	04.01.74	Coun. M. Pessoa	15.06.04
Chile	06.07.79	Ambassador M. Fernández	26.09.02
People's Republic of China	24.09.80	Mr Li Jianhua	06.06.00
Costa Rica	24.07.81	Not notified	
Cote D'Ivoire	08.07.04	Dr A.J. Djobo	16.07.04
Czech Republic	26.01.05	Dr P. Hýčova	17.03.05
Denmark	23.05.50	Mr H. Fischer (Chair)	24.04.86
Dominica	18.06.92	Mr L. Pascal	10.07.01
Finland	23.02.83	Mr E. Jaakkola	15.04.99
France	03.12.48	Mr J.G. Mandon	28.05.03
Gabon	08.05.02	Dr G. Rerambyath	13.04.04
Germany	02.07.82	Mr P. Bradhering	22.06.01
Grenada	07.04.93	Hon G. Bowen	25.06.04
Guinea	21.06.00	Mr I. Sory Touré	29.07.03
Hungary	01.05.04	Dr K. Rodics	06.06.04
Iceland	10.10.02	Mr S. Asmundsson	14.10.02
India	09.03.81	Mr S.V. Rishi	21.05.03
Ireland	02.01.85	Mr C. O'Grady	13.05.03
Italy	06.02.98	Mr G. Ambrosio	01.01.02
Japan	21.04.51	Mr M. Morimoto	12.11.99
Kenya	02.12.81	Mr S. Weru	08.05.01
Kiribati	28.12.04	Not notified	
Republic of Korea	29.12.78	Mr K.H. Barng	15.06.04
Mali	17.08.04	Not notified	
Mauritania	23.12.03	Mr S.M.O. Sidina	04.05.04
Mexico	30.06.49	Dr E.E. Real de Azúa	14.11.03
Monaco	15.03.82	Prof F. Briand	13.06.03
Mongolia	16.05.02	Not notified	
Morocco	12.02.01	Mr A. Fahfouhi	01.04.04
Netherlands	14.06.77	Mr G.B. Raaphorst	11.07.02
New Zealand	15.06.76	Rt Hon Sir G. Palmer	02.12.02
Nicaragua	05.06.03	Mr M. Marenco	05.06.03
Norway	23.09.60	Ambassador K. Klepsvik	26.11.04
Oman	15.07.80	Mr I.S. Al-Busaidi	17.03.03
Republic of Palau		Hon K. Nakamura	17.05.02
Panama	12.06.01	Mr R. Santamaria	07.05.03
Peru	18.06.79	Ms E. Velasquez	02.04.04
Portugal	14.05.02	Mr J.S. Costa	26.01.04
Russian Federation	10.11.48	Mr V.Y. Ilyashenko	02.05.95
San Marino	16.04.02	Mr D. Galassi	10.10.02
St Kitts and Nevis	24.06.92	Mr C. Liburd	12.04.01
St Lucia	29.06.81	Hon I. Jean	28.04.04
St Vincent & The Grenadines	22.07.81	Senator E. Snagg	05.03.03
Senegal	15.07.82	Dr N. Gueye	05.03.02
Solomon Islands	10.05.93	Mr S. Diake	15.03.04
South Africa	10.11.48	Mr H. Kleinschmidt (Vice-Chair)	11.07.03
Spain	06.07.79	Mr R. Centenera	01.08.04
Suriname	15.07.04	Mr J. Sahtoe	09.07.04
Sweden	15.06.79	Prof B. Fernholm	15.02.96
Switzerland	29.05.80	Dr T. Althaus	24.02.97
Tuvalu	30.06.04	Mr P. Neleson	13.07.04
UK	10.11.48	Mr R. Cowan	21.05.01
USA	10.11.48	Mr R. Schmitten	23.06.00

Dr N. Grandy, Secretary to the Commission, 25 April 2005

Preface

Welcome to the seventh of the series, the '*Annual Report of the International Whaling Commission*'. Subscription details for the publications of the International Whaling Commission can be found on the Commission web site (*www.iwcoffice.org*), by e-mailing *subscriptions@iwcoffice.org* or by the more traditional means of writing, telephoning or faxing the Office of the Commission (details are given on the title page and on the back cover of this volume).

This report contains the Chair's Report of the Fifty-Sixth meeting of the IWC, held in Sorrento, Italy in July 2004. The text of the Convention and its Protocol are also included, as well as the latest versions of the Schedule to the Convention and the Rules of Procedure and Financial Regulations. The Chair's Report includes the reports of the Commission's technical and working groups as annexes.

This year has seen the retirement of one of the longest-serving members of the Secretariat, Daphne Ransom, the Assistant to the Executive Officer. Daphne had served the IWC admirably since the establishment of a permanent Secretariat in 1976. The Commission offers its best wishes for her in the future.

Cover photograph: Statue of St Antonino, an Abbot and the patron Saint of Sorrento, thought to have died on 14 February 830AD. He is a popular saint amongst seamen. The most famous miracle attributed to him was that he freed a young boy swallowed by a whale.

G.P. DONOVAN

Editor

Contents

Chair’s Report

Chair's Report: Contents

SUMMARY OF MAIN OUTCOMES, DECISIONS AND REQUIRED ACTIONS FROM THE 56TH ANNUAL MEETING

The main outcomes, decisions and required actions arising from the 56th Annual Meeting of the IWC are summarised in the table below.

Issue	Outcomes, decisions and required actions
Status of stocks	**Antarctic minke whales** • Completion of the revised abundance estimate for Antarctic minke whales continues to be a high priority given that there is no agreed current estimate. **Western North Pacific common minke whales** • The Scientific Committee expects to begin an in-depth assessment of western North Pacific common minke whales, with a focus on the J stock, at next year's Annual Meeting. **Southern Hemisphere blue whales** • The Scientific Committee agreed that (1) on average, the Antarctic blue whale population is increasing at a mean rate of 7.3% per year; (2) had an estimated circumpolar population size of 1,700 (95% CI 860-2,900) in 1996; and (3) that this population is still severely depleted compared with pre-exploitation levels. **Right whales** • The Scientific Committee again reiterated its recommendation that it is a matter of absolute urgency that every effort be made to reduce anthropogenic mortality in the North Atlantic right whale stock to zero. Right whales continue to die or become seriously injured by entanglements in fishing gear or ship strikes. The remaining population is estimated at between 300 and 350 animals. **Western North Pacific gray whales** • The Scientific Committee noted with great concern that the evidence is compelling that this population (only about 100 whales) is in serious danger of extinction and that it faces an obvious and immediate threat from industrial activities, including noise, vessel traffic and the potential for a catastrophic oil spill. It recommended as a matter of urgency that measures be taken to protect this population and its habitat off Sakhalin Island and that research and monitoring programmes on this stock by range states continue and expand. • The Commission adopted Resolution 2004-1 that *inter alia*: (1) endorsed the Scientific Committee's conclusions and recommendations; (2) called on range states to actively pursue all practicable actions to eliminate anthropogenic mortality in this stock and to minimise anthropogenic disturbances in the migration corridor and on breeding and feeding grounds; and (3) requested the Secretariat to offer its services and scientific expertise to organisations concerned with oil and gas development projects and exploration projects in the Sakhalin area. **Small cetaceans** • The Scientific Committee reviewed the status of franciscana and made a number of recommendations including the need for improved estimates of abundance and bycatch. The Committee expressed concern over the status of the vaquita and West Greenland stocks of white whales and narwhals.
Aboriginal subsistence whaling	**Aboriginal Whaling Management Procedure** • The Commission endorsed and adopted the *Strike Limit Algorithm (SLA)* for eastern North Pacific gray whales proposed by the Scientific Committee. This follows the 2002 adoption of an *SLA* for the Bering-Chukchi-Beaufort stock of bowhead whales. The Committee will now work to develop a similar approach for the management of Greenlandic whaling. **Catch limits** • The Commission agreed that no changes to the block quotas renewed in 2002 were needed. The Scientific Committee reiterated its grave concern at being unable to provide management advice on Greenlandic whaling. **Review of Schedule paragraph 13** • Schedule language dealing with the different aboriginal subsistence hunts was consolidated and harmonised.

Issue	Outcomes, decisions and required actions
Whale killing methods and associated welfare issues	• The Commission passed Resolution 2004-3 requesting further work from the Working Group on Whale Killing Methods and Associated Welfare Issues, and in particular to: ➢ examine methods for reducing struck and lost rates; ➢ consider the welfare implications of methods used to kill whales caught in nets; ➢ advise the Commission on establishing better criteria for determining the onset of irreversible insensibility and death, methods for improving the efficiency of whale killing methods and reducing times to death and other associated welfare issues.
The Revised Management Scheme (RMS)	• The Commission endorsed the Scientific Committee's *Requirements and Guidelines for Implementations* and the revised *Requirements and Guidelines for Conducting Surveys and Analysing Data within the RMP.* • The Commission endorsed the Scientific Committee recommendation to initiate a *pre-implementation assessment* for North Atlantic fin whales and the plans to hold a Workshop on the *pre-implementation assessment* of western North Pacific Bryde's whales. • The Commission reviewed a proposal from the Chair for an RMS 'package' of measures. No agreement was reached but Resolution 2004-6 was adopted aimed at having draft text and technical details of an RMS ready for consideration, including for possible adoption, at IWC/57, and/or to identify any outstanding policy and technical issues. The Resolution included a plan of work that revived the RMS Working Group (that last met at IWC/54 in 2002), established a Small Drafting Group and various technical specialist groups and required considerable intersessional work.
Sanctuaries	**Southern Ocean Sanctuary (SOS)** • The Scientific Committee completed its review of the sanctuary as required by the Schedule. The Committee agreed that: (1) whales are not effectively protected from whaling in the SOS, because such Sanctuaries apply only to commercial whaling, and because (apart from stocks that migrate to the IOS) whales also migrate outside of the SOS boundaries; (2) the boundaries of the SOS were appropriately established for some, but not for all stocks; (3) it was not possible to completely evaluate the effectiveness of the SOS because the scientific objectives are not clear and are not associated with quantifiable performance measures. The Committee respectfully requested that the Commission considers clarifying the objective(s) of the SOS in order to allow the Committee to discriminate among designs that would, *inter alia*: protect whales; protect whale species diversity; and increase whaling yields outside the Sanctuary. • A proposed Schedule amendment that would abolish the Southern Ocean Sanctuary and authorise the take of 2,914 minke whales for each of the 2004/05 to 2008/09 seasons was not adopted. • The next SOS review will take place in 2014 unless the Commission decides otherwise. **Proposals for new sanctuaries in the South Pacific and South Atlantic** • As last year, two Schedule amendments were proposed to create sanctuaries in (1) the South Pacific and (2) the South Atlantic. Neither was adopted.
Socio-economic implications and small-type whaling	• Two proposed Schedule amendments that would allow the resumption of community based whaling in Japan were not adopted. One proposal was for the taking of 100 minke whales each year for 3 years from the Okhotsk Sea-West Pacific stock. The other was for the taking of 150 Bryde's whales each year for 5 years from the western North Pacific stock. • Resolution 2004-2 was adopted, reaffirming the Commission's commitment to work expeditiously to alleviate the continued difficulties to the Japanese coastal communities of Abashiri, Ayukawa, Wadaura and Taiji caused by the cessation of minke whaling.
Scientific Permits	• Discussions of the Scientific Committee focused on reviewing the results and future plans for the ongoing programmes of Japan (i.e. JARPA and JARPNII) and Iceland. No consensus recommendations were made. Given that 2004/05 would be the last year of JARPA, the Committee agreed that it will undertake a full review of results from this 16-year programme once they are available, i.e. some time after the Annual Meeting in 2005. • Last year, the Commission adopted Resolution 2003-3 that *inter alia*: (1) called on the Government of Japan to halt the JARPA programme or limit it to non-lethal research methodologies; and (2) recommended that no additional JARPA programmes be considered until the Scientific Committee has completed a review of (a) all JARPA results and (b) its abundance estimates for Southern Hemisphere minke whales. The Resolution also recommended that any future programmes should be limited to non-lethal research. As this Resolution remains in force, and to save time, Australia and other co-sponsors withdrew a similar proposed Resolution this year.

Issue	Outcomes, decisions and required actions
Environmental issues	• The Scientific Committee agreed that there is now compelling evidence that military sonar has a direct impact on beaked whales in particular and that evidence suggests that some sound from other sources, including ships and seismic activities, gives cause for concern. • The Committee reported on progress with work on other habitat-related issues, including POLLUTION 2000+, collaborative research in the Antarctic, SOCER, Arctic issues and the habitat degradation workshop scheduled to take place in Siena in November 2004. • Discussions on ways to advance collaboration between the Standing Working Group on the Environment and the assessment-related sub-committees and working groups was initiated.
Conservation Committee	• The first meeting of the Conservation Committee took place. It addressed general issues relating to the establishment and purpose of the Committee and considered: (1) its relationship with other bodies within the Commission; (2) terms of reference and working methods; (3) items that should fall under its auspices; (4) collaboration with other organisations; and (5) the development of a Conservation Agenda.
Co-operation with other organisations	• The Commission adopted Resolution 2004-5 that requested the Secretariat, *inter alia*, to explore possible synergies between IWC and the Global Environment Facility, including possible support of the involvement of developing country IWC members in projects related to scientific research and/or policies for scientific research concerning the conservation and management of whales.
Future work of the Scientific Committee	• The Commission adopted the report from the Scientific Committee, including its proposed work plan for 2004/2005 that includes activities in the following areas: • Revised Management Procedure (RMP), particularly with respect to (1) finalising the guidelines and requirements for implementing the RMP; (2) completion of the *pre-implementation assessment* for western North Pacific Bryde's whales; and (3) development of stock structure hypotheses as part of the *pre-implementation assessment* for North Atlantic fin whales. • Estimation of bycatch based on genetic data and data from fisheries and observer programmes. • Aboriginal Subsistence Whaling Management Procedure development particularly in relation to Greenlandic whaling. • Annual reviews of catch data and management advice for eastern North Pacific gray whales, BCB bowhead whales, minke and fin whales off Greenland and humpback whales off St. Vincent and The Grenadines; • In-depth assessments, with particular emphasis on abundance estimates for Southern Hemisphere minke and humpback whales; • Review of the stock identity concept in a management context; • Environmental concerns, with a focus on reviewing the report of the Habitat Degradation Workshop and the outcome of the special session on sea ice and whale habitat; • Whalewatching (WW), with a focus on assessing possible population level impacts of WW on whales and the development of a scientific foundation for WW guidelines; • Small cetaceans, including a review of the status of the finless porpoise. • The Scientific Committee also agreed, that given the case- and area-specific nature of the bycatch problem, to hold a series of broad-based regional Workshops focusing on regions where bycatch problems: (1) have been given priority by the Scientific Committee as part of its normal review process; and (2) are not already being addressed.
Secret ballots	• A proposed amendment to the Commission's Rules of Procedure that would increase the opportunities for using secret ballots was not adopted.
Dealing with legal issues	• The Commission reviewed a paper outlining options on how it might address future legal issues arising within the IWC. The matter was referred to the meeting of the F&A Committee at IWC/57.
Administration	**Simultaneous interpretation and document translation** • The Commission agreed that from IWC/57 next year, equipment facilities for simultaneous interpretation into French and Spanish should be provided for the Commission's sub-groups (but not the Scientific Committee), the Commission plenary and private meetings of Commissioners. Governments wishing to make use of these facilities would have to provide the interpreters at their own cost.

Issue	Outcomes, decisions and required actions
Administration cont.	• The Commission also agreed to establish a small Task Force to work with the Secretariat to develop cost estimates and implications for the provision of document translation at Annual Meetings and to report to the F&A Committee at IWC/57. **Amendments to the Rules of Procedure and Financial Regulations** • The Commission adopted revised rules regarding the procedure for the appointment of the Chair and Vice-Chair of the Scientific Committee. **Frequency of meetings** • Via Resolution 2004-7 the Commission decided to explore the principle of IWC meetings being held less frequently than annually as at present. It agreed to establish a working group to investigate and make recommendations on the implications of less frequent meetings. The Working Group should report to the Commission next year.
Financial Contributions	Interim Measure • The Commission adopted Resolution 2004-4 designed to take into account the special position of very small countries in calculating financial contributions. Under the Interim Measure for calculating contributions, member countries are allocated into four capacity-to-pay groups based on their GNI and GNI per capita. Via Resolution 2004-4, the Commission decided that Monaco and San Marino should be transferred from capacity-to-pay Group 3 to Group 2 in view of their much smaller GNI compared with other countries in Group 3. This has the effect of reducing the financial contributions of Monaco and San Marino.
Finance and Budget	**Financial statements and budget estimates** • The Commission approved the Provisional Financial Statement for 2003-2004 subject to audit. It also approved the budget for 2004-2005, including the research budget, and increases in the NGO observer fee from £570 to £590 and in the media fee from £30 to £35 for 2005. **Secretariat office accommodation** • The Commission agreed that for a number of reasons it would not be practical to relocate the Secretariat's offices away from the Cambridge area, but requested the Secretariat to explore alternative premises locally. **Budgetary Sub-committee** • The Commission agreed changes to the membership rota for the Budgetary Sub-committee that included extending the term of members from two to three years, appointing a Vice-Chair as well as a Chair and creating two 'open seats' in addition to the nine allocated on the basis of the capacity-to-pay grouping. The Budgetary Sub-committee was requested to clarify the term for the open seats and the status of observers from Contracting Governments not members of the Sub-committee.
Non-governmental organisations	**Participation** • The Commission requested the Secretariat to work with the Advisory Committee to explore how the Rules of Procedure might be amended with respect to criteria and fees for NGO participation (e.g. removal of the current requirement that NGOs must have offices in more than three countries; allowing NGOs to have more than one observer in the meeting room at any one time; revising the fee structure such that the effect of these changes, if put in place, would not have a significant impact on fees). **Code of Conduct** • The Commission agreed to establish a Working Group comprising Dominica, Iceland (convenor), Japan, the Netherlands, New Zealand, St. Kitts and Nevis, Sweden and the USA to develop a draft Code of Conduct for NGOs for review at IWC/57. The code was to focus on NGO activities during the Annual Meeting and could, if appropriate, include provisions related to the loss of accreditation.
Date and place of Annual Meetings	• The 57th Annual and associated meetings in 2005 will be held in Ulsan, Republic of Korea during the period 30 May to 24 June. • The 58th Annual Meeting in 2006 will be held in St Kitts and Nevis. The dates are to be determined.
Election of the Vice Chair	• Horst Kleinschmidt (South Africa) was elected as Vice-Chair to replace Carlos Dominguez Diaz (Spain).
Advisory Committee	• The Commissioner from Dominica was elected onto the Advisory Committee for a further two years to join the Chair (Denmark), the Vice-Chair (South Africa), the Head of Finance and Administration (Norway) and the UK Commissioner.

Chair's Report of the 56th Annual Meeting

1. INTRODUCTORY ITEMS

1.1 Date and place

The 56th Annual Meeting of the International Whaling Commission (IWC) took place from 19-22 July 2004 at the Hilton Sorrento Palace Hotel, Italy. In the absence of the Chair, Henrik Fischer (Denmark) and Vice-Chair, Carlos Dominguez (Spain) who were both unable to attend, the Commission elected by consensus Rolland Schmitten (USA) and Minoru Morimoto (Japan) as Acting Chair and Vice-Chair respectively for the duration of the meeting. A list of delegates and observers attending the meeting is provided in Annex A. The associated meetings of the Scientific Committee and Commission sub-groups were held at the same venue in the period 28 June to 16 July.

1.2 Welcome addresses

On the first morning of the meeting, Dr Giuseppe Ambrosio, Italy's Commissioner to IWC welcomed all participants on behalf of the Government of Italy. He began by noting that while Italy gives great importance to the protection of cetaceans and is against the resumption of commercial whaling, it also respects those having different cultures and beliefs. He believed that because the concept of conservation is inextricably intertwined with the sustainable use of natural resources, it is logical that the conservation of whales be given due attention. Referring to Italy's concern with regard to degradation of the marine environment, Dr Ambrosio was pleased to note that an IWC workshop on the effects of habitat degradation on cetaceans was scheduled to take place in Siena later in the year. He stressed the importance Italy gives to the use of sanctuaries and marine protected areas in cetacean conservation, given the uncertainties regarding the effects global changes have on the environment, and noted that together with France and Monaco, Italy had established a large sanctuary for the protection of cetaceans in the Mediterranean – 50% of which is in the high seas. Dr Ambrosio indicated that Italy would support the establishment of new sanctuaries in the Southern Hemisphere. Finally, he hoped that the pleasant setting of Sorrento would be conducive to the work of the Commission and that its deliberations would lead to concrete progress in protecting an important natural heritage for which all share responsibility.

A welcome address was also given by the On. Scarpa, Undersecretary of State, Ministero delle Politiche Agricole e Forestali at the opening of the second day of the meeting. Recognising fisheries as an ancient activity on the one hand but at the same time a modern and very topical activity, the On. Scarpa noted that regulating fisheries is as hard, if not harder than regulating other sectors of the economy because of the pressure placed on those responsible. He further noted that fisheries is an area where new policies are being tested to find the right balance between the conservation of natural resources and their commercial use, and referred to work within the European Union to develop a set of shared goals for fisheries in the Mediterranean. He stressed the need to involve all stakeholders, including the fishermen themselves. While being aware of the need to manage the social and cultural problems encountered in conservation, the On. Scarpa believed that cetacean conservation also requires scientists, governments, NGOs and the few whalers left to reflect on how this resource can be protected, noting the multiple risks to which cetaceans are exposed. He considered that the notion of a common resource is particularly cogent for cetaceans and referred to the United Nations Convention of Law of the Sea (UNCLOS) that allows governments to adopt more stringent conservation measures for cetaceans that those that might apply to other species. He also referred to the Monaco Agreement of November 1996 that acknowledges cetaceans as an integral part of the ecosystem and an agreement that has led governments to adopt a common approach to addressing a problem of common interest. Finally, he did not want the negative opinion expressed by some on whaling (an activity in which few are engaged) to influence the general opinion on fisheries (an activity that affects everyone). He saw no need for conflict between the environment and fishermen, stressing that there must be a relationship of mutual understanding with shared goals.

1.3 Opening statements

The Chair welcomed the following six new Contracting Governments who had adhered since the last Annual Meeting:

- Mauritania – adhered on 23 December 2003;
- Hungary – adhered 1 June 2004;
- Tuvalu – adhered 30 June 2004;
- Côte d'Ivoire – adhered 8 July 2004;
- Belgium – adhered 14 July 2004; and
- Suriname – adhered 14 July 2004.

Reminding the meeting that the Commission's practice is to invite oral opening statements only from new Contracting Governments – existing Contracting Governments and observers can submit written opening statements – the Chair invited the new member countries to address the meeting.

Mauritania noted that as a state with a coastline of over 700km, fishing has a predominant role, generating more than 50% of export income and about 25% of budgetary income. Its strategy for the exploitation of marine fishery resources is based on their sustainable use, but it also supports the protection of endangered marine species. Mauritania explained that this strategy is also the basis for its adherence to the IWC and to all other institutions involved in the regulation and management of marine resources. It noted that it will base its decisions on science and, where insufficient data are available, on the application of the precautionary principle.

Hungary noted that as a small country with high biodiversity, it has made great efforts to protect its environment. These efforts have been further strengthened by its recent accession to the European Union. It reported that over 10% of its territory is protected, with 10 national parks – one of which was established over 30 years ago. It has more than 1,000 protected species for which trade is prohibited. Although it is a land-locked country, Hungary believed that it could contribute to the preservation of the oceans – a common heritage of mankind.

Tuvalu noted that its territory comprises eight low-lying atolls and reef islands scattered across the central Pacific Ocean. While its total land area is only 26 square kilometres, its ocean area covers almost one million square kilometres. Tuvalu therefore relies heavily on marine resources and is keenly aware of the impact of overfishing. It wishes to use and conserve marine resources wisely and prevent overexploitation. Since 1978, its national policies have tried to increase fish catches in Tuvalu waters, identify new stocks that have the potential for commercial exploitation, maximise financial returns from foreign fishing operators, and to improve the domestic management of its marine resources. Although whales migrate through its waters, there is no reliable inventory of species and numbers. Tuvalu wishes to establish a long-term whale research programme and would be pleased to receive any technical support, assistance and guidance from IWC or from any of its members in launching such an initiative. It looked forward to working closely with members of the Commission to achieve the Commission's long term goals.

Côte d'Ivoire noted that it has given full support to Conventions aimed at the rational and sustainable exploitation of natural resources, particularly marine resources and adheres fully to the spirit and word of the International Convention for the Regulation of Whaling. It would support Commission resolutions for a sustainable and responsible use of whale resources based on sound science and to this end suggested that the RMS should be completed and implemented. It also noted its determination to work with other Contracting Governments to ensure the preservation of whale stocks.

Belgium noted that its adherence to the Convention was supported strongly by its parliament and civil society. It believed its adherence is coherent with Belgium's early expeditions in Antarctica and its participation as founding members of the Antarctic Treaty and CCAMLR. It also believed it significant that Belgium was joining IWC at the time the Conservation Committee is being launched. It noted that it will work actively and constructively with all Commission members towards a high level of governance, transparency and efficiency with a view to taking the right decisions for the benefit of present and future generations and in collaboration with other international bodies.

Suriname noted that it supports the principle of the sustainable use of all marine living resources, including cetaceans. As part of the Amazon region, it is well-endowed with freshwater and arable land as well as valuable fishery resources. Deep-sea fishing is the largest exporting industry within Suriname's agricultural sector. Suriname has made significant investments to make its fishing industry viable and has taken measures to comply with all international regulations regarding sustainability and biodiversity. It has followed the debate in IWC for many years and is surprised that whales, which consume large quantities of fish, are regarded by many as a resource that should remain unutilised at a time when nations are striving to maintain food security. Suriname recognised IWC as the global authority in relation to the management of whales and the regulation of whaling, but expected it to respect the interests of both the resources and the users of those resources and to base decisions on the best scientific advice available.

1.4 Credentials and voting rights

The Secretary reported that the credentials committee, comprising Japan, New Zealand and the Secretary, agreed that all credentials were in order. She noted that voting rights were suspended for Costa Rica, Côte d'Ivoire, Morocco and Senegal and that when voting commenced she would call on Gabon first. Senegal's voting rights were restored later in the meeting.

1.5 Meeting arrangements

The Chair asked Contracting Governments to:

(1) keep Resolutions to a minimum and to consult widely in their preparation; and
(2) be brief and to the point in their interventions, and to associate themselves, where possible, with earlier speakers who had similar views.

He reconfirmed previous arrangements regarding speaking rights for Intergovernmental Organisations (IGOs), i.e. that he would allow them to make one intervention on a substantive agenda item and that any IGO wishing to speak should let him know in advance. The Secretary drew attention to the arrangements for the submission of Resolutions and other documents.

2. ADOPTION OF THE AGENDA

The Chair drew attention to the provisional annotated agenda and to his proposed order of business. He noted that because of the change in responsibilities of Carlos Dominguez that prevented him from continuing as Vice-Chair of the Commission, a new Vice-Chair needed to be elected. He proposed that a new Item 25 be inserted to deal with this matter. The adopted agenda is given in Annex B. Noting that he was aware of differing views among Contracting Governments as to whether some of the items should be on the agenda, he proposed that, as in previous years, these differences be noted and the agenda adopted with all items retained.

As last year, Japan indicated that it believed a number of items on the agenda were contrary to the objectives or outside the scope of the Convention and that discussion of these matters detracts from the time and resources available to address what in its view were more serious and substantive issues. Japan therefore proposed deletion of Item 7 on whale killing methods and associated welfare issues, Items 8.3 and 8.4 on sanctuaries for the South Pacific and South Atlantic respectively (which had already been discussed thoroughly and rejected by the Commission many times), Item 11 on environmental and health issues, Item 12 on whalewatching, Item 14.1 on small cetaceans and Item 15 on the Conservation Committee. Benin, Republic of Palau, Republic of Guinea, Norway, Gabon, Iceland, St. Kitts and Nevis, St. Lucia, Dominica, Nicaragua, Mauritania, and Morocco spoke in support of Japan. However, the UK, supported by Germany, New Zealand, Italy, India, the USA, Mexico, Brazil, Monaco, Peru, Australia, Spain, and Sweden, could not agree to Japan's proposals. The UK referred to the lengthy discussion on the same issue at last year's Annual Meeting, noted Japan's views, but considered that the items mentioned were legitimate and that it was vital they remained on the agenda and were discussed.

Japan noted the many views both for and against its proposals. Not wishing to prolong the discussion, it withdrew its proposals to delete certain items but indicated that it would make its positions on them clear when those items were discussed.

3. SECRET BALLOTS

3.1 Proposed amendment to Rule of Procedure E.3(d)

Japan again introduced its proposed amendment (that was unsuccessful at the 2001, 2002 and 2003 Annual Meetings[1]) to broaden the application of secret ballots, i.e.

> 'Votes can be taken by show of hands, or by roll call, as in the opinion of the Chairman appears to be most suitable, or by secret ballot if requested by a Commissioner and seconded by at least five other Commissioners except that on any matter related to aboriginal subsistence whaling, voting by secret ballot shall only be used when all the Commissioners representing the Contracting Parties where the aboriginal subsistence take or takes will occur requests the use of a secret ballot and where such requests are seconded by at least five other Commissioners.'

In addition to being available for electing the Chair and Vice-Chair of the Commission, appointing the Secretary of the Commission and selecting Annual Meeting venues – the current situation, Japan believed that voting by secret ballot should be possible for setting catch limits and deciding other regulatory measures. It again noted that the secret ballot is a system commonly used in other international organisations including fisheries management bodies and saw no reason why its proposal should not be accepted by the Commission.

3.2 Commission discussions and action arising

Iceland, Republic of Guinea, Dominica, Antigua and Barbuda, Mauritania, Republic of Korea, Republic of Palau, Norway, Benin, St. Kitts and Nevis, Grenada, St. Vincent and The Grenadines, St. Lucia, Nicaragua, China, Gabon, Tuvalu, Morocco and Dominica spoke in support of Japan's proposal. Iceland noted that national elections are performed by secret ballot and that the same principles should apply internationally. It felt it important that less powerful nations should be able to work without undue pressure from others. As in previous years, Norway believed that transparency should be employed wherever possible but supported Japan's proposal given the real threats of coercion and intimidation surrounding the whaling debate. Others made similar remarks.

The USA, New Zealand, Germany, Italy, UK, Kenya, Australia, Brazil, Monaco, Mexico, Sweden, South Africa, India, Peru, Netherlands, Argentina, Finland, Denmark, Spain, Portugal, France and Switzerland indicated that they could not support the proposal believing it to be contrary to the principles of openness and transparency. Referring to Iceland's comment, Switzerland accepted that secret ballots are appropriate at the level of the individual citizen, but that in the context of intergovernmental organisations, it believed it important that the public be aware of how their countries vote.

In response to a question from Argentina regarding why, in the proposal, there were additional conditions related to secret votes for aboriginal subsistence whaling, Japan explained that this had been included in view of the frequent calls for matters related to aboriginal subsistence whaling to be decided by consensus. Regarding the number of seconds required for a secret ballot, Japan noted that within CITES, a secret ballot can proceed if requested by one country and seconded by 10 others. As IWC has fewer member governments than CITES, Japan proposed that a call for a secret ballot need only be seconded by five countries.

On being put to a vote, the proposal failed to achieve a majority and was therefore not adopted. There were 24 votes in support of the proposal and 29 against.

4. WHALE STOCKS[2]

4.1 In-depth assessment of western North Pacific common minke whales

4.1.1 Report of the Scientific Committee

The Committee reviewed the progress made by an intersessional steering group established last year to plan for the in-depth assessment of western North Pacific common minke whales, with a focus on 'J' stock. The Committee developed a series of priority research items that needed to be accomplished before an assessment could be undertaken, including: analysis of survey data; further work on stock identity; and consideration of ways to elucidate the proportion of 'J' stock animals found in the Sea of Japan. It entrusted this work to a further intersessional group.

4.1.2 Commission discussion and action arising

Japan believed that a reported increase in bycatch of 'J' stock animals is a sign of increasing abundance of this stock which its own research suggests to be greater than 15,000 animals. It anticipated that this would be elucidated by the in-depth assessment. The Republic of Korea was pleased to have started work on this stock around the Korean Peninsular. It too believed that the 'J' stock is increasing, but believed that it should be referred to as the 'Korean peninsular stock'.

The UK, supported by Australia, was concerned by the apparent change in position regarding the abundance of this stock. It recalled that last year, the Scientific Committee had taken a very precautionary variant when determining stock abundance. While it did not dispute that bycatch could be increasing, it suggested that this could be due to a number of reasons, including changes in the distribution of the animals or the effort expended in setting nets.

The Commission noted the Scientific Committee report and endorsed its recommendations.

4.2 Antarctic minke whales

4.2.1 Report of the Scientific Committee

The Committee has carried out annual surveys in the Antarctic (south of 60°S) since the late 1970s. The last agreed estimates for each of the six management Areas for minke whales were for the period 1982/83 to 1989/90. At the 2000 meeting, the Committee agreed that whilst these represented the best estimates for the years surveyed, they were no longer appropriate as estimates of current abundance. An initial analysis of available recent data had

[1] *Ann. Rep. Whaling Comm.* 2001:8, 2002:8 and 2003:6.

[2] For details of the Scientific Committee's deliberation on this item see *J. Cetacean Res. Manage.* 7 (Suppl.).

suggested that current estimates might be appreciably lower than the previous estimates[3].

Subsequently, considerable time has been spent considering Antarctic minke whales with a view to obtaining final estimates of abundance and considering any trend in these. This has included a review of data collection methods and analytical methodology. After considering many of the factors affecting abundance estimates, there is still evidence of a decline in the abundance *estimates*, although it is not clear how this reflects any *actual* change in minke abundance. Three hypotheses that might explain these results have been identified:

(1) a real change in minke abundance;
(2) changes in the proportion of the population present in the survey region at the time of the survey; or
(3) changes in the survey process over time that compromise the comparability of estimates across years.

A considerable amount of work has been undertaken and further work is ongoing. The final part of the Third Circumpolar Survey undertaken as part of the IWC's SOWER research programme has been completed. This work will again be a priority item for discussion at next year's Scientific Committee meeting. Particular attention will be given to the potential relationship between minke whale distribution and the extent and nature of sea ice.

4.2.2 Commission discussion and action arising

Japan considered that the difference in abundance estimates between CPII and CPIII cannot be fully explained by biological reasons and that the employment of different survey designs, survey methods and timing between the series, as well as differences in sea ice, may have had an impact. It was therefore pleased to see that the Scientific Committee is now working on elucidating the reasons for these differences and awaited the outcome with interest. Japan noted that results from JARPA do not show any sign of declines in abundance and concluded that stock abundance is stable, supporting the view that the differences between CPII and CPIII are apparent.

Australia noted that Japan's suggestion that abundance estimates are stable is not the consensus view of the Scientific Committee. Rather it believed it to be clear that uncertainty surrounding stock abundance continues and drew attention to the high priority given by the Scientific Committee on this issue. Referring to its comments on this matter in earlier years, Australia again expressed concern that a large number of minke whales are being taken in the Antarctic despite the uncertainty in stock abundance. The USA and Germany agreed.

St. Lucia congratulated those involved in the SOWER series and thanked Japan for providing the vessels and support to this work. It urged other governments with similar resources to contribute in a similar fashion to ensure continuation of this important work.

The Commission noted the Scientific Committee report and endorsed its recommendations.

[3] *J. Cetacean Res. Manage.* 3 (Suppl.): 29-32.

4.3 Southern Hemisphere whales other than minke whales

4.3.1 Report of the Scientific Committee

4.3.1.1 HUMPBACK WHALES

Considerable progress has been made in recent years in working towards an assessment of humpback whales. Attention has focussed both on data from historic whaling operations and on newly acquired photo-identification, biopsy and sightings data. The Committee made a number of research recommendations to further progress towards an assessment. An intersessional group was established last year to review progress and determine whether it is feasible to set a deadline for the assessment to be completed. Further work was identified this year and progress was reviewed. Further work remains to be completed.

4.3.1.2 BLUE WHALES

The Committee is beginning the process of reviewing the status of Southern Hemisphere blue whales. An important part of this work is to try to develop methods to identify pygmy blue whales from 'true' blue whales at sea and progress is being made on this. Work on genetic and acoustic differentiation techniques is continuing and there is considerable progress with morphological methods. The Committee has agreed on a number of issues that need to be resolved before it is in a position to carry out an assessment, which it believes should commence in 2006. This year, the Committee reviewed a paper by Branch *et al.* (2004[4]). The Committee agreed that this research supported the conclusions that: (1) on average, the Antarctic blue whale population is increasing at a mean rate of 7.3% per annum (95% CI 1.4–11.6%); (2) had an estimated circumpolar population size of 1,700 (95% CI 860–2,900) in 1996; and (3) that this population is still severely depleted with the 1996 population estimate estimated to be at 0.7% (95% CI 0.3–1.3%) of the estimated pre-exploitation level.

4.3.2 Commission discussion and action arising

Australia was encouraged that Southern Hemisphere humpback whales are apparently increasing in and around its waters and reported that it is good news for its whalewatching industry that relies on increasing numbers of humpback whales. Believing that some sightings surveys and modelling exercises may be over-estimating the numbers of some humpback populations, Australia looked forward to greater clarity of what it believed were apparent anomalies.

Japan reported that results from JARPA indicated sharp increases in the numbers of humpback and fin whales. It quoted estimates of 41,000 for humpbacks whales and 15,000 for fin whales in the north of the survey area (suggesting an estimate of 68,000 for the total stock). Australia, the UK and New Zealand believed these estimates to be flawed. Japan responded that the areas where these increases have been seen are south of 60°S. It believed that there are certain biological reasons for these increases but also suggested that some animals may have moved south from Australian waters. Japan also suggested that the increase in numbers of various large whale species in the Southern Hemisphere may not be helpful to the recovery of blue whales, given interspecific competition. Brazil, supported by Australia did not agree.

[4] Branch, T.A., Matsuoka, K. and Miyashita, T. 2004. Evidence for increases in Antarctic blue whales based on Bayesian modelling. *Mar. Mammal Sci.* 20(4): 726-754.

The Commission noted the Scientific Committee report and endorsed its recommendations.

4.4 Other small stocks – bowhead, right and gray whales

4.4.1 Report of the Scientific Committee

4.4.1.1 SMALL STOCKS OF BOWHEAD WHALES

The Committee received information of a number of analyses on the stock identity, movements and abundance of bowhead whales from the Davis Strait/Baffin Bay and Hudson Bay/Foxe basin regions. There were no reports of any catches in 2004.

4.4.1.2 NORTH ATLANTIC RIGHT WHALES

The Committee has paid particular attention to the status of the North Atlantic right whale in the western North Atlantic in recent years (e.g. see *JCRM* Special Issue 2: *Right Whales: Worldwide Status*). The Committee is extremely concerned about this population, which, whilst probably the only potentially viable population of this species, is in serious danger (*ca* 300 animals). By any management criteria applied by the IWC in terms of either commercial whaling or aboriginal subsistence whaling, there should be no direct anthropogenic removals from this stock.

This year, the Committee once again noted that individuals from this stock are continuing to die or become seriously injured as a result of becoming entangled in fishing gear or being struck by ships. It repeated that it is a matter of absolute urgency that every effort be made to reduce anthropogenic mortality in this population to zero. This is perhaps the only way in which its chances of survival can be directly improved. There is no need to wait for further research before implementing any currently available management actions that can reduce anthropogenic mortalities.

The Committee reviewed progress on a number of research and management recommendations concerning this stock.

4.4.1.3 NORTH PACIFIC RIGHT WHALES

The Committee received reports of sightings of the endangered North Pacific right whales, including news of one biopsy sample and three photo-identification photographs

4.4.1.4 SOUTHERN RIGHT WHALES

The Committee received reports of continuing increases in Southern right whale numbers off South Africa. It was estimated that there are more right whales there now than at any time in the last 150 years. The Committee recommends that the over 30 year monitoring programme be continued, noting its value to conservation and management.

The Committee also received reports of right whales off Brazil and Argentina, and reviewed the report of a photo-identification workshop held in Adelaide, Australia.

4.4.1.5 WESTERN NORTH PACIFIC GRAY WHALES

This is one of the most endangered populations of great whales in the world. It numbers less than 100 animals and there are a number of proposed oil and gas-related projects in and near its only known feeding ground. The Committee held a Workshop in October 2002 to review this further. The Workshop report was published in *J. Cetacean Res. Manage.* 6 (Suppl.). Overall, the Workshop agreed with the conclusions of previous reviews on western gray whales. Specifically, that the population is very small, and suffers from a low number of reproductive females, low calf survival, male-biased sex ratio, dependence upon a restricted feeding area and apparent nutritional stress (as reflected in a large number of skinny whales). Other major potential concerns include behavioural reactions to noise (notably in light of increasing industrial activity in the area) and the threat of an oil spill off Sakhalin which could cover all or part of the Piltun area and thus potentially exclude animals from this feeding ground. The Workshop had noted that assessments of the potential impact of any single threat to the survival and reproduction of western gray whales were insufficient and had strongly recommended that risk assessments consider the cumulative impact of multiple threats (from both natural and anthropogenic sources). Last year, the Committee adopted the Workshop report and endorsed its recommendations, including the research and monitoring plan.

In reviewing progress this year, the Committee noted with great concern that the evidence is compelling that this population is in serious danger of extinction. It reiterated that the population is small (only about 100 whales) and appears to have biological problems (only 23 reproductive females, three or more years calving interval, male biased sex ratio, and apparent low calf survival). Furthermore, there is only a single known coastal feeding habitat (approximately 60km long and 5km wide) used by females and calves which faces an obvious and immediate threat from industrial activities, including noise, vessel traffic and the potential for a catastrophic oil spill. Noting, its similarly strong concerns for North Atlantic right whales, the Committee recommended as a matter of absolute urgency that measures be taken to protect this population and its habitat off Sakhalin Island.

Plans for the Russia-USA research collaboration and national research plans from Russia and Korea were presented. As in previous years, the Committee strongly recommended that the ongoing Russia-USA and Russian and Korean national programmes on western gray whale research and monitoring continue and expand into the future. Results from these programmes will be the only way to monitor and assess the status of this critically endangered population.

The Committee also strongly recommended that all range states develop or expand national monitoring and research programmes on western gray whales. The Committee noted particularly that the precise location and status of the breeding grounds of this highly endangered whale (presumably in Chinese waters) are still unknown.

4.4.2 Commission discussion and action arising

New Zealand welcomed the news that there are more southern right whales now than there have been for the past 150 years but noted that the global population is still only around 10% of its estimated pre-exploitation level. It also noted that all these small stocks were once abundant and suggested that it will be centuries, if ever, before they recover.

Further discussion focused on the western North Pacific stock of gray whales. Noting the concern expressed by the Scientific Committee regarding this stock, the Russian Federation considered that as yet there is no evidence that the oil development programme off Sakhalin Island is having an actual impact on the gray whales. The Republic of Korea shared the Scientific Committee's concern and believed that more studies were needed to assess the impact, if any of the oil industry's activities. It noted the historic and cultural importance of this species to the

Korean peoples and that in 1962, the Korean Government had declared its migration corridor a national treasure. It reported that it had conducted a national census that would complement the work of the Scientific Committee, and stressed the importance of involving range states in work on this stock. The USA, Germany and Italy also expressed concern regarding the status of this stock and welcomed the Scientific Committee's recommendations. Japan considered that the countries in which the headquarters of the major oil companies involved are based should work closely with range states on this issue.

The Commission noted the Scientific Committee report and endorsed its recommendations.

RESOLUTION ON WESTERN NORTH PACIFIC GRAY WHALE

The UK introduced a draft Resolution on western North Pacific gray whales of behalf of the other co-sponsors South Africa, Belgium and Germany. Among other things, the draft Resolution:

(1) endorsed all of the Scientific Committee's conclusions and recommendations;
(2) requested the Secretariat to offer its services and scientific expertise to the organisations concerned with oil and gas development projects and to participate actively in any international panels convened to consider the impacts of these projects on the western gray whale; and
(3) requested all range states to develop, begin or continue scientific research programmes on the migration, distribution, breeding, population assessment and other research of the entire range of this stock.

While the general sentiment of the draft Resolution was supported by all, the Republic of Korea, Norway and Japan questioned whether it was necessary given that it was largely a repeat of the Scientific Committee recommendations. Referring to the third pre-ambular paragraph, the Russian Federation repeated its earlier comments that there is no evidence that oil and gas exploration is having an impact on the population and that this population was under threat of extinction prior to these activities beginning. It proposed some revisions to the text to reflect its view. Japan questioned why the co-sponsors had not consulted with the range states. Iceland objected to the last pre-ambular paragraph referring to IWC as the international recognised body for the conservation of whale stocks and believed this statement to be contrary to UNCLOS.

The UK explained that the key difference between the draft Resolution and the Scientific Committee recommendations was that the former urges governments to involve IWC in the independent work taking place around Sakhalin Island. It could not support the Russian Federation's proposed amendments since these would not reflect the Scientific Committee views, and it believed that it had consulted with range states and invited them to comment on the draft Resolution.

Sensing strong support for the draft Resolution, the Chair requested parties to consult to try to resolve differences. Such consultation took place and a revised draft Resolution was submitted with Germany, Italy, Switzerland and Austria being added to the list of sponsors. The Russian Federation believed that the revised proposal would help it in its discussions with the oil and gas industry and called on range states to participate. It hoped that the draft Resolution could be adopted by consensus. The Republic of Korea associated itself with these remarks and urged members to be cognisant of the sovereign rights of range states. Norway's view on the need for a Resolution remained unchanged, believing it to be superfluous. It indicated it would abstain from any vote. Japan was of a similar view and indicated that it too would abstain. In the end, the revised Resolution (2004-1, see Annex C) was adopted by consensus, noting the views of Norway and Japan.

5. ABORIGINAL SUBSISTENCE WHALING[5]

The meeting of the Aboriginal Subsistence Whaling Sub-committee took place on 14 July chaired by Andrea Nouak (Austria). Delegates from 30 Contracting Governments participated. The Chair of the Scientific Committee's Standing Working Group on the Development of an Aboriginal Whaling Management Procedure (SWG) reported the outcome of the Committee's work and discussions. A summary of the discussions of the Sub-committee is included below. The full Sub-committee report is available as Annex D.

5.1 Aboriginal subsistence whaling procedure

5.1.1 Report of the Aboriginal Subsistence Whaling Sub-committee

5.1.1.1 EASTERN NORTH PACIFIC GRAY WHALES

As anticipated, the Scientific Committee had been able to recommend a *Strike Limit Algorithm* (*SLA*) for eastern North Pacific gray whales to the Commission. This was the second *SLA* that the Scientific Committee has recommended in the development process, the first being that for the Bering-Chukchi-Beaufort stock of bowhead whales at the Annual Meeting in 2002.

The candidate procedures for the gray whale case were tested for a broad range of uncertainty in a variety of factors, including: changes in *MSYR* and *MSYL*; model uncertainty; time dependent changes in carrying capacity, natural mortality and productivity; episodic events; stochasticity; survey bias and variability; survey frequency and errors in the historic catch series. The overall performance of candidate *SLA*s was judged by a combination of an examination of the detailed conservation and need satisfaction statistics for each of the *Evaluation Trials* and *Robustness Trials* and human integration of these results in the context of the relative plausibility each member assigns to the individual trials.

Two procedures, J-B2 and the GUP2 (Grand Unified Procedure) based on J-B2 and D-M2 procedures, had performed equally well in the trials. However, after examination of other features that may be used to separate the two *SLA*s (see Annex D for further details), the Scientific Committee unanimously recommended that the GUP2 *SLA* (hereafter the '*Gray whale SLA*') be forwarded to the Commission. It believes that this *SLA* meets the objectives of the Commission set out in 1994 and represents the best scientific advice that the Committee can offer the Commission with respect to the management of the Eastern North Pacific stock of gray whales.

In making this recommendation, the Scientific Committee had noted the integral importance of *Implementation Review*s to the whole process. These would

[5] For details of the Scientific Committee's deliberation on this item see *J. Cetacean Res. Manage.* 7 (Suppl.).

occur every five years and would normally involve at least reviews of information: (1) required for the *SLA* (i.e. catch data, abundance estimates); and (2) to ascertain if the present situation is as expected and within tested parameter space. In addition, to enable swift reaction to new information that gives rise to serious concern, *Unscheduled Implementation Reviews* can be called. There are a variety of possible outcomes of *Implementation Reviews*, including:

(a) the continuation of use of the *SLA*;
(b) the setting of a zero strike limit;
(c) the running of further simulation trials;
(d) the undertaking of a new census immediately; and
(e) a combination of some of the above.

The Sub-committee endorsed the Scientific Committee's recommendations.

5.1.1.2 GREENLANDIC FISHERIES

The Chair of the Standing Working Group (SWG) had reminded the Sub-committee that an urgent need for a Greenland Research Programme was first identified in 1998, primarily due to the lack of recent abundance estimates and the poor knowledge of stock structure. He had noted that it would be extremely difficult, if not impossible, to develop an *SLA* for the Greenlandic fisheries that would satisfy all of the Commission's objectives without such information. This is particularly important in the light of the Scientific Committee's grave concern at its inability to provide management advice for these fisheries.

In reporting to the Sub-committee, the SWG Chair separated out this item into four main issues: stock structure; abundance estimates; biological data and *SLA* development. With respect to the former, the problem was that although the available information suggested that the animals found off West Greenland did not comprise either separate fin or common minke whale stocks, the identity and size of the complete stocks is unknown. The Scientific Committee had agreed to follow a two-step process to further the essential work needed to provide information suitable for management; namely an initial simulation study to focus appropriate genetic analyses.

Regarding genetic analyses, the Scientific Committee had expressed disappointment at the lack of progress in obtaining genetic samples, even though it is mandatory under local regulations to return a sample from each whale caught. It noted that new procedures are in place but repeated its strong recommendation that samples for genetic analysis be collected from the catch as a matter of very high priority. It urged the Commission to encourage the Government of Denmark and the Greenland Home Rule authorities to assist with logistical and, if necessary, financial support and encouraged Greenlandic scientists to investigate other potential sources of samples. The news that some 50 samples are available from the eastern USA and Canada was welcomed and the Scientific Commission urged that these be analysed.

With respect to abundance estimates, last year the Scientific Committee had strongly recommended that a traditional aerial cue-counting survey be carried out in summer 2003 in Greenland. Unfortunately, for logistical and financial reasons it had not been possible to undertake such a survey, but some valuable experimental work had been carried out in 2003 that had been discussed by the Scientific Committee. Greenlandic scientists had presented a plan for a full aerial photographic survey (not cue-counting) to take place in summer 2004. The Scientific Committee had noted the great need for new abundance estimates and, in order to facilitate presentation of appropriate analyses as quickly as possible, had established an intersessional advisory group. The Chair of the SWG noted that the difficult environmental conditions (notably fog and high winds) in Greenland make the undertaking of successful surveys problematic.

In terms of developing an *SLA*, it was noted that the differences between the relatively 'easy' data-rich cases of the bowhead and gray whales and the data-poor Greenlandic cases, may warrant a different approach to the examination of the trade-off between risk and need satisfaction. The SWG had also considered how best to proceed with the development of one or more *SLA*s given the continuing uncertainties about stock structure, abundance, and mixing in the region. One approach would be to postpone *SLA* development until more and better data become available. The SWG had rejected this approach, instead believing that *SLA* development was a matter of considerable urgency. The SWG therefore intends to develop the best *SLA*(s) it can given the data available, and, noting the potential of the simulation approach to help identify appropriate data collection programmes, it recognised that it might become necessary to improve the *SLA*(s) at future *Implementation Review*s when more information is available. The Scientific Committee had endorsed this approach.

The catch data for 2003 were: 6 landed fin whales (2 males and 4 females), with 3 struck and lost; 178 landed West Greenland common minke whales (58 males, 117 females, 3 unknown sex) and 7 struck and lost; and 13 landed East Greenland common minke whales (1 male, 11 females, and 1 unknown sex). An analysis of recent catch data will be provided to the next Committee meeting.

Other aspects of the Scientific Committee's discussions of the Greenlandic fisheries, including the provision of management advice, are given under Item 5.3.1.3

In the Sub-committee New Zealand stated that it considered the data provision by Greenland unsatisfactory and questioned whether restrictions should be imposed on its catch quotas. It asked Denmark to explain how they intended to remedy this situation. Denmark responded that information on the importance of returning samples has been given to the hunters and that efforts are being made to improve communication. The Greenland Home Rule Government regrets the low number of samples collected and, for the 2004 season, letters and phials have been sent to the municipalities and will be handed out to the hunters when licenses are issued. The UK expressed its concern with this response. It recognised that policing of the hunt is difficult, but stated that the conditions under which aboriginal subsistence whaling in Greenland is allowed are known to the hunters and are included in licences. The UK felt that non-compliance with conditions required more serious action.

The Sub-committee endorsed all recommendations of the Scientific Committee on this item.

5.1.2 Commission discussions and action arising

Discussion in the Commission focused on the Greenlandic fisheries.

Following the discussions in the Aboriginal Subsistence Whaling Sub-committee and the Infractions Sub-committee (see section 18 and Annex I) a statement on the Greenland

Research Programme had been prepared and submitted to plenary by Denmark. In this statement, Greenland pointed to the following:

- that the International Whaling Commission has accepted that the West Greenland need for meat from large whales is 670 tons annually;
- that the current IWC quotas do not meet the accepted need;
- further that the Greenland need for whale meat is supplemented by whale meat from stocks not covered by the IWC;
- that Greenland has regularly submitted substantive information on whaling issues to the Commission for decades;
- that the Greenland Home Rule Government has allocated DKK 1.2 – 1.4 mill in each of the years 2002, 2003 and 2004 to surveys and the development of survey methods;
- that attempts were made to carry out aerial surveys in 2002, but due to bad weather these were not carried out as planned, and furthermore, a camera survey test flying was conducted successfully in 2003 in Iceland;
- that Greenland has collected 301 genetic samples from 1998 to 2003, and that 166 samples collected in West Greenland and 30 collected in East Greenland have been analysed in connection with investigations of stock structure of north Atlantic minke whales;
- that the IWC has supported the Greenland Research Program with a total amount of £69,552 in the years 1999 – 2004 to both feasibility study, biopsy study and satellite telemetry;
- that the Commission has decided not to implement the AWMP until the RMS has been implemented;
- that the Greenland annual harvest of the central North Atlantic minke whales constitutes less than 0.01% of the stock;
- that a harvest of minke whale of West Greenland waters has had a larger proportion of females; and
- that the present Schedule foresee a review if new scientific data become available within the present 5 year period (2003-2007) and if necessary amended on the basis of the advice of the Scientific Committee.

Greenland and Denmark further:

- find that the lack of adequate data on abundance and stock structure of West Greenland minke and fin whales is a matter of concern;
- want to complete the research recommended by the Scientific Committee as soon as possible and to continue to facilitate hunters to collect and submit samples from each whale landed; and
- want the Scientific Committee to further discuss the existing results and to guide future analysis of genetic samples.

The statement further requested the Scientific Committee if possible and in concurrence with its own agenda to:

(1) continue development of and complete an AWMP for Greenland whaling when adequate data become available;
(2) continue cooperation and guidance of Greenland scientific activities;
(3) establish adequate guidelines in relation to analysis of the collected samples; and
(4) continue further dialogue with Greenland scientists in order to ensure that the appropriate research activities are successfully undertaken.

The UK referred to the discussions between Denmark/ Greenland and the UK and New Zealand during the Sub-committee meeting. It urged Greenland to carry on its research programme and to try to address the question of sex bias in the catches. The UK also urged the Scientific Committee to consider urgently the effect of this bias in catches on the population dynamics of the stocks involved and to consider what might be done to recognise the difficulties of hunting in the Arctic. It welcomed Denmark's statement and hoped that work could proceed on this basis. New Zealand, Germany and Australia echoed the UK's remarks.

The Minister of Fisheries and Hunting of the Greenland Home Rule Government stressed that his Government recognizes the need to complete the survey and genetic research required for developing abundance estimates. He reported that Greenland is working hard to fulfil its research programme but sought the Commission's understanding of the difficult conditions under which it must be carried out. He requested that a formal review of aboriginal subsistence whaling in Greenland be kept as planned, i.e. a review at the Annual Meeting in 2007.

Japan commented on the different approach being used to develop *SLA*s for aboriginal subsistence whaling (i.e. stock-specific) compared with that for the RMP (i.e. generic), noting that if applied to the B-C-B Seas stock of bowheads the RMP would not give a catch limit. It did not believe these different approaches to be scientifically justified and considered that double standards were being applied. In response, the USA noted that the approaches to the *SLA* and *CLA* are different because the Commission has given different policy advice for the different types of hunt. The USA considered it inappropriate to apply the *CLA* to a stock subject to subsistence whaling. It further noted that the Scientific Committee has indicated that the bowhead *SLA* will have to be reviewed if new information on stock identity comes to light. The Commission noted this part of the Sub-committee's report and endorsed its recommendations.

5.2 Aboriginal subsistence whaling scheme (AWS)

5.2.1 Report of the Aboriginal Subsistence Whaling Sub-committee

As for the last two years, the Scientific Committee recommended a number of scientific aspects of an eventual AWS[6]. These included strike-limit related issues (block limits, carryover, grace period), survey-related issues (survey/census methodology and design, Committee oversight, data analysis and availability), guidelines for data/sample collection and *Implementation Reviews*. During the Sub-committee, Australia recognised that the focus of discussion was on science, but registered its concern over whaling management regimes that it considered should be given equal attention. The USA stated that they have previously expressed concerns over certain provisions of the AWS and that their reservations should continue to be noted. The Sub-committee endorsed the recommendations of the Scientific Committee.

[6] *Ann. Rep. Int. Whal. Comm.* 2002: 74-5.

5.2.2 Commission discussions and action arising

In the Commission, the USA expressed appreciation for the work of the Scientific Committee on the AWS, but believed that some aspects are not appropriate for the B-C-B Seas stocks of bowhead whales. It noted that the 'grace period' (i.e. a mechanism to deal with a hypothetical situation of no abundance estimates being made available with the specified time frame) does not take into account the difficulties of conducting abundance surveys in the Arctic and in any case is redundant as the Commission can request an *Implementation Review* at any time. It further noted that although it agrees in principle with the concept of block quotas, it would like some flexibility regarding their duration; five years would be a minimum. The USA believed that the current management regime provided in paragraph 13(a) of the Schedule has worked well for over 25 years and that any revised scheme must provide a true improvement over the *status quo*.

The Commission noted this part of the Sub-committee report and endorsed its recommendations.

5.3 Aboriginal subsistence whaling catch limits

5.3.1 Report of the Aboriginal Subsistence Whaling Sub-committee

5.3.1.1 BERING-CHUKCHI-BEAUFORT SEAS STOCK OF BOWHEAD WHALES

The Chair of the SWG had noted that this year, the Scientific Committee undertook an in-depth assessment of the B-C-B bowhead whales. The Committee had agreed that substantial progress has been made in investigating possible stock or population structure among B-C-B bowheads but that there is insufficient information at this stage to fully support or refute the hypothesis of a single stock; in fact it is premature to reject any of the hypotheses, or even to draw conclusions about their relative plausibility. The Committee was pleased to receive information on an extensive research programme to address this issue further. Catch information was provided for 2003 by the USA and the Russian Federation (see Annex D).

In terms of management advice, the Scientific Committee agreed that the *Implementation Review* of bowhead whales, due to begin at the 2006 Annual Meeting in time for the major review of subsistence quotas in 2007, will include stock structure issues as a major component, examining the robustness of the *Bowhead SLA* with respect to plausible stock hypotheses via simulation trials.

The Scientific Committee had also noted:

(1) the continuing increase in the abundance estimates derived from the census under the recent catch limits and record high calf counts;
(2) the spatio-temporal distribution and opportunistic nature of the hunt and the low numbers of whales struck annually in St. Lawrence Island and Chukotka; and
(3) the development of an extensive research programme that will address questions of stock structure and allow the formulation of one or more plausible stock structure hypotheses.

Given these factors, the Committee agreed that the *Bowhead SLA* remains the most appropriate tool for providing management advice for this harvest, at least in the short-term. Consequently the results from the *Bowhead SLA* indicate that no change is needed to the current block quota for 2003-2007.

In the Sub-committee, the USA and the Russian Federation commented on planned co-operative research. Noting the Scientific Committee's recommendation on the need for additional research on the bowhead stock identity issue, the USA expressed its commitment to undertake this research so that when the bowhead quota is next reviewed in 2007, management of the stock will be based upon the best science available at that time. The Russian Federation noted its intent to engage in as much joint research as is possible, although it noted that CITES sample requirements may impose difficulties on what is possible. In this respect, Switzerland drew attention to a Resolution adopted at COP 12 of CITES in Santiago (Chile), aimed at facilitating transboundary movement of sensitive biological samples such as scientific research materials for conservation purposes. It suggested that the CITES Management Authorities should be made aware of this if the need arises.

The Sub-committee endorsed the recommendations of the Scientific Committee.

5.3.1.2 NORTH PACIFIC EASTERN STOCK OF GRAY WHALES

Data on catches and information on calf counts from the northbound migration and the breeding lagoons in Mexico were presented to the Scientific Committee. The Committee was encouraged to hear that calf production remains at the mid-range of pre-1999 levels (after low levels in 1999, 2000, 2001). In 2002, the Scientific Committee had carried out an in-depth assessment of the Eastern North Pacific stock of gray whales and agreed that a take of up to 463 whales per year is sustainable for at least the medium term (~30 years), and is likely to allow the population to remain above *MSYL*. No information was presented this year to change that advice. The Committee was pleased to receive the *Gray Whale SLA*, which could be used in future for providing management advice.

The Sub-committee endorsed the recommendations of the Scientific Committee.

5.3.1.3 MINKE AND FIN WHALE STOCKS OFF WEST GREENLAND

The Chair of the SWG had reported that the minke and fin whale stocks off West Greenland was an important issue in the Scientific Committee's deliberations this year. The Committee has never been able to provide satisfactory management advice for either of these stocks. This reflects the lack of data on stock structure and abundance and is the reason for the Committee to first call for the Greenland Research Programme in 1998. He noted that the Commission's financial contributions to the programme had been aimed at testing the feasibility of large-scale biopsy sampling and satellite telemetry to try to obtain information on abundance and stock structure but that unfortunately both proved unsuccessful.

The Scientific Committee stressed that its inability to provide advice on safe catch limits is a matter of great concern, particularly in the case of fin whales where the best available abundance estimate dates from 1987/88 and is only 1,096 (95% CI 520-2,100) while that for West Greenland minke whales dates from 1993 and is 8,371 (95% CI 2,400-16,900). Obtaining adequate information for management must be seen as very high priority by both the national authorities and the Commission. The Committee urged the Commission to encourage the Government of Denmark and the Greenland Home Rule authorities to provide the necessary logistical and financial support. Without such adequate information, the

Committee will not be able to provide safe management advice in accord with the Commission's management objectives, or develop a reliable *SLA* for many years, with potentially serious consequences for the status of the stocks.

The Scientific Committee recommended that every effort be made to ensure that the number of samples collected from the catch in 2004 is considerably higher than in 2003 and close to 100%. It also recommended strongly that these and all existing samples held in Greenland be analysed as soon as possible in accordance with guidance to be given by the intersessional working group.

The Scientific Committee drew attention to the grace period provision that it had agreed previously in the context of a general aboriginal whaling scheme (although it has not yet been accepted by the Commission) associated with agreed *SLA*s. Under such a provision, catch limits would begin to be phased out 10-14 years after an abundance estimate was last obtained and catches would revert to zero at the end of the five-year period during which the catch limit would have been half the previous block. The Committee has not previously suggested that such a grace period should have started for fin whales. However, it drew attention to the fact that if it had, such a period would now be nearing completion.

The SWG Chair reported that it was with great concern that the Scientific Committee advised the Commission that in the absence of an agreed abundance estimate for fin whales arising out of the 2004 survey, it will likely recommend that the take of fin whales off West Greenland be reduced or eliminated immediately. If, as hoped, an abundance estimate is obtained, the Committee will review this next year in its formulation of management advice.

In the Sub-committee, Denmark explained that the Greenland Home Rule Government gave financial support for survey projects of between DKK 1.2-1.4 million annually for the years 2002-2004, and reported on the number of samples collected and analysed (see Annex D) and on the publication of the results. It noted what it considered to be a disappointingly short discussion of these results in the SWG, but hoped to receive some guidance from the SWG on the best directions for future analyses. Greenland was therefore looking forward to a project to be undertaken this winter in cooperation with the SWG. On the question of reduction of the current quota of fin whales, Greenland suggested that the Scientific Committee is not the right body to decide such a reduction. The Greenland Home Rule Government stated that it intended to increase its efforts in cooperation with the hunters' organisation to gain more samples as recommended.

The UK noted that the Scientific Committee recommendations were in the strongest terms it had seen. The UK felt that the Commission would need to agree to take action on the quota if data were not made available. Australia concurred with the UK and suggested that the Scientific Committee concerns should be reinforced by the Sub-committee.

Argentina, New Zealand and the UK expressed concern that the sex ratio of the Greenland's minke hunt is highly female biased: on average, 72% of all minke whales killed in Greenland since 1986 were female. Denmark explained, as it had on earlier occasions, that sex selection is impossible to enforce in Greenland due to both weather and ocean conditions. New Zealand was concerned that the preferential removal of females could significantly affect the regenerative capacity of the stock and suggested that it would be helpful for Greenland to provide information on the date, location and sex of every whale taken, to show precisely what is going on. New Zealand believed that these issues raise fundamental questions of accountability that go to the centre of the integrity of the legal instrument under which the Commission operates. The UK, supported by Switzerland, remarked that if a degree of sex bias is inevitable, it raised some very important questions about the sustainability of the hunt.

With respect to the female bias in the catch, the SWG Chair clarified that it is common for minke whales to segregate both geographically and temporally by sex in the North Atlantic. The sex bias in the catch is longstanding and earlier attempts to model the animals off West Greenland showed that if the minke whales found there comprised a complete stock they would already have become extinct. The sex bias in the catch probably reflects the sex ratio in the waters there and not any selectivity by whalers (which in any case is not possible). He noted that the Committee was expecting a paper on recent catches (both geographical and temporal by sex) at its next meeting.

Greenland explained that the information on the seasonal distribution of the harvest suggests northward movement in early part of hunting season and a southern movement in the autumn, so that the hunting season, which is in any case short, is even shorter in the northern part of the area of distribution of minke whales in West Greenland. Analysis has not so far shown differential distribution of the two sexes. They suggested that knowledge of this bias is long-standing and not recent. This bias suggests that this is probably a part of a larger stock, whose boundaries are uncertain.

The Sub-committee endorsed the recommendations of the Scientific Committee regarding the minke and fin whale stocks off Greenland.

5.3.1.4 NORTH ATLANTIC HUMPBACK WHALES OFF ST. VINCENT AND THE GRENADINES

The Scientific Committee had agreed that it was most plausible that the animals off St. Vincent and The Grenadines are part of the West Indies breeding population (*ca* 10,750 animals in 1992), although it acknowledged that further data to confirm this are desirable. It repeated its previous recommendations that every effort be made to obtain photographs and genetic samples from animals taken. The Scientific Committee was disappointed not to receive information on whether or not any catches had been taken last year (no scientists from St. Vincent and The Grenadines had been present and no national progress report had been submitted). However, it noted that the genetic analyses of at least three samples from caught animals is being conducted and it was pleased to hear that sightings cruises are taking place in the region.

The Scientific Committee agreed that if the humpback whales are part of the West Indies breeding population, the block catch limit of 20 for the period 2003-2007 will not harm the stock.

In the Sub-committee, the UK did not dispute the Scientific Committee recommendations, but urged the need for further data, since it believed there could be ramifications if the animals off St. Vincent and The Grenadines are not part of the West Indies population. Australia understood that St. Vincent and The Grenadines passed new whaling regulations in December 2003, and asked whether a copy of this legislation had been submitted to the Secretariat as is required, and whether it had been found to be consistent with the draft legislation presented to the IWC. The Chair of the SWG indicated that this matter was usually dealt within in the Infractions Sub-committee, but he would investigate this situation.

5.3.2 Commission discussions and action arising

The Commission noted the Sub-committee's report and endorsed its recommendations. Discussions on specific stocks are summarised in the following sections.

5.3.2.1 BERING-CHUKCHI-BEAUFORT SEAS STOCK OF BOWHEAD WHALES

The USA reported that it had undertaken genetic research in response to the request from the Special Meeting of the Commission in October 2002 that an in-depth assessment of this stock be completed with results available for the 2004 Annual Meeting. The USA noted that the results did reveal genetic differences, but that it is too early to draw conclusions regarding stock identity. It drew attention to the Scientific Committee's view that for the time being it is reasonable to continue to apply the bowhead *SLA*, noted the data showing an increase in abundance of this stock and indicated that it saw no need to modify current management approaches. The USA was, however, committed to carrying out further research on stock identity in time for 2007 as requested by the Scientific Committee.

Japan expressed appreciation for the active discussions in the Scientific Committee and believed that the results from work on this stock should be reflected in management advice from this year onwards. As last year[7] it noted what it believed to be double standards in the approach to management of the bowhead stock using the *SLA* and the *Implementation Simulation Trials* on western North Pacific minke whales using the *CLA*. It called for consistency in approach.

5.3.2.2 NORTH PACIFIC EASTERN STOCK OF GRAY WHALES

There were no comments on this stock.

5.3.2.3 MINKE AND FIN WHALE STOCKS OFF WEST GREENLAND

There were no comments on this stock.

5.3.2.4 NORTH ATLANTIC HUMPBACK WHALES OFF ST. VINCENT AND THE GRENADINES

St. Vincent and The Grenadines indicated that it was unfortunate that it had been unable to attend the Scientific Committee and the Aboriginal Subsistence Whaling Sub-committee meetings. It confirmed that it had submitted a copy of its 2003 whaling regulations to the Secretariat, and it reported that on 29 March 2003 one humpback whale, 39ft in length, had been taken.

5.4 Revision of Schedule paragraph 13

5.4.1 Report of the small working group and proposed Schedule amendment

REPORT OF THE SMALL WORKING GROUP

At the 55th Annual Meeting of the IWC, a Small Group comprising the Russian Federation, Denmark, Australia, the USA and the Secretariat was charged with reviewing of the Schedule paragraph 13, that provides for aboriginal subsistence whaling catch limits, to determine how consistency in approach across all such whaling operations could be achieved and to propose some amendments to the Schedule for review and decision-making at the 56th Annual Meeting of the IWC in 2004.

The Small Group worked intersessionally by e-mail and agreed the following.

All provisions governing aboriginal subsistence whaling operations are understood to be, and should be, included in paragraph 13 of the Schedule.

Should the Commission decide to harmonise the Aboriginal Subsistence Whaling Schedule language, the group recommends considering the creation of one option concerning the prohibition on the taking of calves and whales accompanied by calves. The Schedule has such parts in sub-paragraphs 13 (b) (1) and 13 (b) (2), but not in the sub-paragraphs 13 (b) (3) and 13 (b) (4). A new sub-paragraph 13 (a) (4) could be inserted in the general principles governing this form of whaling, to read as follows: 'It is forbidden to strike, take or kill calves or any whale accompanied by a calf.'

The group agreed that nothing in the Russian Federation's proposals to amend Schedule paragraph 13 was intended to allow for commercialisation of the aboriginal subsistence whaling.

The words 'when the meat and products of such whales are to be used exclusively for local consumption' means that some transaction beyond the aboriginal whaling communities under the current Schedule language are acceptable. The definition of aboriginal 'subsistence use' was adopted by the Cultural Anthropology panel of the IWC Meeting of Experts on Aboriginal/Subsistence Whaling in February 1979 (reported in IWC Special Issue 4, 1982) and provided that:

(1) The personal consumption of whale products for food, fuel, shelter, clothing, tools or transportation by participants in the whale harvest.
(2) The barter, trade or sharing of whale products in their harvested form with relatives of the participants in the harvest, with others in the local community or with persons in locations other than the local community with whom local residents share familial, social, cultural or economic ties. A generalised currency is involved in this barter and trade, but the predominant portion of the products from such whales are ordinarily directly consumed or utilised in their harvested form within the local community.
(3) The making and selling of handicraft articles from whale products, when the whale is harvested for the purposes defined in (1) and (2) above.

It was agreed by the Small Group that aboriginal communities in Chukotka, which have quota to take gray and bowhead whales, have equal rights to other aboriginal communities that have Aboriginal Subsistence Whaling quota to use the meat and products of these whale species.

The Small Group noted that the proposal to delete the words 'whose traditional aboriginal subsistence and cultural needs have been recognised' from Schedule sub-paragraph 13(b) (2) was intended to reflect this equality of rights. Without prejudice to any Party's final position and subject to there being no consequential difficulties, it was agreed that should it be necessary to delete the above words to reflect the equality of rights, this would be justified.

PROPOSED SCHEDULE AMENDMENT

After consultation with the Small Group, the Russian Federation proposed the following amendment with a view to improved harmonisation of the Schedule paragraph 13.

[7] *Ann. Rep. Int. Whaling Comm.* 2003:14.

Amend Schedule paragraph 13 as follows (proposed new text is shown in ***bold italics***; deleted text is in ~~strikeout~~ mode):

III. Capture
Baleen Whale Catch Limits

13 (a) ***(4) It is forbidden to strike, take or kill calves or any whale accompanied by a calf.***

13 (b). Catch limits for aboriginal subsistence whaling are as follows:

(1) The taking of bowhead whales from the Bering-Chukchi-Beaufort Seas stock by aborigines is permitted, but only when the meat and products of such whales are to be used exclusively for local consumption by the aborigines and further provided that:

(i) For the years 2003, 2004, 2005, 2006 and 2007, the number of bowhead whales landed shall not exceed 280. For each of these years the number of bowhead whales struck shall not exceed 67, except that any unused portion of a strike quota from any year (including 15 unused strikes from the 1998 - 2002 quota) shall be carried forward and added to the strike quotas of any subsequent years, provided that no more than 15 strikes shall be added to the strike quota for any one year.

~~(ii) It is forbidden to strike, take or kill calves or any bowhead whale accompanied by a calf.~~

~~(iii)~~ ***(ii)*** This provision shall be reviewed annually by the Commission in the light of the advice of the Scientific Committee.

~~(iv)~~ ***(iii)*** The findings and recommendations of the Scientific Committee's in-depth assessment for 2004 shall be binding on the parties involved and they shall modify the hunt accordingly.

(2) The taking of gray whales from the Eastern stock in the North Pacific is permitted, but only by aborigines or Contracting Government on behalf of aborigines, and then only when the meat and products of such whales are to be used exclusively for local consumption by the aborigines ~~whose traditional aboriginal subsistence and cultural needs have been recognised~~ ***and further provided that:***

(i) For the years 2003, 2004, 2005, 2006 and 2007, the number of gray whales taken in accordance with this sub-paragraph shall not exceed 620, provided that number of gray whales taken in any one of the years 2003, 2004, 2005, 2006 and 2007 shall not exceed 140.

~~(ii) It is forbidden to strike, take or kill calves or any gray whale accompanied by a calf.~~

~~(iii)~~ ***(ii)*** This provision shall be reviewed annually by the Commission in light of the advice of the Scientific Committee.

(3) The taking by aborigines of minke whales from the West Greenland and Central stocks and fin whales from the West Greenland stock is permitted and then only when the meat and products are to be used exclusively for local consumption.

(i) The number of fin whales from the West Greenland stock taken in accordance with this sub-paragraph shall not exceed the limits shown in Table 1.

(ii) The number of minke whales from the Central stock taken in accordance with this sub-paragraph shall not exceed 12 in each of the years 2003, 2004, 2005, 2006 and 2007, except that any unused portion of the quota for each year shall be carried forward from that year and added to the quota of any subsequent years, provided that no more than 3 shall be added to the quota for any one year.

(iii) The number of minke whales struck from the West Greenland stock shall not exceed 175 in each of the years 2003, 2004, 2005, 2006 and 2007, except that any unused portion of the strike quota for each year shall be carried forward from that year and added to the strike quota of any subsequent years, provided that no more than 15 strikes shall be added to the strike quota for any one year. This provision will be reviewed if new scientific data become available within the 5-year period and if necessary amended on the basis of the advice of the Scientific Committee.

(4) For the season 2003-2007 the number of humpback whales to be taken by the Bequians of St. Vincent and The Grenadines shall not exceed 20. The meat and products of such whales are to be used exclusively for local consumption in St. Vincent and The Grenadines. Such whaling must be conducted under formal legislation that accords with the submission of the Government of St. Vincent and The Grenadines (IWC/54/AS 8 rev2). The quota for the seasons 2006 and 2007 shall only become operative after the Commission has received advice from the Scientific Committee that the take of 4 humpback whales for each season is unlikely to endanger the stock.

5.4.2 Report of the Aboriginal Subsistence Whaling Sub-committee

In the Sub-committee, while there did not seem to be problems with the report from the Small Group, some concerns were expressed regarding the Schedule amendment proposed by the Russian Federation.

The UK fully accepted that the rights of Chukotka people should be exactly the same as other indigenous peoples but stressed the need to ensure that for aboriginal subsistence whaling operations, the products are, totally or in large measure, used for the people whose needs have been acknowledged. It therefore suggested that rather than simply deleting the text 'whose traditional aboriginal subsistence and cultural needs have been recognised' it be moved so as to apply equally to all indigenous whaling operations. New Zealand made a similar point. Austria sought clarification as to whether deleting this phrase would mean that all future new applications for aboriginal quotas would no longer need to demonstrate that they fulfil these criteria. Several members commented that the appropriate tests of need would continue to apply and that it is the Commission itself that recognises need when it approves aboriginal subsistence whaling quotas.

Grenada supported the proposed Schedule amendment in as much as it was aimed at producing a more uniform code for subsistence whaling operations, but questioned why St. Vincent and The Grenadines is the only one of those operations managed by IWC for which explicit text is included to effect that its operations must be conducted according to national legislation. On the understanding that all IWC members must enact national laws in accordance with the Convention, Grenada suggested that this reference in paragraph 13(b)4 either be deleted or inserted into the sub-paragraphs relating to other subsistence whaling operations. Japan considered that the proposed new paragraph 13(a)4 should refer to female whales accompanied by calves and, noting its long-standing cultural needs for whales, questioned how cultural needs are defined.

The Sub-committee endorsed the recommendation of the small group that its report and the proposed Schedule amendment be put forward to the Commission in plenary. The Sub-committee Chair recommended that those countries suggesting modifications to the proposed Schedule amendment consult prior to the Plenary.

5.4.3 Commission discussions and action arising

In the Commission, the Russian Federation introduced the report of the Small Group (see section 5.4.1), drawing particular attention to the definition of 'subsistence use', and asked that it be adopted by consensus and included in the Chair's Report of the meeting. It noted that since the meeting of the Aboriginal Subsistence Whaling Sub-committee it had worked with Denmark, St. Vincent and The Grenadines and the USA to address the Sub-committee's comments and with them wished to put forward the following slightly revised proposed Schedule amendment:

With the intention to further harmonise Schedule paragraph 13 it is proposed to amend Schedule paragraph 13 as follows (proposed new text is in ***bold italics***; deleted text is in ~~strikeout~~ mode):

'13.*(a)* ***(4) For aboriginal whaling conducted under subparagraphs (b)(1), (b)(2), and (b)(3) of this paragraph, it is forbidden to strike, take or kill calves or any whale accompanied by a calf. For aboriginal whaling conducted under subparagraphs (b)(4) of this paragraph, it is forbidden to strike, take or kill suckling calves or female whales accompanied by calves.***

(5) All aboriginal whaling shall be conducted under national legislation that accords with this paragraph.

(b) Catch limits for aboriginal subsistence whaling are as follows:

(1) The taking of bowhead whales from the Bering-Chukchi-Beaufort Seas stock by aborigines is permitted, but only when the meat and products of such whales are to be used exclusively for local consumption by the aborigines and further provided that:

(i) For the years 2003, 2004, 2005, 2006 and 2007, the number of bowhead whales landed shall not exceed 280. For each of these years the number of bowhead whales struck shall not exceed 67, except that any unused portion of a strike quota from any year (including 15 unused strikes from the 1998 - 2002 quota) shall be carried forward and added to the strike quotas of any subsequent years, provided that no more than 15 strikes shall be added to the strike quota for any one year.

~~(ii) It is forbidden to strike, take or kill calves or any bowhead whale accompanied by a calf.~~

~~(iii)~~ ***(ii)*** This provision shall be reviewed annually by the Commission in the light of the advice of the Scientific Committee.

~~(iv)~~ ***(iii)*** The findings and recommendations of the Scientific Committee's in-depth assessment for 2004 shall be binding on the parties involved and they shall modify the hunt accordingly.

(2) The taking of gray whales from the Eastern stock in the North Pacific is permitted, but only by aborigines or Contracting Government on behalf of aborigines, and then only when the meat and products of such whales are to be used exclusively for local consumption by the aborigines ~~whose traditional aboriginal subsistence and cultural needs have been recognised~~ ***and further provided that:***

(i) For the years 2003, 2004, 2005, 2006 and 2007, the number of gray whales taken in accordance with this sub-paragraph shall not exceed 620, provided that number of gray whales taken in any one of the years 2003, 2004, 2005, 2006 and 2007 shall not exceed 140.

~~(ii) It is forbidden to strike, take or kill calves or any gray whale accompanied by a calf.~~

~~(iii)~~ ***(ii)*** This provision shall be reviewed annually by the Commission in light of the advice of the Scientific Committee.

(3) The taking by aborigines of minke whales from the West Greenland and Central stocks and fin whales from the West Greenland stock is permitted and then only when the meat and products are to be used exclusively for local consumption.

(i) The number of fin whales from the West Greenland stock taken in accordance with this sub-paragraph shall not exceed the limits shown in Table 1.

(ii) The number of minke whales from the Central stock taken in accordance with this sub-paragraph shall not exceed 12 in each of the years 2003, 2004, 2005, 2006 and 2007, except that any unused portion of the quota for each year shall be carried forward from that year and added to the quota of any subsequent years, provided that no more than 3 shall be added to the quota for any one year.

(iii) The number of minke whales struck from the West Greenland stock shall not exceed 175 in each of the years 2003, 2004, 2005, 2006 and 2007, except that any unused portion of the strike quota for each year shall be carried forward from that year and added to the strike quota of any subsequent years, provided that no more than 15 strikes shall be added to the strike quota for any one year. This provision will be reviewed if new scientific data become available within the 5-year period and if necessary amended on the basis of the advice of the Scientific Committee.

(4) For the seasons 2003-2007 the number of humpback whales to be taken by the Bequians of St. Vincent and The Grenadines shall not exceed 20. The meat and products of such whales are to be used exclusively for local consumption in St. Vincent and The Grenadines. ~~Such whaling must be conducted under formal legislation that accords with the submission of the Government of St. Vincent and The Grenadines (IWC/54/AS 8 rev.2).~~ The quota for the seasons 2006 and 2007 shall only become operative after the Commission has received advice from the Scientific Committee that the take of 4 humpback whales for each season is unlikely to endanger the stock.'

In explaining the changes to its earlier proposal, the Russian Federation noted that since all aboriginal subsistence whaling operations must be conducted under national legislation and since St. Vincent and The Grenadines has fulfilled its obligation to develop such legislation, the text referring to legislation could be deleted from paragraph 13(b)4. It also explained that since the hunters of St. Vincent and The Grenadines are able to distinguish between males and females, the distinction between this hunt and the others regarding the prohibition of taking whales accompanied by calves should be retained. The Russian Federation believed that a fragile balance had been reached and on behalf of the other co-sponsors asked that in addition to the report of the small group, the revised proposed Schedule amendment could also be adopted by consensus.

The Commission adopted both the report of the small group and the revised proposed Schedule amendment by consensus. The Russian Federation thanked all Commissioners for their understanding and acknowledged the work of the small group in coming to this result. It hoped that the Commission could continue to work in such a friendly atmosphere. St. Vincent and The Grenadines echoed these sentiments.

6. REVISED MANAGEMENT SCHEME

6.1 Revised Management Procedure (RMP)[8]

6.1.1 Report of the Scientific Committee

6.1.1.1 GENERAL RMP ISSUES

REVIEW OF THE *IMPLEMENTATION* PROCESS AND LEVELS OF INFORMATION REQUIRED FOR *PRE-IMPLEMENTATION ASSESSMENT*S AND FOR PROCEEDING TO AN *IMPLEMENTATION*

The Scientific Committee reviewed the *Implementation* process[9] in light of its experience with western North Pacific minke whales. The aim was to develop a more streamlined and practical approach that would allow the Committee to provide advice to the Commission in a reasonable timeframe regarding particular implementations of the RMP. The unacceptably long time taken to complete the *Implementation* for western North Pacific common minke whales, particularly in comparison with North Atlantic common minke whales, prompted this work.

The Committee Chair reminded the Commission that unlike the case-specific approach used to develop AWMP *Strike Limit Algorithm*s such as that for the *Gray Whale SLA* (see section 5.1), it had been decided that the RMP would follow a generic approach that should be applicable to all baleen whales; the RMP's *Catch Limit Algorithm* (*CLA*) was thus developed on an assumption of a generic single stock. The most important feature of the

[8] For details of the Scientific Committee's deliberation on this Item see *J. Cetacean Res. Manage.* 7 (Suppl.).

[9] i.e. a process by which the Committee makes recommendations to the Commission concerning catch limits (which may be zero or greater than zero) for a particular species in a region.

Implementation Simulation Trials (*IST*s) is to examine RMP performance in a real multi-stock situation and to decide which variant or variants[10] of the RMP can be recommended to the Commission. In all cases it is the *CLA* that is used to calculate the catch limit. In this respect, the Chair noted that some of the reasons for the lengthy process for western North Pacific whales related to the potential complexity of stock structure and the fact that whaling was taking place in coastal waters during migration. He further noted that it is likely that this type of scenario is one that the Commission will request the Committee to provide management advice on in the future.

The Scientific Committee took considerable time to examine the process in detail. Believing that the RMP represents a major step forward in the provision of safe management advice for natural resources, it wanted to make sure that it had a clear set of guidelines as to how it should be used in real situations. In doing this, the Committee looked at a number of issues surrounding, in particular, questions of plausibility, data requirements and availability, and the balance in the nature of the *IST*s. The Committee was also aware that there is almost a paradox in implementing the RMP in that it is a feedback procedure that is designed to learn more as it progresses through time. However, at the beginning of the process (i.e. before feedback starts) there will be the most uncertainty. One of the major discussions of the Committee was to investigate ways to address this issue which do not compromise the appropriate conservative nature of the RMP and the Commission's objectives.

Given this, the Committee developed technical specifications for the 'Requirements and Guidelines for *Implementations*'[11]. The key elements of the Requirements and Guidelines are given below.

(1) The development of a single structure and timetable to avoid the implementation process taking an extended period of time. The important development is that the *pre-implementation assessment* is the forum for ensuring that sufficient information is available to enter into an *Implementation*, with the expectation that the latter can be completed within two years.

(2) Practical ways to deal with the issues that have caused significant difficulty in the past, including:
   - (i) how to deal with plausibility of alternate hypotheses (on *inter alia* stock structure, historical catch/bycatch, *g*(0) for abundance estimates);
   - (ii) how to assign weights to simulation trials; and
   - (iii) how to interpret trial results.

(3) A way to encourage the provision of information while whaling operations are taking place by giving the Commission an option to initiate the RMP by:
   - (i) using a hybrid variant for an initial period whilst ensuring that the objectives of the RMP (particularly with respect to conservation performance) are still met; and
   - (ii) linking this specifically to a research programme designed to reduce key uncertainties.

[10] i.e. options already included in the RMP specification such as catch cascading or catch capping as well as spatial and temporal considerations.
[11] *J. Cetacean Res. Manage.* 7 (Suppl.): Annex D, Appendix 2.

With respect to (3) above, the Committee Chair noted that the general idea, first raised two years ago but not specified in any detail, is that there may be limited circumstances when it is appropriate to give the Commission an option for a hybrid variant, i.e. one that is tested as a combination of a less conservative variant for an initial period of one or two 5-year blocks (whilst data to reduce specific areas of uncertainty are collected), followed by an assumption of a worst case scenario in which it is assumed the associated research programme designed by the Scientific Committee does not result in a reduction of uncertainty and thus the next block reverts to the more conservative variant. The Committee Chair noted that this latter point, although only one aspect of the overall guidelines, had become the focus of some discussion outside the Committee. He therefore provided the following clarifications:

(1) the possibility of using a hybrid variant can only be considered if it has been thoroughly tested in *Implementation Simulation Trials* and found to have fully acceptable conservation performance under the RMP, both in the short term and the long term;
(2) only RMP variants that perform acceptably or 'borderline' on the 'high' weight trials would be considered as candidates for the less conservative variant;
(3) this option will only be considered if the Scientific Committee believes that a research programme can be designed that has a good chance of allowing the Committee to answer its questions on the plausibility of the hypotheses under dispute;
(4) the associated research programme that will be developed and guided by the Committee must identify expected progress in a manner that will allow the Committee to review annually whether the programme has been adequately followed;
(5) the option of using a hybrid variant can only be used once - it is not possible for it to be used again at the end of the initial period under the guidelines we have proposed;
(6) if the Committee does put forward a hybrid variant to the Commission, it will simply be one of several options, i.e. all of the variants that perform acceptably will be put before the Commission for its consideration.

The Committee noted that although this differs from the general guidelines used last year for the western North Pacific common minke whale trials (where acceptable variants needed to perform acceptably in all high plausibility trials and at least borderline in medium plausibility trials), any hybrid variant that the Committee might recommend under the requirements developed this year must perform to the same agreed level of acceptability.

The Chair noted that the 'Requirements and Guidelines for *Implementation*' developed by the Committee relate to:

(1) the information needed to initiate the *pre-implementation assessment*;
(2) the nature and outcomes from a *pre-implementation assessment*; and
(3) the steps in conducting an *Implementation* and the expected input and outcomes at each stage.

Table 1

Recommended schedule for an *Implementation* and subsequent *Implementation Reviews*.

(1) x+ Annual Meetings		(2) First Intersessional Workshop		(3) First Annual Meeting		(4) Second Intersessional Workshop		(5) Second Annual Meeting
'*Pre-implementation assessment*'	→	Trial structure development	→	Conditioning and final trial structure	→	Review results of final trials	→	Committee recommendations
The *pre-implementation assessment* will take place during one or more Annual Meetings and will focus on the following issues: (1) the establishment of plausible stock hypotheses consistent with the data (taken *inter alia* from an agreed list of archetypes) that are inclusive enough that it is deemed unlikely that the collection of new data during the *Implementation* process would suggest a major novel hypothesis (e.g. a different number of stocks) not already specified in the basic trial structure; (2) examination of available abundance estimates; and (3) information on the geographical and temporal nature of 'likely' whaling operations - taking into account the complexity of the situation with regard to spatio-temporal issues. On the basis of this assessment, the Committee will make a recommendation as to whether or not to formally begin the *Implementation* process.		The primary objective is to develop an appropriate *Implementation Simulation Trials* structure and to specify the associated conditioning so that it can be carried out before the First Annual Meeting. Workshop discussions will include: (1) A final review of the plausible hypotheses taking into account the probable management implications to avoid unnecessary work; (2) An examination of more detailed information on expected operations; (3) The determination of the small geographical areas that will be used in specifying the stock structure hypotheses and operational pattern; (4) The development of (options for) potential *Small Areas* and management variants; (5) The specification of the data and methods for conditioning the trials; (6) Further consideration of experimental ways to distinguish amongst competing stock hypotheses. It is important to note that after this stage: (1) there shall be no changes to the agreed trials structure that implements the agreed plausible hypotheses; (2) no new data will be considered.		The primary objective is to review the results of conditioning and to finalise the *IST*s. This review may include new analyses of data but not new data. The Trials may be changed but not the overall structure. Final *IST*s based on: (1) final consideration of plausibility, including weighting trials in terms of the overall balance of the *IST*s; (2) discussion of what data/research may reduce number of hypotheses; (3) updates to standard data sets (i.e. abundance, catches, bycatches) for use in final trials; (4) specification of operational features and management variants: (5) specification and classification of final trials; (6) develop timetable for remaining work		The primary objective is to review the results of the final trials and develop recommendations for consideration by the full Committee on: (1) management areas; (2) RMP variants (e.g. *Catch-cascading*,*Catch-capping*); (3) associated operational constraints (e.g. temporal restrictions); (4) research needs (either within or outside operations) to narrow range of plausible hypotheses; (5) use of 'a less conservative' variant with appropriate research and associated time period.		The primary objective is to review the results of the Second Intersessional Workshop (including any additional trials) and agree recommendations for *Implementation*. If this includes a recommendation for a 'less conservative' option, integral to this will be an agreed research programme guided and approved by the Committee. A progress report on this programme must be submitted annually to the Scientific Committee.

(9) Annual Meeting		(8) Intersessional Workshop		(7) Annual Meeting		(6) Intervening period
	←		←		←	Data collection: see box 5
Carry out *Implementation Review*. Make recommendations to Commission.		Determine new trials to account for new information (depending on complexity, this may resemble either stage (2) or stage (3)).		Examine new information and determine if this is inside/outside tested parameter space and/or if it has narrowed hypotheses. If yes, need new trials and at least one workshop. If no, straight to *Implementation Review* at Annual Meeting (9).		RMP annotation 9 specifies that an *Implementation Review* should normally be scheduled no later than 5 years since completion of the previous *Implementation (Review)*, but earlier if important new evidence on stock identity, major changes to abundance estimation methodology, etc.

He noted that an *Implementation* will normally be completed two years after the Committee recommends that the *pre-implementation assessment* is complete and the assessment can start. The implementation itself will occur during two intersessional workshops and two Annual Meetings. Table 1 summarises the recommended schedule for an *Implementation* and subsequent *Implementation Reviews*.

The Scientific Committee recommended the adoption of the 'Requirements and Guidelines for *Implementation*'.

OTHER

In response to some questions raised by the Commission in the past concerning the spatial-temporal considerations in the RMP, a possible annotation to the RMP specifications was discussed and drafted by the Committee. It will be discussed and finalised at next year's meeting, then presented to the Commission.

The Committee's Requirements and Guidelines for Conducting Surveys and Analysing Data within the RMP were revised and recommended to the Commission for adoption.

The Norwegian representatives to the Committee formally notified it that Norway intended to develop and propose a change to the *CLA* for minke whales in the North Atlantic, in accordance with the guidelines for such a process given in 1992.[12]

6.1.1.2 PREPARATIONS FOR *IMPLEMENTATION*

NORTH PACIFIC BRYDE'S WHALES

The Committee has made relatively slow progress on completing the *Implementation* for western North Pacific Bryde's whales *inter alia* due to its heavy workload. While noting that it was in the *pre-implementation assessment* stage, the Committee noted the considerable work already undertaken and agreed that it should be possible to move faster towards *Implementation* than would be the case for new situations. For a number of reasons, the Committee did not make as much progress as it had hoped on this issue in Sorrento. In order to ensure progress during the coming year it therefore agreed to hold an intersessional Workshop before the next annual meeting.

NORTH ATLANTIC FIN WHALES

The Committee reviewed the available information in order to determine whether there was sufficient information to warrant the initiation of a *pre-implementation assessment* for North Atlantic fin whales. It agreed that there was and recommended that the Committee initiate the *pre-implementation assessment*, beginning at next year's annual meeting.

6.1.1.3 BYCATCHES OF LARGE WHALES

The RMP estimates a limit for the number of non-natural removals, not simply a catch limit for commercial whaling. It is therefore important to estimate the numbers of whales removed from the population by indirect means including for example bycatches in fishing gear and ship strikes.

The Scientific Committee began to consider this issue in some detail three years ago. It agreed that priority should be given to those areas where the RMP is likely to be implemented - such as the northwestern Pacific and the northeastern Atlantic. Four steps are required:

(1) identification of the relevant fisheries;
(2) description and categorisation of those fisheries to allow a sampling scheme to be devised;
(3) identification of a suitable sampling strategy or strategies; and
(4) design and implementation of the sampling scheme to enable estimation of the total bycatch.

The Committee has reviewed general methods for estimating bycatches. These fall under two headings:

(1) those based on fisheries data and observer programmes; and
(2) those based on genetic data.

The former have been used successfully for several small cetacean populations.

The Committee agreed that independent observer schemes are generally the most reliable means of estimating bycatch rates in a statistically rigorous manner, but that they may not always be practical and will require careful design.

Genetic approaches potentially represent a new way of estimating bycatches. The Committee has agreed that although genetic methods based on market samples may not be the primary approach to estimating bycatch, they could provide useful supplementary data that could not be obtained in another way. The use of market samples to provide absolute estimates should not be ruled out at this stage. However, for its value to be properly assessed will require further developments in sampling design with input from experts with detailed knowledge of market sampling issues. A proposal for a Workshop on that subject was developed and this Workshop will be held immediately prior to the next annual meeting in Ulsan, Korea. The objectives of the Workshop are:

(1) to review available methods that have been used to provide estimates of large cetacean bycatches via market samples, including a consideration of their associated confidence intervals in the context of the RMP;
(2) to provide advice as to whether market-sampling-based methods can be used to reliably estimate bycatch for use in addressing the Commissions objectives regarding total removals over time and, if so, the requirements for such methods.

It was also noted that the Workshop will be interested in the question of markets only insofar as determining whether or not such data can be used to provide reliable estimates of bycatch.

Work to further explore improved bycatch estimation methods for the two approaches noted above is continuing. Improved data reporting for large whale bycatches was also recommended and a pro-forma developed.

6.1.2 Commission discussions

6.1.2.1 GENERAL ISSUES

With respect to the proposed 'Requirements and Guidelines for *Implementation*', Japan expressed strong appreciation to the authors of these guidelines that it believed would help the effective functioning of the *Implementation* process and avoid the long delays that have occurred in the past. It sought confirmation from the Scientific Committee Chair that the approach proposed would not increase risk to stocks. Germany also sought clarification on whether a less conservative approach was now being proposed. In response, the Scientific Committee Chair explained that the approach being proposed is appropriately conservative,

[12] *Rep. Int. Whal. Commn.* 43: 97.

adequately precautionary and consistent with guidance from the Commission in the past. Australia was of the opinion that there are a range of issues related to the RMP that require clarification, e.g. methods for estimating populations, the spatial determination of stocks, harvesting strategies, the establishment of pre-exploitation levels, and whether population models are capable of dealing with shifts in ecosystem regimes. Given the complexity of the issue, the turnover of Commissioners and adherence of new countries to the Convention, Australia proposed that the Chair of the Scientific Committee be invited to make a comprehensive presentation on the RMP and related aspects to the Commission at its 57th Annual Meeting in Ulsan. The UK, Italy and Germany supported Australia's proposal. Iceland appreciated the proposal but believed that it should not delay the Scientific Committee's work. The USA noted that the Committee's proposals are guidelines and as such define a process rather than changing fundamental aspects of the RMP. It hoped that the proposed presentation would not turn into an opportunity to pick apart the RMP. Norway supported adoption of the guidelines and saw no reason to delay their implementation.

6.1.2.2 PREPARATION FOR IMPLEMENTATION

Japan noted that work on western North Pacific Bryde's whales began in 1997 but that there had been delays due to other work of the Committee. It regretted that the *Implementation Simulation Trials* had not been initiated this year.

Iceland expressed concern that limited resources meant that it was not feasible for the Scientific Committee to start two *Implementation*s in the same year resulting in a delay of the completion of the *pre-implementation assessment* for North Atlantic fin whales at next year's meeting.

6.1.2.3 ESTIMATION OF BYCATCH

New Zealand welcomed the Scientific Committee's report on this issue and spoke in support of the proposed workshop, as did the UK, Sweden and Australia. Norway, together with Japan, the Republic of Korea, Dominica and Grenada could not support the Committee's strong recommendation for the workshop, believing it to be outside the Commission's mandate and not plausible. The Republic of Korea noted the difficulty in performing market surveys. Instead, it had made efforts to improve bycatch reporting.

6.1.2.4 NORWAY NOTIFICATION

Norway drew attention to its notification to the Scientific Committee, in accordance with existing guidelines, regarding its intention to develop and propose a change to the *CLA* of the RMP for minke whales in the North Atlantic. It gave two scientific reasons for the proposed changes:

(1) the current *CLA* gives inappropriately small catch limits (compared with, for example, the *SLA* of the AWMP for eastern North Pacific bowhead and gray whales); and
(2) when the RMP was developed in the 1980s, the precautionary principle was interpreted 'one-sidedly'. It was important to ensure against over exploitation of whale resources. Under a future ecosystem-based management, the precautionary principle must be interpreted 'two-sidedly' in the sense that it is important to avoid not only to harvest too many whales, but also not to harvest too few, given the plausible resultant impacts on sustainable fishery yields. The UNWDDS (Johannesburg, 2002) encouraged, with regard to exploitation of living marine resources, the application by 2010 of the ecosystem approach. In this context it is important that the operative management procedure for minke whales is a realistic tool for stabilizing stocks at predetermined levels below carrying capacity.

Japan, noting that it believes the current RMP to be too precautionary, sympathised with Norway and looked forward to hearing of progress in its work. St. Kitts and Nevis and St. Lucia also supported Norway. In contrast, Austria, Germany, Switzerland, Brazil, the UK, New Zealand, Italy, the Netherlands, Mexico and Australia all expressed concern. Some viewed this move by Norway to be shaking the foundations of the RMP and called into question the commitment of members to develop a set of mechanisms to manage exploitation of whale resources. Others believed that with respect to incorporation of an ecosystem approach, Norway would be operating under a speculative hypothesis.

Iceland suggested that the Commission should not be having a political debate on a scientific issue. The USA agreed and clarified that at this point Norway is not asking for an amendment to the RMP but simply notifiying their intention to invoke a scientific process. Monaco and Sweden agreed, although Sweden noted that implementation of an ecosystem approach does not necessarily mean that resources should be harvested.

6.1.3 Action arising

The Commission noted the report and endorsed its recommendations, although with respect to the recommended bycatch workshop, the reservations of Norway, Japan, Republic of Korea, Dominica and Grenada were noted. The proposal for a presentation on the RMP at IWC/57 was also noted.

6.2 Revised Management Scheme (RMS)

6.2.1 Report on intersessional work

At IWC/55 in Berlin, the Commission agreed to Henrik Fischer's proposal to convene a small group of his choosing to explore ways and possibilities of taking the RMS process forward. He subsequently invited Denmark, Iceland, Ireland, Japan, the Netherlands, Spain, Sweden and the USA to take part. All except Ireland were able to accept. Ireland had to decline due to pressures of work associated with the lead-up to Ireland's presidency of the EU starting in January 2004. The Chair's small group (CSG) met at the Secretariat's offices in December 2003 and again in March 2004. Based on these discussions, Henrik Fischer developed his proposals for a way forward on the RMS (see Annex E). This document was circulated in confidence to Commissioners prior to IWC/56 and then presented and discussed at a private meeting of Commissioners in Sorrento on Friday 16 July 2004. A summary of the Chair's proposed RMS 'package' is provided below (note that items indicated with an asterisk require modification of the Schedule).

Elements of a Proposed RMS 'Package'

1. **RMP*:** as agreed by the Scientific Committee and endorsed by the Commission.
2. **A phased-in approach to the resumption of commercial whaling*:** for an initial period (e.g. 5

years after the lifting of the moratorium), commercial whaling would only be allowed in waters under national jurisdiction.

3. **National inspection and observation scheme*:** as proposed by the EDG (generally, observers and inspectors on all boats where practical) with VMS on very small vessels with <24hr trips and one observer per catcher attached to a factory ship.
4. **Additional catch verification to combat IUU whaling and/or unreported bycatches (NOT to monitor trade):**
    - National diagnostic DNA registers and market sampling to agreed standards (with outside review) and a procedure to allow checking of samples against the registers*.
    - Resolution urging countries to institute national legislation prohibiting the import of whale products from non-IWC countries as well as from IWC countries that are non-whaling .
    - Documentation up to port of entry if importation from IWC member *.
5. **Compliance*:** compliance Review Committee with duties as developed by the RMS Expert Drafting Group and agreed by the Commission, and inclusion of Schedule text as proposed in Berlin: *'The Compliance Review Committee reports on infringements and the seriousness of these infringements to the Commission and advises the Commission what actions, if any, to be taken'.*
6. **Mechanism to apportion RMS costs among Contracting Governments*:** costs for national activities should be borne by relevant national governments, while international costs for securing transparency could be allocated in the context of the overall financial contributions scheme.
7. **Measures for the lifting of Paragraph 10(e)*:** modify paragraph 10(e) such that it becomes invalid on a specific day whilst ensuring that any whaling operations are undertaken under the full RMS package (N.B. catches other than zero can only be set for species/areas the Scientific Committee provides advice for under the RMP – currently very few).
8. **Whaling under Special Permit:** recognise that it is a Sovereign right under the Convention but develop a Code of Conduct.
9. **Animal welfare considerations:**
    - Explicit recognition of the issue in the Schedule*: 'The hunting of whales shall be undertaken so that the hunted whale does not experience unnecessary suffering and so that people and property are not exposed to danger.'
    - Resolution focussing on improving techniques, voluntary provision of data to regular scientific workshops and possible co-operative research programmes.

In his document, the Chair noted that the above 'package' of measures includes, in some way, all but two of the elements that have been discussed recently in the context of the RMS. The exceptions are blanket trade restrictions and sanctuaries. While some form of trade restriction might be appropriate in deterring IUU whaling, he believed that a blanket ban on international trade in whale products would be discriminatory against some countries, against principles of free trade and outside the competence of IWC. With respect to sanctuaries, he considered that each should be reviewed on its own conservation and management merits and would therefore be difficult to build into any RMS 'package'.

In the absence of Henrik Fischer, the private meeting of Commissioners to discuss his proposals was chaired by Chris O'Grady, Commissioner for Ireland. Henrik Fischer did, however, submit a written statement to Commissioners (see Annex F).

Chris O'Grady reported the outcome of the private meeting of Commissioners to the plenary meeting. He noted that the objective of the meeting was to present and explain the Chair's proposal and that this had been achieved largely thanks to the presentation of Greg Donovan from the Secretariat. He reported that while some Commissioners expressed difficulties with some elements of the Chair's proposed package, there was general agreement that (1) a package approach would be a useful way forward and (2) that the Chair's document formed a good basis for discussion during the Commission plenary. It had also been agreed that the documents circulated to Commissioners in confidence should be made publicly available in response to concerns expressed by some that the intersessional work had lacked transparency. Some criticism had been levelled at the way involvement in the intersessional work had been restricted to certain countries and there was a call from some Commissioners for wider involvement in any future discussions. Finally Chris O'Grady reported that the Commissioners had agreed that substantive discussion on the Chair's proposed RMS package should be left to the plenary and drew attention to the fact that the Chair's proposal would require considerable intersessional activity prior to IWC/57 next year.

6.2.2 Commission discussions and action arising

Discussions were structured by first inviting an initial exchange of views on Henrik Fischer's proposals, then asking for specific comments on the different proposed RMS package elements and then developing a plan for future work.

6.2.2.1 INITIAL COMMENTS

Denmark agreed fully with the sentiments expressed by Henrik Fischer in his statement to Commissioners (Annex F) regarding the RMS process and the need for its early completion and adoption with as broad a support as possible. It agreed that an RMS is needed for both whale conservation and whale management and considered that the Chair's proposal should be the basis for completing this work, while recognising that obstacles remained to be overcome. However, it stressed that the elements included in the proposed RMS package together represent a delicate balance that had been developed in the spirit of compromise and that this balance should not be compromised. Denmark considered that, as proposed by the Chair, there must be a clear link between the adoption of the RMS and the lifting of the moratorium. It considered that if it is not acknowledged that the objective of an RMS is to conserve whale stocks and to manage whaling in practice, not in theory, using one of the most conservative and precautionary systems ever devised for the setting of quotas of any marine resource (i.e. the RMP), then the rationale for continuing the work would be questionable. Denmark acknowledged that how and when this link is activated is open to discussion, but believed that general opposition to this would de-rail the entire process. It also believed that for the sake of conservation, the moratorium should be lifted and an agreed mechanism implemented to allow for the international management of whaling. It considered that the alternative would be the continued and likely increased level of whaling around the world without agreed international control. It respectfully requested those Contracting Governments that have expressed a concern about linking adoption of the RMS with lifting of the moratorium to explain the nature of their concerns. Denmark believed that without an RMS in place, the Commission would cease to function according to its own Convention, and that many Contracting Governments would be forced to consider seriously the purpose of their continued membership. It therefore urged delegates, as representatives of responsible governments in an international body, to keep the RMS work at the top of the agenda with Henrik Fischer's proposal as the window of opportunity and to provide the resources necessary to have an RMS ready for final consideration at IWC/57 in Ulsan next year.

The USA stated that it wished to make clear that it continues to support the moratorium on commercial whaling, but that it nevertheless remains committed to completing the RMS in a timely fashion. It commended the Chair for his efforts in establishing his small group and thus advancing the RMS process. It considered that without his intervention, it is doubtful whether any progress would have been made since IWC/55. The USA noted that it generally agreed with the Chair's proposed process and saw the need to develop a plan for intersessional work on the RMS. It noted that it could not adopt the proposal in its entirety but was willing to use it as a basis for discussions. It expressed some concerns with the Chair's proposal, particularly with respect to paragraph 10(e) – the moratorium, scientific whaling and cost sharing. It noted the need to include transparency in any future process.

Sweden commented that when it voted in 1982 to introduce the commercial whaling moratorium, it envisaged a 10-year period without whaling in which increased research into the status of whale stocks and the development of an RMS would be carried out. It noted that unfortunately, there had been an increase in whaling outside of IWC control since the moratorium was put into force. Nevertheless, Sweden stressed that it remained committed to completion of the RMS that is now much overdue. It believed that no one, and certainly not the whales, benefit from the present situation and that an RMS is necessary to ensure that whaling will be sustainable and that whale stocks will be restored. Sweden noted that it had therefore accepted gladly the Commission's decision last year to allow Henrik Fischer to establish a small group to facilitate the process towards a new RMS. It noted that in contrast to discussions within the whole Commission that have not always been constructive, its participation in the small group had been a very positive experience, indicating that progress on the RMS is still possible. It hoped that the spirit of co-operation and willingness to seek compromises that had existed among members of the Chair's small group could spread among the whole Commission. Sweden was convinced that the formation of the small group had been the only way forward at the time. However, it now believed that the process should be opened up, provided that this is done in a way that will not reduce efficiency. Sweden supported the Chair's proposal that the RMS should comprise a package, and while his proposals did not fulfil all of Sweden's requirements, it believed that they contain all the essential elements for an RMS and provide a good framework for further development. Completion of an RMS is a prerequisite to Sweden agreeing to lift the moratorium and it is willing to take an active part in further work. The Netherlands, who stressed that they continued to support the existing commercial whaling moratorium made similar comments.

Japan recalled that when the moratorium on commercial whaling was adopted in 1982, it was adopted on the clear condition that by 1990 at the latest, the Commission would undertake a comprehensive assessment of the effect of this decision on whale stocks and consider modification of the provision and the establishment of catch limits other than zero. It noted that this undertaking, which now includes completion of an RMS, remains unfulfilled. It also noted that it has supported early completion of the RMS and considered that while it has made a number of compromises during discussions, some nations opposed to whaling had made excessive requests regarding certain elements of the RMS thus delaying its completion. In view of this stalemate, Japan had supported and appreciated the establishment of the Chair's small group, of which it had been a member. Japan accepted that the Chair's proposed RMS package represents a compromise and noted that because of this, it is not happy will all elements (e.g. the inclusion of special permits). Nevertheless, it remained committed to taking part in future work which public opinion in Japan considered should be concluded by IWC/57 next year. If this was not achieved Japan noted that it would be faced with having to make a difficult decision.

Spain noted that it too remains committed to continuing the process to develop an RMS based on the Chair's proposal. It did, however, have some concerns especially relating to proposals to lifting the moratorium, scientific whaling and cost sharing.

Iceland considered that the Chair's document and proposals showed that more progress has been made in the last 10 months than in the last 10 years and that therefore the proposals should not be dismissed lightly. Although having been part of the small group, Iceland noted that it dislikes strongly various elements of the Chair's proposal, and suggested that this would be the case for all Contracting Governments. However, it stressed that all parties should recognise that there can be no compromise solution on any other basis. Iceland considered that the Chair's proposal represented the only way forward – beginning again from the status of discussions at IWC/55 would dismantle any chance of reaching a conclusion.

Ireland thanked the Chair and his small group, including the Secretariat, for their work. It regretted that it had been unable to join this group due to pressures of other work. Ireland noted that it supports the early adoption of a robust and effective RMS and the package approach proposed by the Chair. It believed the alternative of addressing the elements of an RMS one by one would be a recipe for confusion and continued division within the Commission. Ireland recalled that since 1995, it has been the author of a compromise proposal aimed at unlocking the paralysis within the Commission regarding adoption of an RMS and that it has consistently called for other Parties within the Commission to come forward with an alternative proposal that would meet with more favour than its own. It noted that the Chair's proposal is the response for which it has been waiting, and, like others, considered that it is an important and useful basis for moving forward. Although it supported the package approach, Ireland indicated that it could not, at this stage, accept the package put forward by the Chair, although it was open to further discussions. Its concerns with the package proposed centred on three broad issues:

(1) the link between adoption of an RMS and the lifting of the moratorium;
(2) that whale meat taken within the initial period (e.g. five years) would not be confined to local consumption; and
(3) the proposed handling of whaling under special permit.

Nevertheless, Ireland was optimistic that Henrik Fischer's proposals could be used as a useful basis for breaking the log-jam within the Commission regarding adoption of an RMS. It concluded that the only way forward is further compromise from all members of the Commission. Ireland was prepared to contribute to this compromise.

Like Sweden, Switzerland believed that a management regime is needed to bring existing activities under IWC control. It considered that while more work is needed to reach a compromise solution, real progress had been made since last year and that the Chair's proposal provided a good basis for further work. It also considered that the RMS has to be seen as a package of inter-linking elements. Finland, while still supporting the moratorium, commended the work of the Chair and his small group. It too considered the Chair's proposal as a good basis for further work, although it had difficulties with some of the elements as currently included (e.g. costs and scientific permits). Finland believed that a transparent follow-up is needed with extended participation. Oman associated its position with the view expressed by Ireland and Switzerland.

Dominica considered the work reflected in Henrik Fischer's proposal as a valuable step in the quest to finalise the RMS. Like others, it recognised that further work is needed but urged Commissioners to consider objectively the merits of the package approach proposed so that the RMS can be completed at IWC/57. It stressed the need for all parties to compromise. Antigua and Barbuda made similar remarks and hoped that the Commission could adopted a similar openness in future discussions as that shown by the Chair's small group. The Republic of Guinea, St. Lucia, St. Kitts and Nevis, Grenada, Republic of Korea, Morocco and Benin made similar remarks. St. Lucia noted the significant efforts expended in the formation of the Conservation Committee last year, and urged the proponents of that Committee to commit themselves equally to the completion of the RMS along the lines proposed by the Chair.

Monaco believed that a modern and robust RMS is needed as soon as possible in order to restore credibility to the Commission. Like many others, it commended the work of Henrik Fischer and his small group and considered the proposed package of measures to be a useful basis for the construction of a carefully negotiated agreement.

While appreciating the work of the Chair and his small group, Argentina believed the proposal to be unbalanced since the group included neither representatives of countries from the Southern Hemisphere nor representatives from developing countries. It did not consider the Chair's proposal an appropriate basis for further work.

Germany thanked the Chair, his small group and the Secretariat for their work since the Annual Meeting in Berlin. It noted that it would strive for an RMS based on best practices, drawing on the internationally-accepted high standards in regional fishery organisations. Germany viewed the Chair's proposal as being helpful, but identified concerns related to lifting of the moratorium, catch verification, compliance, costs, special permit whaling and animal welfare (see next section). It considered that sanctuaries should be included as part of the RMS package. It believed that further work should be done in a fully transparent way according to a framework defined clearly by the Commission.

Italy complemented the Chair for his work. It noted that Italy continues to support the moratorium but at the same time believes it very important to make progress on the RMS. While it agreed that the proposed package was a useful tool for making progress, it saw problems with the proposal, particularly in relation to the proposed handling of scientific permits. Like Germany, Italy called for future work to be done in a more transparent way.

South Africa identified itself as a Southern Hemisphere developing country having concerns regarding the welfare of whales in its Exclusive Economic Zone (EEZ) and adjacent Southern Ocean. It noted that it is no longer a whaling country and that it has no intention of ever returning to this practice. It reported that it has benefited greatly from whalewatching, considering this form of non-consumptive use as the preferable means by which its people, and poor communities in particular, gain from the presence of whales along its coast. Indeed it asserted its right to non-consumptive use and its right to have a stake, through the IWC, in the management and conservation of whales on the high seas and in the Southern Oceans in particular. It described some specific concerns with Henrik Fischer's proposal which are given in the section below and associated itself with the remarks of Germany. In general terms, South Africa believed that a greater degree of unanimity and convergence is needed among IWC members in relation to scientific advice (e.g. the RMP). It considered that the divergence evident at each Annual Meeting does not bode well for good management.

Brazil noted that it has participated in good faith in the long and difficult discussions on the RMS and had tried to be open and transparent about its two main interests, i.e.

(1) the construction of an adequate foolproof international inspection and observation scheme to prevent reoccurrence of past abuses and damage caused by legal and illegal whaling operations; and
(2) the proper discussion of an agreement to respect the rights of coastal states to appropriate whale resources in a given ocean basin through non-lethal means.

It reiterated its view that there should be no more private/closed door meetings on the RMS, and that Contracting Governments should be able to be represented at meetings with a full delegation as governments see fit. It stressed that transparency, full accountability and due respect to the rights of states that appropriate whale resources non-lethally are, in its view, integral aspects of RMS negotiations.

New Zealand associated itself with the remarks of Germany and South Africa. While recognising the Chair's efforts to move the RMS process forward, it considered his proposal to be fundamentally flawed and indicated that it would oppose it strongly in its present form for both general policy and legal reasons. It would not compromise on its fundamental views but it was willing to continue negotiations. New Zealand drew attention to the fact that the Commission has presided over the calamitous decline in whale stocks and believed that the negligence of the organisation in this matter is clear and palpable. It was this decline that had led to the 1982 decision to establish a commercial whaling moratorium, thereby taking steps to rebuild public confidence. New Zealand did not believe that the world's public was yet ready for the resumption of commercial whaling, and questioned whether the lessons from past mistakes have been adequately learned and heeded. Regarding the future process for RMS discussions, New Zealand proposed that:

(1) the mandate of any groups established should be to develop proposals without precondition as to their content;
(2) participation in any groups established should be unrestricted; and
(3) meeting schedules and venues should be selected to facilitate the greatest number of participants.

New Zealand considered completion of the RMS to be important, and suggested that this be done prior to the lifting of the moratorium. Furthermore, noting that the Convention is nearly sixty years old and that it is showing signs of weakness that come with age, New Zealand believed it to be badly out of date and in need of revision. Without revision, New Zealand considered that the burdens of administering an RMS would be beyond the capacity of the Commission to handle. In its view, the Convention has serious weaknesses compared with modern treaty instruments. It believed these weaknesses could be remedied, given the collective will to do this, but it was New Zealand's view that commercial whaling could not resume unless and until there are appropriate international enforcement mechanisms and an appropriate international dispute settlement mechanism in place. It advocated revision of the Convention by way of a diplomatic conference to negotiate a Protocol.

The UK while appreciating the efforts of Henrik Fischer and his small group, considered that while the Chair's proposal may form the basis for further discussion, like Germany and New Zealand, it doubted whether the proposal, in its present form, is a package that could form the basis of an agreement. The UK accepted however that work should proceed, believed that it should be done an inclusive a manner as possible, and agreed with New Zealand that there should be no preconditions as to its policy content. It also stressed, that if the Commission is to discuss the RMS in Ulsan with a view to reaching a final conclusion, then any draft package should be agreed as early as possible to allow adequate opportunities for public airing.

Australia associated itself with the comments made by South Africa and Germany. While referring to its well-known position that it would not support the resumption of commercial whaling, Australia noted its legitimate interest in ensuring that, in case this should occur, any management scheme developed has been tested against best and improving practice. It asserted its right to be part of an open and transparent process within the Commission regarding development of an RMS.

Kenya noted that it had never been a whaling nation and had no plans to become one. It believed its policy of the non-consumptive use of wildlife is well known, and in this spirit it favoured the continuation of the moratorium and was opposed to the proposed RMS package, despite its progressive intentions. It associated itself with the views expressed by South Africa and New Zealand.

Portugal associated itself with the views expressed by Germany and Ireland. Austria associated itself with the views of Germany, the UK, New Zealand and others. Peru associated itself with Argentina and Brazil. France indicated that while it is opposed to the resumption of commercial whaling, it recognised the work done by the Chair and his small group and awaited the outcome of future work with interest. Mexico supported the statement of South Africa. It also supported the views expressed by Brazil, Argentina and Peru in the sense that the RMS development process has to be more inclusive of geographic diversity, especially countries in the Southern Hemisphere that oppose whaling and are devoted to the conservation of whales. India wanted RMS development to be expedited, but did not support the suggestion that adoption of an RMS should be linked with lifting of the moratorium.

Dominica noted that last year, the Commission gave the Chair the mandate to form a small group of his choosing to work on a way forward. It therefore regretted the remarks made by some delegations regarding what they considered to be a lack of transparency in the intersessional work since the Annual Meeting in Berlin.

6.2.2.2 DISCUSSION OF PROPOSED RMS PACKAGE ELEMENTS

This section collates comments made on specific elements in the Chair's proposed RMS package. It should be noted that absence of comments by countries neither implies acceptance or rejection of the Chair's proposals.

RMP

The USA believed that the version of the RMS to be included in the Schedule should be that version adopted by the Commission by consensus in 1994 that incorporated the tuning level of 0.72 and a protection level of 0.54 adopted by the Commission in 1992. This is in line with the Chair's proposal. Belgium made similar comments.

The UK noted that the Commission had been advised that the RMS linked to the RMP will provide adequate protection to whale stocks and that catch limits would only be set for whale stocks when scientific advice is given on those catch limits. It therefore viewed with concern Norway's proposal to develop its own version of the RMP (see section 6.1.2).

PHASED-IN APPROACH TO COMMERCIAL WHALING

Brazil viewed this proposal to be one of the most unacceptable provisions within the package. It believed it to be inconsistent with the Convention on the Law of the Sea.

Germany sought clarification as to whether the proposal was to initially restrict whaling to within waters of national jurisdiction (that it understood as being normally a 12 mile limit) or to EEZs (i.e. 200 mile limit). Iceland explained that in fact waters under national jurisdiction extend to 200 miles not 12 miles. The USA confirmed that the Chair's proposal was intended to restrict whaling to within 200 miles initially.

As indicated above, Ireland was concerned that whale meat taken within the initial period (e.g. 5 years) would not be confined to local consumption.

China suggested that domestic legislation needed to be taken into account since its legislation prohibits the taking of whales in national waters.

NATIONAL INSPECTION AND INTERNATIONAL OBSERVATION

Australia, supported by the UK considered that inspection as well as observation should be co-ordinated at the international level by the Commission, and that the proposed provisions for use of vessel monitoring systems (VMS) do not reflect current best practice. Belgium believed that VMS should be compulsory for all whaling vessels.

ADDITIONAL CATCH VERIFICATION MEASURES

Sweden considered additional catch verification measures as a very important part of the RMS, believing it crucial that any systems put in place are transparent and allow for independent checking. It recalled the proposed Schedule amendment it and other countries submitted to the Commission at the Annual Meeting in 2002 and suggested that in the absence of alternative proposals to achieve a similar level of transparency in DNA registers, this remained the best option.

The USA indicated its willingness to support establishment of a DNA register with appropriate IWC oversight and catch documentation based on CITES requirements. It noted its concern regarding the status of current stockpiles of whale meat and other products and how these might be accounted for. Although its preference was that such stockpiles be disposed of by a certain date, it could accept having them entered into a DNA registry.

Belgium considered that the proposed DNA register has to be organised on an international basis for it to be effective. Germany agreed. With respect to catch documentation, Germany considered that it is not satisfactory to simply refer to CITES documentation. It considered that a specific system is needed for IWC and that this would require extensive further work.

Australia did not view the Chair's proposal as being current best practice and suggested that the provisions of CCAMLR should be examined.

COMPLIANCE

Germany considered that provisions should be developed that would equate to the highest standards in other international organisations. Belgium believed that provisions regarding compliance needed to be carefully drafted. New Zealand believed that enforcement could not be left to national procedures as they would not work. Rather, New Zealand proposed that international enforcement mechanisms are necessary.

APPORTIONING COSTS

Germany, Spain, Netherlands, South Africa, Finland the UK, Monaco and the USA expressed concerns regarding the Chair's proposals on how to apportion costs of an RMS among Contracting Governments and considered this to be an area where further work is needed. Germany did not believe that there should be cost sharing between all members and those members participating in whaling. It noted that in regional fisheries organisations, it is common practice that the fishing nations have to pay for international oversight (observers). Germany believed this same principle should apply to IWC. Spain made similar remarks. While the UK accepted that there may be certain central costs resulting from the operation of an RMS which might be appropriate to be borne by IWC's budget as a whole, the UK found it unacceptable that it should be asked to contribute to the costs of enforcement and oversight. The USA, supported by Brazil, believed that the Chair's proposal would result in certain delegations paying a disproportionate share of the total cost of implementing the RMS and called for a more equitable scheme.

Responding to the comparisons made between IWC and other fisheries management organisations in which costs of observers are borne by the fishing nations (user pays), Denmark drew attention to the fact that other fisheries organisations do not require both a national inspector and an international observer to be present on all vessels and neither do they require DNA analyses of every fish caught. Consequently, Denmark believed that a compromise had to be found and indicated its open-mindedness regarding what the solution might be. Iceland associated itself with these comments and added that the fundamental difference between IWC and other fisheries bodies is that the latter do not have some members that wish to prevent others from fishing. It therefore did not consider such comparisons appropriate. China agreed with the remarks of Denmark and Iceland.

South Africa noted that the likelihood of increasing costs to Contracting Governments associated with the proposal is of concern to a country like itself that cannot be a major contributor.

St. Kitts and Nevis indicated that RMS costs must be shared on the basis of equitable principles.

MEASURES FOR THE LIFTING OF PARAGRAPH 10(E)

Denmark, Japan, Norway, St. Lucia, St. Kitts and Nevis, and Grenada all stressed the need to link adoption of an RMS with the lifting of the commercial whaling moratorium. Norway failed to see the logic of discussing the RMS if there is no intention to use it. Japan, St. Kitts and Nevis and Grenada called for simultaneous lifting of the moratorium with adoption of an RMS. (See also Denmark's comments in section 6.2.2.1).

Germany, Brazil, New Zealand, the UK, Australia, Belgium, Monaco, India and Argentina were strongly opposed to linking adoption of an RMS with lifting of the moratorium. Spain and Ireland expressed concern with the Chair's proposal, while the Netherlands called for further elaboration of the phasing in of an RMS package with the phasing out of paragraph 10(e). Brazil believed that discussions on the lifting of paragraph 10(e) should be considered from a geographical as well as time perspective so as to take account of its position on the right of states to use whale resources non-lethally. New Zealand considered that there is no link as a matter of law between adoption of an RMS and lifting of the moratorium - each must be considered on its own merits. It further noted that should the conditions ever be right for lifting the moratorium, this could only happen once an RMS has been adopted. The UK could not see any way in which a package containing both elements will necessarily result in the moratorium only being lifted if an RMS is place without objection. The UK believed that if an objection is raised to the RMS, either at the time of its proposal as a Schedule amendment or subsequently by a government withdrawing from the Convention and re-adhering with a reservation (of which there is a precedent), the RMS should be scrapped and the moratorium immediately put back into force. Australia felt it legitimate for Contracting Governments to have strongly held views on the nature of a robust management procedure should whaling recommence, while maintaining their opposition to commercial whaling and to the lifting of the moratorium. Australia also questioned whether it would be technically possible to achieve the Chair's proposal, i.e. that paragraph 10(e) would become invalid on a specific day while ensuring that any whaling operations are undertaken under the full RMS package. It noted in particular that this proposal puts constraints on the rights of Parties to the Convention (i.e. the right to object) and it was not clear how this could be managed. In this respect, the Secretariat noted that it had not yet done any further work on this aspect as suggested in the Chair's proposal.

WHALING UNDER SPECIAL PERMIT

Several governments believed that Article VIII of the Convention, allowing Contracting Governments to issue permits for the taking of whales for research purposes had been grossly abused in past years and particularly since the moratorium. Germany, Ireland, South Africa, the UK and New Zealand considered that the voluntary code of conduct proposed by the Chair was insufficient. Germany believed that binding rules are needed to regulate whaling under special permits. Ireland's view was that special permit whaling should cease or at the very least be phased-out, if as proposed, commercial whaling is phased-in. It did not believe that public confidence in IWC's ability to manage whaling would be achieved if whaling under special permit continued at the same time as commercial whaling was resumed. The UK found it unacceptable that any RMS could be put in place without some real control and preferably cessation of permit whaling. New Zealand suggested that special permit whaling is practised for improper and non-scientific motives and believed that the issue needs to be addressed in its own right regardless of whether or not an RMS is approved. New Zealand considered it inconceivable that special permit whaling could be allowed to continue and considered Article VIII to be one of the most abused provisions of the Convention and the one at which greatest criticism is levelled. New Zealand considered that Article VIII should be included in its proposals to revise the Convention (see earlier comments).

While it viewed the proposed voluntary code of conduct as a good-faith effort to address this issue, the USA did not believe it goes far enough. The USA reported that whaling under special permit is a major issue for them and stressed the need for substantive progress in terms of halting or deferring scientific whaling, irrespective of rights under Article VIII. It did not see an easy solution, but noted its preparedness to review any creative proposals for moving forward. Sweden associated itself with these remarks.

Spain, Italy and Finland also expressed concern regarding the Chair's proposal. The Netherlands sought further elaboration. Monaco believed that special permit whaling should be brought under full modern control. Belgium considered that quotas for whaling under special permit should be determined by the RMP.

In response to New Zealand's comments, Japan suggested that if New Zealand considers Japan's activities on special permit whaling to be an abuse of Article VIII, then it had the option of bringing a case to the International Court of Justice. It therefore did not consider that preparation of a Protocol is necessary, but viewed it as a delaying tactic. Iceland believed it was clear that to change the Convention along the lines suggested by New Zealand would require more of a consensus than Iceland considered politically possible. It suggested that advocating a revision of the Convention as part of the RMS package is, in effect, rejecting an RMS. Norway supported Iceland's views.

ANIMAL WELFARE CONSIDERATIONS

Noting the importance of animal welfare considerations, Germany indicated that provisions requiring the collection of animal welfare data on a regular basis must be included in the Schedule. It also believed that provisions are needed for killing methods that guarantee instantaneous death or insensibility. Belgium considered that animal welfare considerations should be part of the RMS package. The UK viewed as inadequate the Chair's proposals in this respect, suggested that they add nothing to what is currently included in various Resolutions and in requests for data that are sometimes honoured and sometimes not. The UK believed that if the Commission as a body is to sanction the killing of whales, then it has an ethical duty and moral responsibility to have input into the way whales are killed, e.g. specifying the types of equipment, specifying the weather conditions and sea state under which whales may be taken, and insisting on the collection of data on the efficiency of hunting methods. It recognised that some of these statistics may be difficult to obtain, but nevertheless believed them to be an essential part of an RMS. Without them, the UK considered that there would be no guarantee that whale welfare would be respected.

6.2.2.3 DEVELOPMENT OF A PLAN FOR FURTHER WORK

Denmark, on behalf on the other co-sponsors (Ireland, Iceland, Republic of Korea, Japan, Netherlands, Spain, Sweden, Switzerland and the USA) introduced a draft Resolution to proceed expeditiously towards the completion of both the drafting of text and technical details of the RMS, with the aim of having the results ready for consideration and adoption at IWC/57 (see Table 2). Denmark explained that the proposed Resolution tried to build on the increasing trust and determination of Contracting Governments to overcome the deadlock on the RMS that has plagued the Commission for so long. It stressed that crucial to the building of trust is the recognition of the dual role of the Commission to both conserve whale stocks and to manage whaling. This recognition had been the point of departure for the Chair's initiative in developing his proposed RMS package, and Denmark believed that it should be at the heart of the work proposed in the Resolution. Denmark noted that the co-sponsors also recognised the importance of taking account of the key questions and concerns raised in response to the Chair's proposals (drawing attention to the third preambular paragraph of the Resolution) and in particular the need for full transparency and geographical representation. Assuring delegates that the speedy completion, adoption and implementation of the RMS is an issue on which there is full consensus within the Kingdom of Denmark and noting that the Resolution represented a delicate balance of interest, Denmark urged countries to support the proposed Resolution without amendments.

The USA introduced the proposed intersessional plan of action included with the draft Resolution (see Table 2). It noted that over the course of discussions in Sorrento, a general agreement had emerged that progress on completion of the RMS should be facilitated by intersessional work prior to IWC/57. It also noted the Secretariat's paper (IWC/56/36) summarising the further work required based on the Chair's proposal that demonstrated the need for a mix of activities by some of the Commission's existing sub-groups, such as the RMS Working Group, Scientific Committee and Contributions Task Force, and some new expert groups to advise on technical matters, e.g. in relation to catch verification.

To balance the need for transparency with the need to be able to work efficiently, the plan of action proposed to (1) address the former by reviving the RMS Working Group (that is open to all Contracting Governments and observers) under the Chairmanship of Henrik Fischer and (2) address the latter by establishing a small drafting group under the RMS Working Group. With respect to size, composition and leadership of the small drafting group, the USA proposed that delegations advise the Chair of their interest in serving and that the Commission leave it to the Chair to decide on the group's membership and Chair. It was suggested that the Chair of the Commission should also serve on the small drafting group and that the Secretariat be involved in all groups to provide continuity, expertise, oversight and co-ordination. The USA stressed that the process included in the draft Resolution would require a substantial commitment, i.e. involvement of the Secretariat as described, commitment of delegations to attend intersessional meetings or to provide written views and expansion of the duration of the Annual Meeting so this effort could be accorded the highest priority. And finally it noted that these activities would be counter to prevailing attitudes regarding costs, intersessional work and the priority to be accorded to certain issues.

While thanking Denmark and the USA for their introductions, Australia considered that the proposed Resolution had not, unfortunately, been developed in a way as to be fully inclusive of the interests across the Commission. However, it believed that there was scope to revise the Resolution in a way that could meet the requirements of all parties and suggested that further discussion in plenary be postponed to provide an opportunity for interested governments to discuss possible revisions. The Commission agreed to postpone discussions.

On returning to the issue, Australia introduced a revised draft Resolution (see Table 2), explaining where changes had been made. It believed that the revised proposal, which had been developed by a number of countries, represented a delicate balance and suggested that if it could be adopted by consensus, the Commission would have rebuilt its approach to the RMS.

Dominica indicated that with respect to the last operative paragraph it wished to retain the text in the initial draft, i.e. retaining the words *'with the aim of having the results ready for consideration and adoption at IWC/57'*, and accordingly proposed an amendment to this effect. It felt that the revised text would simply encourage further prolongation of discussions. Palau and Iceland spoke in support of Dominica's proposed amendment and noted that as reference to IWC/57 was included in the intersessional plan of action and in the proposed Terms of Reference for the RMS Working Group, they saw no problem with its inclusion in the Resolution itself. The USA and New Zealand spoke in support of retaining the revised version. The USA expressed concern regarding the inclusion of the term 'adoption' since it believed that adoption of an RMS could not be predetermined.

In view of Dominica's concerns, Australia wondered whether it would be acceptable to include text along the following lines: *'agrees to proceed expeditiously towards the completion of both the drafting of text and technical details of the RMS according to the attached Intersessional Plan of Work with the aim of having the results ready for consideration at IWC/57'*. While Dominica appreciated this suggestion, it could not accept it. As an alternative, Sweden proposed taking text from the Terms of Reference for the RMS Working Group and inserting them in the Resolution, i.e. *'....ready for consideration including for possible adoption at IWC/57'*. Iceland did not believe that Dominica's proposed amendment pre-empted any action by the Commission, but rather simply set an aim. However, if there could not be consensus on Dominica's proposal, then Iceland suggested that Sweden's suggestion provided a way forward. The UK disagreed, believing this to be close to breaching the Commission's Rule of Procedure E.3(b).[13]

On being put to a vote by a show of hands, Dominica's proposed amendment was rejected. Sweden's proposed amendment was accepted by a show of hands. Australia then proposed an amendment to the Resolution as amended by Sweden. It proposed that the third operative paragraph be amended to read *'....with the aim of having the results ready for consideration, including for possible adoption at IWC/57 and/or to identify any outstanding policy and technical issues'*, thus including all the text from the RMS Working Group proposed Terms of Reference. While St. Kitts and Nevis expressed concern that Australia's latest proposal may be in breach of the Rules of Procedure, the Commission adopted by consensus the Resolution as amended by Australia. The amended Resolution (Resolution 2004-6) is provided in Annex C. While accepting that consensus had been reached, Denmark noted its unhappiness at having to explain the outcome to Henrik Fischer. It stressed that the amended Resolution must not lead to a repetition of returning to a square-brackets exercise, and that only fine-tuning of the Chair's proposal was needed, nothing more.

7. WHALE KILLING METHODS AND ASSOCIATED WELFARE ISSUES

In introducing this item, the Chair explained that given the limited time available at IWC/56, the number of sub-groups that had needed to meet and the fact that there had been a 3-day workshop on Whale Killing Methods and Associated Animal Welfare Issues at last year's meeting, the Advisory Committee had agreed not to schedule a meeting of the Working Group in Sorrento. He noted that this agreement was reached on the understanding that:

(a) this issue would be placed early on the plenary agenda and given an adequate time allocation;
(b) Contracting Governments would be asked to provide data and information as requested in a number of Resolutions to the Secretariat for circulation to Contracting Governments well in advance of the plenary; and
(c) the Working Group would meet at IWC/57 in 2005.

[13] Rule of Procedure E.3(b): *Action in pursuance of Article V shall contain the text of the regulations proposed to amend the Schedule. A proposal that does not contain such regulatory text does not constitute an amendment to the Schedule and therefore requires only a simple majority vote. A proposal that does not contain such regulatory text to revise the Schedule but would commit the Commission to amend the Schedule in the future can neither be put to a vote nor adopted.*

Table 2

Draft Resolutions proposed on completion of the RMS.

DRAFT RESOLUTION ON COMPLETION OF THE REVISED MANAGEMENT SCHEME (RMS) Proposed by Denmark *et al.*	REVISED DRAFT RESOLUTION ON COMPLETION OF THE REVISED MANAGEMENT SCHEME (RMS)
Recognising the dual mandate of the IWC for the conservation of whales and the management of whaling according to the 1946 International Convention for the Regulation of Whaling; Noting that on this basis, considerable progress has been made in identifying the major elements necessary to reach broad agreement on the RMS, as reflected in the Chairman's Proposal for a Way Forward on the RMS (Doc IWC/56/26); Taking note of the comments of Contracting Parties on the Chairman's Proposal at the 56th Annual Meeting of the Commission; and Concerned that the failure to reach broad agreement on the RMS in the near future may seriously jeopardise the ability of the IWC to fulfil its responsibility of ensuring the effective conservation of whale stocks and the responsible management of whaling; NOW THEREFORE THE COMMISSION: Commends the efforts of the Chairman in providing the basis for further work and discussion towards the finalisation of the RMS, as reflected in document IWC/56/26; Agrees to re-establish the Working Group on the RMS with a view to holding an intersessional meeting prior to IWC/57, as outlined in the attached Intersessional Plan of Work; and Agrees to proceed expeditiously towards the completion of both the drafting of text and technical details of the RMS according to the attached Intersessional Plan of Work, with the aim of having the results ready for consideration and adoption at IWC/57.	Recognising the dual mandate of the IWC for the conservation of whales and the management of whaling according to the 1946 International Convention for the Regulation of Whaling; Noting that on this basis, considerable progress has been made in identifying the major elements necessary to reach broad agreement on the RMS, as reflected in the Chairman's Proposal for a Way Forward on the RMS (Doc IWC/56/26); Taking note of the comments of Contracting Parties on the Chairman's Proposal at the 56th Annual Meeting of the Commission; and Concerned that the failure to reach broad agreement on the RMS in the near future may seriously jeopardise the ability of the IWC to fulfil its responsibilities; NOW THEREFORE THE COMMISSION: Commends the efforts of the Chairman in providing a basis for further work and discussion towards finalizing the RMS; Agrees to re-establish the Working Group on the RMS with a view to holding an intersessional meeting prior to IWC/57, as outlined in the attached Intersessional Plan of Work; and Agrees to proceed expeditiously towards the completion of both the drafting of text and technical details of the RMS according to the attached Intersessional Plan of Work.
Intersessional plan of work Sufficient material is available from previous efforts, or will have been developed by the end of IWC 56, that the Commission could proceed to develop appropriate draft text for the RMS working on the basis of the Chairman's proposal (IWC/56/26), his statement (IWC/56/26) and the Secretariat's document on further work (IWC/56/36). The goal of this effort is to have a finalized text of an RMS package ready for adoption at IWC/57. The following iterative process would occur to develop such a text over the intersessional period. 1. Commission formally revives the RMS Working Group and agrees to establish a small drafting group under it (see respective terms of reference in Appendices 1 and 2). 2. Secretariat collates and organises available materials. Technical specialist groups identified in IWC/56/36 are set up. 3. Technical specialist groups meet and finish their work before December 2004. 4. Small drafting group meets (one week) in December 2004. 5. Draft text is circulated to delegations for review and comment. Secretariat circulates comments to all delegations and to members of the small drafting group. 6. RMS Working Group convenes in late February – early March 2005 to consider the draft text and submitted comments, and to develop input to the small drafting group for development of the next iteration. 7. The small drafting group meets immediately afterwards to develop the second draft, which the Secretariat circulates to delegates. 8. The RMS Working Group meets for two days during the week prior to the IWC/57 Plenary session to consider the second draft. 9. The results of the RMS Working Group are presented to the Plenary for its consideration at IWC/57.	**Intersessional plan of work** The Chair's Proposal for a way forward (IWC/56/26), supplemented by his statement (IWC/56/26), other comments made at IWC 56 in relation to the Chair's proposal and the Secretariat's document (IWC/56/36), provides a basis for the development of draft text for the RMS, to clarify policy and technical issues and draft text for the RMS. The goal of this effort is to have clarified outstanding policy and technical issues and, as far as possible, have finalized text of an RMS package ready for consideration at IWC/57. The following iterative process would occur to develop such a text over the intersessional period. 1. Commission formally revives the RMS Working Group and agrees to establish a small drafting group under it (see respective terms of reference in Appendices 1 and 2). 2. All Contracting Governments are invited to send comments/ positions on key issues to the RMS Working Group. 3. Secretariat collates and organises available materials. Technical specialist groups meet and finish their work before December 2004. 4. RMS Working Group to provide guidance on major policy issues to small drafting group (before December) 5. Small drafting group meets (one week) in December 2004. 6. Draft text is circulated to delegations for review and comment. Secretariat circulates comments to all delegations and to members of the small drafting group. 7. RMS Working Group convenes in early March 2005 to consider the draft text and submitted comments and to develop input to the small drafting group for development of the next iteration. 8. The small drafting group meets immediately afterwards to develop the second draft, which the Secretariat circulates to delegates. 9. The RMS Working Group meets for two days during the week prior to the IWC/57 Plenary session to consider the second draft. 10. The results of the RMS Working Group are presented to the Plenary for its consideration at IWC/57.
Appendix 1. Terms of Reference for RMS Working Group The RMS Working Group will have the following responsibilities: (3) To complete work on the RMS package, with the goal of having a finalised RMS text ready for adoption at IWC/57. (4) To take account of delegates comments at IWC/56, as well as written submissions from delegates unable to attend the RMS Working Group in person. (5) To provide guidance to, and to review the work of, the Small Drafting Group.	**Appendix 1. Terms of Reference for RMS Working Group** The RMS Working Group will have the following responsibilities: 1. To complete work on the RMS package, with the goal of having a finalised RMS text ready for consideration, including for possible adoption, at IWC/57, and/or to identify any outstanding policy and technical issues. 2. To take account of delegates' comments at IWC/56, as well as written submissions from delegates. 3. To provide guidance to, and to review the work of, the Small Drafting Group. RMS WG to be open to observers.

Cont.

DRAFT RESOLUTION cont.	REVISED DRAFT RESOLUTION cont.
Appendix 2. Terms of Reference for the Small Drafting Group (SDG) Under the auspices of the RMS Working Group, the SDG will have the following responsibilities: 1. To prepare a consolidated draft text for the replacement of parts of Chapters V and VI of the current Schedule. 2. To prepare consolidated draft text on other related issues in the RMS package 3. To utilize the Chair's proposal (IWC/56/26) and his statement (IWC/56/28), as a basis for this work. 4. To rearrange, revise and renumber paragraphs in the draft text for Chapters V and VI as appropriate but not to attempt to merge them with other parts of the Schedule.	**Appendix 2. Terms of Reference for the Small Drafting Group (SDG)** 1. To prepare a consolidated draft text for the replacement of parts of Chapters V and VI of the current Schedule. 2. To prepare consolidated draft text on other related issues in the RMS package. 3. To utilise the Chair's proposal (IWC/56/26) and his statement (IWC/56/28), as a framework for this work. 4. To rearrange, revise and renumber paragraphs in the draft text for Chapters V and VI as appropriate but not to attempt to merge them with other parts of the Schedule. **Representation on SDG and Technical Specialist Groups (TSGs):** Chair to seek expressions of interest to ensure regional and policy diversity in the groups. The SDG and TSGs should include Governments with adequate regional coverage, and adequate coverage of those For/Against/Neutral on the key issues.

The Chair further noted that a request for information went out to all Contracting Governments, since previous Resolutions call not only for the reporting of data on whales killed and improvements to whaling operations but also for all Contracting Governments to (1) provide appropriate technical assistance to reduce unconsciousness and death in all whaling operations; and (2) to provide relevant data from the killing of other large mammals.

7.1 Reporting on data on whales killed and on improving the humaneness of whaling operations

Denmark and the Russian Federation submitted documents in response to the call for information. These are provided in Annex G. The USA gave an oral report which is summarised in Annex G. Japan did not submit data to the Commission, but did provide information on a bilateral basis. It noted that while it considers this issue to be outside the mandate and scope of the Convention, is has nevertheless worked to improve hunting methods and times to death and has participated in workshops and provided information on a voluntary basis. Japan believed that the data on whales killed should be used by those engaged in whaling to improve the hunts, rather than being used in a non-constructive way by those against whaling. It was disappointed that repeated requests for similar data for terrestrial animals had met with little success.

7.2 Commission discussions and action arising

In the Commission, while appreciation was expressed for the reports submitted there were no specific comments on them.

In response to remarks of Japan, the UK recognised that whale killing data have been used in the past to criticise whaling nations, but stressed that this was not its own intention. The UK sees a need to improve efficiency of the hunts and to reduce times to death. While it is satisfied that efforts are being made by all concerned, the UK believes there is a need for continuous improvement. It did not agree with those who consider animal welfare issues to be outside the mandate of the Convention, and again put forward its view that IWC has a moral obligation to ensure minimum suffering of hunted animals.

Germany noted that animal welfare issues are of vital importance to it, and expressed concern regarding:

(1) that current whaling methods do not guarantee instantaneous insensibility or death;
(2) that the data presently collected and submitted to the Commission are of insufficient quality and completeness to allow a fully-informed assessment of the welfare implications of whaling operations; and
(3) that the criteria used to determine death or irreversible insensibility are inadequate.

It regretted that a meeting of the Working Group had not been scheduled in Sorrento, and stressed the need for the group to meet next year. Australia associated itself with Germany's remarks.

The Russian Federation suggested that when countries call for more humane hunts, they should also be prepared to provide help. It noted that following its call for assistance at last year's meeting, only the Netherlands had responded by providing support to a training workshop to be held in Chukotka but also involving the Eskimos of Alaska. It thanked the Netherlands for this support.

Sweden saw the usefulness of comparing data from whaling with data from other hunts, since it believed it important to improve times to death in all hunts. It had therefore tried to gather data on Sweden's moose hunt in which more than 94,000 animals are shot annually. It noted that while no detailed information on times to death are available (there are no official observers of the hunt), information from a questionnaire organised by the hunters association in 1999 had indicated that 75% of animals fell where they were shot and a further 11% fell nearby. Sweden believed that these data suggest that the instantaneous death rate is in the order of 75-86%, i.e. similar to the instantaneous death rate in the Norwegian minke whale hunt. However, Sweden noted that the main concern is the 3.8% (i.e. approximately 3,500 animals) per year that are not found when searched for.

Resolution on whale killing issues

New Zealand introduced a draft Resolution on Whale Killing Issues on behalf of the other co-sponsors (UK, Italy, Germany, Austria, Mexico, South Africa, the Netherlands, Belgium, Brazil, Portugal, Sweden, Spain, India, Argentina, Finland and the USA). It indicated that its own position is that it does not want any whales to be hunted, but that if this is to be done, then those involved should be encouraged to use more humane methods. New Zealand indicated that this is the purpose of the proposed Resolution. It considered that the many variables associated with hunting whales at sea make it difficult to ensure a swift and humane death, as demonstrated by the data submitted over the years to the Working Group. It believed that Article V of the Convention provides the legal mandate to the Commission to address welfare issues, and that it was time that modern animal welfare science should be employed to improve whale hunts. The proposed Resolution:

(1) expressed concern that current whaling methods do not guarantee death without pain, stress or distress; that data presently collected and submitted to the Commission are of insufficient quality or completeness for it to make a fully informed assessment of the welfare implications of all whaling operations; and that the criteria currently used to determine the onset of death or irreversible insensibility are inadequate;
(2) requested the Secretariat to update the data collection form so that Contracting Governments may report data for each whale taken, the killing method used and samples taken;
(3) requested that the Working Group on Whale Killing Methods and Associated Welfare Issues reconvene at IWC/57 to examine methods for reducing struck and lost rates and to consider the welfare implications of methods used to kill whales caught in nets; and
(4) requested the Working Group to advise the Commission on: establishing better criteria for determining the onset of irreversible insensibility and death; methods of improving efficiency of whale killing methods; and reducing times to death and other associated welfare issues.

Germany and India spoke in support of the Resolution.

Norway noted that it takes the issue of animal welfare very seriously, agreed that there is a moral responsibility to do the utmost to reduce animal suffering and referred to the work its scientists have done in this area. However, it had problems with the Resolution proposed and considered it unnecessary in view of the outcome of the 3-day workshop held at IWC/55 last year, of which the draft Resolution made no mention. Regarding the operative paragraphs, Norway knew of no situation in which animals are killed (e.g. euthanasia, pets, stunning of livestock, hunting), where it can be guaranteed that every animal will die without pain, stress or distress, since even with the greatest of precautions, mishaps will occur. While noting that in many countries it is considered acceptable that in industrial slaughter houses instant insensibility should be achieved with one shot for 95% of animals killed, Norway indicated that the reality can be very different, reporting that for pigs, this can be 80% and that for bulls it can be as low as 53%. Referring to Sweden's earlier comments on its moose hunt, it suggested that an animal falling where it is shot is not necessarily an indication of instantaneous death. Its own studies had indicated a rate of 20%. Norway also objected to the statement that *'data presently collected and submitted to the Commission are of insufficient quality or completeness for it to make a fully informed assessment of the welfare implications of all whaling operations'*. It noted that Norway had collected detailed data for over 20 years, and that its research had led to not only its own hunting methods being safer and more efficient but also those of other hunting nations through transfer of expertise and technology. It further noted that it has presented annual reports to the IWC on welfare issues for many years and published many papers in scientific journals. It therefore did not believe that there is any problem with access to Norwegian data. Regarding the concern expressed in the proposed Resolution to the current criteria used to determine the onset of death or irreversible insensibility, Norway agreed that there are problems with these criteria as they are not sufficient to determine the onset of unconsciousness and death exactly, but that provided the data are being collected by competent individuals using the same methods, the criteria can be used to compare different hunting methods and to evaluate the skills of individual whalers. Norway also reported that from neuropathological research it had done, it is evident that the IWC criteria will result in some animals being classified as alive, when in fact they are dead, thus suggesting some overestimation of times to death. Norway therefore considered that its 80% instantaneous death rate should be regarded as a minimum. Finally, Norway requested that the Commission should:

(1) take note of the substantial information provided by Contracting Governments at the Workshop on Whale Killing Methods held in Berlin last year;
(2) encourage Contracting Government to continue the co-operative approach agreed to at the Workshop regarding improvements in data collection and reporting, technical developments of killing methods, and criteria and methods to determine death, both operationally and from post-mortem approaches; and
(3) to employ the best methods available for killing whales, both for purposes of hunting and euthanasia, including stranded whales and whales taken incidentally in fishing operations.

Denmark noted that it supports all efforts to conduct hunting in as humane a way as possible. However, like Norway it thought the proposed Resolution was redundant in view of last year's workshop, and was disappointed that neither the workshop nor past work was mentioned. Japan made similar remarks and asked that the Resolution be withdrawn. Monaco indicated that despite its concern for animal welfare issues, it would have problems in supporting the Resolution as currently proposed as it did not adequately recognise the real efforts and progress made on this issue, particularly by Norway. Iceland associated itself with Norway and appreciated Monaco's remarks. It believed that in some countries, public concern is being directed away from domestic issues to whaling. The Russian Federation associated itself with Monaco and in addition noted that from its perspective, the issue of struck and lost rates is more an issue related to conservation than to humane killing.

The USA noted its support for IWC's long-standing commitment to animal welfare issues, that it has held workshops periodically since 1980 and that it is working closely with others on the criteria used to determine the onset of death or irreversible insensibility.

Sweden was disappointed that it appeared that the Resolution could not be adopted by consensus. Recognising the importance of previous workshops, the Netherlands indicated that it would not have a problem if these were referenced in the Resolution. Austria suggested something similar and the addition of some of Norway's statements. The Chair therefore requested that New Zealand work with Austria, Norway, Sweden and Denmark with a view to revising the proposed Resolution.

On returning to this issue, New Zealand reported that although the cosponsors had consulted widely with others, no agreement had been reached that would enable the Resolution to be passed by consensus. It did, however, propose a minor amendment that would explicitly recognise the significant contribution of Norway in this area.

On being put to a vote, the Resolution was adopted (see Resolution 2004-3, Annex C), there being 29 votes in support of the Resolution and 22 against.

8. SANCTUARIES

8.1 Review of the Southern Ocean Sanctuary

8.1.1 Report of the Scientific Committee[14]

The Committee had been asked by the Commission to review the Southern Ocean Sanctuary (SOS) in 2004 and an intersessional working group had been appointed to develop a proposed framework to carry out the review. In summary, the Committee agreed that:

(1) whales are not effectively protected from whaling in the SOS, because such Sanctuaries apply only to commercial whaling, and because (apart from stocks that migrate to the IOS) whales also migrate outside of the SOS boundaries;
(2) the boundaries of the SOS were appropriately established for some, but not for all stocks; and
(3) it was not possible to completely evaluate the effectiveness of the SOS because the scientific objectives are not clear and are not associated with quantifiable performance measures.

The Committee respectfully requested that the Commission considers clarifying the objective(s) of the SOS in order to allow the Committee to discriminate among designs that would, *inter alia*: protect whales; protect whale species diversity; and increase whaling yields outside the Sanctuary. The Committee also developed a series of recommendations that, once the overall objectives of the SOS have been refined, will allow these objectives to be evaluated, and will facilitate evaluation in future reviews.

8.1.2 Commission discussions and action arising

Norway recalled that it did not take part in the voting procedure when the Southern Ocean Sanctuary was established as there was no clear advice from the Scientific Committee. It admitted that although initially sceptical over the proposal for an independent review of the Southern Ocean Sanctuary, it was pleased with its outcome and was disappointed that this appeared to have been watered down in the Scientific Committee report. Norway considered the Southern Ocean Sanctuary to do little for conservation, believed that it should be abolished and that IWC should remain a resource management organisation. Japan made similar remarks, believing that the external review had confirmed its well-known views. It too called for the sanctuary to be abolished. Believing that the Commission's decisions should be based on science, St. Lucia joined the comments of Norway and Japan. Gabon considered that range states should be consulted in the absence of scientific justification.

Australia considered that the Scientific Committee went through a comprehensive and thorough process in the review and respected its outcomes. It believed that the Committee's conclusions raise issues regarding Marine Protected Areas, scientific concepts and IWC sanctuaries, demonstrating that further work is needed. It accepted the Committee's suggestions and regarding the Committee's request for further guidance, volunteered to take the lead in developing a paper for next year's meeting on this. The UK, Brazil, the USA, Germany, Italy and Belgium associated themselves with Australia's remarks. The USA and Belgium expressed interest in helping to develop a paper. Brazil supported the ongoing process in the Scientific Committee to review sanctuaries and to bring in external expertise. However it stressed that the work should not be misrepresented. The Scientific Committee had not concluded that the Southern Ocean Sanctuary is invalid. Brazil considered sanctuaries to be valid from both scientific and management standpoints, and supports continuation of the existing sanctuaries and creation of new ones. Argentina agreed.

France, recalled that when it initially introduced the proposal in 1994 to create the Southern Ocean Sanctuary, it had focused on two aspects:

(1) protection of all whale species of the Southern Hemisphere from commercial whaling on their feeding grounds, thus supplementing the protection afforded by the Indian Ocean Sanctuary of whales on their reproductive grounds; and
(2) to supplement the management measures envisaged as part of the RMS with zones where whales would be completely protected.

In addition, France had believed that creation of this sanctuary would contribute to the recovery of species seriously depleted by decades of industrial whaling, noting that when proposed, no Southern Hemisphere country had opposed it. It had also taken into account that no aboriginal subsistence whaling was conducted within the proposed sanctuary area. Now that the sanctuary was under review, France thought it worthwhile to revisit the initial justifications in light of events since 1994. France acknowledged the efforts over the years to improve management regimes (from the 'blue whale unit' to the New Management Procedure) but noted that scientific uncertainties remain, and that even with such regimes in place, legal quotas had been set too high and illegal exploitation had not been prevented. It also questioned whether, even if a management procedure could be adopted that took account of past mistakes, successful management could be guaranteed. For this reason, France believed that sanctuaries are needed to ensure long-term conservation, and, even if an RMS were to be adopted, indicated that they would be complementary to exploitation allowed elsewhere.

Addressing the criticism that the Southern Ocean Sanctuary lacked a scientific basis, France recalled that the main reason for its creation was not to meet scientific goals (although it was created on the basis of scientific knowledge) but for conservation purposes. It believed that since 1994, a number of elements had emerged to confirm the need for this long-term measure:

(1) the discovery of new species or sub-species in the sanctuary;
(2) the discovery of important oscillations in population levels creating difficulties in drawing conclusions regarding the capacity of whale populations to recover;
(3) uncertainties regarding the population size of minke whales in the Southern Hemisphere;
(4) other threats to whales, e.g. from pollution, shipping, noise, climate change, incidental catches;

[14] For details of the Scientific Committee's deliberations on this Item see *J. Cetacean Res. Manage.* 7 (Suppl.).

(5) the difficulty of detecting signs of recovery in whale populations other than humpback and southern right whales;
(6) the development of marine protected areas and of international ocean conservation bodies;
(7) the emergence of whalewatching as a form of non-consumptive use of whale resources; and
(8) a collection of international provisions to safeguard the Antarctic.

France believed these elements also justified the creation of new sanctuaries such as those proposed for the South Atlantic and the South Pacific. It recognised that a sanctuary in which only commercial whaling is prohibited does not correspond to the modern concept of protected areas where all aspects of conservation are included, and believed that evolution of the sanctuary concept within IWC should be one of the Commission's next concerns, particularly in view of the discussions this year in the Scientific Committee.

The Commission noted the Scientific Committee report and endorsed its recommendations.

PROPOSED SCHEDULE AMENDMENT

Japan introduced the following proposed Schedule amendment:

> 'Delete paragraph 7(b) and to add the following sub-paragraph (h) to existing paragraph 10:
>
> > (h) Notwithstanding the over provisions of this paragraph, the taking of 2,914 Antarctic minke whales from the Antarctic sector 40°E - 140°W south of 60°S shall be permitted for each of the whaling seasons 2004/05, 2005/06, 2006/07, 2007/08 and 2008/09[1].
>
> * Explanatory note: Adoption of this schedule amendment will require amendment to Table 1 of the Schedule.
>
> [1]This provision shall be modified if the Commission, before the 2008/09 season, adopts other catch limits for this stock based on an agreed management procedure.'

The effect of deleting paragraph 7(b) would be to abolish the Southern Ocean Sanctuary.

In justifying the proposed Antarctic whaling, Japan noted that a comprehensive assessment of the Antarctic minke whale populations completed in 1990 showed that the population was healthy with numbers of around 761,000 whales. It further noted that the RMP was completed in 1992 and in the following year, the continuation of an annual catch limit of 2,049-4,490 Antarctic minke whales for 100 years was calculated using the RMP. Yet despite this, IWC has not yet permitted the resumption of commercial whaling on the grounds that the RMS has not yet been completed. Japan believed this delay to be due to the deliberate stalling by some Contracting Governments and because a three-quarter majority is required to implement an RMS. It reported that its research under special permit in Areas IV and V from the 1987/88 season reveals that Antarctic minke whales are abundant, and that the population level has remained stable. Japan therefore believed that a larger catch limit could be established. It went on to describe proposed pelagic whaling operations and provisions for monitoring and control.

Australia opposed Japan's proposed Schedule amendment. It believed that since the proposed takes of minke whales were not based on an agreed abundance estimate (as there is no currently agreed estimate), the credibility of the proposal was brought into question. At the request of Australia, the Scientific Committee Chair clarified that although Japan's document contained scientific assumptions and calculations based on the RMP and Committee discussions on minke whale abundance, the document had not been submitted to the Scientific Committee as would have been expected. New Zealand's view was that such a proposal should not be submitted before the introduction of an RMS and asked that it be withdrawn. Sweden believed that the Southern Ocean Sanctuary is fully justified and that the moratorium should remain in place until an RMS is agreed. It expressed concern that the Scientific Committee had been by-passed. The UK, Germany, USA, Mexico, Italy, Monaco, France, India, Kenya, Finland, Spain and Chile also spoke against Japan's proposal. The Republic of Korea considered that the discussion on whether or not to continue the Southern Ocean Sanctuary should be postponed to await the outcome of further work. With respect to Japan's proposed takes of whales, the Republic of Korea believed that such a proposal would hinder the development of an RMS and asked that Japan remove this part of its proposal.

St. Kitts and Nevis noted that it had opposed creation of the sanctuary, and that the independent scientific review had discredited it as an effective management tool. Norway supported Japan's proposal to abolish the Southern Ocean Sanctuary, but stressed that it does not intend to harvest whales in the Southern Ocean. Iceland associated itself with Norway's remarks. The Republic of Palau suggested that, coupled with a commercial whaling moratorium that has been in place since 1986, the sanctuary had contributed to the recovery of some species. It therefore believed that the sanctuary had fulfilled its purpose and should be abolished. The Republic of Guinea, Benin and St. Lucia also supported Japan's proposals.

On being put to a vote, the proposed Schedule amendment did not achieve the necessary three-quarter majority for it to be adopted, there being 19 votes in support, 30 against and 2 abstentions.

8.2 Improvements to the review process

8.2.1 Report of the Scientific Committee

The Committee agreed that the inclusion of outside experts in the review process was beneficial and agreed that this should continue. The major improvement to the review process will arise out of the development by the Commission of clearly identified and quantified objectives. The Committee **agreed** to a series of recommendations that, once overall objectives of the SOS have been refined, will allow these objectives to be realised, and will facilitate evaluation in future reviews.

The Committee agreed to the recommendations listed below.

(1) The purpose(s) of the Sanctuaries should be better articulated through a set of refined overall objectives (e.g. preserving species biodiversity; promoting recovery of depleted stocks; increasing whaling yield). In particular, the relationships between the RMP and any Sanctuary programme should be articulated.
(2) Appropriate performance measures for Sanctuaries should be developed. These performance measures should link the objectives of a Sanctuary with field monitoring programmes.
(3) Systematic inventory and research programmess should be established or further developed so as to build the required information base for a Sanctuary

management plan and subsequent monitoring programs.

(4) A Sanctuary management plan should clearly outline the broad strategies and specific actions needed to achieve Sanctuary objectives (e.g. how to protect *x*% of a given feeding area for stock *y*).

(5) A monitoring strategy that measures progress toward achieving the Sanctuary objectives should be undertaken. A key component of this monitoring strategy should be the development of tangible indicators to monitor progress.

(6) Review criteria that reflect the goals and objectives of the Sanctuary (as described above) should be established.

(7) The Sanctuary management plan should be refined periodically to account for ecological, oceanographic and possible other changes in an adaptive fashion.

8.2.2 Commission discussions and action arising

The Commission noted the report and endorsed its recommendations.

8.3 South Pacific Sanctuary

8.3.1 Proposal to amend the Schedule to establish a sanctuary

For the fifth year[15], Australia and New Zealand proposed to establish a South Pacific Sanctuary as follows:

> In accordance with Article V (1)(c) of the Convention, commercial whaling, whether by pelagic operations or from land stations, is prohibited in a region designated as the South Pacific Sanctuary.
>
> This Sanctuary comprises the waters of the Southern Hemisphere enclosed within the following line: starting from the southern coast of Australia at 130°E; thence due south to 40°S; thence due east to 120°W; thence due north to the equator; thence due west to 141°E; thence generally south along the Papua New Guinea – Indonesian maritime boundary to the northern coast of Papua New Guinea at 141°E; thence generally east, south thence west along the coast of Papua New Guinea to the southern coast of Papua New Guinea at 141°E; thence due south to the northern coast of Australia at 141 °E; thence generally east, south thence west along the coast of Australia to the starting point.
>
> This prohibition applies irrespective of the conservation status of baleen or toothed whale stocks in this Sanctuary as may from time to time be determined by the Commission. However, this prohibition shall be reviewed ten years after its initial adoption, and at succeeding ten year intervals and could be revised at such times by the Commission.

New Zealand indicated that it remains convinced that the creation of a South Pacific Sanctuary is vital to ensure the conservation of whales in the region and drew attention to new and continuing efforts of range states and organisations in this regard. It reported that at a national level, the network of domestic sanctuaries continues to grow, with that of New Caledonia being added to the list since the IWC Annual Meeting last year (the others are Australia, New Zealand, Tonga, Vanuatu, Fiji, Niue, American Samoa, Baker Island, Java Island, Cook Islands and French Polynesia). New Zealand indicated that as a result, whales are now protected over approximately 13.5 million square kilometres, and suggested that if this growth of national sanctuaries continues, around 50% of the area proposed as the South Pacific Sanctuary would be covered by them. It stressed that nothing in the proposed Schedule amendment prejudices the sovereign rights of coastal states under the UN Law of the Sea Convention. At a regional level, New Zealand reported that states and territories of the South Pacific have continued to express support under various auspices including the South Pacific Regional Environment Programme and the Pacific Island's Forum) for the sanctuary and for whale conservation. It noted that in March 2004, SPREP hosted a workshop to discuss how a regional initiative for marine mammal conservation under the Convention on Migratory Species could enhance existing national measures. The workshop and agreed that a Memorandum of Understanding under CMS should be drawn up with an vision of *'a Pacific Ocean where populations of marine mammals have recovered to healthy levels of abundance, have recovered to their former distribution, and continue to meet and sustain the cultural aspirations of Pacific peoples'*. Stressing that the overwhelming majority of peoples of the region want a sanctuary to be established, New Zealand urged that the proposed Schedule amendment be adopted.

While recognising that some whales in the South Pacific region appear to be recovering well, Australia indicated that scientific information shows that recovery is uneven. For example, Australia noted that despite 30 years of IWC protection, humpback whales have still not reappeared in significant numbers in their former breeding grounds in Fiji, Vanuatu, Samoa or New Zealand. Australia considered that the best way to secure recovery of all populations is to protect them on their breeding grounds and migration routes – which the South Pacific Sanctuary, combined with the Southern Ocean Sanctuary would afford.

8.3.2 Commission discussions and action arising

On a point of order, Iceland indicated that the legality of the proposal should be addressed before any discussion on the proposal itself. It indicated that it did not believe that the proposal met criteria set out in the Convention, particularly in relation to Article V.2 (a), (b) and (d), i.e. that Schedule amendments be: as necessary to carry out the objectives and purposes of the Schedule; based on scientific findings; and take into consideration the interests of consumers of whale products and the whaling industry. Several countries including Norway, Antigua and Barbuda and Japan took a similar view. Australia and New Zealand noted that the same issue was raised last year and had been settled in favour of the proposal's sponsors by a ruling of the Chair. They did not wish to rehearse previous discussions. Noting the previous debate, the Chair ruled in favour of the sponsors.

The UK, France, Sweden, Brazil, Italy, Kenya, Germany, Peru, Argentina, Mexico, Chile, USA and Monaco spoke in support of the establishment of a South Pacific Sanctuary. The Republic of Palau, Norway, Iceland, Denmark, Antigua and Barbuda, St. Kitts and Nevis, Republic of Guinea, Japan, Tuvalu and St. Lucia spoke against. Some noted that a sanctuary is not currently needed given the existing moratorium and that a scientific need has not been sufficiently demonstrated. Others also believed that the creation of sanctuaries is not consistent with the policy of the sustainable use of marine resources.

The proposed Schedule amendment did not attract the required three-quarter majority when put to a vote. There were 26 votes in support, 21 against and 4 abstentions. Several countries explained their vote. Ireland, who had abstained, indicated that they are supportive of sanctuaries in principle but believed that any new proposals should have maximum consensus and, notably, support from

[15] *Ann. Rep. Int. Whal. Comm.* 1999: 10-11; *Ibid.* 2000: 15-17; *Ibid.* 2001: 33-34; *Ibid.* 2003: 24-26.

whaling nations. Switzerland had been instructed to abstain if the proposal was not supported by all states bounded by the proposed sanctuary.

8.4 South Atlantic Sanctuary

8.4.1 Proposal to amend the Schedule to establish a sanctuary

For the fourth year, Brazil introduced its proposal, co-sponsored by Argentina and others, to create a South Atlantic Whale Sanctuary. The amendment proposed was the same as in previous years, i.e., the inclusion of a new sub-paragraph in Chapter III of the Schedule as follows:

> 'In accordance with Article V(1)(c) of the Convention, commercial whaling, whether by pelagic operations or from land stations, is prohibited in a region designated as the South Atlantic Whale Sanctuary. This Sanctuary comprises the waters of the South Atlantic Ocean enclosed by the following line: starting from the Equator, then generally south following the eastern coastline of South America to the coast of Tierra del Fuego and, starting from a point situated at Lat 55°07,3'S Long 66°25,0'W; thence to the point Lat 55°11,0'S Long 066°04,7'W; thence to the point Lat 55°22,9'S Long 65°43,6'W; thence due South to Parallel 56°22,8'S; thence to the point Lat 56°22,8'S Long 67°16,0'W; thence due South, along the Cape Horn Meridian, to 60°S, where it reaches the boundary of the Southern Ocean Sanctuary; thence due east following the boundaries of this Sanctuary to the point where it reaches the boundary of the Indian Ocean Sanctuary at 40°S; thence due north following the boundary of this Sanctuary until it reaches the coast of South Africa; thence it follows the coastline of Africa to the west and north until it reaches the Equator; thence due west to the coast of Brazil, closing the perimeter at the starting point. This prohibition shall be reviewed twenty years after its initial adoption and at succeeding ten-year intervals, and could be revised at such times by the Commission. Nothing in this sub-paragraph shall prejudice the sovereign rights of coastal states according to, *inter alia*, the United Nations Convention on the Law of the Sea.'

Brazil noted that the proposed sanctuary incorporates environmental, social and scientific issues and takes account of the regional interests of its neighbouring nations. It explained that the objective of the sanctuary is to enhance the global effort to establish Marine Protected Areas for marine mammals and to complement existing IWC whale sanctuaries. It believed the initiative is justified by the recognition that after centuries of exploitation, most whale species have had their numbers drastically reduced and are only now showing signs of recovering from the edge of extinction, with many still at less than 10% of the pre-whaling population. On World Biodiversity Day, Brazil had re-iterated the importance it attaches to the proposal through a letter from its President to the Heads of State of member nations of the IWC and range states of the South Atlantic requesting support for the sanctuary. The many positive responses encouraged Brazil to resubmit the proposal. Brazil noted that since 1987, it has been proud to be among those countries embracing the principle of non-lethal use of whales as a way to profit sustainably from the species inhabiting its waters and reported that whalewatching has been responsible for an important tourism influx to its coastal regions. It believed that creation of the sanctuary would contribute significantly to fostering international co-operative research among developed and developing countries which would in turn help developing countries to realise the potential of cetacean conservation. It therefore hoped that all developing nations that are range states to the proposed sanctuary would support the proposal. With respect to developed nations, Brazil did not understand how some who take progressive stances on environmental issues in other multilateral fora take a position at the IWC that is in contradiction with the interests of biodiversity conservation, particularly when those developed countries raise the argument of economic difficulties when whaling is of no real significance for their economies. Ten years after the entering into force of the Convention on Biological Diversity, Brazil believed that the establishment of the South Atlantic whale sanctuary is a fundamental step forward in ensuring recognition of the rights of developing countries to protect and use their resources under their own management regime. It urged member countries to support the proposal.

Argentina noted that the proposal for a South Atlantic Sanctuary has broad-based support from its nationals. Like Brazil, it has developed whalewatching as a new brand of ecotourism that has contributed to the welfare of local communities by opening up new livelihoods and to an increased interest in marine mammal conservation among the public. Argentina believed that the proposed sanctuary will provide a useful tool in the protection of whales in their breeding and feeding grounds as well as on their migration routes and contribute to: recovery of whale populations; protection of biodiversity; research on depleted stocks and their habitats; the promotion of modern educational activities; and the development of environmentally friendly tourism in the region. It noted the co-operative activities among countries of the region on other environmental and conservation-related issues that could serve as an example to others and urged their support on this issue.

8.4.2 Commission discussions and action arising

Iceland noted that the content of its point of order raised in relation to the proposed South Pacific Sanctuary was also applicable to the proposal for a South Atlantic Sanctuary. However, discussion of the proposal proceeded.

South Africa, Australia, Germany, New Zealand, India, Peru, Mexico, Monaco, UK, USA, Chile and Portugal spoke in support of the proposed sanctuary. A number of them congratulated Brazil and Argentina on the further work done. Iceland, Norway, Japan, Republic of Guinea, Antigua and Barbuda, Gabon and St. Lucia spoke against the proposal, with several countries indicating that they did not consider that sufficient scientific justification for the sanctuary had been presented and noted that there is no consensus among the Scientific Committee. The Republic of Guinea, speaking as a range state for the proposed sanctuary, indicated that its priority is to complete the RMS and was against vast ocean areas being closed to commercial whaling in principle. With Japan, it made reference to the consumption of fisheries resources by whales that it considered to be a problem. On this matter, Brazil could not agree that whales are the real problem in declining fish stocks given the high level of fisheries activities in the South Atlantic. It noted that the proposal for the sanctuary has been submitted to the Scientific Committee and that it is paying due consideration to the further work of the Committee in this area. It considered that the Commission should be honest and fair to the public by stating clearly that there will never be consensus from the Scientific Committee for the creation of new sanctuaries since on this issue, it is as polarised as the Commission itself.

As there was clearly no consensus on the proposal the Chair proceeded to a vote. There were 26 votes in support, 22 against and 4 abstentions. The proposed Schedule amendment to create a South Atlantic Sanctuary was therefore not adopted. Ireland and Switzerland (who both abstained) explained their votes by referring to their statements for the South Pacific Sanctuary proposal. Senegal (who voted against the sanctuary) noted that after many years of being unable to participate actively in the Commission, it had made great efforts to regain its voting rights for this meeting. It wished to inform the Commission that it intended to use its vote responsibly and objectively. It wished to make it clear that Senegal is not participating in IWC as a pro- or anti-whaling nation, but as a fishing nation that believes that all marine resources should be used in a sustainable manner.

9. SOCIO-ECONOMIC IMPLICATIONS AND SMALL-TYPE WHALING

Japan reported on the Third Summit of Japanese Traditional Whaling Regions held in Muroto, Kochi prefecture on 30 May 2004. The Summit adopted the 'Muroto Declaration on Traditional Whaling', that has been endorsed by the Japanese government.

9.1 Proposed Schedule amendment for the taking of minke whales in the North Pacific

9.1.1 Introduction by Japan

Japan introduced its proposal to add the following sub-paragraph (f) under paragraph 10 of the Schedule:

> '(f) Notwithstanding the other provisions of this paragraph, the taking of 150 minke whales from the Okhotsk Sea-West Pacific stock shall be permitted for the whaling season in each of the years 2004, 2005, 2006, 2007 and 2008[1].'
>
> Explanatory note: Adoption of this Schedule amendment will require amendment to Table 1 of the Schedule.
>
> [1]This provision shall be modified if the Commission, before 2008, adopts other catch limits for this stock based on an agreed management procedure.

This proposal was the same as that introduced last year.

As last year, Japan recalled that it had been sixteen years since the imposition of the moratorium on commercial whaling in Japanese coastal waters and that during this time, it had repeatedly requested an interim relief allocation of 50 minke whales to alleviate the hardships of its small-type coastal whaling communities. It noted that even though the Commission had recognised the severe impacts of the moratorium on the four small-type whaling communities and had agreed to work expeditiously to alleviate their distress, the Commission had rejected these requests. In the meantime, Japan believed that whale abundance has increased, while its coastal fisheries have become impoverished, leading to considerable discontent among fishermen over the competition between fisheries and whales.

Japan again noted:

(1) that the Scientific Committee's Comprehensive Assessment of the Okhotsk Sea-West Pacific stock of the North Pacific minke whales completed in 1991 showed the stock to be robust;
(2) that although the RMP had been adopted in 1994 it had not been implemented; and
(3) that effective monitoring and control measures have been discussed exhaustively for over 10 years and have now turned into unrealistically excessive demands designed to delay completion and implementation of the RMS.

Again as last year, Japan indicated that it wished to resume community-based whaling for the sustainable use of robust whale stocks, the management of fishery resources, and the revitalization of the impoverished community-based coastal whaling communities. It noted that all the edible parts of the harvested whales would be used as food, and a substantive part of them distributed primarily among the four community-based coastal whaling communities and neighbouring areas, as well as Kushiro, where a land station would be built. It considered that the resumption of community-based whaling would promote the local processing industries and stimulate distribution of whale products and tourism, leading to more employment opportunities and a stimulation of the local economy. It also believed that the resumption of community-based whaling would reinstate traditional practices associated with sales of whale meat, and revitalize traditional festivals and rituals of the regions.

Japan gave specifics of the proposed whaling operation (whaling ground, season, catch quota) and monitoring and control provisions.

9.1.2 Commission discussions and action arising

Japan clarified that the proposed takes would be from within its own EEZ.

The UK noted that similar requests from Japan have been discussed over the last several years. In addition to the fact that the proposal undermined the commercial whaling moratorium, the UK was also concerned about the status of the 'J' stock. It could not support Japan's proposal. Monaco expressed concern that the proposed takes would be in addition to those taken under special permit and asked whether the meat from these whales could not be used to satisfy the needs of the four Japanese coastal communities. Like the UK, Sweden viewed the proposal as being inconsistent with the moratorium, considered that it by-passed the Scientific Committee and used a number of incorrect assumptions. The USA, Switzerland, India, New Zealand, Germany, Australia endorsed the remarks of the UK, Monaco and Sweden.

The Republic of Korea expressed sympathy with the Japanese communities involved, but asked whether Japan could delay its request to await progress with the RMS.

St. Vincent and The Grenadines, Dominica, Nicaragua, Republic of Guinea, Russian Federation, Senegal, St. Lucia, Benin, Antigua and Barbuda and China understood and recognised the traditional rights and needs of Japan's coastal communities and supported Japan's proposed Schedule amendment. Several of them recognised the proposal's scientific merits. The Republic of Guinea noted that aboriginal subsistence quotas have been granted for the USA and the Russian Federation with respect to bowhead and gray whales and asked for equal treatment for Japan's coastal whaling communities. The Russian Federation believed that Monaco's suggestion to use meat from whales taken under scientific permit to satisfy the needs of the four Japanese coastal communities ignored the 9,000-year cultural tradition of these peoples to harvest their own whales – it is not simply an issue of providing protein. It noted that voting against Japan's proposal would be voting against a long cultural tradition and urged that the matter not be brought to a vote. The Republic of Palau believed the suggestion of the Russian Federation should be pursued and a compromise found. Monaco indicated that it would be willing to support the proposal if Japan agreed to stop its scientific permit takes. Denmark and Côte d'Ivoire also did not see why the matter should be rushed. However, as there was clearly no consensus on this, several countries urged the Chair to proceed to a vote.

Japan noted that it was willing to reduce the proposed take of minke whales from 150 to 100 and to reduce the period of the quota to three years. This amended proposal was put to a vote. There were 19 votes in support, 26 against and one abstention. The proposed Schedule amendment was therefore not adopted.

9.2 Proposed Resolution on Japanese Community-Based Whaling

9.2.1 Introduction by Japan

Stressing that the proposed Resolution was nothing to do with its previous quota request (see section 9.1.1), Japan indicated that it was again seeking the Commission's commitment to work expeditiously to solve the problems caused by the cessation of minke whaling. It noted that the spirit of the Resolution is very similar to that first adopted at the IWC Annual Meeting in Kyoto in 1993. The draft Resolution did, however, refer to the outcome of recent Summits of Japanese Traditional Whaling Communities and Declarations issued from them. The draft Resolution proposed that the Commission (1) reaffirms its commitment to work expeditiously to alleviate the distress caused by the cessation of minke whaling to the communities of Abashiri, Ayukawa, Wadura and Tajii; and (2) welcomes the initiatives of the Government of Japan to resolve this matter.

The proposed Resolution was co-sponsored by Antigua & Barbuda, Belize, Benin, Cote d'Ivoire, Dominica, Gabon, Grenada, Republic of Guinea, Iceland, Mauritania, Mongolia, Nicaragua, Norway, Republic of Palau, Panama, Russian Federation, St. Kitts and Nevis, St. Lucia, St. Vincent and The Grenadines, Solomon Islands, Suriname, and Tuvalu.

9.2.2 Commission discussions and action arising

The UK noted that in discussions under item 9.1, parallels had been drawn between the requests of Japan for a quota of minke whales and the position of aboriginal subsistence whalers. The UK did not believe that this was appropriate, partly because the peoples of the four Japanese communities are reasonably prosperous, but more particularly because the Commission has never received the kind of 'needs' information that could promote discussion on the aboriginal need for these communities. The UK reminded the meeting that after IWC/54 in Shimonoseki, some Contracting Governments suggested that a way forward on Japanese coastal whaling might be for Japan to develop a proposal allowing for non-commercial whaling. No such proposal had been received. Consequently, although the UK was ready to reaffirm sympathy for the position of the communities, it could not endorse the Resolution as Japan had not actually taken the necessary initiatives. New Zealand and Germany endorsed these comments.

The USA indicated that it could not adopt the Resolution as written, and proposed that the operative paragraphs be revised to read: (1) reaffirms its commitment to work expeditiously to alleviate the continued difficulties caused by the cessation of minke whaling to the communities of Abashiri, Ayukawa, Wadura and Tajii; and (2) encourages IWC members to co-operate towards a Resolution of this matter. Japan thanked the USA for its proposal and indicated it could accept the revisions.

The Chair asked if the Resolution could be adopted by consensus. Sweden explained that it could support the Resolution as revised by the USA on the understanding that the intention was 'to finish the RMS in order to be able to initiate an agreed process for setting possible quotas that might alleviate the continued difficulties caused by the cessation of minke whaling….'. It stressed that it did not seek further revision of the Resolution.

The Resolution, revised as proposed by the USA, was then adopted by consensus (Resolution 2004-2, Annex C).

9.3 Proposed Schedule amendment for the taking of Bryde's whales from the Western Stock of the North Pacific

9.3.1 Introduction by Japan

As last year, Japan introduced a proposed Schedule amendment to add the following sub-paragraph (g) under paragraph 10:

> (g) Notwithstanding the other provisions of this paragraph, the taking of 150 Bryde's whales from the Western Stock of the North Pacific shall be permitted for the whaling season in each of the years 2004, 2005, 2006, 2007 and 2008[1]."
>
> Explanatory note: Adoption of this Schedule amendment will require amendment to Table 2 of the Schedule.
>
> [1]This provision shall be modified if the Commission, before 2008, adopts other catch limits for this stock based on an agreed management procedure.

Explaining the rationale for its proposal, Japan again noted that the western North Pacific stock of Bryde's whale was classified as an initial management stock (IMS) or a sustained management stock (SMS) when the moratorium was placed on commercial whaling and that present abundance is estimated at 23,751, according to the Scientific Committee's Comprehensive Assessment completed in 1996. It considered the stock to be very robust. As with its proposal relating to minke whales discussed under section 9.1, Japan referred to the fact that the RMP has been adopted but not implemented and that an RMS has still not been agreed despite discussions over many years. It again noted that work on the development of *Implementation Simulation Trials* has made little progress within the Scientific Committee. Nevertheless, by applying the RMP together with an appropriate monitoring and control regime (which it described), Japan believed that sustainable whaling on this stock of Bryde's whales could be achieved and the impoverished coastal communities revitalised as a result.

9.3.2 Commission discussions and action arising

Nicaragua supported Japan's proposal. Sweden referred to its remarks made under section 9.1 and indicated that they were also applicable to this request. It further noted that work on the *Implementation Simulation Trials* for this stock of Bryde's whales has only just begun. Switzerland agreed with Sweden, emphasising that the moratorium is still in place.

On being put to a vote, Japan's proposed Schedule amendment failed to achieve the necessary three-quarter majority, there being 22 votes in support, 29 against and 2 abstentions.

10. SCIENTIFIC PERMITS

Japan gave a short PowerPoint presentation on its JARPA and JARPN II programmes.

10.1 Report of the Scientific Committee[16]

10.1.1 Improvements to review procedures

Last year, the Committee had noted that the existing guidelines, which had developed over a number of years, inevitably include some duplication and overlap within the broad headings used. With the aim of providing a proposal to the Commission on restructuring the guidelines, it agreed to revisit this issue in a year in which there is no major new scientific permit proposal to review. Although the Committee considered a number of options this year, there was no consensus to change the current procedures.

10.1.2 Review results from existing permits

JAPAN: SOUTHERN HEMISPHERE (JARPA)

The Committee received a number of reports of work undertaken as part of the recent field season of JARPA as well as documents using some or all of the JARPA data collected thus far. These were considered where relevant to the main Scientific Committee agenda.

JAPAN: NORTH PACIFIC (JARPNII)

The Committee reviewed the results of the second full year of the JARPN II programme reviewed last year[17]. A total of 150 common minke, 50 Bryde's, 50 sei and 10 sperm whales were taken. There was considerable diasagreement over the value and conclusions that could be drawn over the two-year feasibility study (and see section 10.1.3 below).

ICELAND: NORTH ATLANTIC

Most of the discussion at the 2003 meeting centred on the proposal for a two-year feasibility study in Icelandic waters involving the taking of 100 common minke whales, 100 fin whales and 50 sei whales. The stated goal was to improve understanding of the biology and feeding ecology of important cetacean species in Icelandic waters for better management of living resources based on an ecosystem approach. It includes multiple specific objectives with different priorities for the different species. For common minke whales the primary specific objective is to increase the knowledge of the species' feeding ecology in Icelandic waters. For fin and sei whales the primary specific objective is the study of biological parameters during the apparent increase in population size in recent decades. These objectives are the basis for the proposed sample sizes. Other research objectives include studies of population structure, pollutants, parasites and pathogens, and the applicability of non-lethal methods. There had been considerable disagreement within the Committee over most aspects of this research programme, including objectives, methodology, sample sizes, likelihood of success, effect on stocks and the amount and quality of data that could be obtained using non-lethal research techniques.

In 2003, a total of 37 common minke whales had been taken. The Committee briefly considered the preliminary results of analyses presented. It noted that no permits had been issued for fin and sei whales which had been part of the proposal it had reviewed last year.

10.1.3 Review of new or continuing proposals

JAPAN: SOUTHERN HEMISPHERE

The Committee briefly discussed the JARPA proposal. This was the final year of a 16-year programme. Progress had been fully reviewed in 1997[18]. The Committee agreed that it will undertake a full review of the JARPA programme when the complete set of results are available following the completion of the 16-year programme, i.e. some time after the 2005 annual meeting of the Committee.

JAPAN: JARPN II

Most of the discussion at this year's meeting centred on the proposal for a JARPN II programme. The stated goals (to obtain information to contribute to the sustainable use of marine living resources in the western North Pacific via sub-projects on feeding ecology and ecosystems; monitoring of environmental pollutants in cetaceans and the marine ecosystem; further elucidation of stock structure) remain unchanged. A total of 220 common minke whales (100 from the offshore survey and 120 from the coastal survey), 50 Bryde's whales (offshore survey), 100 sei whales (offshore survey) and 10 sperm whales (offshore survey) will be sampled in sub-areas 7, 8, and 9. Regarding the coastal survey component, 60 common minke whales will be sampled in each of the early season and the late season. There was considerable disagreement within the Committee over most aspects of this programme including objectives, methodology, sample sizes, likelihood of success, effect on stocks and the amount and quality of data that could be obtained using non-lethal means.

ICELAND: NORTH ATLANTIC

The Committee noted that the proposal remains the same as last year, except that the schedule for taking 200 minke whales in two years has been revised. The revised schedule implies that the sample of 200 minke whales will be completed in 2006.

The objectives, methodology and arrangements for participation by scientists from other countries remain unchanged from the original proposal. The revised plan for sampling minke whales reduces the numbers of whales sampled per year in 2004 and 2005.

10.2 Commission discussions and action arising

As the meeting was running seriously behind schedule, Australia, with the agreement of other co-sponsors (Argentina, Brazil, Finland, France, Germany, Italy, Mexico, Monaco, the Netherlands, New Zealand, Portugal, San Marino, South Africa, Spain, Sweden, Switzerland, UK and the USA), withdrew a proposed draft Resolution that *inter alia* called on Japan to halt its research whaling in the Southern Ocean Sanctuary. The co-sponsors stressed that this withdrawal should not be interpreted as a reduction in their concern on this matter and requested that the record refer to a similar Resolution adopted last year (i.e. Resolution 2003-3[19]). Australia went on to note that during the 15 years over which JARPA has taken place, some 6,500 whales had been killed despite the fact that there has been no comprehensive assessment under peer review and no agreed abundance estimate for the stocks targeted. It believed that a full and comprehensive review of the outcome of the JARPA programme is needed before further work is contemplated and that any further research should employ non-lethal techniques. The UK and Germany associated themselves with these remarks.

New Zealand referred to the concern it has expressed for many years over scientific permit whaling, believing that the development of modern techniques such as molecular genetics have rendered lethal whale research redundant.

[16] For details of the Scientific Committee's deliberations on this Item see *J. Cetacean Res. Manage.* 7 (Suppl.).

[17] *J. Cetacean Res. Manage.* 5 (Suppl.).

[18] *Rep. Int. Whal. Commn.* 48: 95-105.

[19] *Ann. Rep. Int. Whaling Comm.* 2003: 103.

Furthermore, it did not believe that the research being done by Japan and Iceland to support fisheries management, rather than whale management, could be justified on moral or ethical grounds and questioned whether the research programmes would meet the ethical requirements of these countries domestic legislation. New Zealand did not dispute the right under Article VIII of the Convention for governments to issue special permits for research whaling, but was of the opinion that this right is being abused. Brazil also acknowledged these rights but considered that the current level of research whaling amounts to commercial-scale operations. It appealed to Japan to reconsider issuing permits to take whales in the Southern Ocean Sanctuary. Argentina associated itself with the remarks of New Zealand and Brazil. Sweden agreed with the moral/ethical argument put forward by New Zealand. It was also opposed to PowerPoint presentations during the plenary, preferring to have documents presented during the plenary with presentations outside the meeting room.

Italy suggested that an overlap between the diet of cetaceans and fish does not necessarily point to competition for food since this depends on the availability of a particular resource. It believed that catching whales to look at stomach contents is a too simplistic way to look at ecosystem trophodynamics. Rather it is necessary to apply complex models, which it did not believe had been done. The USA noted its strong opposition to the scientific permit whaling programmes that it believed had no quantifiable objectives. Like others, Monaco expressed concern regarding the escalation of scientific permit whaling and noted that in the last few years there has been a wealth of information published illustrating that problems with declining fisheries are due to massive over-fishing rather than competition between whales and fish. The UK made similar remarks. Switzerland was against the culling of whales on the assumption that they are in competition for fishery resources and associated itself with the comments of Italy and Monaco. The Netherlands associated itself with earlier remarks, particularly those of Australia, Sweden and Switzerland.

Japan, the Republic of Korea, Norway, St. Kitts and Nevis, Iceland and Dominica spoke in support of research programmes under special permit. Japan noted that it publishes the results from its research programmes in an open manner and that it would welcome scientists from New Zealand and other countries at its own planned JARPA review meeting. Contrary to the view of New Zealand, it did not believe its research under special permit to be either unethical or immoral. The Republic of Korea noted that some of its scientists had taken part in Japan's JARPN II programme and thanked Japan for this opportunity to co-operate. It believed that the results from the work would improve both fisheries and whale management. Norway stressed the importance of taking an ecosystem-based approach to the management of marine living resources and referred to on-going co-operation in this area with Iceland and Japan. It stressed that this type of research requires some time to yield useful results, noting that sufficient information for use in ecosystem modelling approaches had only been obtained in its own programme after some 10 years. It commended Japanese scientists on the interesting preliminary results from JARPN II. St. Kitts and Nevis suggested that those governments holding the view that alternative approaches to lethal whale research exist should develop their own research programmes to demonstrate this. It supported the work of Japan and urged them to continue. Iceland noted the agreement in various international fora that an ecosystem approach should be applied to the management of marine living resources. As part of the marine ecosystem, it believed that whales must be included in multi-species modelling for ecosystem-based management and that the only way to get information on feeding ecology with the accuracy necessary for such modelling is to look at stomach contents. It therefore considered such research important. Furthermore, Iceland indicated that it does not believe that there is anything wrong or unethical in taking animals from abundant stocks for scientific research. It does not take the view that some animals are more equal than others. Dominica welcomed the debate on this agenda item. It supported the remarks of Norway and Iceland and the continuation of research activities from which countries like itself without the capability for running such programmes could benefit. Referring to Iceland's comment on ecosystem management, Australia noted that this does not mean ecosystem manipulation which it believed seemed to be the objective of some of the existing research programmes.

Finally, the Chair of the Scientific Committee clarified that the Committee would continue to use existing guidelines to review future scientific permit research proposals and that it would not include work to revise the process as part of its standing agenda.

The Commission noted the Scientific Committee report and endorsed its recommendations.

11. ENVIRONMENTAL AND HEALTH ISSUES

11.1 Integration of environmental concerns with other Scientific Committee work and habitat-related issues

11.1.1 Report of the Scientific Committee

There is an increasing awareness that whales should not be considered in isolation but as part of the marine environment; detrimental changes to their habitat may pose a serious threat to whale stocks. The Committee has examined this issue in the context of the RMP and agreed that the RMP adequately addresses such concerns. However, it has also emphasised that the species most vulnerable to environmental threats might well be those reduced to levels at which the RMP, even if applied, would result in zero catches. Over a period of several years, the Committee has developed two multi-national, multi-disciplinary research proposals. One of these, POLLUTION 2000+ has two aims: to determine whether predictive and quantitative relationships exist between biomarkers (of exposure to and/or effect of PCBs) and PCB levels in certain tissues; and to validate/calibrate sampling and analytical techniques. The other, SOWER 2000 (IWC, 2000) aims to examine the influence of temporal and spatial variability in the physical and biological Antarctic environment on the distribution, abundance and migration of whales. Progress reports on both of these programmes were considered at this year's meeting.

Given the emergent threat of anthropogenic sound on cetaceans and other elements of marine ecosystems and also the potential for the Committee to assist in the development and interpretation of studies aimed at elucidating the potential impacts of anthropogenic noise on cetaceans, the Committee held a mini-symposium at this year's meeting, with presentations on the following topics:

(a) the effects of anthropogenic noise on marine animals and the possible synergistic effects between ambient ocean noise levels and other environmental stressors;
(b) physical acoustics and ambient noise in the ocean;
(c) audition and the physiology of hearing in cetaceans and the effects of intense sounds on cetacean hearing; and
(d) whale communication behaviour.

In conclusion, the Committee noted with great concern the impact on large whales in critical habitats of exposure to seismic sound pulses, particularly with respect to severely threatened populations such as the western gray whale. It agreed that there is now compelling evidence implicating that military sonar has a direct impact on beaked whales in particular. It also agreed that evidence of increased sounds from other sources, including ships and seismic activities, were cause for serious concern. The potential for cumulative or synergistic effects of sounds, as found in other taxa, with non-acoustic anthropogenic stressors was noted. A number of detailed recommen-dations were made concerning beaked whales and military sonar, mitigation and monitoring protocols with respect to seismic operations, and general recommendations on anthropogenic noise.

The Committee was pleased to hear that the intersessional Workshop on Habitat Degradation will take place in November 2004 at the University of Siena, Italy. The Committee also forwarded this year's SOCER (State of the Cetacean Environment Report) to the Commission.

The Committee also agreed that it was important to integrate work on environmental concerns with that of the other Sub-committees. It noted that next year's symposium on sea ice would be a joint venture with the IA (in-depth assessments) and BRG (bowhead, right and gray whales) Sub-committees.

11.1.2 Commission discussions and action arising

The UK believed that environmental concerns are paramount in the conservation and management of cetaceans and considered that the greatest threat to cetaceans is the degradation of their environment through chemical pollution, commercial fisheries and global environmental changes. Noting that the effects of noise pollution are a growing concern, the UK endorsed the Scientific Committee's comprehensive recommendations on this issue. It also applauded the Committee's work on other habitat degradation issues and looked forward to the outcome of the habitat degradation workshop. It believed the ongoing work on chemical pollution under POLLUTION 2000+ to be important in relation to conservation and consumption of cetaceans and encouraged its continued funding. The UK supported the steps being taken to integrate environmental concerns with other parts of the Scientific Committee's agenda but noted that the issues of noise and chemical pollution are agreed priority areas for the Standing Working Group on Environmental Concerns. Finally it thanked the editors of the SOCER report. New Zealand, Germany and Australia associated themselves with the remarks of the UK. Referring to the SOCER report, Australia noted the steps it is taking to protect the Great Barrier Reef and was pleased to see that the report next year will include a review of Antarctic cetacean issues.

The Commission noted the Scientific Committee's report and endorsed its recommendations.

11.2 Reports from Contracting Governments

There were no reports from Contracting Governments on national and regional efforts to monitor and address the impacts of environmental change on cetaceans and other marine mammals.

11.3 Health issues

There were no issues raised under this item.

12. WHALEWATCHING

12.1 Report of the Scientific Committee[20]

In 2000, the Committee had identified a number of areas for further research on possible long-term effects of whalewatching on whales and a number of possible data types that could be collected from whalewatching operations to assist in assessing their impact. The Committee developed this further at the 2004 meeting. The primary topic considered was a review of the results from the Workshop on the Science for Sustainable Whalewatching held in Cape Town, 6-9 March 2004. The Committee endorsed a number of recommendations from the Workshop concerning:

(1) the value of experimental studies to measure the impacts of whalewatching;
(2) new approaches and quantitative studies of relevance to the Scientific Committee;
(3) further development of a framework for the management of whalewatching similar in concept to those codified in the FAO Code of Conduct for fisheries;
(4) use of the precautionary approach in the absence of information of possible damaging effects of whalewatching;
(5) use of case studies to promote broad conclusions about assessing impacts of whalewatching on different taxonomic groups at a variety of life history stages;
(6) the development of whalewatching guidelines based on criteria that are simple, practical and objectively measurable under field conditions; and
(7) further development of the IWC's 1997 General Principles for the Development of Regulatory Frameworks for Whalewatching (see *www.iwc office.org*).

The Committee also reviewed whalewatching guidelines and regulations, and new information on dolphin feeding and 'swim-with' programmes.

12.2 Commission discussions and action arising

New Zealand, Brazil, the UK, Australia, Germany, Italy, Argentina, the USA and Spain supported the Scientific Committee's work in this area and in particular thanked South Africa for hosting the whalewatching management workshop. They endorsed the workshop's recommend-ations and expressed regret that there is still disagreement regarding the competency of Commission on this issue which they believed did fall within its mandate. Several

[20] For details of the Scientific Committee's deliberation on this Item see *J. Cetacean Res. Manage.* 7 (Suppl.).

countries noted that whalewatching is an ideal way to achieve optimal use of whale resources with New Zealand and Australia providing information on the contribution of whalewatching to their economies. Brazil ask the convenors of the Scientific Committee to give due attention to the funding of Invited Participants who could contribute to this debate. South Africa thanked the UK for its financial contribution to the workshop.

Norway noted that it supports whalewatching, has several whalewatching activities in northern Norway and sees no conflict between whalewatching and whaling. Its own experience is that they can benefit from each other. Iceland made similar remarks. Japan also believed that whalewatching and whaling can co-exist, but considered that the collection of data for scientific research from the former has limitations. It believed that whalewatching is outside the scope of the Convention. The Republic of Palau associated itself with the remarks of Norway, Iceland and Japan. The Republic of Korea noted that a recent effort to establish some whalewatching activities had failed because of conflict with fishing grounds.

The Commission noted the report of the Scientific Committee and endorsed its recommendations.

13. CO-OPERATION WITH OTHER ORGANISATIONS

13.1 Report of the Scientific Committee[21]

The Scientific Committee received reports of its co-operation with CMS (Convention on the Conservation of Migratory Species), ASCOBANS (Agreement on Small Cetaceans of the Baltic and North Seas), ACCOBAMS (Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area), ICES (International Council for the Exploration of the Sea), IATTC (Inter-American Tropical Tuna Commission); ICCAT (International Commission for the Conservation of Atlantic Tuna), CCAMLR (Convention for the Conservation of Antarctic Marine Living Resources), Southern Ocean GLOBEC, NAMMCO (North Atlantic Marine Mammal Commission), FAO - Sub-committee on Fish Trade); PICES (North Pacific Marine Science Organisation); IUCN (International Union for the Conservation of Nature) and ECCO (Eastern Caribbean Cetacean Commission).

The Scientific Committee Chair drew particular attention to the part of its report dealing with co-operation with IUCN. He noted that in response to a request from IUCN, the Committee had reviewed its list of recognised species, including a critique of the status of the new Bryde's whale species *Balaenoptera omurai*. The Committee agreed that inclusion of the species in the IWC list of recognised species would be premature at present. It recommended that the Bryde's whale complex continue to be listed under the name *B. edeni* on a provisional basis and that research to resolve the uncertainties be undertaken. In particular, the Scientific Committee recommended that the Government of India be requested to facilitate collection and genetic analysis of a bone sample from the holotype specimen of *B. edeni* in Calcutta so that the taxonomy and nomenclature can be resolved.

[21] For details of the Scientific Committee's deliberation on this Item see *J. Cetacean Res. Manage.* 7 (Suppl.).

13.2 Commission discussions and action arising

The Commission noted the report from the Scientific Committee and endorsed its recommendations. There were no other reports.

The Commission noted that the 13th Conference of the Parties to CITES would be held in Bangkok between 2 and 14 October 2004. It agreed that IWC should be represented at the meeting but left it to the Advisory Committee to decide who the representative should be.

RESOLUTION ON POSSIBLE SYNERGIES WITH THE GLOBAL ENVIRONMENT FACILITY

Mexico, who introduced this draft Resolution on behalf of the other co-sponsors (Argentina, Belize, Brazil, Chile, Nicaragua, Panama, Peru and South Africa), explained that the Global Environment Facility (GEF) is primarily a financial mechanism designed to facilitate and direct financial resources into agreed areas of international environmental concerns. It noted that many international environmental Conventions (like the Convention on Biodiversity) work directly with GEF and was sure that many IWC delegates would be familiar with the GEF and its work. Noting that the Commission has limited resources to fund scientific work and that certain priority areas for some members continue to receive little or no funding, the Resolution's sponsors believed that it would be worth exploring with the GEF possible synergies, including funding.

After interventions from Dominica, Kenya and Ireland, the operative paragraphs of the draft Resolution were amended to read:

> 'NOW THEREFORE THE COMMISSION:
>
> DIRECTS the Secretariat to establish high level contact with the Secretariat of the Global Environment Facility and to:
>
> explore possible synergies and their possible utility of the GEF to the IWC, and investigate, *inter alia*, possible avenues for the utilisation of GEF funding for IWC related projects, with specific regard to:
>
> (i) Assistance for developing countries for scientific research and policies for scientific research, as directed by the IWC.
>
> (ii) The utility in joint projects seeking funding with other international organisations, such as, *inter alia*, the Convention on Biological Diversity, the Convention on Migratory Species, the World Heritage Convention, and the Ramsar Convention on Wetlands,
>
> (iii) An examination of the modalities that the GEF seeks to satisfy and whether IWC projects, now or in the future, could be made to fit such objectives.
>
> The Secretariat shall report back to the 57th IWC meeting on these matters.'

Switzerland pointed out that GEF's organisational structure identifies a GEF representative in each country, known as a focal point. It believed that if a country has a particular project for which they seek funding, it should approach GEF through the appropriate focal point. It indicated that it would abstain if the draft Resolution was put to a vote.

Norway sought clarification on the type of projects that might be undertaken in the proposed co-operation with GEF. Mexico stressed that for the moment the sponsors simply wished to begin to explore possibilities, but that from its own perspective, it would be interested in projects on issues such as bycatch and whalewatching. South Africa gave the example of aerial surveys of right whale populations. Norway suggested that perhaps the draft Resolution would best be discussed under agenda Item 15 on the Conservation Committee. The Republic of Korea questioned whether a Resolution is needed if all that is intended at this stage is for the Secretariat to contact GEF and explore possibilities. Japan found the proposal relating to joint projects unclear and believed that they probably would refer to areas that Japan did not consider of high priority for the Commission. It did not see any need to explore co-operation with GEF. Australia found the intention of the draft Resolution clear (i.e. to explore possible synergies) and considered that the developing countries sponsoring it deserved the Commission's support.

Responding to Norway, the Chair indicated that he did not think that it would be appropriate to refer this matter to discussions associated with the Conservation Committee given that that Committee is still in its early stages. The sponsors agreed. On being put to a vote the Resolution was adopted (Resolution 2004-5, Annex C), there being 30 votes in support, 8 against and 14 abstentions.

14. OTHER SCIENTIFIC COMMITTEE ACTIVITIES, ITS FUTURE WORK PLAN AND ADOPTION OF THE SCIENTIFIC COMMITTEE REPORT

14.1 Small cetaceans

14.1.1 Report of the Scientific Committee

Despite disagreement within the Commission over the management responsibilities of the IWC with respect to small cetaceans, it has been agreed that the Scientific Committee can study and provide advice on them. As part of this programme, the Committee has reviewed the biology and status of a number of species and carried out major reviews of significant directed and incidental catches of small cetaceans.

In 2001, the Government of Japan had indicated that it would no longer co-operate with the Committee on small cetacean related matters. In 2002, the Committee referred to the great value of the information provided by the Government of Japan on the status of small cetaceans in previous years and respectfully requested that the Government of Japan reconsider its position on this matter and resume the valuable contribution of Japanese scientists to its work on small cetaceans. Unfortunately, this has not yet happened.

This year, the primary topic considered was the franciscana. The franciscana is found along the Atlantic coasts of Brazil, Uruguay and Argentina, from approximately 18º to 42ºS. The Committee reviewed available information on stock structure, abundance, life history, ecology, incidental catches and status. It made a number of research recommendations given the paucity of information for some areas. Bycatch in gillnet fisheries occurs throughout the range of the franciscana. The Committee expressed its concern that in some areas, annual removal rates due to bycatch were between about 1.6 and 3.3% exceeding the 1% removal level determined by the Committee as sufficient to warrant concern regarding the status of small cetaceans.

The Committee referred to its endorsement of the concept of a series of regional Workshops with the general objectives of developing a short- and long-term approach to the successful management and mitigation of the cetacean bycatch problems in a region, building upon work already undertaken by the Committee (see section on Regional Workshops).

The Committee also reviewed progress on previous recommendations it had made, particularly those concerning the critically endangered baiji (*Lipotes vexillifer*) and vaquita (*Phocoena sinus*). The Committee received some information from China and welcomed the initiatives being taken, although it noted that the prospects for the baiji remain extremely poor.

The Committee has followed with considerable interest progress on conservation of the highly endangered vaquita; several members of the Committee also serve on the International Committee for the Recovery of the Vaquita (CIRVA). This year the Committee reviewed the report of the third meeting of CIRVA. The Committee reiterated its endorsement of the fundamental conclusions drawn by CIRVA - that the current grave conservation status of this species is due to fisheries bycatch. The Committee noted at least six records of bycatch in the past seven months and, in general, was disheartened by the lack of any substantial progress in reducing bycatches since last year's meeting. Therefore, the Committee urged the Government of Mexico to implement the previous recommendations of CIRVA and to take immediate action to eliminate the bycatch of this species in the northern Gulf of California.

The Committee has had considerable involvement in the assessment of the harbour porpoise (*Phocoena phocoena*) in the North Atlantic and has worked closely with ASCOBANS in the formulation of conservation programmes. This year the Committee reviewed and endorsed plans for the project *Small Cetaceans of the European Atlantic and North Sea*, or SCANS-II, which has three primary objectives: to update estimates of abundance from the original SCANS survey area and to obtain estimates for previously unsurveyed areas; to develop a management framework for assessing the impact of bycatches and setting safe bycatch limits; and to develop methods for monitoring small cetacean populations during periods between major decadal surveys.

The Committee also reiterated previous advice concerning the need to minimise or eliminate anthropogenic direct removals or threats to habitat of the Irrawaddy dolphin and the Ganges river dolphin.

In the light of new evidence, the Committee repeated its concern over the catches and quotas for some stocks of white whales and narwhals, particularly in Greenland, east Hudson Bay and the Russian Arctic. The Committee repeated previous requests for all Governments to submit relevant information on direct and incidental catches of small cetaceans in their national progress reports and for improved information on stock identity and abundance.

14.1.2 Commission discussions and action arising

Switzerland noted that the Scientific Committee had reinforced the recommendations it made last year concerning narwhals and white whales and informed the Commission that the CITES Animals Committee has subjected narwhals to significant trade review. Switzerland also explained that the CITES proposal on Irrawaddy dolphins deals with international trade and not bycatch or direct removals for national use. Germany, the UK and Sweden associated themselves with Switzerland's remarks. With respect to Irrawaddy dolphins, the UK drew attention to the Scientific Committee recommendation that all direct removals should cease until affected populations have been assessed to which it attached considerable importance. The UK further noted that the Scientific Committee has reviewed some but not all of the actions from past Resolutions on small cetaceans, and that the table of estimates of abundance and catches is incomplete. It was particularly concerned regarding the absence of information on directed takes of Dall's porpoise noting that the Scientific Committee in the past has indicated that takes were unsustainable. Australia associated itself with the UK's remarks on Dall's porpoise but particularly wished to highlight the Committee's concerns regarding the West Greenland stock of whale whales and narwhals. It believed that the Commission should also express serious concern given the statement that continued hunting at recent levels 'may result in the extinction of West Greenland narwhals in the near future'. New Zealand and Finland associated themselves with the remarks of Switzerland, the UK and Australia.

With respect to the recommendations on the West Greenland narwhal, Denmark referred to its well-known position that small cetaceans are outside the competence of the IWC.

The Commission noted the Scientific Committee report and endorsed its recommendations.

14.2 Other activities

14.2.1 Report of the Scientific Committee

STOCK IDENTITY

Of general concern to the assessment of any cetaceans is the question of stock identity. Examination of this concept in the context of management plays an important role in much of the Committee's work, whether in the context of the RMP, AWMP or general conservation and management. In recognition of this, the Committee has established a Working Group to review theoretical and practical aspects of the stock concept in a management context. The Committee has noted that it is important in any application of stock structure methods, to examine the sensitivity of conclusions to different *a priori* decisions about the definition of initial units, to ascertain which population structure hypotheses to examine.

A specialist Workshop to examine the use of simulation testing to assess the performance of methods to identify population structure was held in January 2003 and discussed at the annual meeting later that year. The Workshop developed a suitable simulation framework to allow evaluation of genetic methods used in inferring population structure both in general terms (the issue is of great relevance to conservation and management outside the IWC) and from a specifically IWC viewpoint (particularly in an RMP/AWMP context).

It was recognised that such a complex project must proceed in an iterative fashion and the Workshop concentrated on specifying the various modular tasks needed for Phase I of the process (*c.f. Initial Exploration Trials* in the AWMP process), for which some results might be expected within a year, while also identifying the types of scenarios that would need to be covered in Phase II and beyond. The Workshop report was published in *J. Cetacean Res. Manage.* 6(Suppl.). This year the Committee reviewed progress under Phase I of the TOSSM project (Testing Of Spatial Structure Models). It was pleased to see that great progress had been made on the most challenging module, i.e. the development and validation of a program to simulate realistic genetic datasets. Preliminary testing of various methods under certain simple scenarios will begin during the intersessional period.

DNA TESTING

This item is discussed in response to Commission Resolution 1999-8[22]. The Committee considered a report on the public sequence archive GenBank (National Center for Biotechnology Information, *http://www.ncbi.nlm.gov/*). The Committee recommended that members be urged to deposit sequences to be used in a published report in GenBank and include the GenBank accession numbers in publications, whether or not this is required by the journal (the Guide for Authors for the *Journal of Cetacean Research and Management* will be modified accordingly). It further recommended that similar practices be established for public archiving of non-sequence genetic data, such as microsatellite loci, primers, alleles, and profiles, where feasible. Such data are not presently accepted by GenBank, and some research may be necessary to identify a suitable archive. One potential provisional venue is the websites maintained by most major journals for supplementary data and information accompanying published papers.

The Committee welcomed the information on the status of the Norwegian minke whale DNA-register covering the years 1997-2002. It was noted that progress has been made toward achieving a fully diagnostic register; no samples were missing for the 625 whales landed in 2002. The number of missing samples in earlier years ranged from 3 to 11. No samples were reported from stranded whales.

No information on collection and archiving of samples in Japan was available to the Committee. It was noted that provision of a progress report on collection and archiving of samples would assist the Committee in meeting its terms of reference as assigned by the Commission.

PUBLICATIONS

The year 2004 was another productive year with respect to the IWC's scientific publications.

The IWC website now includes a downloadable file containing well over 6,500 references to documents that have been presented to the Committee since 1969. The file lists all of the documents by meeting and includes information on whether and where they have been published. The Committee reiterated the importance of Committee members urging their respective institutes and colleagues to subscribe to the *Journal* and to submit high quality papers to it. The success of the *Journal* will be greatly increased as it becomes established in more institutional libraries.

The Committee stressed the vital contribution the *Journal* makes to the work of the Committee and to the wider issues of the management and conservation of whales.

14.2.2 Commission discussions and action arising

Referring to the Scientific Committee report on (1) progress with the collection and archiving of samples from catches and bycatches and (2) reference databases and standards for a diagnostic register of DNA profiles, Sweden noted that while a report had been received from Norway, no reference was made to information from Japan. It asked whether there was an explanation for this omission. The Scientific Committee Chair noted that a request to Japan for information had been made but that nothing had been received.

[22] *Ann. Rep. Int. Whaling Comm.* 1999: 55.

14.3 Scientific Committee future work plan

14.3.1 Report of the Scientific Committee

The Chair of the Scientific Committee described the work plan drawn up by the Convenors, with the agreement of the Scientific Committee, after the close of the meeting. The work plan takes account of:

(1) priority items agreed by the Committee last year and endorsed by the Commission and, within them the highest priority items agreed by the Committee on the basis of Sub-committee discussions;
(2) general plenary discussions on this item and in particular the need to reduce the Committee's workload; and
(3) budget discussions in the full Committee.

14.3.1.1 RMP

As last year, this Sub-committee will concentrate on general issues as well as preparations for *Implementation*. The priority topics will be in priority order:

General issues

(1) finalise the guidelines and requirements for implementing the RMP;
  (a) develop the thresholds for defining 'acceptable', and 'borderline' performance for classifying the performance of RMP variants for *Implementation Simulation Trials*.
  (b) develop a list of agreed stock structure archetypes (in conjunction with SD, as necessary);
(2) further develop the 'simple model filter';
(3) finalise the issue of spatio-temporal considerations; and
(4) finalise the issue of the CATCHLIMIT program for running it in a trials situation.

Implementation process

(1) conduct an intersessional workshop to allow the Committee to be in a position to complete the *pre-implementation assessment* for western North Pacific Bryde's whales; and
(2) review progress on the development of stock structure hypotheses as part of the *pre-implementation assessment* for North Atlantic fin whales.

14.3.1.2 AWMP

The priority topics for this Sub-committee are:

(1) Greenland *SLA* development:
  (a) the 2004 aerial survey;
  (b) genetics simulation studies; and
  (c) *SLA* exploration and development;
(2) undertake annual review of catch data and management advice for minke and fin whales off Greenland;
(3) undertake annual review of catch data and management advice for humpback whales off St. Vincent and The Grenadines; and
(4) initiate planning for a bowhead whale *Implementation Review*.

14.3.1.3 BOWHEAD, RIGHT AND GRAY WHALES (BRG)

Given the workload of BRG anticipated during the 2005 meeting, a priority item was agreed concerning southern right whales (see below). The Sub-committee will therefore:

(1) review any new information on bowhead whale stock identity;
(2) undertake annual review of catch data and management advice for ENP gray whales;
(3) undertake annual review of catch data and management advice for BCB bowhead whales;
(4) participate in a joint symposium on the effects of high latitude (Arctic and Antarctic) sea ice on cetaceans;
(5) undertake annual review of the status of the western North Pacific stock of gray whales;
(6) undertake a review of new information on southern right whales; and
(7) if there is time: review new information on small stocks of bowhead and northern right whales.

14.3.1.4 IN-DEPTH ASSESSMENT (IA)

The topics of this Sub-committee, in order of priority, will be:

(1) estimate abundance of Antarctic minke whales;
(2) participate in a joint symposium on the effects of high latitude (Arctic and Antarctic) sea ice on cetaceans;
(3) review workshop report on SOWER cruise plans beyond 2004/05;
(4) begin work on an in-depth assessment of western North Pacific common minke whales, with a focus on J stock, assuming the availability of an abundance estimate for this stock;
(5) continue to examine reasons for differences between minke abundance estimates from CPII and CPIII; and
(6) brief review of report from an anticipated non-IWC sponsored workshop on sperm whales.

14.3.1.5 BYCATCHES AND OTHER ANTHROPOGENIC REMOVALS (BC)

This Sub-committee will, as its highest priority:

(1) further review methods to estimate bycatch based on fisheries data and observer programmes;
(2) further review methods to estimate bycatch based on genetic data, especially results from the workshop; and
(3) empirical analysis of the functional relationship of bycatch levels to fishing effort and to population abundance.

It is intended that the following topics will be priority items in 2006 given work expected to be completed by 2006 by other Sub-committees; thus in 2005 if there is time it may also briefly consider:

(4) information and methods on estimates of cetacean mortality caused by vessel strikes; and
(5) information and methods on estimates of cetacean mortality caused by other human activities.

14.3.1.6 SOUTHERN HEMISPHERE WHALES OTHER THAN ANTARCTIC MINKE WHALES (SH)

Priority items in order will be:

(1) complete in-depth assessment of Southern Hemisphere humpback whales with a focus on the C, D and E stocks:
  (a) investigate the distribution and allocation of historic catches to
    (i) proposed sub-areas of breeding grounds and
    (ii) from Antarctic Peninsula to Stocks A and G;
  (b) update the tables summarising the present state of knowledge and work required to continue a

Comprehensive Assessment of SH humpback whales;
(c) further investigation and clarification of proposed sub-areas for stocks on the breeding grounds; and

(2) preparation for assessment of blue whales in 2006.

14.3.1.7 ENVIRONMENTAL CONCERNS (E)

Priority items will be:

(1) sea ice and whale habitat: a joint special session with IA and BRG;
(2) review of the report of the Habitat Degradation Workshop.

It will also receive progress reports on:

(3) POLLUTION 2000+: finalise Phase 1 and prepare for Phase 2;
(4) Southern Ocean collaboration: planning and coordination of IWC participation and report back;
(5) SOCER: review of Arctic and Antarctic cetacean issues;
(6) Arctic issues: report on potential for future collaboration;
(7) issues related to impacts of anthropogenic noise on cetaceans; and
(8) issues related to habitat concerns.

14.3.1.8 STOCK DEFINITION (SD)

The priority items will be:

(1) review progress on the TOSSM project;
(2) continue review of statistical and genetic issues related to population structure (including DNA quality issues);
(3) possible definitions of unit-to-conserve and the implications for management;
(4) progress on use of tagging data in studying population structure; and
(5) review list of stock structure archetypes provided by RMP.

14.3.1.9 WHALEWATCHING (WW)

The two major priority items will be:

(1) assessing the possible population level impacts of whalewatching on whales;
(2) development of the scientific foundation of whalewatching guidelines.

In addition, the following lesser priority items in order will be:

(3) review of published whalewatching guidelines and regulations;
(4) reports of the Intersessional Working Groups;
(5) review of risks to cetaceans from whalewatching vessels (high-speed and others); and
(6) review of potential impacts of swim-with programmes.

14.3.1.10 SMALL CETACEANS (SM)

The Committee agreed that the priority items will be:

(1) review of status of the finless porpoise;
(2) review progress on previous recommendations; and
(3) review incidental catches and takes of small cetaceans by country.

14.3.1.11 SCIENTIFIC PERMITS (P)

The priority items will be:

(1) review research results from existing permits (including plans for a major review of the JARPA programme); and
(2) review plans for new and continuing permit proposals.

14.3.1.12 DNA

The priority items will be:

(1) review genetic methods for species, stock and individual identification;
(2) collect and archive tissue samples from catches and bycatch; and
(3) reference databases and standards for diagnostic DNA registries.

14.3.2 Commission discussions and action arising

The Republic of Korea welcomed the Scientific Committee proposal to look at the status of finless porpoise at next year's meeting. While it noted that its position is that management of small cetaceans is outside the competence of IWC, it would nevertheless ask its scientists to contribute to this review.

Japan believed that too much of the Scientific Committee's time is spent on items that Japan believes are lower priority and outside the mandate of the Commission (e.g. whalewatching, small cetaceans, environmental concerns), detracting from more important items such as in-depth assessments, work on the RMP, etc. It requested that if these lower priority items continue to be included on the Scientific Committee's agenda, that the Committee Chair and Vice-Chair prioritise the time allocated to different items. Japan noted that it shares the concern expressed by the Scientific Committee that the RMP is becoming unworkable, particularly in view of the outcome of the RMP *Implementation* for North Pacific minke whales. It believed that a significant part of the problem is due to the unnecessarily high tuning level used in the RMP and the fact that the RMP is generic rather than species or case specific. Japan considered that the Commission should give high priority to discussing these issues together with developing a management procedure that included ecosystem considerations. Finally it believed that the Scientific Committee should take a consistent approach to how it deals with uncertainty, e.g. in the RMP and in the AWMP and in determining stock structure. From this intervention, Australia understood Japan to be expressing a fundamental problem with the generic nature of the RMP and noted that this view is of concern.

Germany drew attention to the work on bycatch and in particular to the Committee's recommendation for a workshop on the use of market sampling to estimate bycatch. It considered it important that steps are taken to develop both short- and long-term approaches to solving or at least mitigating the cetacean bycatch problem. It believed that this should be done through regional workshops under the auspices of IWC in co-operation with regional organisations like ASCOBANS and ACCOBAMS. Sweden, Australia, Italy, New Zealand, Spain and Finland associated themselves with these remarks. Germany also informed the Commission that the European Union had recently adopted a regulation with measures to minimise cetacean bycatch through:

(1) a ban on drift nets;
(2) an obligation to use pingers in the gill net fishery; and
(3) an obligation to have scientific observers on pelagic trawlers.

PROPOSAL TO REALLOCATE FUNDING

On behalf of the 23 co-sponsors[23], Grenada introduced a proposal to redistribute the funding allocated to the proposed workshop on the use of market sampling to estimate bycatch across a number of other Scientific Committee activities that the proposers considered to be of higher priority but which were not fully-funded in the F&A Committee recommendations (i.e. the international workshop on North Pacific Byrde's whales, the AWMP developers fund, the estimation of abundance of Antarctic minke whales and SOWER 2004/05). Grenada explained that the proposal's sponsors had serious concerns over the utility of using market sampling to provide a better estimate of bycatch than can be gained from onboard observer programmes and by monitoring animals taken in set nets and traps that enter the market. They believed that the precision of the DNA mark/recapture method is quite low, meaning that it could not be used to account for total catches over time for purposes of the RMP. Furthermore, these countries considered that the market-based genetic methodology cannot be used in any case for estimating bycatch in countries where bycaught animals do not enter the market, even though these represent the majority of countries who have fisheries that are likely to take whales as bycatch. The proposers believed that the bycatch workshop could be put off without ill effect, while the other high priority items deserve to be completed as expeditiously as possible.

Austria, Australia, the UK and New Zealand spoke against this proposal, noting in particular that the Scientific Committee's recommendation for the bycatch workshop had already been discussed on two earlier occasions (in the F&A Committee and see section 6.1). Austria noted that should the proposal be adopted, it would feel obliged to revisit allocation across all projects, particularly those which currently have attracted no funding.

On a point of order, Sweden supported by Kenya, moved to adjourn the debate on this item. This motion was carried by a show of hands. On being put to a vote, the proposal to reallocate funding was not adopted, there being 19 votes in favour, 26 against and 2 abstentions.

14.4 Adoption of the Report

The Commission adopted the Scientific Committee report and its recommendations, including the future work plan.

15. CONSERVATION COMMITTEE

The meeting of the Conservation Committee took place on the afternoon of Wednesday 14 July and the morning of Thursday 15 July 2004. It was chaired by Horst Kleinschmidt (South Africa and Vice-Chair of the Commission). Delegates from 26 Contracting Governments participated. A summary of the Committee's discussions is included below. The full Sub-committee report is available as Annex H.

[23] Antigua and Barbuda, Belize, Benin, Dominica, Gabon, Republic of Guinea, Japan, Republic of Korea, Mauritania, Mongolia, Morocco, Nicaragua, Norway, Republic of Palau, Panama, St. Kitts and Nevis, St. Lucia, St. Vincent and The Grenadines, Senegal, Solomon Islands, Suriname, Tuvalu.

15.1 Report of the Conservation Committee

15.1.1 General discussion

As this was the inaugural meeting of the Conservation Committee, the Chair had invited members to address general issues relating to the establishment and purpose of the new Committee before turning to specific agenda items. There was consensus that all members of the IWC should be and were committed to conservation, and that the new Committee should not supervise or duplicate the work of any other bodies of the Commission. However, a range of views were expressed about the appropriateness or otherwise of the steps taken to establish the Conservation Committee and it was agreed that efforts since IWC/55 to improve the level of communication between members in disagreement were important.

Many of the co-sponsors of Resolution 2003-1, by which the Committee was established, stated that the new body should be viewed as pro-conservation, not anti-whaling. These members recognised that the Convention provides for both conservation and management of whale stocks, and believed that the establishment of the Conservation Committee did not prevent the fulfilment of either of these objectives. The conservation of whale stocks was in the common interest.

These members held the view that the establishment of the Committee would not alter or in any way impinge upon the attributions or work of any of the Commission's active bodies, nor would it change any of the functions or terms of reference of such bodies, or of the Commission itself. Rather, the primary objective in setting up the Conservation Committee in their view was to rationalise the Commission's work on that part of its agenda that deals with conservation issues, as well as to institutionalise and better distribute the Commission's workload. They emphasised that the Conservation Committee would not have any supervisory function over the work of the Scientific Committee, which has its agenda and terms of reference clearly established by the Commission.

Those who had supported the establishment of the Committee looked forward to the Committee improving the way the IWC met its responsibility for managing whales by addressing issues not only from the perspective of whaling. To date, conservation issues had been typically addressed late in the plenary, and the Committee would allow such issues to be discussed in detail several days before the plenary. The Committee could provide advice and guidelines on conservation-related functions that were currently dispersed, and serve as a central node to identify and prioritise topics. This might prevent overload on other bodies of the Commission.

Other members, who had opposed Resolution 2003-1, indicated that they still had reservations about the establishment of the Committee, especially because in their view it took the objective of the 'conservation of whale stocks' out of the context of the objective of making possible 'the orderly development of the whaling industry'. They were committed to the sustainable use of natural resources, and viewed completion of a Revised Management Scheme to prevent over-exploitation as a higher priority conservation measure than items that might be addressed under a Conservation Committee. Their participation in the first meeting should not be construed as change of position on the Resolution. These members stated that the process used at IWC/55 to create a new body made no attempt to bring the members of the IWC together:

a mechanism to address those conservation issues which are capable of attracting widespread support ought not to have been promoted in a manner which did not effectively consult nearly half of the members of the IWC. Some efforts to discuss alternative language had been rejected out of hand, which was not conducive to open and fair dealings.

Those who had opposed the establishment of the Committee noted that, even if nothing in Resolution 2003-1 defined conservation narrowly, the wording of the Resolution and its appendix of past decisions of the Commission made it clear that the initiative would alienate nearly half of the members of the IWC. Nonetheless, members present who had opposed the process had decided to attend the first meeting, expecting a change to the name of the Committee and amendment of the original Resolution, in order to reciprocate their goodwill.

The Committee discussed the question of how to define 'conservation', and particularly whether that should be construed as including 'sustainable use'. It was noted that various definitions were available, both from dictionaries (though there was no equivalent term in some languages), and in the texts and agreements of other treaties. While it was agreed that conservation was of interest to all members, and that further discussion on its definition would be worthwhile, a definitive answer was beyond the capacity of the Committee's first meeting. Some indicated that they had envisaged the Committee addressing issues that did not fit the remit of 'sustainable use', while others would welcome further discussion on this.

It was noted that many members of the Commission were absent. This could be viewed as an indication of dissatisfaction with the process by which the Committee was established. Supporters of the Committee indicated that they were engaged in a constructive dialogue with some of the absent members, in the interest of seeking broad participation, and hoped that the Committee's report might demonstrate to them the value of the Committee.

15.1.2 Relationship between the Conservation Committee and other bodies within the Commission

It was recognised that relationships between the Conservation Committee and other bodies within the Commission will be vital to the success and effectiveness of the new Committee and that relationships should be based on the principle of complementarity, not duplication.

The Committee agreed that interactions with the Scientific Committee would occur in the same way that the Scientific Committee interacts with other subsidiary bodies already established by the Commission. As with the Aboriginal Subsistence Whaling Sub-committee and the first meeting of the Conservation Committee, the Chair of the Scientific Committee would attend and provide information on scientific matters that are germane to that body's work.

Relationships with the Technical Committee were also addressed. Some members viewed the reference to 'conservation' in the Rules of Procedure that relate to the Technical Committee as evidence of potential overlap with the Conservation Committee. It was noted that Rule of Procedure M7 might need to be changed to avoid duplication of functions. The alternative view was that appropriate delegation of responsibility could ensure complementarity: the Commission could refer to the Technical Committee the development of proposed management measures that the Commission considered for adoption into the Schedule (i.e. matters pertaining to Article V), while referring to the Conservation Committee the development of the conservation agenda and related proposed recommendations (i.e. matters pertaining to Article VI).

15.1.3 Proposed Terms of Reference, working methods and funding considerations

Resolution 2003-1 contained three terms of reference for the Conservation Committee:

(1) the preparation and recommendation to the Commission of its future Conservation Agenda;
(2) the implementation of those items in the Agenda that the Commission may refer to it;
(3) making recommendations to the Commission in order to maintain and update the Conservation Agenda on a continuing basis.

Many felt that these should guide the initial work of the Committee and that additional terms should be developed if and when required. Further drafting work should proceed in an open process under the auspices of the Commission as a whole or its Chair. Others who would prefer alternative terms of reference or who had not commented were encouraged to make specific proposals.

In light of the concerns raised by those who had opposed Resolution 2003-1, a small group was formed to examine the language of the Resolution and further discuss terms of reference, outside of the Committee meeting. The group discussed concepts of conservation, ways to move forward after Resolution 2003-1, and terms of reference. It agreed to the importance of addressing conservation in the IWC and to respect different views on whaling. Furthermore the group offered for discussion a collection of possible ways forward, including different ways of defining the concept of conservation, and various alternatives, including Resolutions, that could clarify the work of the new Committee (see Annex H, Appendix 3).

The Committee agreed to hold annual meetings, in line with the practice of other committees and working groups. The Conservation Committee would not normally 'meet' intersessionally, other than by e-mail correspondence when necessary.

Paragraph 8 of Resolution 2003-1 charged the Committee with beginning to explore the possibility of a trust fund to make resources available both to the Commission and to Contracting Governments to implement research related to the Conservation Agenda. Discussion indicated it was premature to discuss this in detail and that in any case it would be up to the Commission to decide whether to establish such a fund.

15.1.4 Consideration of items to fall under the auspices of the Conservation Committee

The Committee recognised the value of establishing a list of items to address as part of the 'extensive conservation agenda' mentioned in its founding Resolution. The following were proposed as initial items of common interest: endangered species and populations; human impacts (e.g. noise, vessel strike, bycatch, entanglements, strandings); habitat protection for cetacean conservation; whalewatching best practice guidelines; reporting systems for strandings, entanglements and bycatch; legal and regulatory arrangements for cetacean conservation.

Some countries argued that the list is too general and too extensive. These countries argued that conservation issues are very important, but only for a small number of species and stocks of large whales. Many species and stocks of large whales are either quite numerous or rapidly growing, and for these, in their opinion, the items on the list above are not important for conservation.

Of the conservation-related items currently addressed by the Scientific Committee, the following were identified as most germane to the work of the Conservation Committee: highly endangered species and populations; scientific research related to development of techniques for improved assessment of status and mitigation measures to potential threats where identified; incidental takes of cetaceans including assessment of problems at the population level and development and evaluation of mitigation measures; non-consumptive utilisation of cetaceans; whales and their environment, with an emphasis on population level effects and interaction with interpreting abundance estimates; sanctuaries, in particular their value to the monitoring and recovery of depleted populations; scientific advice relevant to enforcement and compliance with conservation measures; collaboration with other organisations; voluntary submission of national reports on cetacean conservation.

15.1.5 Collaboration with other organisations

Through Resolution 2003-1, the Conservation Committee was directed 'to explore how the Commission can co-ordinate its conservation agenda through greater collaboration with a wider range of other organisations and conventions'. It was noted that the Committee could centralise collaboration, maintain an overview of those who serve as ambassadors for the IWC, and identify opportunities for new and improved collaborations. The Memorandum of Understanding between CMS and IWC was noted and a member of the CMS Secretariat indicated that CMS looks forward to continuing to work closely with IWC.

15.1.6 Development of a Conservation Agenda

The Committee viewed its discussion of terms of reference, relationships with other bodies, and items to fall under its auspices as the first steps towards the development of a conservation agenda. Some delegations considered it premature to enter into substantive discussions until a conclusion has been reached regarding the nature of the Conservation Committee. Other delegations disagreed with this and felt it was appropriate to start substantive discussions at this time.

15.2 Commission discussions and action arising

Austria, The Netherlands, Sweden, France, Australia, Mexico, Germany, New Zealand, the USA, Peru, Spain, the UK, Monaco, Oman and Finland all welcomed the report from the Conservation Committee, indicated their continued support for the Committee and looked forward to further intersessional work. Many congratulated the Chair on his preparation and management of the meeting and many stressed the need for wider participation from IWC members. Austria expressed the hope that constructive work could be done to save some of the most endangered species. The Netherlands drew attention to the report from the small group established within the Conservation Committee (see Appendix C, Annex H) and suggested that the Commission endorse the proposed way forward, i.e. that further discussions on the expectations of the work of the Conservation Committee should be continued under the responsibility of the IWC or its Chair to ensure that all views will be taken into account. Sweden was of the opinion that the Conservation Committee should start work on substantive matters at IWC/57 next year and indicated that it would work with others to ensure that concrete work does take place.

Iceland welcomed the apparent new-found willingness to discuss the nature of the Conservation Committee and expressed the hope that the preparatory work that should have been done last year to engage all members of the Commission would now be done. It believed this is necessary before the Committee enters into any substantive discussions.

Japan drew attention to the controversy surrounding the establishment of the Conservation Committee at the meeting in Berlin last year[24] and continued to be against it. Along with many other Commission members, Japan believed that the current objectives of the Conservation Committee are not in line with the dual objectives of the Convention, i.e. the conservation and management of whale resources. It further noted that it will not attend any meetings of the Committee unless its name and objectives are changed to include sustainable use of whale stocks. Dominica reaffirmed its position of last year and reserved its rights not to participate in the work of the Conservation Committee.

The Commission adopted the report of the Conservation Committee noting the reservations of Japan and Dominica.

16. CATCHES BY NON-MEMBER NATIONS

There were no contributions or discussion under this item.

17. FUTURE SUSTAINABLE WHALING

This new item had been included on the agenda at the request of Japan.

17.1 Introduction by Japan

Japan introduced, using a PowerPoint presentation, a document entitled '*The centennial of Antarctic whaling – from the history of over-harvesting to the creation of new sustainable whaling*'. The paper addressed:

(1) lessons from the past as a guide to the future;
(2) the status of Antarctic whaling;
(3) an overview of Antarctic whaling from 1904 to 2004;
(4) Japanese whaling in the Antarctic – its characteristics as compared to the whaling by other nationals – including sections on the importance of whale meat in Japanese Antarctic whaling (which compared how Norway, the UK, the USSR, the Netherlands and Japan used whale products, i.e. for oil, animal food, human consumption and other), and continuity of Japan's whaling culture from its traditional whaling to Antarctic whaling;
(5) failures of the past to manage large whales in the Antarctic – a meaningful lesson to make whaling successful in future;
(6) how international legal instruments prescribe the need for full utilisation of whales; and
(7) some aspects of future whaling.

Japan gave the following as the main points regarding how whaling should be conducted in the future.

[24] *Ann. Rep. Int. Whaling Comm.* 2003: 7-10.

(1) Setting of the catch limits with which the sustainability and the optimum utilisation of whale stocks are to be achieved is critical. The RMP must be structured to meet the original objectives. It is a management tool that is intended to achieve three objectives:
   (a) assurance to maintain the whale population at a safe level;
   (b) long term sustainability of whaling;
   (c) all possible risks are to be avoided. It might be necessary to improve the RMP to enhance these three factors in order to achieve optimum utilisation of whale resources.

   Further, research effort needs be strengthened with a view to implementing multi-species management, through which all the components of marine ecosystem, including large whale stocks, can be rationally used in a well-balanced manner.
(2) Scientific research as an integral part of whaling operations: As the realisation and pursuit of sustainable whaling is dependent and based on healthy whale populations, it is imperative that reliable scientific data should be made available. With this as a basis for the new sustainable whaling in future, unbiased scientific data collection must accompany whaling operations. For the purpose of achieving the sustainability of whale stocks and whaling activities at the same time, scientific research aspects should be incorporated as a part of whaling operations even if it is more burdensome to the efficiency of commercial operations or the pursuit of maximum profit. The successful results from the JARPA demonstrate that such research activities would make a significant contribution to our understanding and monitoring of the marine ecosystem and environment. Using whale management as a core to the ecosystem approach to the management of ocean resources, the potential for optimum utilisation of whales and other marine living resources can be enhanced.
(3) A full utilisation of catches made possible by human consumption of whales as food: A prime characteristic of Japanese whaling is that whales are regarded as a valuable food resource that must be fully used, not be wasted. This characteristic has been evidenced throughout the history of whaling in Japan, from the pre-modern whaling in the Edo Era to Antarctic whaling and the current research take of whales under the JARPA. The full utilisation of whales taken and the thought that whales are gifts bestowed by heaven to sustain humans are two sides of the same coin. The fact that respect to the whales' souls has been religiously manifested in many areas and in various periods of history in Japan gives a special feature to whaling culture in Japan. In considering the future of whaling activities, it seems quite beneficial to re-evaluate these aspects of full utilisation in Japanese whaling culture as a moral bulwark against the over-harvesting of resources, such as whales. This is ethically legitimate in the Japanese culture, and should be promoted in environmentally friendly societies.
(4) International contribution: Only abundant and robust whale stocks distributed in the Antarctic Ocean including Antarctic minke whales, estimated by the Scientific Committee of the IWC at 760,000 animals, will be harvested under the operation of new sustainable whaling. Sustainable utilisation of such rich resources is open to all nations subject to their rights and obligations under international law. However, at least at present, it seems that only Japan has the will and capacity to harvest the abundant whale stocks in the Antarctic. Therefore, it is our strong suggestion that, when Japan will commence this new whaling in the Antarctic Ocean, Japan should consider voluntarily using a part of any profit from the whaling activities to benefit the world's interests. This would provide other members of international community, especially developing countries, with the opportunity to benefit from the rich whale resources in the Antarctic. We hope that other countries will participate in new sustainable whaling and thus promote the noble purpose and objective of the ICRW.

Japan expressed the hope that this renewed approach to whaling would be welcomed.

17.2 Commission discussions and action arising

Norway noted that the information presented by Japan on Norway's use of whale products (i.e. mainly for oil) was correct but that it applied only to products from whales caught in the Antarctic. During the period 1945 to 1972, Norway was not using whales caught in the Antarctic for human consumption. However this was not the case with whales caught elsewhere. Norway stressed its long tradition of using whale meat for human consumption extending back to Medieval times using minke whales and some other species along Norway's coast. This tradition continues to this day, although of course the technology for taking whales has changed.

Referring to item (4) above, Australia stressed that there is no currently agreed Scientific Committee abundance estimate for Antarctic minke whales.

Regarding Japan's request that this item be kept on the agenda and anticipating future PowerPoint presentations, the UK respectfully suggested that in view of the already crowded agenda, this item be dealt with as a side event, e.g. during a coffee or lunch break. The Chair responded that the Secretary and Advisory Committee would consider, before the next Annual Meeting, how best to handle PowerPoint presentations.

18. INFRACTIONS, 2003 SEASON

The Infractions Sub-committee met on 14 July with delegates from 30 Contracting Governments. The Sub-committee's Chair, Sung Kwon Soh (Korea), summarised the group's discussions. The full report is given in Annex I.

As in previous years, despite differences of opinion as to whether the item concerning stockpiles of whale products and trade questions is within the scope of the Convention, the Sub-committee agreed that an exchange of views was useful.

The summary of catches by IWC member nations in the 2003 and 2003/2004 seasons is available as Annex J.

18.1 Report of the Infractions Sub-committee

18.1.1 Infractions reports from Contracting Governments

Infractions reports for 2003 were received from Denmark, St. Vincent and The Grenadines, the USA, the Russian Federation and the Republic of Korea. Only the USA and the Republic of Korea reported infractions.

The USA reported two infractions in 2003, which occurred during an aboriginal subsistence hunt, when a female bowhead whale accompanied by a calf was taken. The female was landed whilst the status of the calf was unknown. The taking of cow-calf pairs is prohibited in Eskimo hunting tradition, and also under the regulations both of this Commission and of the AEWC (Alaska Eskimo Whaling Commission) Management plan. The AEWC has primary enforcement responsibility under a cooperative agreement with the Government of the USA. Following a hearing, the AEWC Commissioners concluded that the crew had not acted with proper caution and rescinded the bowhead subsistence captain's registration for two years.

The Republic of Korea reported that the Ministry of Maritime Affairs and Fisheries and the marine police of Korea had exposed five illegal catches of minke whales in 2003 and had taken judicial and administrative measures (see Annex I, Appendix 3). Four of the cases were deliberate, the catches being taken covertly with a spear by small fishing vessels. The fifth case was that of a dead whale found floating with spearheads stuck into it. The Korean authorities perceive these incidents to be a result of poachers trying to make money. The Government of Korea does not think poaching to be a major problem since all suspect poachers are listed and their movements watched by the police. The bycatch reporting system has proved useful in discriminating between illegal catches and bycatches. In addition, the authorities have continued to strengthen public awareness of poaching activities through the mass media. The Government of Korea will continue its efforts to bring an end to these illegal activities. The Republic of Korea clarified that it is not permitted to carry harpoons on fishing vessels.

18.1.2 Surveillance of whaling operations

Information submitted by the USA, the Russian Federation and St. Vincent and The Grenadines indicated that 100% of their catches were under direct national inspection. Denmark (Greenland) reported on quota monitoring.

Following questions from New Zealand and the UK concerning internal legal requirements in Denmark for collection of DNA samples and actions in the event of the samples not being provided, Denmark reported that it was mandatory to supply samples, and that it had written to all municipal authorities in Greenland to inform them of this fact.

New Zealand considered that failure to collect samples should be reported as an Infraction since Article IX of the Convention requires each Contracting Government to 'take appropriate measures to ensure the application of the provisions of this Convention and the punishment of infractions against the said provisions in operations carried out by persons or by vessels under its jurisdiction' and Paragraph 29(b) of the Schedule requires samples to be collected.

Denmark did not agree with New Zealand's interpretation, as Paragraph 29(b) refers to small type whaling and not to aboriginal subsistence whaling. Denmark will try to take appropriate measures to ensure samples are collected in the future, but it considered that missing samples are not infractions in the sense of Article IX of the Convention. In addition, it would help if the hunters knew the samples would be put to good use, as at present many samples seem to be stored in freezers but not analysed. The Department of Fishing and Hunting will continue its efforts to collect samples.

New Zealand reiterated its opinion that collection of samples is obligatory under Para 29(b) of the Schedule and that failure to do so is an offence that should be reported as an infraction, particularly in view of the definition of 'small type whaling' in the Schedule and the strong language used by the Scientific Committee to express its concerns on this matter.

Following a suggestion from the Chair, New Zealand and Denmark agreed to discuss this matter further on a bilateral basis.

The UK noted that a bowhead whale was reported to have been killed in Greenland on 25 April 2004[25].

Australia expressed concern that since a new law had been enacted by Japan in 2001 allowing whales caught in nets to be killed, that the numbers of bycatch in Japan had increased dramatically, from 29 in 2000 to 79 in 2001, 109 in 2002 and to 125 in 2003. They cautioned that this could be considered an active hunt. Japan considered the question was not relevant to the Infractions Sub-committee. Rather, the Scientific Committee is the right forum for such discussions and Japan had provided information on bycatch to that Committee. It would respond directly to Australia on this issue if asked.

The UK noted that other countries e.g. Iceland and Korea also have significant levels of bycatch. It recognised that some other countries have a different opinion as to whether bycatch should be regarded as an infraction. However, the UK believed that everyone should agree that numbers of bycaught whales should be taken off any quota and, since the quota was zero, bycatch constituted an infraction.

18.1.3 Checklist of information required or requested under section VI of the Schedule

The following information was provided:

Denmark: Information on date, position, species, length and sex is collected for between 83-100% of the catch, depending on the item. Other biological data and information on killing methods and struck and lost animals are also collected.

USA: Information on date, species, position, length, sex, whether a foetus is present, killing method and numbers struck and lost is collected for between 97-100% of the catch depending on the item. Biological samples are collected for about 50% of animals.

Russian Federation: Information on date, species, position, length, sex, whether a foetus is present, killing method and numbers struck and lost is collected for 100% of the catch.

St. Vincent and The Grenadines: Information on date, species, position, length, sex, killing method and numbers struck and lost is collected for 100% of the catch.

Norway: the required information has been submitted to the Secretariat as noted in the Scientific Committee report[26].

[25] Denmark responded to a first question, which related to 2003, and said that no bowhead had been killed in 2003. It did not respond to the question of 2004 during the meeting, but subsequently reported that a bowhead whale had been seen in fishing nets in 2004 but that it had not been killed.
[26] *J. Cetacean Res. Manage.* 7 (Suppl.).

18.1.4 Submission of national laws and regulations
A summary of national legislation supplied to the Commission was prepared by the Secretariat. The UK and the USA applauded St. Vincent and The Grenadines for adopting domestic legislation that governs the aboriginal take of humpback whales. Australia expressed similar sentiments and enquired whether the regulations met the requirements of Schedule Para 13b(4). The Secretariat believed that they do and noted that the regulations were available if Australia wished to confirm this.

18.1.5 Other matters
The Secretariat had received no reports from Contracting Governments on availability, sources and trade in whale products and no comments were made during the meeting.

The UK referred to six northern bottlenose whales killed in the Faroe Islands in 2002 and noted that the Scientific Committee had expressed concern over the status of this stock in the 1970s. The UK asked a series of questions requesting details of the incidents. It noted that this species is included in Schedule Table 3 with a zero catch limit, and believed that the killing of these whales constituted an infraction.

Denmark responded that six whales had died as a result of stranding and that such events were not infractions. Denmark has provided information on similar events on a bilateral basis on many occasions in the past and would be happy to do so again.

The UK repeated that, because the species is in the Schedule, the reasons for the kills need to be documented.

Australia notified the Sub-committee of an alleged incident that occurred in 2004 in which a whale of unknown species was caught by an Australian fishing vessel, and the vessel returned to port with whale meat on board. The allegation has been referred to the Australian Federal Police for investigation. Australia will inform the IWC of the outcome of this matter once further details are available

18.2 Commission discussions and action arising
The UK noted that in the Sub-committee it had raised the issue of the killing of six Northern bottlenose dolphins in the Faroe Islands and asked for details of these incidents. It had been informed by the representative of the Faroese government that (a) the matter was no concern to the UK and (b) that the whales had stranded. The UK expressed concern with this response since it had heard from another source in the Faroes that stranded animals are normally successfully and relatively easily returned to the sea. It questioned why this had not been done in this case and why the kills were authorised. Germany associated itself with these remarks. Denmark did not respond. Japan considered the matter to be outside the competence of IWC. New Zealand disagreed.

The Commission took note of and adopted the Sub-committee's report.

19. LEGAL ADVICE IN RELATION TO THE IWC

19.1 Proposal regarding legal advice in relation to the IWC
As a first step in exploring how legal advice should be sought in the future, last year the Commission agreed that the Secretariat should investigate how other Conventions deal with legal issues and the sort of legal issues they have faced. This paper was provided as background information.

In addition, the Netherlands (who had first brought this matter to the attention of the Commission at the 5th Special Meeting of the Commission in October 2002[27]) introduced a paper that set out options on how to address future legal issues that may arise within IWC. It had prepared the paper to help to maintain momentum on this issue and to facilitate discussions. The options included:

(1) appointment of a legal officer;
(2) establishment of a legal committee;
(3) putting together a roster of legal experts;
(4) recourse to external legal advice on an ad hoc basis; and
(5) access to existing international judicial institutions.

The Netherlands noted that the options were not mutually exclusive and that an optimal legal function may require the selection of a mix of options. The paper did not include options for the settlement of disputes that may arise between Parties to the Convention or in connection with compliance with the Convention by Parties.

The Netherlands invited comments on the proposed options and the formulation of alternatives with the aim of the Commission taking an informed decision that would assist future deliberations. However, recognising that time remaining at this 56th Annual Meeting was short, the Netherlands proposed that its paper be referred to the F&A Committee at its meeting next year. The Netherlands remained convinced that establishing a mechanism for dealing with legal issues would help to depolarise and depoliticise debate and contribute to confidence building among countries.

19.2 Commission discussions and action arising
New Zealand welcomed the papers from the Secretariat and the Netherlands which reflected careful research and thought. New Zealand re-iterated its view that the 1946 Convention is deficient in its legal mechanisms and that legal issues would continue to cause difficulties with the work of the Commission. Its preferred approach in resolving the situation would be through a diplomatic conference that would have the goal of bringing the Convention's legal instrument up to date through the adoption of a Protocol covering a range of matters as raised under item 6.2 on the RMS. It accepted that consensus on such an approach would be illusive at present, and in the mean time noted the sovereign right of member states to determine their views on legal issues. That being said, New Zealand took the view, and would support, the Commission seeking legal advice, although the source of such advice would have to be carefully determined. Australia associated itself with these remarks.

Noting that FAO has a fairly substantial legal section, India suggested that early consultation with them may be helpful. Sweden, the USA, Argentina, Antigua and Barbuda also welcomed the paper from the Netherlands and supported the proposal to explore the matter further in the F&A Committee. Sweden found the options put forward in the paper interesting and believed that Option 1, appointment of a legal officer within the Secretariat, might be a good way to proceed. Argentina and Antigua and Barbuda expressed concern about the potential costs of this option, with Antigua and Barbuda suggesting that Option 2, establishment of a legal committee might be the best

[27] *Ann. Rep. Int. Whaling Comm.* 2003: 137-148.

approach at least in the first instance. Argentina stressed that the role of any legal adviser(s) or committee should be simply to provide advice, since it is the Commission that takes decisions. In view of the discussions on the RMS, the USA suggested that the F&A Committee also consider the need and role of a parliamentarian. Norway also welcomed the papers but was of the view that unless and until a new arbitration clause is included in the Convention (through a diplomatic conference), it is the sovereign right of member states to regulate their own obligations within the Convention. It therefore saw no need to investigate the matter further at this stage.

Noting Norway's comments, the Chair proposed that the issue be referred to the F&A Committee at IWC/57 as proposed by the Netherlands. The Commission agreed.

20. ADMINISTRATIVE MATTERS

Agenda items 20-22 covering administrative and financial matters were considered first by the Finance and Administration (F&A) Committee that met on Friday 16 June 2004 under the chairmanship of Halvard Johansen (Norway). Delegates from 35 Contracting Governments attended the meeting. The F&A Committee report is attached as Annex K.

20.1 Annual Meeting arrangements and procedures

20.1.1 Need for a Technical Committee

The Technical Committee (TC) has not met since in IWC/51 in 1999. However, the F&A Committee recommended that the need for the TC be kept under review and remain on the agenda since it may have a role to play when the RMS is completed and catch limits set.

The Commission agreed.

20.1.2 Use of simultaneous translation

Through Resolution 2003-4 adopted at IWC/55, the Commission had decided to establish a Working Group to explore the implications for the provision of technical components for simultaneous interpretation and to make recommendations on how provision of technical components for simultaneous interpretation may be provided at the IWC to accommodate the needs of contracting parties for whom English is a second language. Members of the Working Group comprised Antigua and Barbuda, Benin, France, Gabon, Republic of Guinea, Japan, Senegal, Spain and the Secretariat.

The Working Group proposed the following.

- Initially facilities for three languages would be provided (French, Spanish and Japanese). Japanese was proposed since most Japanese delegates speak in their mother tongue at the meetings. French and Spanish were proposed since, out of IWC's membership as of 2 July 2004, 15 countries are French-speaking and 16 countries are Spanish-speaking. In addition, requests have been made in the past for interpretation into these languages. It was further proposed that provision for additional languages could be considered at a later date (e.g. after two years).
- Initially, to help reduce costs, the technical set-up used would be that where headsets would be provided only for those national delegations using simultaneous interpretation, but with a view to moving toward the usual set up where headsets are provided to all delegates.
- Initially simultaneous interpretation would be provided only for the Commission plenary. Provision at other meetings (i.e. Commission sub-groups and private Commissioners' meetings) could be considered at a later date (e.g. after two years). It would seem prudent, both financially and technically to have a phased approach to provision of simultaneous interpretation.
- The Commission would meet most of the costs through an increase in the budget provision for the Annual Meeting (approx. 2% initially). If costs are in excess of this, then the host government would cover additional expenses. In the case where the Annual Meeting is arranged by the Secretariat in the UK (in the absence of an offer from a Contracting Government), the Working Group proposed that any additional costs to provide simultaneous interpretation equipment be met by drawing on the Commission's reserves.

The F&A Committee welcomed the Working Group report, recognised the importance of this issue and agreed that some action should be taken to facilitate the participation of delegates for whom English is not their first language so as to put all member countries on the same footing. There was general agreement that the costs of providing the technical facilities for simultaneous interpretation should be met by the Commission, although a suggestion was made that the Commission may also wish to seek voluntary contributions to support this provision.

Some F&A Committee members supported the approach proposed by the Working Group, although the view was expressed that if possible (e.g. by restricting the number of languages for which interpretation facilities would be provided to two rather than three), it would be desirable to extend provision of simultaneous interpretation facilities to the Commissions sub-groups (not including the Scientific Committee) and to the private Commissioners' meetings. Others felt that, with the increasing membership and increasing number of languages spoken by members, it would be appropriate for the Commission to take broader steps, allocating a higher percentage of the budget so as to provide, for example (and perhaps even in time for IWC/57 in Ulsan), interpretation for a greater number of languages and the translation of documents - as is the case in some other intergovernmental organisations. A number of members, however, expressed concern regarding the proposal to include translation of documents before the implications, particularly of cost, could be properly assessed. They did not believe there was sufficient time to make this assessment during IWC/56.

After a further exchange of views, the Committee agreed to recommend the following compromise to the Commission:

(1) That the Committee acknowledges the importance of facilitating the effective participation of all Contracting Governments in the work of the Commission and that no government should be disadvantaged by language;
(2) That in the first instance, equipment facilities for the provision of simultaneous interpretation be provided for French and Spanish for the Commission's sub-groups (but not the Scientific Committee), the Commission plenary and private Commissioners' meetings. This would come into effect in time for IWC/57 in Ulsan next year.

(3) That the budget provision for the Annual Meeting would be increased by 2%, as recommended by the Working Group.
(4) That the Secretariat should work intersessionally, with a small Task Force (composition to be decided), to develop cost estimates and implications for the provision of document translation at Annual Meetings and to report to the F&A Committee at IWC/57 in Ulsan for possible decision-making.

The Commission agreed to this approach.

20.2 Amendments to the Rules of Procedure and Financial Regulations

20.2.1 Election of the Chair and Vice-Chair of the Commission

Japan had introduced to the F&A Committee the following proposals concerning Rules of Procedure F.1 and G.1:

> Amendment of Rule F. 1: that the text be amended such that the Chair may be elected from among the Commissioners and Alternate Commissioners. The specific text of this proposal is that line 1 of rule F. 1. be amended to read: ***The Chair of the Commission shall be elected from time to time from among the Commissioners and Alternate Commissioners and shall…***
>
> Amendment of Rule G. 1: that the text be amended such that the Vice-Chair may be elected from among the Commissioners and Alternate Commissioners. The specific text of this proposal is that line 1 of rule G. 1 be amended to read: ***The Vice-Chair of the Commission shall be elected from time to time from among Commissioners and Alternate Commissioners and…***

In the Committee, a number of governments indicated that while they appreciated and understood the motivation behind the proposed amendments, they considered – as pointed out when this same matter was raised at IWC/54 in Shimonoseki – that the proposal was contrary to Article III.2 of the Convention and therefore illegal.

Japan noted this position. It indicated that it did not wish to pursue the matter any further with the Committee but noted that it may raise it in the Plenary. Japan subsequently withdrew the proposal and there was no discussion in Plenary.

20.2.2 Appointment of the Chair and Vice-Chair of the Scientific Committee

At the 2002 Scientific Committee meeting, the Scientific Committee developed a proposed procedure and amendment to the Rules of Procedure for the Scientific Committee regarding the appointment of its Chair and Vice-Chair. At its meeting this year, the Scientific Committee proposed that a second paragraph be added to Rule of Procedure C.5 of the Scientific Committee Rules of Procedure as follows (proposed new text in ***bold italics***):

> **C. Organisation**
>
> 5. The Committee shall elect from its members a Chair and Vice-Chair who will normally serve for a period of three years. They shall take office at the conclusion of the annual meeting at which they are elected. The Vice-Chair shall act for the Chair in his/her absence.
>
> ***The election process shall be undertaken by the heads of national delegations who shall consult widely before nominating candidates. Under normal circumstances, the Vice-Chair will become Chair at the end of his/her term, and a new Vice-Chair will then be elected. If the election of the Chair or Vice-Chair is not by consensus, a vote shall be conducted by the Secretary and verified by the current Chair. A simple majority shall be decisive. In cases where a vote is tied, the Chair shall have the casting vote. If requested by a head of delegation, the vote shall proceed by secret ballot. In these circumstances, the results shall only be reported in terms of which nominee received the most votes, and the vote counts shall not be reported or retained.***

The Scientific Committee proposal was reviewed by the Heads of Delegation to the Scientific Committee. They reconfirmed by consensus the Committee's support for its earlier position regarding secret ballots and agreed that the proposed Rule of Procedure should be revised to indicate that it was expected that the Vice-Chair would become Chair at the end of his/her term unless he/she declined. They therefore recommended that the following amended text be put forward to the Commission via the F&A Committee for adoption (proposed new text ***bold italics***):

> The election process shall be undertaken by the heads of national delegations who shall consult widely before nominating candidates. ~~Under normal circumstances,~~ The Vice-Chair will become Chair at the end of his/her term ***(unless he/she declines)***, and a new Vice-Chair will then be elected. ***If the Vice-Chair declines to become Chair, then a new Chair must also be elected.*** If the election of the Chair or Vice-Chair is not by consensus, a vote shall be conducted by the Secretary and verified by the current Chair. A simple majority shall be decisive. In cases where a vote is tied, the Chair shall have the casting vote. If requested by a head of delegation, the vote shall proceed by secret ballot. In these circumstances, the results shall only be reported in terms of which nominee received the most votes, and the vote counts shall not be reported or retained.

The Commission adopted the proposal.

20.3 NGO participation

20.3.1 NGO participation and Rules of Procedure

In September last year, the Secretariat had been approached by a representative of one of the large environmental NGOs regarding changes that a number of NGOs would like to rules of NGO accreditation in particular but also in their level of participation in Commission affairs. The Secretariat had brought this matter to the attention of the Advisory Committee to seek advice on the best way to proceed. The Advisory Committee agreed that this issue should be brought to the attention of the F&A Committee via a paper outlining the issues raised and the potential implications of these. The focus of the paper was on NGO participation in the Commission and its sub-groups excluding the Scientific Committee. The Advisory Committee had suggested that the F&A Committee have a general discussion on the matter this year and that if changes were suggested, decisions could be taken at IWC/57 next year, as appropriate

The Advisory Committee's discussion document addressed the four following issues:

(1) removal of the requirement that non-governmental organisations maintain offices in more than three countries;
(2) allowing accredited NGOs to send up to [five?] representatives to IWC meetings as observers with the possibility of all observers being in the meeting room at any one time;
(3) revising the fee structure for NGOs, such that the effect of the changes listed above is fee-neutral (cost-neutral?) in the year of its introduction and that thereafter, fees should not in general increase by more than such an amount as is necessary to keep pace with inflation in the UK (as host country to the IWC);
(4) formally confirming the right of NGO representatives to speak at IWC meetings, but with some limitation on the number of interventions that could be made.

The document stressed that, should the Commission decide to consider whether, and if so how, its Rules of Procedure might be amended to accommodate the wishes of some

NGOs for more active participation, certain requirements are paramount, i.e. that changes in the rules should not:

- impede the orderly and timely conduct of business in meetings of the Commission or its subsidiary bodies;
- result in an increase in the IWC's costs nor a diminution in its income;
- significantly increase either the number of NGO observers present at meetings, nor the volume of documentation which the IWC Secretariat is required to produce to accommodate them.

Given the discussions in the F&A Committee, its Chair concluded that IWC is already transparent since it is open to observers from non-member governments, other intergovernmental organisations, NGOs and in the case of the plenary, also to the media. He noted that some members had serious concerns regarding the granting of speaking rights to NGOs, but suggested that further consideration might be given to items (1) to (3) above. The F&A Committee agreed to his proposal that the Secretariat work with the Advisory Committee intersessionally to explore how items (1)-(3) might be implemented and to report to the F&A Committee next year, together with any recommendations as appropriate. It was understood that it will be necessary for the Secretariat to consult with NGOs on this issue and it was agreed that the issue of speaking rights be set aside for the time being. The Committee also supported the suggestion that if Contracting Governments do not consider the pre-conditions listed under the three bullet points above cover all of their concerns, they should be invited to contribute proposals for further pre-conditions that would help in limiting/better defining NGO attendance.

The Commission endorsed the approach proposed by the F&A Committee.

20.3.2 NGO code of conduct[28]

On Wednesday 21 July, the Chair reported to Plenary that a number of Commissioners had brought to his attention press releases and media interviews in which certain NGOs had made allegations regarding vote buying within IWC. One such press release had been made available to participants via the tables provided for the distribution of non-official documents. The Chair noted that a number of private meetings of Commissioners had been held to discuss this matter and to consider what, if any, action might be appropriate. While he noted that the Commission has traditionally welcomed the contributions of NGOs at its meetings, it considered that attendance carries certain responsibilities. On behalf of the Commission, the Chair expressed extreme concern regarding the circulation of unsubstantiated allegations that had caused offence to many Contracting Governments and urged all NGOs to behave with due and proper respect to all member Governments. He also noted the disruption to the Commission meeting caused by such allegations both in Sorrento and at IWC/55 in Berlin. As a result, the Chair reported that the Commission intends to develop a Code of Conduct for NGOs that would focus on NGO activities during the Annual Meeting and that could, if appropriate, include provisions related to the loss of accreditation. A working group convened by Iceland (members: Dominica; Japan; the Netherlands; New Zealand; St. Kitts and Nevis; Sweden; and the USA) had been established to develop this Code of Conduct that would hopefully be ready for review by the whole Commission at IWC/57 next year.

21. FORMULA FOR CALCULATING CONTRIBUTIONS

At its meeting last year, the Commission agreed that the Contributions Task Force should meet again prior to IWC/56 to try to finalise a proposal for a revised contributions formula. A meeting had been scheduled for May 2004. However, given the intersessional work of the Commission and its potential implications for any revised contributions formula, Henrik Fischer believed that it would be prudent to delay further work of the Task Force until these implications could be assessed. Consequently, while continuing to recognise the high priority the Commission gives to the development of a revised contributions formula, it was decided, after consultation with the Task Force members and with the Advisory Committee, to postpone the Task Force meeting.

In the F&A Committee, while recognising the sense of postponing the May 2004 Task Force meeting, a number of delegations stressed the importance of completing expeditiously the work on a revised financial contributions formula. There was also some discussion regarding Chair of the Task Force, given that Daven Joseph (Antigua and Barbuda) was no longer Commissioner or representing Antigua and Barbuda. There was some debate as to whether Chairs are appointed as individuals or as countries and whether Task Force Chairs should be appointed by the Commission or elected by the group itself. Noting these different views, the new Commissioner for Antigua and Barbuda was invited to convene a meeting of Task Force members to elect a Chair. Following a short meeting, the convenor was able to report that by consensus, the Task Force recommended that, if the Commission so wishes, the Task Force continue with the Commissioner for Antigua and Barbuda (Anthony Liverpool) as Chair and with the Commissioner for Argentina (Eduardo Iglesias) as Vice-Chair.

The Commission noted the F&A Committee report and endorsed its recommendations regarding the Chair and Vice-Chair of the Contributions Task Force. St. Vincent and The Grenadines expressed appreciation for the work that the Contributions Task Force had done and urged expeditious completion of its work. It fully supported retaining the Interim Measure adopted at IWC/54 in Shimonoseki for calculating financial contributions until a replacement is available. The new Task Force Chair noted his commitment to ensuring the Task Force completes its work in a timely manner and hoped that significant progress will be made by the Annual Meeting next year. St. Lucia associated itself with the remarks of St. Vincent and The Grenadines and the Task Force Chair.

Resolution to take into account the special position of very small countries in calculating financial contributions

Monaco and San Marino introduced a proposal to transfer their two countries from capacity-to-pay Group 3 to Group 2 under the Interim Measure. It was also proposed that this transfer have no effect on the contribution of Contracting Governments belonging to capacity-to-pay Group 1.

Under the Interim Measure, Contracting Governments are allocated into one of four 'capacity-to-pay' groups depending on their GNI and GNI per capita as follows:

[28] This was not a matter discussed by the F&A Committee.

Group 1 – countries with GNI < US $10 billion and GNI/capita <US$ 10,000;

Group 2 – countries with GNI > US $10 billion and GNI/capita <US$ 10,000;

Group 3 – countries with GNI < US$ 1,000 billion and GNI/ capita >US$ 10,000;

Group 4 – countries with GNI > US$ 1,000 billion and GNI/ capita >US$ 10,000.

Financial contributions are initially calculated using the ‘old’ formula. Group 1 and 2 countries were then given a 50% and 25% discount for the years 2002/03 and 2003/04 which was further reduced in 2004/05 by 25% and 10% respectively. The shortfall is distributed according to the following proportions: whaling countries 10%, Group 3 countries 30%, Group 4 countries 60%.

Monaco explained that the aim of the proposal was to correct an anomaly in the Interim Measure caused by an overestimation of the capacity-to-pay of very small countries. It suggested that Monaco qualified for this status as it has an area of only two square kilometres and a population of only 32,000. Most of the population are expatriates who, because no tax is levied, contribute nothing to the GNI of Monaco. It also noted that Monaco’s GNI (some 1.3 billion US$) is one of the lowest of those countries that are members of IWC. With such a GNI, Monaco is not able to sustain a military force or a navy, has only seven embassies around the world and can participate in only a limited number of international organisations of which the IWC is obviously one. Since adhering to the Convention in 1982, Monaco felt that it has contributed its fair share to resources and to debate and had hosted a number of meetings. However, it noted that since the introduction of the Interim Measure, Monaco’s financial contributions had increased from around £15,000 to over £25,000 putting a strain on the extent to which it has been able to participate in meetings. Monaco did not believe that it should be placed in Group 3 simply because it has many wealthy expatriates and suggested that it and San Marino (for the same reasons) be transferred to Group 2. Monaco added that if the Commission rejected the proposal, it would likely not be able to participate for much longer. It called for adoption of the proposal by consensus.

San Marino associated itself with the statements of Monaco.

France, Iceland, UK, Australia and New Zealand indicated that they could support the proposal. Argentina was sympathetic with the proposal but expressed concern that this would lead to other countries requesting re-allocation to a different capacity-to-pay group. It indicated, however, that it would not block a consensus. Norway expressed similar concerns and believed that the groupings should not be changed at this time. It suggested that the proposal be postponed to await the outcome of the work of the Task Force. Dominica also did not see the need to set such a precedent in view of the work of the Task Force. The USA noted that the problem described by Monaco is only one of several problems associated with the Interim Measure. It hoped therefore that the Commission would give a mandate to the Task Force to complete its work and submit a comprehensive formula to the Commission at IWC/57. Spain associated itself with the remarks of the USA. The UK did not believe that the Task Force could complete its work until an agreement had been reached regarding apportioning of costs associated with a future RMS. Japan associated itself with the remarks of the USA and others and asked the sponsors if they would withdraw their proposal and await the outcome of the work of the Task Force. Monaco declined as there is no guarantee that the Task Force would complete its work as early as suggested.

The proposal was adopted on being put to a vote (Resolution 2004-4, Annex C). There were 20 votes in support, 15 against and 17 abstentions. The Chair suggested that the Task Force give some consideration to defining was is meant by ‘very small countries’. Monaco suggested that Group 2 countries be those with GNI < 5 billion US$.

While congratulating Monaco and San Marino on the outcome, Ireland explained that it had abstained as it was concerned that such a move would set a precedent, with other countries making different cases for re-allocation of capacity-to-pay group. It urged the Task Force to complete its work. The USA associated itself with Ireland, and again called for the necessary mandate to be given to the Task Force. There was no further discussion on this matter. Switzerland who had abstained, associated itself with Ireland and the USA.

22. FINANCIAL STATEMENTS AND BUDGETS

The F&A Committee had received the report of the Budgetary Sub-committee that had worked intersessionally and had met during IWC/56 with Jean-Pierre Plé (USA) as Chair. The Budgetary Sub-committee had reviewed the provisional statement for 2003/2004 and proposed budgets for 2004/2005 and 2005/2006.

22.1 Review of provisional financial statement, 2003/2004

At the recommendation of the F&A Committee, the Commission approved the Provisional Financial Statements subject to audit.

During the F&A Committee, the Secretariat had reported that approximately 90% of financial contributions for the Financial Year 2003/04 had been received by the due date for settlement (28 February 2004). It had noted that the charging of penalty interest of 10% for late payments and the loss of voting rights provided a strong incentive for members to pay on time. In the Committee, concern was expressed by some that the 10% penalty interest charge presented difficulties to developing countries. The fixed rate of 10% interest was questioned at a time when market rates of interest are much lower. Dominica raised this issue during the Commission meeting and indicated that it planned to propose amendments to the Rules of Procedure next year.

22.2 Consideration of estimated budgets, 2004/2005 and 2005/2006

As recommended by the F&A Committee, the Commission:

(1) adopted the proposed budget for the 2004/2005 financial year (Annex L), including a 2% increase in provision for the Annual Meeting to take account of costs associated with simultaneous interpretation (see section 20.1.2) and the provision for research expenditure (Annex M); the reservations of Norway, Japan and Germany were noted (see Annex K);

(2) agreed that for the 2005 Annual Meeting the registration fee for non-government observers be set at £590 and that the media fee at £35; and

(3) noted the forecast budget for 2005/2006.

The USA noted that the outcome of discussions on the RMS and the intersessional plan of activity agreed as part of Resolution 2004-6 (Annex C), had cost implications that needed to be considered in relation to the budget for the next financial year (2004/05). The Secretary noted that the budget proposed had anticipated a certain level of intersessional activity of the RMS, and that apart from the RMS Working Group meeting scheduled to take place before December 2004, all other activities should be covered. She suggested that a Contracting Government may wish to host the first meeting of the RMS Working Group.

22.3 Secretariat offices

Last year, the Commission had agreed to the Budgetary Sub-committee's recommendation that the Secretariat explore a range of alternatives to its existing premises including:

(1) continuing to rent the Red House;
(2) purchasing the Red House or another suitable property in Cambridge or elsewhere in the UK; or
(3) relocation of the Secretariat to another member country.

The background to these recommendations is that the cost of the Secretariat represents a significant percentage of the IWC's budget (i.e. £958k out of £1,623k of operating expenditure - as per the 2002-03 audited accounts). The rental of Red House (i.e. £69k) represents 4.3% of the £1,623k of operating expenditure, while salaries, and allowances (i.e. £622k) represent 38% of the £1,623k of expenditure.

The Secretariat's report examined the criteria for relocation within the UK and overseas and the associated variables (rents, wind–up costs, set–up costs, transition costs, loss of expertise and effects on organisational effectiveness etc). It reached the conclusions given below.

- Currently there are savings to be made from relocating the IWC abroad, both in terms of lower rental costs and local salaries. The savings however may be sensitive to currency/economic fluctuations. Savings in expenditure in the early years of relocation could easily revert to additions to expenditure in later years.
- Over the transition period it is possible that transition costs (e.g. paying rent on two properties – if relocation occurred before the current lease expired) would equal or even exceed cost savings.
- If the current lease is continued until 2009, the rent will be capped at around £ 73,700 per annum from June 2005. This will give stability to costs and still provide a competitive rent in relation to alternative sites in the Cambridge area.
- The renewal of the lease in 2009 offers the chance to re-negotiate the current terms. The current lease only allows increases in rent. The chance to reduce the rent and allow rent decreases at each 5-yearly rent review could be explored.
- The focus of much of this paper has been on the relative costs of property and the relative costs of operating in various parts of the world. The costs associated with losing staff with the operational expertise and relationships that have been developed over many years should also be taken into consideration.
- The volatility of international markets make budgeting over a long time frame problematic. An effective Secretariat needs stability to function effectively and so its location should be considered within a long-term perspective. A country that can offer a stable cost base allied to operational effectiveness should give an acceptable balance between value and performance in the face of fluctuations in the world economy.

Recognising that:

(1) rent of the The Red House is not an excessive cost;
(2) expertise within the Secretariat would be lost if the Secretariat were moved away from the Cambridge area; and
(3) that there is still over five years until the current lease expires

the F&A Committee endorsed the Sub-committee's recommendations that the Secretariat explore alternatives within the Cambridge area, including those listed below.

- Ask the NASCO (North Atlantic Salmon Conservation Organisation) Secretariat in Edinburgh, Scotland how it managed to purchase its Headquarters building in terms of funding and what effect their status as an International Organisation had in buying property. (Financing any purchase would have to be carefully considered in the context of minimising the effects on Financial Contributions).
- Near the date of renewal of the lease, examine whether there might be any scope for the owners of Red House to 'gift' the property to the IWC. This might be an option if the inheritance tax status of the owner made this option advantageous.
- Keep the property market in Cambridge under active review to allow the early assessment of rental or purchase alternatives.
- If new property was acquired, to assess the possibility to renting part of that property as a means of minimising total property costs.

The Commission endorsed these recommendations.

22.4 Budgetary Sub-committee rota

At IWC/54 in Shimonoseki, 2002, the Commission adopted a rota for membership of the Budgetary Sub-committee. In summary:

- using the same country groupings as the Interim Measure for Financial Contributions[29], membership comprises:

  - 2 members from Group 1;
  - 2 members from Group 2;
  - 2 members from Group 3; and
  - Japan, USA + one other from Group 4;

- membership is for 2 years (except for Japan and the USA who have a 'permanent' place since they are likely to be the two highest paying contributors under almost any formula for the calculation of financial contributions for the foreseeable future being the highest payers now and probably in the future);
- any member that declines to serve to be replaced by the next member in alphabetical sequence within its Group;

[29] It is recognised that these country groupings were developed solely for the purposes of the Interim Measure for calculating financial contributions and may need revision when a new formula is adopted.

- new members of the Commission to be fitted into the cycle at the nearest alphabetical point after they have had a period in which to familiarise themselves with the organisation;
- the appointment of the Sub-committee Chair should be handled by the Chair of the Commission and the Advisory Committee.

At IWC/55 last year, the Commission agreed that the Secretariat review the current rota system with a view to:

(1) making it more attractive for countries to serve on the Sub-committee;
(2) providing greater continuity;
(3) improving the process for selection of the Sub-committee Chair; and
(4) reporting back to the Budgetary Sub-committee for further action as appropriate.

At its meeting this year, the Sub-committee reviewed a variety of options put forward by the Secretariat for consideration regarding items (1) to (3) above and recommended to the F&A Committee that the following be incorporated into the membership rota system:

<u>To encourage participation in the Sub-committee:</u>

A. When inviting countries to serve, stress not only the importance of the work of the Sub-committee (it really does make the job of the F&A Committee much easier and more efficient), but also that the workload is not high - either intersessionally or at Annual Meetings. The Sub-committee is only active during the period from March to when the annual meeting is held – and this only involves responding to documents/proposals from the Secretariat. All intersessional work is done by email/fax and no meetings are involved. At annual meetings, the Sub-committee generally meets for only 1-2 sessions.
B. Undertake to schedule meetings of the Budgetary Sub-committee when other Commission sub-groups are not meeting and try to avoid scheduling the Budgetary Sub-committee at the beginning of the series of Commission sub-group meetings (because not all delegations arrive in time to otherwise participate).
C. Keep the four economic groups, but add two 'open seats' (i.e. for any interested countries) as a fifth category. Countries filling the two open seats would need to be identified and agreed at the meeting of the Finance and Administration Committee. Formalise the current informal arrangement allowing Contracting Governments not members of the Budgetary Sub-committee to attend meetings as observers.

<u>To provide greater continuity:</u>

D. Extend the term of members from 2 to 3 years.
E. Appoint not only a Sub-committee Chair but also a Vice-Chair. Under normal circumstances, the Vice-Chair would replace the outgoing Chair. This would have the effect of two Sub-committee members serving for either four years (under the current system) or six years if the term of all members was extended as proposed in D above.

<u>Improving the process for the selection of the Sub-committee Chair and Vice-Chair</u>

F. That the Sub-committee elects its own Chair (as is the case in other Commission sub-groups – and indeed the Commission itself);

The Commission endorsed these recommendations. It also agreed that:

- Germany and Norway be invited to take the 'open seats' commencing immediately following IWC/56;
- the Budgetary Sub-committee provide clearer guidelines for its operation (i.e. term for the 'open seats' and status of observers from Contracting Governments not on the Sub-committee) and to report back its conclusions to the F&A Committee next year.

The proposed rota for the budgetary Sub-committee for 2004/05 onwards is given in the F&A Committee report (Annex K).

22.5 Other matters

In the F&A Committee, Brazil briefly drew attention to its concern regarding the costs incurred to Contracting Governments, especially those of developing countries, of sending delegations to Annual Meetings, particularly given the length of the meeting series. It hoped that host governments and the Secretariat would take account of these concerns when determining the timing and location of Annual Meetings. This was supported by a number of other governments. The Committee took note of this concern and drew it to the attention of the Commission.

23. ADOPTION OF THE REPORT OF THE FINANCE AND ADMINISTRATION COMMITTEE

The Commission adopted the report of the F&A Committee.

Resolution on the frequency of meetings of IWC

On behalf of the other sponsors (Australia, Belgium, France, Germany, Italy, Kenya, Monaco, Norway, San Marino, Spain, South Africa and Switzerland), Ireland introduced a draft Resolution to, *inter alia*:

(1) accept the principle of IWC meetings being held less frequently than regular Annual Meetings, coupled with ensuring that intersessional meetings do not increase as a counter balance;
(2) create a working group to investigate (by correspondence) and make recommendations to IWC/57 on the implications of less frequent meetings;
(3) use the working group recommendations as a basis for a detailed Resolution at IWC/57 and a change in the Rules of Procedure of the Commission at IWC/58; and
(4) apply the principle of less frequent meetings after IWC/58 in 2006.

Ireland noted that that the increasing burden of Annual Meetings in terms of costs and personnel has been discussed on previous occasions and that the suggestion of less frequent meetings is not a new one. It drew attention to other Conventions dealing with fisheries, biodiversity and the environment who organise their affairs effectively on the basis of biennial or triennial meetings and hoped that the draft Resolution could be adopted by consensus.

The UK expressed its willingness to consider the proposal for less frequent meetings in principle, but noted that less than annual meetings might cause difficulties if the Commission adopts an RMS and starts to set catch limits. It noted that other Conventions with biennial or triennial meetings are set-up rather differently than IWC, with, in many cases, Sub-committees being established to do the bulk of the work. By contrast, the ICRW requires actions to be taken by the Commission. It therefore was not generally in favour of the proposal. South Africa appreciated these remarks but urged that the issue be pursued fully.

The USA was not opposed to considering less frequent meetings, but suggested a number of amendments to the draft Resolution to: (1) propose that the principle of less frequent meetings be 'explored' rather than 'accepted'; and (2) delete reference to the draft Resolution and changes to Rules of Procedure. Ireland indicated that it could accept these amendments and suggested that as a result, reference to implementation of less frequent meetings be applied after IWC/58 be deleted. The other co-sponsors agreed to these changes.

Denmark could agree to explore the issue, but like others, suggested that less frequent meetings might not be practical if an RMS was adopted and catch limits had to be set.

Dominica welcomed the proposal but suggested that a clause be inserted to urge that work on the RMS proceed expeditiously during the intersessional period leading up to IWC/57 next year.

Iceland and Japan indicated that they could not support the proposal at present, believing it to be premature. Iceland considered that it might delay adoption and implementation of an RMS. Japan believed that work on the RMS should be completed first and that for the time being, it is necessary for the Commission to meet annually. Kenya saw no connection with the RMS and urged that the proposal be adopted by consensus. Chile was against the proposal for more practical reasons. It believed: (1) that intersessional activity would increase and that it would have difficulties in finding the funds necessary to enable it to be involved; and (2) that its Government would force a reduction in annual contributions (since meetings would no longer be held annually). In response to Chile's second remark, Ireland suggested that less frequent meetings should lead in any case to either a freezing or a reduction in financial contributions.

Although Iceland, Japan, Chile and Argentina were not in favour of the proposal, they indicated that they would not block consensus. The Resolution, amended as described above, was then adopted, noting the concerns of these countries (see Resolution 2004-7, Annex C).

24. DATE AND PLACE OF ANNUAL AND INTERSESSIONAL MEETINGS

24.1 57th Annual Meeting, 2005

The Republic of Korea reported that IWC/57 will be held at the Lotte Hotel in Ulsan during the period 30 May to 24 June 2005 – the exact timing to be decided by the Commission.

The Secretary introduced a provisional schedule for the meeting, noting in particular that given Resolution 2004-6 on Completion of the RMS, two days had been allocated for a meeting of the RMS Working Group, and the meeting of the Commission had been extended from four days to five. The Commission agreed with the timing proposed, i.e. that the Scientific Committee meet from 30 May to 10 June (with a pre-meeting on sea ice and whale habitat and a workshop on the use of market sampling to estimate bycatch taking place in the period 27-29 May), the Commission sub-groups in the period from 13 to 17 June, and the Commission from Monday 20 to Friday 24 June 2005.

24.2 58th Annual Meeting, 2006

The Commission had received two offers to host the Annual Meeting in 2006; one from France, the other from St. Kitts and Nevis. As neither country was able to offer to host a meeting in a subsequent year, the location of IWC/58 was put to a vote by secret ballot. There were 27 votes for St. Kitts and Nevis, 25 for France and 1 abstention. The 2006 meeting will therefore be held in St. Kitts and Nevis.

24.3 Other

Spain indicated its willingness to host the Annual Meeting in 2007 but indicated its flexibility regarding the year. Kenya indicated that it intended to offer to host the meeting in 2008, but like Spain, was willing to be flexible.

25. ELECTION OF THE CHAIR AND VICE-CHAIR

At last year's meeting, Henrik Fischer (Denmark) and Carlos Dominguez Diaz (Spain) were elected as Chair and Vice-Chair respectively for a 3-year term. However, as Carlos Dominguez Diaz was unable to continue as Vice-Chair a replacement had to be elected. Horst Kleinschmidt (Commissioner for South Africa) and Minoru Morimoto (Commissioner for Japan) were proposed. On being put to a vote by secret ballot, Mr Kleinschmidt was elected. He received 26 votes. Mr Morimoto received 25 and there were two abstentions. It was agreed that Mr Kleinschmidt's appointment would be for three years.

26. ADVISORY COMMITTEE

At last year's meeting, the Commissioners from Dominica and the UK were elected onto the Advisory Committee to replace the Commissioners from St. Lucia and the USA respectively. Since St. Lucia had remained on the Advisory Committee for three years (instead of the usual two years as stipulated in Rule of Procedure M.9), the Commission agreed that Dominica should serve on the Advisory Committee for one year only – its term ending at IWC/56. At IWC/56, the Commission reappointed Dominica to serve on the Advisory Committee for a further two years.

27. SUMMARY OF DECISIONS AND REQUIRED ACTIONS

A summary of decisions and actions required is provided at the beginning of this report.

28. OTHER MATTERS

On behalf of the Commission, the Chair warmly thanked the Government of Italy for hosting the 56th Annual Meeting and for providing such a magnificent location and venue. He also extended his thanks to Mr Morimoto for his support as Vice-Chair, the Secretariat, the interpreters and the staff of Studio Ega who had helped in meeting organisation.

Several countries expressed deep appreciation to both the Chair and Vice-Chair for managing in an extremely efficient and accommodating way what they considered to be a very good meeting.

The meeting was closed at 17.10 on Thursday 22 July 2004.

29. AMENDMENTS TO THE SCHEDULE

The amendments to the Schedule adopted at the meeting are provided in Annex N.

Annex A

Delegates and Observers Attending the 56th Annual Meeting

(C) Commissioner; (AC) Alternate Commissioner; (I) Interpreter;
(S) Support Staff; (Alt) Alternate Observer

Antigua & Barbuda
Anthony Liverpool (C)
Colin Murdoch (AC)
Joanne Massiah

Argentina
Eduardo Iglesias (C)
Raúl Comelli (AC)
Miguel Iniguez (AC)

Australia
Conall O'Connell (C)
Stephen Powell (AC)
Marina Tsirbas
Nicola Beynon
Pam Eiser

Austria
Andrea Nouak (C)
Michael Stachowitsch (AC)
Antje Helms (S)

Belgium
Alexandre de Lichtervelde (C)
Xavier Leblanc (AC)
Koen Van Waerebeek

Belize
Ismael Cal (C)
Beverly Wade (AC)

Benin
Yaba Bantole (C)
Sogan Simplice
Lucie Kouderin (I)

Brazil
Maria Teresa Pessôa (C)
Régis Pinto de Lima (AC)
José Truda Palazzo (AC)
Rômulo José Fernandes Barreto de Mello
Marcia Engel

Chile
Mariano Fernández (C)
Francisco Devia Aldunate (AC)

China
Liu Xiaobing (C)
Xiao Jianguo
Luo Ming
Shen Wenjuan (I)

Côte d'Ivoire
Jeanson Anvra Djobo (C)
Andre Kouakou Kouassi (AC)
Adjoumani Kouassi Kobenan

Denmark
Ole Samsing (C)
Amalie Jessen (AC)
Kate Sanderson (AC)
Simon Olsen
Leif Fontaine
Ole Heinrich
Michael Kingsley
Kim Mathiasen
Maj Friis Munk
Kelly Berthelsen (I)

Dominica
Lloyd Pascal (C)
Andrew Magloire (AC)

Finland
Esko Jaakkola (C)
Risto Rautiainen (AC)
Penina Blankett

France
Jean-Georges Mandon (C)
Martine Bigan
Vincent Ridoux

Gabon
Guy Anicet Rerambyath (C)
Rosalie Avomo (AC)

Germany
Peter Bradhering (C)
Matthias Berninger (AC)
Marlies Reimann (AC)
Wolfgang Hoelscher-Obermaier
Andreas von Gadow
Karl-Hermann Kock
Petra Deimer

Grenada
Gregory Bowen (C)
Justin Rennie (AC)
Claris Charles
Frank Hester (I)

Republic of Guinea
Ibrahima Sory Toure (C)
Amadou Telivel Diallo (AC)
Sidiki Diane (I)

Hungary
Mária Pánczél (C)

Iceland
Stefan Asmundsson (C)
Asta Einarsdottir (AC)
Gunnar Palsson (AC)
Jon Gunnarsson
Gisli Vikingsson
Kristjan Loftsson

India
Himachal Som (C)
Sampat Singh Bist (AC)

Ireland
Chris O'Grady (C)

Italy
Giuseppe Ambrosio (C)
Giuseppe Notarbartolo Di Sciara (AC)
Paolo Galoppini (AC)
Caterina Fortuna
Michele Alessi
Rosa Caggiano
Domitilla Senni (S)
Massimiliano Rocco (S)
Domitilla Pulcini (S)
Lorenza Conti (S)

Japan
Minoru Morimoto (C)
Toshiyuki Iwado (AC)
Masayuki Komatsu (AC)
Akira Nakamae (AC)
Kiyoshi Ejima
Keishiro Fukushima
Gabriel Gomez Diaz
Dan Goodman
Mutsuo Goto
Hiroshi Hatanaka
Yoshimasa Hayashi
Noriyoshi Hattori
Masato Hayashi
Isamu Hidaka
Yasuo Iino
Hajime Ishikawa
Makoto Ito
Eiko Kaneta
Atsushi Kato
Hidehiro Kato
Chikao Kimura
Tadamasa Kodaira
Yoshikazu Kojima

Motohiko Kondo
Konomu Kubo
Akihiro Mae
Susumu Miura
Joji Morishita
Takanori Nagatomo
Keiichi Nakajima
Shuya Nakatsuka
Futoshi Nishiyama
Seiji Ohsumi
Kayo Ohmagari
Itsunori Onodera
Hirohiko Shimizu
Yoshihiro Takagi
Hirohito Takahashi
Tokuichiro Tamazawa
Sunao Taura
Ichiro Wada
Daishiro Yamagiwa
Kazuo Yamamura
Hideo Inomata (S)
Mihoko Takagi (S)
Rieko Motouchi (S)
Mikiko Inoue (I)
Rei Kawagishi (I)
Midori Ota (I)
Akiko Tomita (I)

Kenya
Sam Weru (C)
Connie Maina (AC)

Republic of Korea
Ki Hiok Barng (C)
Sung Kwon Soh (AC)
Zang Geun Kim (AC)
Oh Seuyng Kwon
Jae Taek Park
Chang Moyeng Byen
Hyon Min Yoon (I)
Byang Soo Jun (S)
Byung Hee Park (S)
Ji Chun Kim (S)
Bu Ho Jin (S)
Kyu Hwa Sim (S)
Hyung Mun Choi (S)
Dong Ik Choi (S)
Si Sang Song (S)

Mauritania
Sidi Mohamed Ould Sidina (C)
Ba Abou Sidi (AC)
Sidi Ould Aly (AC)

Mexico
Exequiel Ezcurra (C)
Lorenzo Rojas-Bracho (AC)

Monaco
Frederic Briand (C)

Mongolia
Ts. Damdin (C)
P. Naranbayer

Morocco
Abdessla Fahfouhi (C)
Abdelaziz Zoubi

Netherlands
Giuseppe Raaphorst (C)
Henk Eggink (AC)
Anne-marie van der Heijden (AC)
Peter Reijnders
Rene Lefeber (S)

New Zealand
Geoffrey Palmer (C)
Chris Carter (AC)
Alan Cook (AC)
Mike Donoghue (AC)
Nigel Fyfe (AC)
Chris Anderson
Alexander Gillespie
Simon Lambourne
Wally Stone

Nicaragua
Miguel Marenco (C)

Norway
Bengt Johansen (C)
Turid Eusebio (AC)
Halvard Johansen (AC)
Jorhill Andreassen
Hild Ynnesdal
Lars Walløe
Egil Øen
Nina Buvang Vaaja (S)
Jan Skjervø (S)
Bjørn Hugo Bendiksen (S)

Oman
Ibrahim Said Al-Busaidi (C)

Republic of Palau
Kuniwo Nakamura (C)
Victorio Uherbelau (AC)

Panama
Rogelio Santamaria (C)
Epimenides Diaz

Peru
Roberto Seminario (C)

Portugal
Edgar Afonso (C)
Marina Sequeira

Russian Federation
Valentin Ilyashenko (C)
Valery Knyazev (AC)
Rudolf Borodin (AC)
Ivan Slugin (S)
Vladimir Etylin (S)
Gennady Inankeuyas (S)
Alexander Borodin (S)
Olga Ipatova (I)
Olga Gogoleva (I)

Saint Kitts and Nevis
Ian Liburd (C)
Daven Joseph (AC)
Joseph Simmonds

Saint Lucia
Ignatius Jean (C)
Vaughn Charles (AC)

Saint Vincent and The Grenadines
Edwin Snagg (C)
Raymond Ryan (AC)

San Marino
Dario Galassi (C)

Senegal
Ndiaga Gueye (C)

Solomon Islands
Sylvester Diake (C)
Paul Maenuu

South Africa
Horst Kleinschmidt (C)
Herman Oosthuizen
Chris Badenhorst

Spain
Carmen Asencio (C)

Suriname
Jaswant Sahtoe (C)
Deuwperkaas Jairam (AC)

Sweden
Bo Fernholm (C)
Stellan Hamrin (AC)
Martin Attorps (AC)
Thomas Lyrholm (AC)
Anna Roos (AC)

Switzerland
Thomas Althaus (C)
Martin Krebs (AC)

Tuvalu
Panapasi Nelesone (C)
Nikolasi Apinelu (AC)

UK
Richard Cowan (C)
Trevor Perfect (AC)
Laurence Kell (AC)
Rob Bowman (AC)
Ben Bradshaw (AC)
Geoff Jasinski (AC)
Kath Cameron
Denise Hart
Jenny Lonsdale
Mark Simmonds

USA
Rolland Schmitten (C)
William Hogarth (AC)
William Brennan (AC)
Michael Tillman
Robert Brownell
Jean Pierre-Plé
Thomas Napageak
Dave Sones
Nancy Azzam
Chris Yates
Stanley Speaks (S)
Roger Eckert (S)
Scott Smullen (S)
Emily Lindow (S)
Gary Rankel (S)
George Ahmaogak (S)
Harry Brower Jr. (S)
Keith Johnson (S)
Shannon Dionne (S)
Debra Larson (S)
Dave Whaley (S)
Brad Smith (S)
Federica Signoretti (S)
Amy Frankel (S)
Todd Bertloson (S)

Chair of Scientific Committee
Doug DeMaster

NON-MEMBER GOVERNMENT OBSERVERS

Canada
Patrice Simon

Czech Republic
Pavla Hycova

Slovakia
Henrieta Baloghova
Milan Paksi

INTERGOVERNMENTAL ORGANISATION OBSERVERS

ACCOBAMS
Marie-Christine Van Klaveren

CITES
Willem Wijnstekers

ECCO
Horace Walters
Nigel Lawrence

IUCN
Justin Cooke

NAMMCO
Grete Hovelsrud-Broda
Charlotte Winsnes

UNEP/CMS Secretariat
Marco Barbieri

NON-GOVERNMENTAL ORGANISATION OBSERVERS

ACOPS
Patrick Ramage
Irene Donadio (I)

Alaska Cambridge Group
Mare Core
John Tichotsky (Alt)

All Japan Seamen's Union
Yoji Fujisawa

American Cetacean Society
Katy Penland

American Friends Service Committee
Robert Suydam
Charlotte Brower (Alt)

Animal Care International
Nicolas Entrup

Animal Kingdom Foundation
Margi Prideaux

Animal Welfare Institute
Susan Tomiak
Ben White (Alt)

Antarctic and Southern Ocean Coalition (ASOC)
Emanuela Marinelli

Association of Traditional Marine Mammal Hunters of Chukotka
Edward Zdor
Gennady Inankeuyas (Alt)
Liz Beiswenger (I)
John Tichotsky (I)

Barrow Arctic Science Consortium
Gennady Zelensky
Keith Hill (Alt)
Mary Core (Alt)

Biodiversity Action Network East Asia (BANEA)
Ayako Okubo

Campaign Whale
Andy Ottaway
S Dawes (I)

Canadian Marine Environment Protection Society
Annelise Sorg
Doug Imbeau (I)

Care for the Wild
Barbara Maas

Caribbean Conservation Association
Joth Singh
Andrée Griffith

Center for Respect of Life and Environment
Kitty Block

Cetacean Society International
Heather Rockwell

Citizen's Institute for Environmental Studies
Yeyong Choi
Taeyoung Moon (Alt)

Conservacion De Mamiferos Marinos De Mexico A.C.
Beatriz Bugeda
Laura Rojas (Alt)
Yolanda Alaniz (I)

Cousteau Society
Clark Lee Merriam

David Shepherd Conservation Foundation
Sue Fisher

Dolphin and Whale Action Network
Nanami Kurasawa

Dolphin Connection
Deb Adams

Earth Island Institute
Mark Palmer
David Rinehart (Alt)

Earth Voice
Betsy Dribben
Naomi Rose (Alt)

Eastern Caribbean Coalition for Environmental Awareness (ECCEA)
Lesley Sutty

Ecodetectives
Ralf Sonntag

Environmental Consultants & Associates
Karen Steuer

Environmental Investigation Agency
Clare Perry
Rosemary Lonsdale (Alt)

Eurogroup for Animal Welfare
Philip Lymbery

European Bureau for Conservation & Development
Despina Symons

Florida Caribbean Conservation Coalition
Alberto Szekely

Fondation Brigitte Bardot
Brice Quintin
Stephanie Roche (I)

Friends of the Earth International
Ma Yong-UN

Friends of Whalers
Alan Macnow
Tse Fungwong (I)

Fundación Cethus
Marta Hevia

Gesellschaft zum Schultz der Meeressäugetiere e.V. GSM
Birgith Sloth

Global Guardian Trust
Yasuyuki Teruki
Toshikazu Miyamoto (I)

Greenpeace International
John Frizell

Group to Preserve Whale Dietary Culture
Komei Wani

High North Alliance
Rune Frovik
Laila Jusnes (Alt+I))
Jan Odin Olavsen (Alt)
Tom Joran Olavsen (Alt+I)

Humane Society International
Patricia Forkan
Naomi Rose (Alt)

Indigenous World Association
Jessica Lefevre
Taqulik Hepa (Alt)

International Association for Religious Freedom
Craig George
Charlotte Brower (Alt)

International Environmental Advisors
Junko Sakurai
Yusuke Inoue (I)

International Dolphin Watch
Philippa Brakes

International Fund for Animal Welfare
Fred O'Regan
Christine Jones (Alt)
Gaia Angelini (I)

International Institute for Environment and Development
Duccio Centili

International League for the Protection of Cetaceans
Leslie Busby

International Marine Mammal Association
Vassili Papastavrou

International Marine Researchers
Thilo Maack

International Ocean Institute
Sidney Holt

International Primate Protection League
Ashley Misplon
Ross Lonsdale

International Transport Workers' Federation
Suezo Kondo
Yuji Iijima (I)

International Wildlife Coalition
Daniel Morast
Elsa Cabrera (I)

International Work Group for Indigenous Affairs
Petra Rethmann

Inuit Circumpolar Conference
Aqqaluk Lynge

Inuit Circumpolar Conference Env. Comm.
Erna Lynge

IWMC World Conservation Trust
Eugene Lapointe
Janice Henke (Alt)
Helene Lapointe (I)

Japan Fisheries Association
Jay Hastings

Japan Small-Type Whaling Association
Ito Nobuyuki

Japan Whale Conservation Network
Naoko Funahashi

Japan Whaling Association
Toru Yamamoto

Minority Rights Group
Mark Major

Monitor
Craig Van Note

Natural Resources Defense Council
Joel Reynolds

Nordic Council for Animal Welfare
Ann-Carin Torrissen
Anne Westen (I)

North Star League
Vladimir Melnikov
Piers Vitebsky (Alt)
John Tichotsky (I)

Project Jonah
Daniel Owen

Robin des Bois
Charlotte Nithart

RSPCA
Laila Sadler

Safety First
Tomoko Kajiki

Sino Cetacean International Institute
Grace Gao

Survival for Tribal People
Taqulik Hepa

TEN
Shigeko Misaki

Werkgroep Zeehond
Geert Drieman

Whale & Dolphin Conservation Society
Georgina Davies
Annika Winter (I)

Whale & Dolphin Watch Australia
Frank Future

Whale Cuisine Preservation Association
Maki Noguchi
Yoko Shimozuru (I)

Whales Alive
Darren Kindleysides

Women's Forum for Fish
Yuriko Shiraishi
Akiko Sato (I)

Women's International League for Peace and Freedom
Maggie Ahmaogak

Working Group for the Protection of Marine Mammals (ASMS)
Sigrid Lüber
Annalisa Bianchessi (I)

World Society for the Protection of Animals
Peter Davies
Leah Garces (Alt)

WWF International
Sue Lieberman

Annex B
Agenda

1. INTRODUCTORY ITEMS
   - 1.1 Welcome Address
   - 1.2 Opening Statements (IWC/56/OS)
   - 1.3 Secretary's Report on Credentials and Voting Rights
   - 1.4 Meeting Arrangements
   - 1.5 Review of Documents (IWC/56/1)

2. ADOPTION OF THE AGENDA (IWC/56/2)

3. SECRET BALLOTS
   (*Chair's Report of the 55th Annual Meeting, Section 3*)
   - 3.1 Proposal to amend Rule of Procedure E.3 (d)
   - 3.2 Commission discussions and action arising

4. WHALE STOCKS
   (*Chair's Report of the 55th Annual Meeting, Section 6*)
   - 4.1 In-depth assessment of western North Pacific common minke whales
     - 4.1.1 Report of the Scientific Committee (IWC/56/Rep 1)
     - 4.1.2 Commission discussions and action arising
   - 4.2 Antarctic minke whales
     - 4.2.1 Report of the Scientific Committee (IWC/56/Rep 1)
     - 4.2.2 Commission discussions and action arising
   - 4.3 Southern Hemisphere whales other than minke whales
     - 4.3.1 Report of the Scientific Committee (IWC/56/Rep 1)
     - 4.3.2 Commission discussion and action arising
   - 4.4 Other small stocks – bowhead, right and gray whales
     - 4.4.1 Report of the Scientific Committee (IWC/56/Rep 1)
     - 4.4.2 Commission discussion and action arising
   - 4.5 Other

5. ABORIGINAL SUBSISTENCE WHALING
   (*Chair's Report of the 55th Annual Meeting, Section 7*)
   - 5.1 Aboriginal subsistence whaling scheme
     - 5.1.1 Report of the Aboriginal Subsistence Whaling Sub-committee (IWC/56/Rep 3)
     - 5.1.2 Commission discussions and action arising
   - 5.2 Aboriginal subsistence whaling catch limits
     - 5.2.1 Report of the Aboriginal Subsistence Whaling Sub-committee (IWC/56/Rep 3)
     - 5.2.2 Commission discussions and action arising
   - 5.3 Revision of Schedule paragraph 13 (IWC/56/4)
     - 5.3.1 Report of the Aboriginal Subsistence Whaling Sub-committee (IWC/56/Rep 3)
     - 5.3.2 Commission discussions and action arising
   - 5.4 Other

6. REVISED MANAGEMENT SCHEME (RMS)
   (*Chair's Report of the 55th Annual Meeting, Section 9*)
   - 6.1 Revised Management Procedure (RMP)
     - 6.1.1 Report of the Scientific Committee (IWC/56/Rep 1)
       - general issues
       - preparation for implementation (western North Pacific Bryde's whales, North Atlantic fin whales)
       - bycatch
     - 6.1.2 Commission discussions and action arising
   - 6.2 Revised Management Scheme
     - 6.2.1 Chair's report on intersessional work
     - 6.2.2 Commission discussions and action arising
   - 6.3 Other

7. WHALE KILLING METHODS AND ASSOCIATED WELFARE ISSUES
   (*Chair's Report of the 55th Annual Meeting, Section 8*)
   - 7.1 Reporting on data on whales killed and on improving the humaneness of whaling operations (IWC/56/5-8)
   - 7.2 Commission discussions and action arising

8. SANCTUARIES
   (*Chair's Report of the 55th Annual Meeting, Section 10*)
   - 8.1 Review of the Southern Ocean Sanctuary
     - 8.1.1 Report of the Scientific Committee (IWC/56/Rep 1)
     - 8.1.2 Commission discussions and action arising and possible Schedule amendment proposal
   - 8.2 Improvements to the sanctuary review process
     - 8.2.1 Report of the Scientific Committee (IWC/56/Rep 1)
     - 8.2.2 Commission discussions and action arising
   - 8.3 South Pacific Sanctuary
     - 8.3.1 Proposal to amend the Schedule to establish a sanctuary (IWC/56/9)
     - 8.3.2 Commission discussions and action arising
   - 8.4 South Atlantic Sanctuary
     - 8.4.1 Proposal to amend the Schedule to establish a sanctuary (IWC/56/10)
     - 8.4.2 Commission discussions and action arising
   - 8.5 Other

9. SOCIO-ECONOMIC IMPLICATIONS AND SMALL-TYPE WHALING
   (*Chair's Report of the 55th Annual Meeting, Section 11*)
   - 9.1 Proposal to amend the Schedule
   - 9.2 Commission discussions and action arising

10. SCIENTIFIC PERMITS
    (*Chair's Report of the 55th Annual Meeting, Section 12*)
    - 10.1 Report of the Scientific Committee (IWC/56/Rep 1)
      - 10.1.1 Improvements to review procedures
      - 10.1.2 Review of results from existing permits
      - 10.1.3 Review of new or continuing proposals
      - 10.1.4 Other
    - 10.2 Commission discussions and action arising

11. ENVIRONMENTAL AND HEALTH ISSUES
    (*Chair's Report of the 55th Annual Meeting, Section 13*)
    - 11.1 Integration of environmental concerns with other Scientific Committee work
      - 11.1.1 Report of the Scientific Committee (IWC/56/Rep 1)

11.1.2 Commission discussions and action arising

11.2 Habitat-related issues

11.2.1 Report of the Scientific Committee (IWC/56/Rep 1)

- POLLUTION 2000
- SO-GLOBEC/CCAMLR
- State of the Cetacean Environment (SOCER)
- Arctic issues
- Anthropogenic noise
- Habitat degradation workshop

11.2.2 Commission discussions and action arising

11.3 Reports from Contracting Governments on national and regional efforts to monitor and address the impacts of environmental change on cetaceans and other marine mammals

11.4 Health Issues - Commission discussions and action arising

11.5 Other

12. WHALEWATCHING
(*Chair's Report of the 55th Annual Meeting, Section 5*)
12.1 Report of the Scientific Committee (IWC/56/Rep 1)
12.2 Commission discussions and action arising

13. CO-OPERATION WITH OTHER ORGANISATIONS (IWC/56/11)
(*Chair's Report of the 55th Annual Meeting, Section 14*)
13.1 Report of the Scientific Committee (IWC/56/Rep 1)
13.2 Other reports
13.3 Commission discussions and action arising

14. OTHER SCIENTIFIC COMMITTEE ACTIVITIES, ITS FUTURE WORK PLAN AND ADOPTION OF THE SCIENTIFIC COMMITTEE REPORT
(*Chair's Report of the 55th Annual Meeting, Section 15*)
14.1 Small cetaceans
14.1.1 Report of the Scientific Committee (IWC/56/Rep 1)
14.1.2 Commission discussions and action arising
14.2 Other activities
14.2.1 Report of the Scientific Committee (IWC/56/Rep 1)
14.2.2 Commission discussions and action arising
14.3 Scientific Committee Future Work Plan
14.3.1 Report of the Scientific Committee (IWC/56/Rep 1)
14.3.2 Commission discussions and action arising
14.4 Adoption of the Report

15. CONSERVATION COMMITTEE
(*Chair's Report of the 55th Annual Meeting, Section 4 and Resolution 2003-1*)
15.1 Report of the Conservation Committee (IWC/56/Rep 5 and IWC/56/12)
15.2 Commission discussions and action arising

16. CATCHES BY NON-MEMBER NATIONS
(*Chair's Report of the 55th Annual Meeting, Section 16*)
16.1 Commission discussions and action arising

17. FUTURE SUSTAINABLE WHALING – FULL UTILISATION OF HARVESTED WHALES
17.1 Introduction by Japan
17.2 Commission discussions and action arising

18. INFRACTIONS, 2003 SEASON
(*Chair's Report of the 55th Annual Meeting, Section 17*)
18.1 Report of the Infractions Sub-committee (IWC/56/Rep 4)
18.2 Commission discussions and action arising

19. LEGAL ADVICE IN RELATION TO THE IWC
(*Chair's Report of the 55th Annual Meeting, Section 18*)
19.1 Secretary's report on how other Conventions deal with legal issues (IWC/56/13)
19.2 Commission discussions and action arising

20. ADMINISTRATIVE MATTERS
(*Chair's Report of the 55th Annual Meeting, Section 19*)
20.1 Annual Meeting arrangements and procedures
20.1.1 Report of the Finance and Administration Committee (IWC/56/Rep 2)
- Need for a Technical Committee
- Use of simultaneous translation

20.1.2 Commission discussions and action arising
20.2 Amendments to the Rules of Procedure, Financial Regulations and Rules of Debate
20.2.1 Report of the Finance and Administration Committee (IWC/56/Rep 2)
20.2.2 Commission discussions and action arising

21. FORMULA FOR CALCULATING CONTRIBUTIONS
(*Chair's Report of the 55th Annual Meeting, Section 20*)
21.1 Report of the Finance and Administration Committee (IWC/56/Rep 2)
21.2 Commission discussions and action arising

22. FINANCIAL STATEMENTS AND BUDGETS (IWC/56/14)
(*Chair's Report of the 55th Annual Meeting, Section 21*)
22.1 Review of the provisional financial statement, 2003/2004
22.1.1 Report of the Finance and Administration Committee (IWC/56/Rep 2)
22.1.2 Commission discussions and action arising
22.2 Consideration of estimated budgets, 2004/2005 and 2005/2006
22.2.1 Report of the Finance and Administration Committee (IWC/56/Rep 2)
22.2.2 Commission discussions and action arising
22.3 Other
22.3.1 Report of the Finance and Administration Committee (IWC/56/Rep 2)
22.3.2 Commission discussions and action arising

23. ADOPTION OF THE REPORT OF THE FINANCE AND ADMINISTRATION COMMITTEE (IWC/56/Rep 2)

24. DATE AND PLACE OF ANNUAL AND INTERSESSIONAL MEETINGS
24.1 57th Annual Meeting, 2005 (IWC/56/15)
24.2 58th Annual Meeting, 2006
24.3 Other

25. ADVISORY COMMITTEE

26. SUMMARY OF DECISIONS AND REQUIRED ACTIONS

27. OTHER MATTERS

Annex C

Resolutions Adopted during the 56th Annual Meeting

Resolution 2004-1

RESOLUTION ON THE WESTERN NORTH PACIFIC GRAY WHALE

CONCERNED that the IUCN listed the western gray whale as ‘critically endangered’ in 2000 because of its geographic and genetic isolation combined with the small population size of about 100;

FURTHER CONCERNED that the Scientific Committee has noted that only 23 reproductive females are known;

NOTING that the Scientific Committee in 2004 strongly agreed that the evidence that this population is in serious danger of extinction is compelling;

RECALLING that in 2001 the Commission passed a Resolution (Resolution 2001-3) calling on range states and others to actively pursue all practicable solutions to eliminate anthropogenic mortality in the western North Pacific gray whale stock and to minimise anthropogenic disturbances in the migration corridor and on their breeding and feeding grounds;

DEEPLY CONCERNED by the report of the 2004 Scientific Committee that states that the recovery and growth of the population appear to be hindered by a variety of biological difficulties and that the onset of oil and gas development programs is of particular concern with regard to the survival of this population;

NOTING the management recommendations of the 2004 Scientific Committee that as a matter of absolute urgency measures are taken to protect this population and its habitat off Sakhalin Island;

NOTING that although there already was independent scientific advice, there is, nevertheless, a continued need for expert and independent scientific advice on the effects that oil and gas development projects might have on the western North Pacific gray whale stock;

NOTING that in recent years significant resources and effort in studying the western North Pacific gray whale stock near Sakhalin Island, and that in view of the uncertainty over the possible negative impacts on the population and its habitat by current oil and gas activities, this kind of research and monitoring must be continued in greater detail as oil and gas activities increase in scale; and

FURTHER NOTING that the International Whaling Commission is internationally recognised as having competence for the management and conservation of whale stocks, has a wealth of scientific knowledge and expertise and has been reviewing research on the western gray whale population off Sakhalin Island since 1995;

NOW THEREFORE THE COMMISSION:

CALLS UPON range states and others to be mindful of Resolution 2001-3 when contemplating exploration projects in and around Sakhalin Island and to continue to observe the recommendations to actively pursue all practicable actions to eliminate anthropogenic mortality in this stock and to minimise anthropogenic disturbances in the migration corridor and on breeding and feeding grounds;

ENDORSES all conclusions and recommendations of the 2004 Scientific Committee concerning western gray whales including that:

(1) ‘as a matter of absolute urgency that measures be taken to protect this population and its habitat off Sakhalin Island’;
(2) ‘strongly recommends that the ongoing Russian-US and Russian and Republic of Korea national programmes on western gray whale research and monitoring continues and expands into the future’;
(3) ‘strongly recommends that all range states develop or expand national monitoring and research programmes on western gray whales’;
(4) ‘strongly recommends that in situations when displacement of whales could have significant demographic consequences, seismic surveys should be stopped.’

REQUESTS that the Secretariat urgently offers its services and scientific expertise to the organisations concerned with oil and gas development projects and potential exploration projects in the Sakhalin area, and provides them with the findings of any relevant research and Scientific Committee reports;

FURTHER REQUESTS that the Secretariat makes every effort to actively participate and provide advice and expertise at any international expert panels convened to consider the impacts on the western gray whale of oil and gas development projects in and around Sakhalin Island; and

FURTHER REQUESTS that the Commission request all the range states to develop, begin or continue scientific research programmes on the migration, distribution, breeding, population assessment and other research of the entire range of the western gray whale.

Resolution 2004-2

RESOLUTION ON JAPANESE COMMUNITY-BASED WHALING

WHEREAS, since 1986, the International Whaling Commission has repeatedly discussed in-depth the importance of the history and culture of Japanese traditional whaling at its various working groups and the Commission itself;

WHEREAS the International Whaling Commission, recognising the socio-economic and cultural needs of the four community-based whaling communities in Japan (Abashiri, Ayukawa, Wadaura and Taiji), has repeatedly resolved to work expeditiously to alleviate the distress to the communities which has resulted from the cessation of minke whaling (first, IWC/45/51; most recently, IWC Resolution 2001-6);

WHEREAS, more recently, the Summits of Japanese Traditional Whaling Communities were held in three consecutive years in Japan (Nagato, Yamaguchi in 2002, Ikitsuki, Nagasaki in 2003, and Muroto, Kochi in 2004) and they have further examined the long-lasting whaling history and culture which are deeply rooted in various places of Japan, not only in four community-based whaling communities but also throughout Japan;

WHEREAS the Summits acknowledged that archaeological findings have shown that the ancient Japanese could have started to utilise beached whales at least 9,000 years ago, could have begun active hunting of dolphins and porpoises at least 5,000 years ago, and could have launched grand-scale active hunting of large whales at least 2,000 years ago;

WHEREAS the Summits emphasised that, among others, holding the philosophy and having skills to utilise whales fully was and is the core essence of the Japanese whaling culture;

WHEREAS the Declarations adopted at the Summits (the 2002 Nagato Declaration, the 2003 Ikitsuki Declaration, and the 2004 Muroto Declaration) pledged that Japanese time-honoured whaling traditions and culture are to be passed onto the future generations; and

WHEREAS various UN conventions, treaties, and other documents upheld the importance of sustainable use of natural resources in general and the significance of continued customary resource use for communities;

NOW THEREFORE BE IT RESOLVED THAT THE COMMMISSION:

REAFFIRMS the Commission's commitment to work expeditiously to alleviate the continued difficulties caused by the cessation of minke whaling to the communities of Abashiri, Ayukawa, Wadaura and Taiji, and

ENCOURAGES IWC members to co-operate towards a resolution of this matter.

Resolution 2004-3

RESOLUTION ON WHALE KILLING ISSUES

RECOGNISING that welfare considerations for cetaceans killed for food is of international concern;

NOTING that Article V.1.f of the International Convention for the Regulation of Whaling empowers the Commission to amend the Schedule 'to adopt regulations with respect to the conservation and utilisation of whale resources by fixing … types and specifications of gear and apparatus and appliances which may be used', and that the Commission has exercised this welfare mandate through modification of the schedule and adopting 15 resolutions on welfare aspects of whaling which have established several technical fora for addressing welfare issues;

RECALLING that the IWC has defined 'Humane Killing' as 'Death brought about without pain, stress, or distress perceptible to the animal. That is the ideal. Any humane killing technique aims first to render an animal insensitive to pain as swiftly as technically possible. In practice this cannot be instantaneous in the scientific sense' (IWC/33/15 & IWC/51/12) and that, in order to determine whether these criteria are met, various data must be collected from whaling operations;

FURTHER RECOGNISING that the IWC criteria used to determine death or irreversible insensibility are inadequate; while also recognising that the IWC Working Group and Workshops on Whale Killing Methods are attempting to develop criteria to more adequately determine death or irreversible insensitivity both operationally and from post-mortem approaches;

NOTING that the efficiency of killing methods is influenced by many factors including the calibre of the weapon used, the nature of the ammunition, the target area of the whale, the angle of the shot, the proximity of the whale to the vessel, the accuracy of the gunner, prevailing weather conditions and sea state, including sea ice, and the size and species of the whale targeted;

NOTING FURTHER that data collection requirements are not being met in some hunts, while appreciating that efforts have been made by some member nations to provide available data;

RECALLING that Contracting Parties should make reasonable attempts to release alive, with the minimum harm possible, whales that have been incidentally captured (IWC Resolution 2001-4), but that the Commission has not considered the welfare implications of this practice nor the killing methods that might be employed if the whale cannot be released;

NOTING WITH CONCERN that the number of whales struck in some hunts can have significant welfare implications, while appreciating the efforts of certain member nations, especially Norway, to improve the humaneness of their hunts through weapons improvement programs and increased hunt efficiency;

NOW THEREFORE THE COMMISSION:

EXPRESSES CONCERN, in light of its mandate and long-standing commitment to address welfare issues, that current whaling methods do not guarantee death without pain, stress or distress; that data presently collected and submitted to the Commission are of insufficient quality or completeness for it to make a fully informed assessment of the welfare implications of all whaling operations; and that the criteria currently used to determine the onset of death or irreversible insensibility are inadequate;

REQUESTS THE SECRETARIAT to update the data collection form for the reporting of data in order that contracting governments may report data for each whale taken, the killing method used and samples taken;

REQUESTS the IWC/57 annual meeting to reconvene the Working Group on Whale Killing Methods and Associated Welfare issues, to examine methods for reducing struck and lost rates in whaling operations and to consider the welfare implications of methods used to kill whales caught in nets;

REQUESTS the Working Group on Whale Killing Methods and Associated Welfare Issues to advise the Commission on:

- establishing better criteria for determining the onset of irreversible insensibility and death;
- methods of improving the efficiency of whale killing methods; and
- reducing times to death and other associated welfare issues.

Resolution 2004-4

PROPOSAL TO TAKE INTO ACCOUNT THE SPECIAL POSITION OF VERY SMALL COUNTRIES IN CALCULATING FINANCIAL CONTRIBUTIONS

NOTING that contracting parties should contribute financially to the Commission in a fair and equitable manner;

RECOGNISING that two contracting parties that currently belong to capacity-to-pay Group 3, according to the Interim Measure for calculating contributions, are very small countries with a very small population, and thus a much smaller Gross National Income than the other countries that belong to that Group;

ALSO RECOGNISING that in all other international organisations the special position of these two countries is properly taken into account in the calculation of financial contributions; and

RECOGNISING further that taking account of the special position of these countries within the IWC should not affect the financial contributions of those contracting parties that have the least capacity to pay, and thus belong to Group 1 according to the Interim Measure for calculating contributions;

NOW THEREFORE THE COMMISSION:

DECIDES that, under the Interim Measure for calculating contributions, Monaco and San Marino are transferred from capacity-to-pay Group 3 to Group 2; and

FURTHER DECIDES that this transfer shall have no effect on the contribution of contracting parties that belong to capacity-to-pay Group 1.

Appendix 1

Current Capacity-to-Pay Grouping under 'Interim Contribution Measure'

Group 1	Group 2	Group 3	Group 4
GNI less than $10 billions and GNI/capita less than $10,000	GNI greater than $10 billions and GNI/capita less than $10,000	GNI less than $1,000 billions and GNI/capita greater than $10,000	GNI greater than $1,000 billions and GNI/capita greater than $10,000
Antigua & Barbuda	Argentina ±	Australia	France
Belize	Brazil ±	Austria	Germany
Benin	Chile	Belgium	Italy
Dominica	China, People's Republic of ±	Denmark	Japan
Gabon	Costa Rica	Iceland	UK
Grenada	Côte d'Ivoire	Ireland	USA
Guinea, Republic of	Hungary	Monaco *	
Mauritania	India ±	Netherlands	
Mongolia	Kenya	New Zealand	
Nicaragua	Korea, Republic of ±	Norway	
Palau, Republic of	Mexico ±	Portugal	
Senegal	Morocco	San Marino *	
St. Kitts and Nevis	Oman	Spain	
St. Lucia	Panama	Sweden	
St. Vincent and The Grenadines	Peru	Switzerland	
Solomon Islands	Russian Federation ±		
Suriname	South Africa ±		
Tuvalu			

±GNI > $100 billions; *GNI < $2 billions.

Resolution 2004-5

RESOLUTION ON POSSIBLE SYNERGIES WITH THE GLOBAL ENVIRONMENT FACILITY

COGNIZANT of the need to have strong supporting relationships with other international bodies that deal with subject matter with a strong overlapping interest;

RECOGNISING Paragraph 121 of the 2002 Plan of Implementation from the World Summit on Sustainable Development which called for an 'Institutional Framework for Sustainable Development' which would be strengthened by:

> Increasing effectiveness and efficiency through limiting overlap and duplication of activities of international organizations, within and outside of the United Nations system, based on their mandates and comparative advantages.

APPRECIATIVE of the International Whaling Commissions long standing interactions with, *inter alia*, CITES, CMS & CCAMLR;

DESIROUS to support synergies between overlapping conventions so as to improve mutually reinforcing scientific, administrative, policy and financial assistance objectives;

CONSCIOUS of the need to fully support the respective primacy of each organisation;

NOW THEREFORE THE COMMISSION:

DIRECTS the Secretariat to establish high level contact with the Secretariat of the Global Environment Facility and to:

explore possible synergies and their possible utility of the GEF to the IWC, and investigate, *inter alia*, possible avenues for the utilization of GEF funding for IWC related projects, with specific regard to:

(i) assistance for developing countries for scientific research and policies for scientific research, as directed by the IWC;

(ii) the utility in joint projects seeking funding with other international organizations, such as, *inter alia*, the Convention on Biological Diversity, the Convention on Migratory Species, the World Heritage Convention, and the Ramsar Convention on Wetlands;

(iii) an examination of the modalities that the GEF seeks to satisfy and whether IWC projects, now or in the future, could be made to fit such objectives.

The Secretariat shall report back to the 57th IWC meeting on these matters.

Resolution 2004-6

RESOLUTION ON COMPLETION OF THE REVISED MANAGEMENT SCHEME (RMS)

RECOGNISING the dual mandate of the IWC for the conservation of whales and the management of whaling according to the 1946 International Convention for the Regulation of Whaling;

NOTING that on this basis, considerable progress has been made in identifying major elements necessary to reach broad agreement on the RMS, as reflected in the Chairman's Proposal for a Way Forward on the RMS (Doc IWC/56/26);

TAKING NOTE of the comments of Contracting Parties on the Chairman's Proposal at the 56th Annual Meeting of the Commission; and

CONCERNED that the failure to reach broad agreement on the RMS in the near future may seriously jeopardise the ability of the IWC to fulfil its responsibilities;

NOW THEREFORE THE COMMISSION:

COMMENDS the efforts of the Chairman in providing a basis for further work and discussion towards finalising the RMS;

AGREES to re-establish the Working Group on the RMS with a view to holding an intersessional meeting prior to IWC/57, as outlined in the attached Intersessional Plan of Work; and

AGREES to proceed expeditiously towards the completion of both the drafting of text and technical details of the RMS according to the attached Intersessional Plan of Work with the aim of having the results ready for consideration, including for possible adoption, at IWC/57, and/or to identify any outstanding policy and technical issues.

INTERSESSIONAL PLAN OF WORK

The Chair's Proposal for a way forward (IWC/56/26), supplemented by his statement (IWC/56/28), other comments made at IWC/56 in relation to the Chair's proposal and the Secretariat's document (IWC/56/36), provides a basis for the development of draft text for the RMS, to clarify policy and technical issues and draft text for the RMS. The goal of this effort is to have clarified outstanding policy and technical issues and, as far as possible, have finalised text of an RMS package ready for consideration at IWC/57. The following iterative process would occur to develop such a text over the intersessional period:

1. Commission formally revives the RMS Working Group and agrees to establish a small drafting group under it (see respective terms of reference in Appendices 1 and 2).
2. All Contracting Governments are invited to send comments/positions on key issues to the RMS Working Group.
3. Secretariat collates and organises available materials. Technical specialist groups meet and finish their work before December 2004.
4. RMS Working Group to provide guidance on major policy issues to small drafting group (before December 2004).
5. Small drafting group meets (one week) in December 2004.
6. Draft text is circulated to delegations for review and comment. Secretariat circulates comments to all delegations and to members of the small drafting group.
7. RMS Working Group convenes in early March 2005 to consider the draft text and submitted comments and to develop input to the small drafting group for development of the next iteration.
8. The small drafting group meets immediately afterwards to develop the second draft, which the Secretariat circulates to delegates.
9. The RMS Working Group meets for two days during the week prior to the IWC/57 Plenary session to consider the second draft. The results of the RMS Working Group are presented to the Plenary for its consideration at IWC/57.

Appendix 1

Terms of Reference for RMS Working Group

The RMS Working Group will have the following responsibilities:

1. To complete work on the RMS package, with the goal of having a finalised RMS text ready for consideration, including for possible adoption, at IWC/57, and/or to identify any outstanding policy and technical issues.
2. To take account of delegates' comments at IWC/56, as well as written submissions from delegates.
3. To provide guidance to, and to review the work of, the Small Drafting Group.

RMS Working Group to be open to observers.

Appendix 2

Terms of Reference for the Small Drafting Group (SDG)

Under the auspices of the RMS Working Group the SDG will have the following responsibilities:

1. To prepare a consolidated draft text for the replacement of parts of Chapters V and VI of the current Schedule.
2. To prepare consolidated draft text on other related issues in the RMS package.
3. To utilise the Chair's proposal (IWC/56/26) and his statement (IWC/56/28), as a framework for this work.
4. To rearrange, revise and renumber paragraphs in the draft text for Chapters V and VI as appropriate but not to attempt to merge them with other parts of the Schedule.

Representation on SDG and Technical Specialist Groups (TSGs): Chair to seek expressions of interest to ensure regional and policy diversity in the groups. The SDG and TSGs should include Governments with adequate regional coverage, and adequate coverage of those For/Against/Neutral on the key issues.

Resolution 2004-7

RESOLUTION ON THE FREQUENCY OF MEETINGS OF THE INTERNATIONAL WHALING COMMISSION

AWARE that the Rules of Procedure of the International Whaling Commission (IWC) provide for a regular Annual Meeting of the Commission, and that the positions of Chair and Vice-Chair of the IWC shall serve for a period of three years;

NOTING that other international Conventions dealing with fisheries, species, biodiversity and the environment organise their affairs very effectively on the basis of biennial or triennial meetings;

CONCERNED that the costs of the annual meetings of the IWC are increasing from year to year;

NOTING that many Contracting Parties, especially from developing countries, have difficulty in meeting the high costs of attending annual meetings of the Commission;

NOW THEREFORE THE COMMISSION HEREBY DECIDES:

That the principle of meetings of the IWC being held less frequently than regular Annual Meetings be explored;

That, in applying this principle, the intention should be to avoid holding more frequent inter-sessionary meetings as a counter-balancing measure;

That a working group be established by the Commission to investigate and make recommendations on the implications of less frequent meetings of the IWC;

That, in its deliberations, the working group should have particular regard to the implications of less frequent meetings for the term of office of the Chair and Vice-Chair of the Commission; for the work of the other Committees of the IWC; and, with specific regard to the deliberations of the Scientific Committee, that the group should examine whether the current pattern of holding annual meetings should be maintained in the initial years of the new arrangements at least;

That the working group should report to IWC/57 in Ulsan, Republic of Korea.

Annex D

Report of the Sub-Committee on Aboriginal Subsistence Whaling

Wednesday 14 July 2004, Sorrento, Italy

1. INTRODUCTORY ITEMS

The meeting took place at the Hilton Sorrento Palace Hotel, Sorrento, Italy on 14 July 2004. A list of participants is given in Appendix 1. The terms of reference of the Aboriginal Subsistence Whaling Sub-committee are to consider relevant information and documentation from the Scientific Committee, and to consider nutritional, subsistence and cultural needs relating to aboriginal subsistence whaling and the use of whales taken for such purposes, and to provide advice on the dependence of aboriginal communities on specific whale stocks to the Commission for its consideration and determination of appropriate management measures (*Rep. int. Whal. Commn*. 48: 31).

1.1 Election of Chair

Andrea Nouak (Austria) was elected Chair.

1.2 Appointment of Rapporteur

Alexander Gillespie (New Zealand) was appointed as rapporteur.

1.3 Review of documents

The documents for discussion included:

IWC/56/AS1 Revised Draft Agenda.
IWC/56/AS2 Documentation to IWC on Greenland Whaling, 1979-2003.
IWC/56/4 Report of the Small Working Group Reviewing Schedule paragraph 13 Regarding ASW Provisions: Proposals to Amend the Schedule.
IWC/56/Rep 1 Report of the Scientific Committee, Items 8 and 9.
IWC/54/5, Appendix 4. The Aboriginal Whaling Management Procedure - Possible Text. (*Ann. Rep. Int. Whaling Comm.* 2002: 74-75).

2. ADOPTION OF THE AGENDA

The adopted agenda is given as Appendix 2.

3. ABORIGINAL SUBSISTENCE WHALING SCHEME

3.1 Aboriginal Whaling Management Procedure (AWMP)

3.1.1 Report of the Scientific Committee

3.1.1.1 GRAY WHALES (IWC/56/REP 1, ITEM 8.2)

The Chair of the Scientific Committee's Standing Working Group on the Development of an Aboriginal Whaling Management Procedure, Greg Donovan (hereafter Chair of the SWG), reported on the Scientific Committee's work in this regard. Last year, he had informed the Sub-committee that the Scientific Committee expected to be able to recommend a *Strike Limit Algorithm* (*SLA*) for eastern North Pacific gray whales to the Commission at the present meeting. This will be the second *SLA* that the Scientific Committee has recommended in the development process. Because the Committee were making a major recommendation, the Chair of the SWG gave a thorough presentation of the work of the Committee on this issue over the whole development process. The full presentation is available upon request to interested delegations as an electronic file or as a printout of the slides used. He also noted that as in previous years, he is happy to discuss any issues raised with interested parties. What follows is a very short summary of the key points made in the presentation. Full details of the Scientific Committee's work can be found in IWC/56/Rep 1, Item 8 and Annex E.

The Scientific Committee began addressing aboriginal subsistence management procedures in the early 1990s after completion of the RMP. In 1994, the Commission formally instructed the Scientific Committee to work on the development of an aboriginal whaling management procedure (Resolution 1994–4). The Commission had reiterated the objectives of such a scheme as to:

(1) ensure risks of extinction are not seriously increased (highest priority);
(2) enable harvests in perpetuity appropriate to cultural and nutritional requirements; and
(3) maintain stocks at highest net recruitment level and if below that ensure they move towards it.

The advantages (to both the management body and the users) of a management procedure over '*ad hoc*' management were stressed, as was the value of computer simulations to try out potential candidate procedures. The simulation trial structure is designed to test procedures against the inevitable uncertainty in scientific knowledge about the whales and their environment.

The Commission agreed in 1998 that the eventual aboriginal whaling scheme (which includes both the scientific and non-scientific aspects of management) would include both generic and case-specific elements. In particular, it was agreed that *SLA*s (the way in which the need requests forwarded by the Commission to the Scientific Committee are evaluated to determine whether they are acceptable from the point of view of the risk-related objectives given above - it is assumed for the purposes of trials that all strikes result in death) could be case-specific and introduced to the AWS as they became available. The Scientific Committee had agreed that it would proceed with the data-rich fisheries first, i.e. the bowhead and gray whale hunts. In 2002 it proposed the *Bowhead SLA*. Throughout the process, the Scientific Committee placed great emphasis on feedback from the Commission and hunters via the Commission's Aboriginal Whaling Sub-committee, and each year the Chair of the SWG has made a detailed presentation of the development process, requested advice on various matters and been available for consultation with interested delegations and individuals.

The candidate procedures for the gray whale case were tested for a broad range of uncertainty in a variety of factors, including: changes in *MSYR* and *MSYL*; model uncertainty; time dependent changes in carrying capacity, natural mortality and productivity; episodic events; stochasticity; survey bias and variability; survey frequency and errors in the historic catch series. The overall performance of candidate *SLA*s was judged by a combination of an examination of the detailed conservation and need satisfaction statistics for each of the *Evaluation Trials* and *Robustness Trials* and human integration of these results in the context of the relative plausibility each member assigns to the individual trials.

Two procedures performed equally well in the trials, one was the J-B2 and the other was the GUP2[1] based on J-B2 and D-M2 procedures. The Scientific Committee therefore had examined other features that may be used to separate the two *SLA*s. Recalling the discussions about the value or otherwise of the 'unified' (averaging) approach when recommending the *Bowhead SLA*, the Committee noted that the GUP approach includes a built-in check and balance system in that if one of the component *SLA*s behaves poorly for a particular scenario, this effect may be balanced by the other *SLA* and vice versa. Averaging has also been recommended by MCDM[2] experts as an appropriate method. It again followed this philosophical approach and agreed that the GUP2 *SLA* fully met the Commission's management objectives. It also noted that it might be possible to 'polish' the GUP2 *SLA* and its two constituent *SLA*s further. However, the Committee agreed that it should not expend resources unnecessarily in further attempting to achieve some hypothetical level of 'perfection'. It strongly believed that these resources should be dedicated to addressing the serious issue of the Greenland fisheries for fin and minke whales, for which the Committee has never been able to provide management advice.

In conclusion, the Scientific Committee unanimously recommended that the GUP2 *SLA* (hereafter the '*Gray whale SLA*') be forwarded to the Commission. It believes that this *SLA* meets the objectives of the Commission set out in 1994 (IWC, 1995) and represents the best scientific advice that the Committee can offer the Commission with respect to the management of the Eastern North Pacific stock of gray whales.

In making this recommendation, the Scientific Committee noted the integral importance of *Implementation Reviews* to the whole process. Regular *Implementation Reviews* would occur every five years and normally involve at least reviews of information:

(1) required for the *SLA* (i.e. catch data, abundance estimates); and
(2) to ascertain if the present situation is as expected and within tested parameter space.

In addition, to enable swift reaction to new information that gives rise to serious concern, *Unscheduled Implementation Reviews* can be called. He provided a number of examples as to possible 'triggers' for such early reviews. There are a variety of possible outcomes of *Implementation Reviews*, including:

(a) the continuation of use of the *SLA*;
(b) the setting of a zero strike limit;
(c) the running of further simulation trials;
(d) the undertaking of a new census immediately; or
(e) a combination of some of the above.

The Chair of the SWG thanked Eva Dereksdóttir, Kjartan Magnússon, Sue Holloway (neé Johnston) and Doug Butterworth (incidentally all Invited Participants) for the enormous amount of work and thought they had put into the development process. He also specifically thanked Cherry Allison and André Punt for the tremendous support they provided. He noted that this was the second *SLA* that had been developed by the SWG under the auspices of the Scientific Committee and he thanked them as a whole for the atmosphere of co-operation was always been present, even when there are genuine scientific differences of opinion at the various stages of the development process. He believed that a continuation of this mode of working will be essential if the SWG is to address successfully the most difficult case it has faced, that of the Greenland fisheries.

DISCUSSION AND RECOMMENDATIONS

In response to a question from Sweden about what might happen if no surveys occur for longer than a 10-year period, the Chair of the SWG referred to the discussions on the AWS that had been presented two years ago and are available in *Ann. Rep. Int. Whal. Commn*. 2002: 74-75. In summary, the 'grace period' process would be evoked whereby, unless an agreed abundance estimate was forthcoming, then the block limit for the following block would be half that for the present block, after which it would revert to zero. In response to a question from the UK about the appropriateness of the GUP2 approach, the Chair of the SWG reiterated that, as in the case of the *Bowhead SLA*, the Scientific Committee noted that from an MCDM perspective the *Gray Whale SLA* is a perfectly valid approach and it noted the benefits of the inbuilt check-balance by merging two quite different procedures.

In conclusion the Sub-committee endorsed the report and recommendations of the Scientific Committee.

3.1.1.2 GREENLANDIC FISHERIES (IWC/56/REP 1, ITEMS 8.3, 8.4)

The Chair of the SWG reminded the meeting that an urgent need for a Greenland Research Programme had been first identified in 1998. This is primarily due to the lack of recent abundance estimates and the poor knowledge of stock structure. It will be extremely difficult, if not impossible, to develop an *SLA* for the Greenlandic fisheries that will satisfy all of the Commission's objectives without such information. This is particularly important in the light of the Scientific Committee's grave concern at its inability to provide management advice for these fisheries.

He separated out this item into four main issues: stock structure; abundance estimates; biological data and *SLA* development. With respect to the former, the problem was that although the available information suggested that the animals found off West Greenland did not comprise either separate fin or common minke whale stocks, the identity and size of the complete stocks is unknown. The Committee has agreed to follow a two-step process to further the essential work needed to provide information suitable for management; namely an initial simulation study to focus appropriate genetic analyses.

[1] Grand Unified Procedure.
[2] Multiple criteria decision-making.

In this regard, he noted that the Scientific Committee has previously strongly recommended that genetic samples be taken for all of the catch. However, the numbers for 2003 were very low (12 minke whale and 1 fin whale), even though it is mandatory under local regulations to return a sample from each whale that is caught. The Committee expressed disappointment at the lack of progress in obtaining genetic samples, although it noted new procedures were in place. It repeated its strong recommendation that samples for genetic analysis be collected from the catch as a matter of very high priority. It urged the Commission to encourage the Government of Denmark and the Greenland Home Rule authorities to assist with logistical and, if necessary, financial support. Finally, it encourages Greenlandic scientists to investigate other potential sources of samples. It also welcomed the news that some 50 samples are available from the eastern USA and Canada and it urged that these be analysed.

With respect to abundance estimates, the Chair of the SWG noted that, last year, the Committee had strongly recommended that a traditional aerial cue-counting survey be carried out in summer 2003 in Greenland. For logistical and financial reasons it had not been possible to undertake such a survey, but some valuable experimental work had been carried out in 2003 that had been fully discussed. Greenlandic scientists presented a plan for a full aerial photographic (not cue-counting) survey this summer. The Committee had noted the great need for new abundance estimates and, in order to facilitate presentation of appropriate analyses as quickly as possible, had established an intersessional advisory group. The Chair of the SWG noted that the difficult environmental conditions (notably fog and high winds) in Greenland made the undertaking of successful surveys problematic.

The catch data for 2003 were: 6 landed fin whales (2M and 4F), with 3 struck and lost; 178 landed West Greenland common minke whales (58M, 117F, 3 unknown sex) and 7 struck and lost; and 13 landed East Greenland common minke whales (1M, 11F, and 1 unknown sex). An analysis of recent catch data will be provided to the next Committee meeting.

In terms of developing an *SLA*, the Chair of the SWG was pleased to report that three papers, albeit preliminary, had been presented and that these will help to provide a framework for future work. The differences between the relatively 'easy' data-rich cases of the bowhead and gray whales and the data-poor Greenlandic cases, may warrant a different approach to the examination of the trade-off between risk and need satisfaction and the Committee will develop such a statistic to add to the list of those it normally considers. The issues will be considered in depth at the next SWG meeting.

The SWG had also considered how best to proceed with the development of one or more *SLA*s for Greenlandic aboriginal whaling, given the continuing uncertainties about stock structure, abundance, and mixing in the region. One approach would be to postpone *SLA* development until more and better data become available. The SWG rejected this approach, instead believing that *SLA* development was a matter of considerable urgency. The SWG intended to develop the best *SLA*(s) it could given the data available, and noting the potential of the simulation approach to help identify appropriate data collection programmes, it recognised that it might become necessary to improve the *SLA*(s) at future *Implementation Reviews* when more information is available. The Committee had endorsed this approach. The Chair of the SWG advised that issues related to management advice would be presented under later Agenda Items (4.3 and 4.4).

3.1.2 Discussion and Recommendations

After this exchange of views, the Chair summarised that the Sub-committee endorsed all recommendations of the Scientific Committee on these items.

New Zealand stated that what has occurred with regard to data provision by Greenland is unsatisfactory. New Zealand suggested that the Commission has an obligation to probe what has caused this situation and what can be done about it. The annual take of fin and minke whales has created serious difficulties, and Scientific Committee has been unable to provide scientific advice. Despite the Scientific Committee's efforts, very little has been achieved to improve the knowledge of the Greenland stocks. New Zealand was concerned that this year, Greenland reported to the Scientific Committee that they had only provided one genetic sample from six fin whales taken. New Zealand questioned whether it is now time to impose restrictions on the catch quota for Greenland. They then asked Denmark what explanations they had and how they intended to remedy this situation, which given the Scientific Committee advice, is a very urgent one.

Denmark responded that information on the importance of returning samples has been given to the hunters. Only one sample from a fin whale, and 12 from minke whales have been returned in 2003. The Home Rule Government regrets the low number of samples collected. For the 2004 season, letters and phials have been sent to the municipalities, and when issuing licenses, the municipal officers hand out phials to the hunters. The Home Rule Government also works to improve the collection of samples in cooperation with the hunters association and by making a press release, so that the information is conveyed. The UK expressed its concern with this response. The UK recognised that the policing of the hunt was difficult, but stated that the conditions under which ASW is enabled to take place in Greenland are known to the hunters, and were included in licences. The UK felt that non-compliance with conditions required more than a slap on the wrist.

3.2 Aboriginal Whaling Scheme (AWS)

3.2.1 Report of the Scientific Committee (IWC/56/Rep 1, Item 8.2.6)

The Chair of the SWG noted that at the 2002 meeting, the Committee had developed generic scientific aspects of an aboriginal whaling management scheme that would be used in conjunction with the case specific *SLA*s. (These had been reported in detail to this Sub-committee but no agreement had been reached on these by the Commission.) This year, as last, the Committee again recommends these to the Commission. They are specified in *Ann. Rep. Int. Whal. Commn*. 2002: 74-75. The Chair of the SWG will be happy to spend time explaining these further with interested delegations at any time.

3.2.2 Discussion and recommendations

Australia recognised that the focus of discussion was on science, but sought to register its concern over whaling management regimes. This Sub-committee should give equal attention to management considerations as to the scientific considerations. The USA stated that they have previously expressed concerns over certain provisions of the AWS and that their reservations should continue to be noted.

After this exchange of views, the Sub-committee endorsed the recommendations of the Scientific Committee on these items.

4. ABORIGINAL SUBSISTENCE WHALING CATCH LIMITS

4.1 Bering-Chukchi-Beaufort (B-C-B) Seas stock of bowhead whales

4.1.1 Report of the Scientific Committee (IWC/56/Rep 1, Item 9.1)

The Chair of the SWG noted that this year, the Scientific Committee had undertaken an in-depth assessment of the B-C-B bowhead whales. Considerable focus had been given to the question of stock structure and a number of papers were presented that were facilitated by the provision of data under the Committee's new data availability agreement. The Committee agreed that substantial progress has been made in investigating possible stock or population structure among B-C-B bowheads but that there is insufficient information at this stage to fully support or fully refute the hypothesis of a single stock; in fact it is premature to reject any of the hypotheses, or even to draw conclusions about their relative plausibility. The Committee was pleased to receive information on an extensive research programme to address this issue further.

The Scientific Committee also received information on traditional assessment methods, not to provide management advice *per se* but as a way of examining whether 'reality' was still within the parameter space tested in the trial structure of the *Bowhead SLA*. It was noted that stock structure issues applied equally to these methods as to the use of the *Bowhead SLA*.

Catch information was provided for 2003 by the USA: a total of 41 bowhead whales were struck resulting in 35 animals landed. The efficiency (the ratio of the number landed to the number struck) of the hunt was 85%, which is higher than the average efficiency over the past 10 years (77%). Of the 35 landed whales, 17 were females and the sex was not determined for one whale. Of the 17 females, 5 were presumably mature (>13.4m in length). Three of these large females were closely examined; two had recently given birth and the other was not pregnant.

In addition, there was a Russian harvest of three male bowhead whales in Chukotka waters.

In terms of management advice, the Scientific Committee agreed that the future *Implementation Review* of bowhead whales will include stock structure issues as a major component. This *Implementation Review* will examine the robustness of the *Bowhead SLA* with respect to plausible stock hypotheses via simulation trials. If shown to be necessary, this may result in changes to the *Bowhead SLA*. Such an *Implementation Review* will begin at the 2006 Annual Meeting, with a view to ensuring that management advice at the 2007 meeting is based on the best science then available. The Committee also recommended that a report on the progress of the research programme should be provided each year to the Scientific Committee and it encourages cooperative research amongst the various interested research groups.

The Scientific Committee also noted:

(1) the continuing increase in the abundance estimates derived from the census under the recent catch limits and record high calf counts;
(2) the spatio-temporal distribution and opportunistic nature of the hunt and the low numbers of whales struck annually in St. Lawrence Island and Chukotka; and
(3) the development of an extensive research programme that will address questions of stock structure and allow the formulation of one or more plausible stock structure hypotheses.

Given these factors, the Committee agreed that the *Bowhead SLA* remains the most appropriate tool for providing management advice for this harvest, at least in the short-term, and consequently the results from the *Bowhead SLA* (see IWC/56/Rep 1, Item 9.1.4) indicate that no change is needed to the current block quota for 2003-2007.

4.1.2 Discussion and recommendation

The USA noted the collaborative efforts of US scientists with scientists of other countries, particularly Russia, Norway and Japan. They also noted the recommendation of the Scientific Committee on the need for additional research on the bowhead stock identity issue. The USA is committed to undertaking this research so that by 2007, when the bowhead quota is next reviewed, its management will be based upon the best science available at that time.

Japan asked the USA if it could provide Japan with the baleen plates of bowhead whales caught by the Alaskan hunters. In response, the USA agreed to discuss this issue with Japan outside of the Sub-committee. The Russian Federation stated that during this IWC meeting the USA and Russia intend to sign a Memorandum of Understanding and also intend to start work in 2004 on genetic research, as well as biological research. Russia intends to engage in as much joint research as is possible, although it noted that CITES requirements may impose difficulties on what is possible. Switzerland drew the attention of the Sub-committee to the fact that at COP 12 of CITES in Santiago (Chile), a resolution was adopted aiming at facilitating transboundary movement of sensitive biological samples such as scientific research materials for conservation purposes, and that the CITES Management Authorities should be made aware of IWC transboundary issues if the need arises.

After this exchange of views, the Sub-committee endorsed the recommendations of the Scientific Committee on these items.

4.2 North Pacific Eastern stock of gray whales

4.2.1 Report of the Scientific Committee (IWC/56/Rep 1, Item 9.2)

Twenty-two Chukotka aboriginal whaling organisations submitted requests for harvesting a total of 167 gray whales. However, according to permit regulations of the Russian Federation Ministry of Natural Resources, only 135 permits for gray whales were distributed among aboriginal whaling organisations and native settlements. A total of 126 gray whales (70 males and 56 females) were taken in 2003 and two gray whales were struck and lost.

New information on calf counts from the northbound migration and the breeding lagoons in Mexico was presented. The Committee was encouraged to hear that calf production remains at the mid-range of pre-1999 levels (after low levels in 1999, 2000, 2001). In 2002, the Scientific Committee had carried out an in-depth assessment of the Eastern North Pacific stock of gray whales and agreed that a take of up to 463 whales per year is sustainable for at least the medium term (~30 years), and is likely to allow the population to remain above *MSYL*. No information was presented this year to change that advice. The Committee was also pleased to receive the *Gray Whale SLA*, noting that this now represents its best look for providing management advice.

4.2.2 Discussion and recommendations

There was no discussion on this item. The Sub-committee endorsed the recommendations of the Scientific Committee.

4.3 and 4.4 Minke whale stocks and West Greenland stocks of fin whales off Greenland

4.3.1 and 4.4.1 Report of the Scientific Committee (*IWC/56/Rep 1, Item 8.5*)

The Chair of the SWG reported that this was an important issue in the Scientific Committee's deliberations this year. As it has stated on many occasions, the Committee has never been able to provide satisfactory management advice for either the fin or minke whales off Greenland. This reflects the lack of data on stock structure and abundance and is the reason for the Committee to first call for the Greenland Research Programme in 1998. He noted that the Commission's financial contributions to the programme had been aimed at testing the feasibility of large-scale biopsy sampling and satellite telemetry in order to try to obtain information on both abundance and stock structure. Unfortunately, for a number of reasons, these both proved unsuccessful. He clarified that the Commission's funds had not been used towards aerial surveys, noting that these are considerably more expensive than the Commission normally provides funds for.

The Scientific Committee stressed that its inability to provide any advice on safe catch limits is a matter of great concern, particularly in the case of fin whales where the best available abundance estimate dates from 1987/88 and is only 1,096 (95% CI 520-2,100). That for West Greenland minke whales dates from 1993 and is 8,371 (95% CI 2,400 – 16,900).

Obtaining adequate information for management must be seen as of very high priority by both the national authorities and the Commission. The Committee urged the Commission to encourage the Government of Denmark and the Greenland Home Rule authorities to provide the necessary logistical and financial support. Without such adequate information, the Committee will not be able to provide safe management advice in accord with the Commission's management objectives, or develop a reliable *SLA* for many years, with potentially serious consequences for the status of the stocks.

The Scientific Committee recommended that every effort be made to ensure that the number of samples collected from the catch in 2004 will be very considerably higher than in 2003 and close to 100%. It also strongly recommended that these and all existing samples held in Greenland be analysed as soon as possible in accordance with guidance to be given by the intersessional working group.

The Scientific Committee drew attention to the grace-period provision that it had agreed previously in the context of a general aboriginal whaling scheme (although it has not yet been accepted by the Commission) associated with agreed *SLA*s. As shown in IWC/54/5 Appendix 4, under such a provision, catch limits would begin to be phased out 10-14 years after an abundance estimate was last obtained and catches would revert to zero at the end of the five-year period during which the catch limit would have been half the previous block. The Committee has not previously suggested that such a grace-period should have started for fin whales. However, it drew attention to the fact that if it had, such a period would now be nearing completion.

It is with great concern that the Scientific Committee advised the Commission that in the absence of an agreed abundance estimate for fin whales arising out of the 2004 survey, it will likely recommend immediately that the take of fin whales off West Greenland be reduced or eliminated. If, as hoped, an abundance estimate is obtained, the Committee will review this next year in its formulation of management advice.

4.3.2 and 4.4.2 Discussion and recommendations

The Chair summarised that the situation is serious especially for fin whales, and that a reduction of the quota might be considered.

With regard to the financial questions, Denmark explained that the Home Rule Government has given financial support for survey projects between DKK 1.2-1.4 million annually for the years 2002-2004. Between 1998-2003, a total of 301 samples have been collected making it about 50 per year. 166 samples have been analysed in 2003. There are 200 samples in the freezers to be analysed. Results from the samples have been published in the *Marine Ecology Progress Series*. There has been disappointingly little discussion of these results in the SWG, but Greenland hopes to receive some guidance from the SWG on the best directions for future analyses. Greenland is therefore looking forward to a project to be undertaken this winter, in cooperation with the SWG. A simulation study of possible connections between minke whale stocks will provide guidelines that will guide the analysis of the samples in the freezers and the coming samples. On the question of reduction of the current quota of fin whales, Greenland suggested that the Scientific Committee is not the right body to decide such a reduction. Greenland suggested it would be strange if quotas would be reduced due to bad weather this August and expressed their hope that the weather was with them in August. In conclusion, the Greenland Home Rule Government stated that it intended to increase its efforts to gain more samples as recommended in cooperation with the hunters organisation. The UK noted Denmark's remarks with interest but stated that this was not the first time this problem had arisen. The Scientific Committee recommendations were in the strongest terms the UK had seen. The UK felt that the Commission would need to agree to take action on the quota if data were not made available. Australia concurred with the UK in noting that the Scientific Committee wording was unprecedented, and suggested that the Scientific Committee concerns should be reinforced by this Sub-Committee.

Argentina expressed concern because the sex ratio of the Greenland's minke hunt is highly female biased: on average, 72% of all minke whales killed in Greenland since 1986 were female. Argentina asked Greenland why it believes the bias occurs and what might be the solution to this problem? Denmark answered that this kind of question has been raised before. Nevertheless, they explained again that sex selection is impossible to enforce in Greenland due to both weather and ocean conditions.

New Zealand questioned whether the answer given by Denmark was sufficient. They noted that the information given showed a high female sex bias (72% for all minke whales caught in Greenland and 92% for East Greenland minke whales since 1996). New Zealand was concerned that the preferential removal of females could significantly affect the regenerative capacity of the stock. It would be helpful for Greenland to provide information on the date, location and sex of every whale taken, to show precisely what is going on. These issues raise fundamental questions of accountability that go to the centre of the integrity of the legal instrument under which the Commission operates. The time for accountability has arrived.

Germany stated that more information about what was going on was required, and were appreciative that this matter will be followed up next year. They also appreciated the strong recommendations given by the Scientific Committee relating to the failure of abundance estimates. Germany suggested that this is clearly a matter which the Commission has to follow up on.

The UK expressed its concern about sex bias, and remarked that if a degree of sex bias was inevitable, it raised some very important questions about the sustainability of the hunt. Switzerland agreed with the UK, suggesting that if the harvest is overtly biased on females, questions of sustainability must arise.

With respect to the female bias in the catch, the Chair of the SWG clarified that it is common for minke whales to segregate both geographically and temporally by sex in the North Atlantic. The sex bias in the catch is longstanding and earlier attempts to model the animals off West Greenland showed that if the minke whales found there comprised a complete stock they would already have become extinct. The sex bias in the catch probably reflects the sex ratio in the waters there and not any selectivity by whalers (which in any case is not possible). He noted that the Committee was expecting a paper on recent catches (both geographical and temporal by sex) at its next meeting.

Greenland explained that the information on the seasonal distribution of the harvest suggests northward movement in early part of hunting season and a southern movement in the autumn, so that the hunting season, which is in any case short, is even shorter in the northern part of the area of distribution of minke whales in West Greenland. Analysis has not so far shown differential distribution of the two sexes. They suggested that knowledge of this bias is long standing and not recent. This bias suggests that this is probably a part of a larger stock, whose boundaries are uncertain.

After this exchange of views, the Sub-Committee endorsed the recommendations of the Scientific Committee on these items.

4.5 North Atlantic humpback whales off St. Vincent and The Grenadines

4.5.1 Report of the Scientific Committee (IWC/56/Rep 1, Item 8.6)

The Chair of the SWG reported that in recent years, the Scientific Committee has examined the stock structure of humpback whales in the North Atlantic. It is most plausible that the animals from St. Vincent and the Grenadines are part of the West Indies breeding population (ca. 10,750 in 1992). However, further data to confirm this are desirable and the Committee repeated previous recommendations that every effort be made to obtain photographs and genetic samples from St. Vincent and the Grenadines. The Scientific Committee was disappointed not to receive information on whether or not any catches had been taken last year. There were no scientists from St. Vincent and the Grenadines present at the meeting and no national progress report had been submitted. However, it noted that the genetic analyses of at least three samples from caught animals is being conducted. It was also pleased to hear that sightings cruises are taking place in the region and looked forward to receiving a report in the future.

The Commission has adopted a total block catch limit of 20 for the period 2003-2007. The Scientific Committee agreed that if the humpback whales are part of the West Indies breeding population, this catch limit will not harm the stock.

4.5.2 Discussion and recommendations

The UK did not dispute the Scientific Committee recommendations, but urged the need for further data. The UK suggested that if not identified as part of the West Indies stock, there could be ramifications on the stock. Australia understood that St. Vincent and the Grenadines passed new whaling regulations in December 2003, and asked whether a copy of this legislation had been submitted to the Secretariat as is required, and whether it had been found to be consistent with the draft legislation presented to the IWC. The Chair of the SWG indicated that this matter was usually dealt within in the Infractions Sub-committee, but he would investigate this situation. The Chair noted that St. Vincent and the Grenadines were not present.

5. SCHEDULE PARAGRAPH 13

The Chair drew attention to Document IWC/56/4 and asked the Russian Federation to introduce the item. The Russian Federation explained that at IWC/55 in Berlin last year, they had drawn attention to what it considered anomalies in the way that the Chukotka peoples are treated compared with other aboriginal groups and proposed changes to the Schedule to address these inconsistencies. However, after discussions within the Aboriginal Subsistence Whaling Sub-committee and in the Commission, the Russian Federation agreed to withdraw its proposed Schedule amendments and to work intersessionally on this issue. To this end, the Commission agreed that a small group (comprising of the Russian Federation, Denmark, Australia and the USA, working with the Secretariat) should work intersessionally by email to review Schedule paragraph 13 to determine how consistency in approach to ASW operations could be achieved and to propose a Schedule amendment for review and decision-making at IWC/56. A report from this group, together with proposed Schedule revisions is available as IWC/56/4.

The SWG agreed that all the provisions governing aboriginal subsistence whaling operations are understood to be, and should be, included in paragraph 13 of the Schedule. Should the Commission decide to harmonise the ASW Schedule language, the group recommends considering the creation of one option concerning the prohibition on the taking of calves and whales accompanied by calves. A new sub-paragraph could be inserted in the general principles governing this form of whaling to read as follows:

> '13. (a) (4) It is forbidden to strike, take or kill calves or any whale accompanied by a calf.'

The Small Group agreed that nothing in the Russian Federation's proposal to amend Schedule paragraph 13 was intended to allow for commercialisation of aboriginal subsistence whaling. The native peoples never harvested whales for commerce. The native peoples use the predominant portion of the products for their own needs and only an insignificant part is exchanged or used for transactions with other communities.

The words 'when the meat and products of such whales are to be used exclusively for local consumption' in sub-paragraphs 13(b)1, 13(b)2, 13(b)3 and 13(b)4 means that some transaction beyond the aboriginal whaling communities under the current Schedule language are acceptable. The definition of aboriginal 'subsistence use' was adopted by the Cultural Anthropology panel of the IWC Meeting of Experts on Aboriginal/Subsistence Whaling in February 1979 (IWC Special Issue 4, 1982) and provided that:

(1) the personal consumption of whale products for food, fuel, shelter, clothing, tools or transportation by participants in the whale harvest;
(2) the barter, trade or sharing of whale products in their harvested form with relatives of the participants in the harvest, with others in the local community or with persons in locations other than the local community with whom local residents share familial, social, cultural or economic ties. A generalised currency is involved in this barter and trade, by the predominant portion of the products from such whales are ordinarily directly consumed or utilised in their harvested form within the local community; and
(3) the making and selling of handicraft articles from whale products, when the whale is harvested for the purposes defined in (1) and (2) above.

The Russian Federation indicated that the words '…the aborigines whose traditional aboriginal subsistence and cultural needs have been recognised,' in sub-paragraph 13(b)(2) is not related to the right of native peoples in taking gray whales, but, rather, to the right of native peoples in using harvested gray whales. These kind of limitations in the use of meat and products of whales do not exist in the other sub-paragraphs of Paragraph 13. A representative of the Chukotka native peoples explained that the existing condition leads to paradoxical situations where in different villages, even in the same village, and even for the same person, people have different rights in using legally harvested gray and bowhead whales. This situation violates human rights and discriminates against native peoples of Chukotka.

It was agreed by the Small Group that aboriginal communities in Chukotka, which have a quota to take gray whales and bowhead whales, have equal rights to other aboriginal communities that have Aboriginal Subsistence Whaling quotas to use the meat and products of these whale species.

The Small Group noted that the proposal to delete the words – 'whose traditional aboriginal subsistence and cultural needs have been recognised' – from Schedule sub-paragraph 13(b)(2) was intended to reflect this equality of rights.

The Russian Federation noted that any limitations of human rights of entire peoples, especially minority native peoples, are an extremely delicate question, with great ethical and political implications. In relation to these issues, the Russian Federation asked the delegations of Contracting Governments to be politically correct in their discussion, and expressed a preference that the ASW Sub–committee recommend that the Commission include an item on its agenda to adopt the Report of the Small Group and adopt the proposal to amend the Schedule paragraph 13 by consensus.

5.1 Discussion and recommendations

The Chair summarised that the proposal suggests a new Para 13(a)4, a deletion of the relevant sentences in Para 13(b) as well as the deletion of the phrase 'whose traditional aboriginal subsistence and cultural needs have been recognised'.

The USA thanked the Russian Federation for their leadership of the small group. They noted that although the group represented different views, they had reached consensus on the report, and encouraged the Sub-Committee to accept the report in the same spirit. The UK congratulated the Small Group on its work. Although the UK generally had no difficulty with the report it was uneasy about the suggested solution. The UK fully accepted that the rights of Chukotka people should be exactly the same as other indigenous peoples, regardless of the whales taken, but stressed the obligation to ensure that for ASW operations the products are in large measure, or totally, used for the people whose needs have been acknowledged. As such, the UK would be inclined to delete the 'objectionable' part from the end of the paragraph, and put it at the top of the section, so as to apply equally to all indigenous whaling operations. Australia emphasised the need for the Russian Federation to explain to the Commission precisely how the current Schedule provisions discriminate against the native peoples of Chukotka in practice. Australia also pointed out that recommending adoption of the report, is not the same as accepting the Schedule amendments.

Grenada expressed support for the proposal by the Russian Federation in as much as it is aimed at producing a more uniform code for ASW, thereby qualifying equality and respecting human rights for each of the four ASW operations. However, with regard to the stated aim of providing equality of rights the wording of the proposed Amendment of the paragraph 13 of the Schedule, Grenada wondered why only St. Vincent and the Grenadines of the four ASW operations is required to conduct whaling according to national legislation. Does this mean that the other three ASW schemes are not required to follow national laws? The Chair of the SWG replied that it was his understanding that all nations have to enact national laws, in accordance with the Convention. Grenada then stated that in the interests of uniformity, fairness and human rights either the sentence singling out of St. Vincent and the Grenadines should be deleted, or the requirement to whale according to national legislation should be inserted into the appropriate subsections of paragraph 13 (b)(1),(2) and (3) for each of the four ASW schemes.

Austria raised a question of clarification on the striking of the phrase 'whose traditional aboriginal subsistence and cultural needs have been recognised.' Whilst it may be correct to strike that here, where does this sentiment remain anchored in the International Convention for the Regulation of Whaling (ICRW)? Does striking it mean that all future, new applications for aboriginal quotas no longer need to demonstrate that they fulfil these criteria? New Zealand agreed with Austria and felt that Russia had made a compelling case, and that Russia ought not to be subject to the problems outlined here. The issue, however, is whether the current proposed drafting will provide the required results. New Zealand suggested that a possible solution would be to place the phrase on the recognition of need at the top of paragraph 13, as an over-riding principle for all IWC-approved ASW operations. New Zealand stated that the recognition of cultural need was at the heart of the aboriginal whaling, and that the language that it was proposed to delete had been included as a result of the Makah quota request and was needlessly confused by the allocation of a block quota.

The USA responded to the intervention from the UK by stating that the phrase in question is not necessary, and the position of the USA is that the Commission itself recognizes needs when it approves a quota request. The USA noted, in response to the intervention by New Zealand, that the Commission recognised the needs of the Makah Tribe in both 1997 and 2002 when it approved requests for quotas put forth on their behalf.

The Republic of Guinea expressed their support for the Russian Federation's proposal. Australia explained that it was their understanding that appropriate tests of need should continue be applied. Japan stated that it could support the sentiments contained in the proposal but had some questions on it. The first question was why the proposed 13(a)(4) states 'any whale accompanied by a calf'. It should, in the Japan's view, be 'female' whale. The second question was how to define the cultural needs. It stated that Japan has long-standing cultural needs for whales dating back to 9,000 BC and that those needs had been satisfied through commercial whaling and are being satisfied to some extend by the byproducts from research whaling activities which is perfectly legal under the ICRW. Australia noted the fine balance of this report, and the need to treat this matter with some delicacy. Australia suggested that the proposals by Japan could upset this balance. Benin expressed their support for the Russian Federation and invited the Committee to review the proposals of the Russian Federation.

The Chair concluded that the Sub-Committee takes note of the report IWC/56/4 and records that the issue had not been fully resolved. She reminded the Sub-Committee that the Russian Federation's new proposal is a Schedule Amendment and has to be officially proposed in the Plenary to be either adopted by consensus or, if this is not possible, a three quarters majority vote.

The Russian Federation did not agree with the Chair's conclusion and qualified that the issue was resolved in the Sub-Committee.

The Small Group recommended that the report and the proposal to amend the Schedule be put forward to the Plenary. The Sub-Committee supported this recommendation.

While there may not have been consensus in the Sub-Committee, the Russian Federation pointed out that based on the interventions there seemed to be agreement that there exists a problem of unequal rights among native people and that this problem should be resolved. The Russian Federation noted that since this is an aboriginal subsistence issue it should be resolved by consensus and that no one should provoke voting on an aboriginal question. The UK stated that it had not proposed the additional sentence(s), merely that between now and Plenary, it would need to reflect on whether they were necessary or not.

Australia pointed out that despite these discussions, there is no disagreement with the report. Australia further noted that no alternative text has been put forward for the report itself. Nonetheless, it was still an open question whether members should support a Schedule amendment text.

Japan raised the question why St. Vincent and the Grenadines were not represented on the Small Working Group. Australia explained this was because it was a small volunteer group, and St. Vincent and the Grenadines had not volunteered.

The Chair repeated that the issue will have to be brought forward to the Plenary and recommended that the respective countries meet to discuss some of the proposed modifications before the Plenary.

6. OTHER MATTERS

There were no other matters raised.

The Chair thanked the Sub-committee for its constructive and efficient work.

7. ADOPTION OF REPORT

The Report was adopted at 17:00 on Friday 16 July 2004 by correspondence.

Appendix 1

LIST OF PARTICIPANTS

Antigua & Barbuda
Anthony Liverpool

Argentina
Miguel Iñiguez

Australia
Conall O'Connell
Stephen Powell
Nicola Beynon
Pam Eiser

Austria
Andrea Nouak
Michael Stachowitsch

Belgium
Koen Van Waerebeek
Alexandre de Lichtervelde

Benin
Bantole Yaba
Sogan Simplice

Brazil
Regis De Pinto Lima
Jose Truda Palazzo Jr.
Marcia Engel

Denmark
Amalie Jessen
Leif Fontaine
Michael Kingsley
Kim Mathiasen
Ole Samsing
Ole Heinrich
Maj F. Munk

Dominica
Andrew Magloire
Lloyd Pascal

Finland
Esko Jaakkola

France
Vincent Ridoux

Germany
Peter Bradhering
Karl-Herman Kock
Marlies Reimann

Grenada
Frank Hester
Justin Rennie

Republic of Guinea
Amadou Telivel Diallo
Sidiki Diane

Iceland
Stefan Asmundsson
Ragnar Baldursson
Asta Einarsdottir

Italy
Rosa Caggiano
Riccardo Rigillo

Japan
Mutsuo Goto
Hiroshi Hatanaka
Yasuo Iino
Hidehiro Kato
Chikao Kimura
Masayuki Komatsu
Akihiro Mae
Minoru Morimoto
Joji Morishita
Shuya Nakatsuka
Kayo Ohmagari
Seiji Ohsumi
Akiko Tomita

Republic of Korea
Chang Myeng Byen
Zang Geun Kim
Oh Seuyng Kwon
Sung Kwon Soh

Mexico
Exequiel Ezcurra Read de Azua
Lorenzo Rojas Bracho

Netherlands
Henk Eggink
Anne-Marie van der Heijden

New Zealand
Simon Childerhouse
Mike Donoghue
Al Gillespie
Geoffrey Palmer
Nigel Fyfe

Norway
Bengt Johansen
Halvard Johansen
Turid Eusebio
Egil Øen
Lars Walløe
Hild Ynnesdal
Jan Skjervø

Panama
Epimenides M. Diaz

Russian Federation
Valentin Ilyashenko
Rudolf Borodin
Inankeuyas Gennady
Olga Gogoleva
Olga Ipatova
Valery Knyazev
Ivan Slugin
John Tichotsky

St. Lucia
Vaughn Charles

Solomon Islands
Sylvester Diake
Paul Maenu

South Africa
Herman Oosthuizen
Horst Kleinschmidt

Spain
Santiago Lens
Carmen Asencio

Switzerland
Tom Althaus

UK
Richard Cowan
Geoff Jasinski
Laurence Kell
Jenny Lonsdale
Trevor Perfect
Mark Simmonds

USA
Nancy Azzam
Roger Eckert
Robert Brownell
Keith Johnson
Nathan Pamplin
Jean Pierre Plé
Gary Rankel
Rolland Schmitten
Dave Sones
Michael Tillman
Chris Yates
Brad Smith
Thomas Napageak
George Ahmaogak

Chair of Scientific Committee
Doug DeMaster

Secretariat
Nicky Grandy
Greg Donovan

Appendix 2

AGENDA

1. Introductory items
   - 1.1 Appointment of Chair
   - 1.2 Appointment of Rapporteur
   - 1.3 Review of documents
2. Adoption of the Agenda
3. Aboriginal Subsistence Whaling Scheme
   - 3.1 Aboriginal Whaling Management Procedure (AWMP)
     - 3.1.1 Report of the Scientific Committee
     - 3.1.2 Discussion and recommendations
   - 3.2 Aboriginal Whaling Scheme (AWS)
     - 3.2.1 Report of the Scientific Committee
     - 3.2.2 Discussion and recommendations
4. Aboriginal subsistence whaling catch limits
   - 4.1 Bering-Chukchi-Beaufort Seas stock of bowhead whales
     - 4.1.1 Report of the Scientific Committee
     - 4.1.2 Discussion and recommendations
   - 4.2 North Pacific Eastern stock of gray whales
     - 4.2.1 Report of the Scientific Committee
     - 4.2.2 Discussion and recommendations
   - 4.3 Minke whale stocks off Greenland
     - 4.3.1 Report of the Scientific Committee
     - 4.3.2 Discussion and recommendations
   - 4.4 West Greenland stock of fin whales
     - 4.4.1 Report of the Scientific Committee
     - 4.4.2 Discussion and recommendations
   - 4.5 North Atlantic humpback whales off St. Vincent and The Grenadines
     - 4.5.1 Report of the Scientific Committee
     - 4.5.2 Discussion and recommendations
5. Schedule Paragraph 13
6. Other matters
7. Adoption of the Report

Annex E

Chair's Proposals for a Way Forward on the RMS

SUMMARY OF CHAIR'S PROPOSAL FOR AN RMS 'PACKAGE'

A small group comprising myself [Henrik Fischer], Denmark, Iceland, Japan, the Netherlands, Spain, Sweden, the USA and the Secretariat met twice in Cambridge. Based on the very constructive discussions held, I would like to bring a proposal forward for consideration by the whole Commission on how to take us forward towards an RMS. I believe that an effective RMS is essential both for the wise management and conservation of whale stocks; the present stalemate is not conducive to either.

The proposal included in this document and summarised below is based on the principle of compromise and respect of the various viewpoints held by Commission members within a framework that ensures that the rules and regulations of the Commission are obeyed and seen to be obeyed in an efficient and cost-effective manner. This will involve use of both the Schedule and voluntary measures such Resolutions and codes of conduct (issues requiring Schedule text are shown with an asterisk below).

ELEMENTS OF A PROPOSED RMS 'PACKAGE'

1. **RMP*:** as agreed by the Scientific Committee and endorsed by the Commission.
2. **A phased-in approach to the resumption of commercial whaling*:** for an initial period (e.g. 5 years after the lifting of the moratorium), commercial whaling would only be allowed in waters under national jurisdiction.
3. **National inspection and observation scheme*:** as proposed by the EDG (generally, observers and inspectors on all boats where practical) with VMS on very small vessels with < 24hr trips and one observer per catcher attached to a factory ship.
4. **Additional catch verification to combat IUU whaling and/or unreported bycatches (NOT to monitor trade):**
   - national diagnostic DNA registers and market sampling to agreed standards (with outside review) and a procedure to allow checking of samples against the registers;*
   - resolution urging countries to institute national legislation prohibiting the import of whale products from non-IWC countries as well as from IWC countries that are non-whaling; and
   - documentation up to port of entry if importation from IWC member *.
5. **Compliance*:** Compliance Review Committee with duties as developed by the RMS EDG and agreed by the Commission, and inclusion of Schedule text as proposed in Berlin:

   'The Compliance Review Committee reports on infringements and the seriousness of these infringements to the Commission and advises the Commission what actions, if any, to be taken'.

6. **Mechanism to apportion RMS costs among Contracting Governments*:** costs for national activities should be borne by relevant national governments, while international costs for securing transparency could be allocated in the context of the overall financial contributions scheme.
7. **Measures for the lifting of Paragraph 10(e)*:** modify paragraph 10(e) such that it becomes invalid on a specific day whilst ensuring that any whaling operations are undertaken under the full RMS package (N.B. catches other than zero can only be set for species/areas the Scientific Committee provides advice for under the RMP – currently very few).
8. **Whaling under Special Permit:** recognise that it is a Sovereign right under the Convention but develop a Code of Conduct.
9. **Animal welfare considerations:**
   - Explicit recognition of the issue in the Schedule*:

     'The hunting of whales shall be undertaken so that the hunted whale does not experience unnecessary suffering and so that people and property are not exposed to danger.'

   - Resolution focusing on improving techniques, voluntary provision of data to regular scientific workshops and possible co-operative research programmes.

This 'package' of measures includes, in some way, all but two of the elements that have been discussed recently in the context of the RMS. The exceptions are blanket trade restrictions and sanctuaries. While some form of trade restriction might be appropriate in deterring IUU whaling, I believe that a blanket ban on international trade in whale products would be discriminatory against some countries, against principles of free trade, and outside the competence of IWC. With respect to sanctuaries, each should be reviewed on its own conservation and management merits and would therefore be difficult to build into any RMS 'package'.

If the Commission reacts favourably to my proposals in Sorrento, recognising that they are of course open to discussion, then I believe it should be possible to have firm proposals ready for adoption at the meeting in 2005. This will however require substantial intersessional activity of both a technical and policy nature.

PREFACE TO CHAIR'S PROPOSALS – WHY AN RMS IS NEEDED

The 1946 International Convention for the Regulation of Whaling clearly gives IWC a dual mandate, i.e. both the conservation and the management of whaling and whale stocks; these are not mutually exclusive but directly inter-related. It is for the following reasons that I believe that an RMS is essential for the credibility of the IWC.

It is a fact that whales are being caught by some IWC members. While recognising and respecting the different views on whaling held by member nations, from the point of view of conservation and wise management, it is best that whaling is managed using a scientific, consistent and fair approach. The highly migratory behaviour of the large whales makes international co-operation on management essential and the IWC is best placed to fulfil this management role. However, at present our organisation is not generally seen to be working effectively and indeed the present polarised views and actions are, I believe, detrimental to conservation.

The IWC Scientific Committee spent several years developing the RMP - the most advanced method for the conservation and management of a natural resource. This procedure was developed specifically for baleen whales with the aim of maintaining all whale stocks at healthy levels and avoiding the problems identified with past scientific management approaches, particularly by taking scientific uncertainty specifically into account in accordance with the Precautionary Principle. As already mentioned, this approach was agreed by the Commission in 1994 but has not yet been implemented. If implemented today, the RMP would only allow catches of some stocks of minke whales. It would not result, contrary to popular opinion in some countries, in a 'free for all' on all stocks of all whale species.

As has been recognised since at least 1992, effective conservation and management measures developed using the RMP must be accompanied by a modern supervision and control system (i.e. the RMS) that ensures that those measures are not only obeyed, but are seen to be obeyed. However, despite some nine years of discussions, agreement on the RMS has still not been reached.

I strongly believe that if the IWC is to fulfil its role in the conservation and management of whale stocks and to avoid past errors, real effort must be made to complete the RMS expeditiously. To do this parties must respect the views of others, and in that light, develop a package of measures that is as broadly acceptable as possible whilst meeting the agreed objectives in the most practical and cost effective manner. Building on the progress made in a number of important areas and working in good faith, it should be possible to rapidly complete this work, thereby ensuring the conservation and management of whale stocks for the future, restoring the credibility of the IWC as an effective organisation and providing an example of how modern natural resource management should be carried out. Failure to put an RMS in place will jeopardise the future of the IWC and serves neither the interests of whale conservation nor management.

CHAIR'S PROPOSALS FOR A WAY FORWARD ON THE RMS

1. INTRODUCTION

Following the adoption of the 'moratorium' on commercial whaling in 1982, that came into effect in 1986, the Scientific Committee spent several years developing the Revised Management Procedure (RMP). The RMP is a conservative scientific method for determining safe catch limits that explicitly takes scientific uncertainty into account. The Commission adopted the RMP in 1994, but agreed that it would not be implemented until a Revised Management Scheme (RMS) was completed. In addition to the RMP, the RMS was to include measures to ensure that regulations were obeyed, primarily via an updated and revised national inspection and International Observer Scheme (IOS). Subsequent discussions of what the RMS should contain have included the need for catch verification measures in addition to those within an IOS and the collection of animal welfare data. Additionally, related issues such as limiting catches to waters under national jurisdiction, trade restrictions, scientific permits, sanctuaries and the relationship between completion of the RMS with Schedule paragraph 10(e) have also been discussed – many of these having been introduced as part of the 'Irish Proposal' brought forward in 1997 as a way to help overcome the impasse that developed within IWC following adoption of the moratorium.

Many Contracting Governments have spent considerable time and effort over the years on RMS discussions. Despite the fact that progress has been made in some areas, particularly with the inspection and observation scheme, there has been no progress in others and hence no overall agreement. This has led to increasing frustration among Contracting Governments and accusations as to who was responsible for the delay. At last year's Annual Meeting in Berlin, a private meeting of Commissioners was neither able to make recommendations regarding possible components of an RMS or on how to take the RMS process further.

During the plenary meeting, the Commission did, however, agree to my proposal to convene a small group of my choosing to explore ways and possibilities of taking the RMS process forward. I subsequently invited Denmark, Iceland, Ireland, Japan, the Netherlands, Spain, Sweden and the USA to take part. All except Ireland were able to accept. Ireland had to decline due to pressures of work associated with the lead-up to Ireland's presidency of the EU starting January 2004.

The 'Chair's Small Group' (CSG) met at the Secretariat's offices in December 2003 and again in March 2004. The discussions were very productive and based on their outcome, I would like to bring some thoughts and proposals forward for consideration by the whole Commission. I was heartened that the CSG operated in a spirit of openness with a desire to understand the differing points of view on RMS-related issues, without assigning dishonest or underhand motives where there was disagreement. All recognised the current problems within the Commission stemming from a lack of mutual trust and agreed that it was vital that these are overcome if the Commission is to fulfil its mandate. Similarly, there was widespread recognition that all must be willing to compromise to reach an agreement that is broadly acceptable; any compromises must of course still enable the objectives of the RMS (see below) to be met.

In the Preface to this document, I have explained why I believe an RMS is needed. In the following pages I reiterate the framework and objectives against which an RMS should be developed, review the major obstacles to completing the RMS that remained at the Berlin meeting, including general ideas on how they might be overcome, outline a possible RMS 'package' and touch on possible next steps. I use the phrase RMS 'package' since it is clear from past discussions that resolution of the RMS will necessarily involve the inclusion of some elements not strictly related to ensuring that regulations are obeyed and seen to be obeyed.

2. THE FRAMEWORK AND OBJECTIVES FOR DEVELOPING AN RMS

For several years leading up to and including the meeting of the RMS Working Group at IWC/53 in London, discussions on the RMS had focused on trying to make progress largely through revisions to draft Schedule language (i.e. a 'square bracket exercise'). This meant that Schedule language was debated in isolation rather than within a framework looking at the RMS as a 'whole'. This approach changed with the establishment of the Expert Drafting Group (EDG) at IWC/53 when a framework was developed that established objectives for an RMS. This framework has provided an objective way to develop and evaluate proposals, and has been instrumental during the development of the proposals I outline in this document.

The EDG framework

The EDG agreed that the primary objectives of any IOS scheme are to:

(1) ensure that the rules and regulations of the Commission are obeyed;
(2) ensure that the rules and regulations of the Commission are seen to be obeyed;
(3) report to the Contracting Government any infractions of those rules and regulations; and
(4) report to the Commission any infractions of those rules and regulations.

In developing a scheme to meet these objectives, account must be taken of:

(1) certain desired features of any credible combined scheme, including that it be to the extent possible robust, independent, transparent and based on best practice;
(2) the need for the scheme to be as simple, practical and cost-effective as possible, concomitant with meeting its objectives; and
(3) the nature of likely future operations (whilst noting that any scheme must be sufficiently generic to be able to incorporate new vessels, etc. without modification).

The following progression was used to structure its discussions:

(1) identify the nature of the regulation or information required;
(2) determine appropriate method(s) to monitor the regulation;
(3) assess efficiency and practicality of method(s);
(4) select most appropriate;
(5) determine whose responsibility to ensure method is used and who uses it;
(6) determine reporting hierarchy; and
(7) determine who pays.

Using this approach, the drafting of Schedule text is left until considerable agreement has been reached on a particular issue or indeed on the whole RMS 'package'.

3. OBSTACLES TO COMPLETING AN RMS AND HOW THEY MIGHT BE OVERCOME

The elements that have been discussed as possible components of an RMS and related issues are given in the table below. The status of discussions on all elements and issues as of the 55th Annual Meeting in Berlin is summarised in Document IWC/56/COMMS 3.

Main potential elements of the RMS

Scientific

RMP – including:
- survey guidelines; and
- total catches over time.

Non-scientific

Chapter V: Supervision and Control:
- vessels, points of landing, processing plants;
- national inspection schemes;
- International Observer Scheme;
- verification of catch data;
- costs; and
- oversight/compliance.

Chapter VI: Information Required:
- scientific information; and
- animal welfare data.

Related issues under discussion
- relationship with paragraph 10(e);
- limiting catches to national waters;
- trade restrictions;
- Special Permits; and
- sanctuaries.

There is consensus within the Commission that the RMS should at least include the RMP (including the agreed survey guidelines[1] and together with provisions to adjust catch limits to account for other human-induced mortalities to ensure that removals over time do not exceed limits set

[1] In Resolution 1996-6, the Commission agreed to accept as a component part of the RMS the *'Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme'*. Since then, the Guidelines have been revised slightly by the Scientific Committee and the RMP text has been revised to include the following paragraph: the only estimates of abundance acceptable for use in the *Catch Limit Algorithm* are those obtained in accordance with the most recent version of the *'Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme'*.

by the RMP[2]), an inspection and observation scheme, some form of compliance monitoring and a mechanism to apportion costs of any RMS among member countries. However, lack of agreement remains concerning not only the details of some of these 'agreed' elements (particularly the cost-sharing arrangement) but also on which other elements should be included as part of the 'package'.

The major obstacles now remaining are:

- the relationship between the RMS and Paragraph 10(e);
- whether additional catch verification measures beyond those provided by the inspection and observation scheme are necessary;
- how RMS costs should be apportioned among member countries;
- whether commercial catches should be limited (at least initially) to waters under national jurisdiction;
- whether restrictions should be placed on international trade;
- whether animal welfare data should be collected;
- whether there should be any link/relationship between the RMS and special permits; and
- whether there should be any link/relationship between the RMS and sanctuaries.

Section 3 below summarises the status of discussions on these particular issues up to and including IWC/55 and presents ideas emerging from discussions within the CSG on how obstacles may be overcome.

3.1 The RMS and Schedule paragraph 10(e)

The issue

The most important obstacle revolves around the relationship between the RMS and Schedule paragraph 10(e). To date the views expressed on this relationship have ranged from:

(1) agreement on the RMS should result in simultaneous deletion of paragraph 10(e) from the Schedule and catch limits other than zero should be established based on the advice of the Scientific Committee; to

(2) even though an RMS is agreed, paragraph 10(e) should remain until such time as the Commission takes action to remove it.

Rationales for these opinions varied from the view that an RMS is meaningless if no whaling is allowed on stocks for which the RMP would set a catch limit other than zero, through a lack of trust that countries may object to one or more provisions of an RMS and thus not be bound by them, to the view that whaling should not be allowed but that an RMS should be in place in case a three-quarter majority is in favour.

Towards resolution

Aside from the view of some member governments that commercial whaling is always unacceptable, the primary concern that has been expressed is that if adoption of the RMS is simultaneous with the lifting of the moratorium, there is a possibility that a whaling nation might exercise its right to object to one or more of the RMS provisions and thus be able to whale legally but outside the RMS. However, as noted at the October 2002 private Commissioners' meeting on the RMS, practical ways to address this concern can be found, e.g. the addition of a clause to paragraph 10(e) such that it becomes invalid on a specific day, provided that no objections to the RMS provisions have been received. During discussions within the CSG, there was a general feeling that a simple provision that meant that even a single objection (be it from either a pro- or anti-whaling country) could frustrate a widespread agreement to the twin objectives of lifting paragraph 10(e) and ensuring that whaling occurs under a full RMS was not acceptable. Further thought is needed to design a provision that ensures that these twin objectives are met.

3.2 Catch verification

The issue

The National Inspection and International Observer Scheme (IOS) as foreseen by the EDG (IWC/54/RMS 1) will provide for the checking of catches taken by authorised vessels under the jurisdiction of IWC member countries. However, some governments have proposed that additional catch verification measures, such as DNA registers/market sampling and/or catch documentation are necessary. At the October 2002 private meeting of Commissioners, it was noted that some form of catch verification can provide additional valuable information in the context of:

- RMP requirements with respect to total catches/human-induced mortalities over time – especially with regard to non-IOS monitored mortalities such as bycatches, IUU fishing etc; and
- the questions of ensuring that regulations both are obeyed and are seen to be obeyed.

A working group on catch verification was therefore established to explore the matter further. The working group met in Antigua in April 2003 (IWC/55/COMMS 3) and reached broad agreement on the following issues:

- the Inspection and Observation Scheme (IOS) would satisfy the requirements that the regulations are obeyed and are seen to be obeyed for registered IWC operations;
- there are advantages in an RMP context, to some additional catch verification (e.g. with respect to IWC illegal vessels, non-IWC vessels with and without export to IWC countries, and other removals such as illegal (i.e. unreported) bycatch);
- DNA/market sampling (DNA/MSS) systems and catch documentation schemes (CDS) share many of the same attributes but differ in terms of cost, ease of fraud and instant checking – however, while there are no features of a CDS that cannot be fulfilled by a DNA/MSS, the reverse is not true;
- if DNA registers are used there is no need to have a single IWC registry (i.e. national registries could be continued) provided common standards (techniques and laboratories) are met;
- if a DNA/MSS is used, some form of audit at all stages is necessary from the perspective of transparency;
- any market sampling would require careful design; and
- if DNA registers are used, samples for testing must be submitted via governments or appropriate intergovernmental organisations to avoid fraudulent claims.

The working group did not agree on:

[2] At IWC/52 the Commission endorsed text on total catches over time – see section 3.7.

- whether both DNA registers and a Catch Documentation Scheme (CDS) might be needed. Some thought application of both systems would be duplicative, others that they would be complementary. However, in the absence of a specific proposal, there has been some confusion over what is intended in relation to the form and scope of any CDS, e.g. should it be to the point of import or through to the consumer (product labelling); and
- the need for, and level of, international/independent oversight of a DNA/MSS if used – and who might provide such oversight.

Towards resolution

No further progress was made during IWC/55, but considerable time was spent discussing catch verification by the CSG. From these discussions it is clear that the objectives of a catch verification scheme are to ensure that:

(1) IWC commercial catch limits (and other regulations) are not exceeded by member countries; and

(2) total anthropogenic removals (direct catches and bycatch) are not exceeded (both in terms of IWC and non-IWC countries) – this involves obtaining information on their levels.

The aim is NOT to monitor trade *per se.*

For vessels registered by Contracting Governments, the EDG's IOS proposal will provide internationally verified information on all aspects of the catch (including quota monitoring) required by the IWC (position, sex, date etc.). However, for vessels from IWC member countries operating illegally or vessels from non-member countries (i.e. IUU whaling) there clearly will be no inspectors/observers and consequently other measures will be needed to detect/deter such operations. Similarly, measures would be needed to detect/deter unreported bycatches.

Given the above, the CSG broadly recognised the value of some combination of the following additional catch verification measures:

- diagnostic DNA registers and market sampling – against the background that national registers meeting the requirements of the Scientific Committee are already in place in Japan and Norway;
- some form of catch documentation – recognising that at present, whale products require CITES export/import permits and that these should be taken into account in the development of any further documentation;
- national regulations only allowing importation of whale products from other IWC countries with DNA registers – recognising that while regulations about trade in whale products are outside the IWC's remit, there is some precedent since the Commission did adopt a Resolution at its 31st Annual Meeting in 1979 that resolved, among other things that 'all member nations shall cease immediately any importation of whale meat products from, and the export of whaling vessels and equipment to non-member countries and operations'. Japan already has national legislation prohibiting the import of whale meat from non-IWC member countries as well as from IWC countries that are non-whaling. It also prohibits importation of whale meat from whales taken in violation of IWC regulations.

PROCEDURE FOR CHECKING SAMPLES

An agreed specified system for submitting samples to the register(s) for 'checking' must also be developed to prevent fraudulent claims of illegal products being found. Under this system it is proposed that:

(1) samples must be submitted via national governments or appropriate intergovernmental organisations with proof of origin of the samples; and

(2) analysis must follow agreed techniques in approved laboratories.

3.3 Costs

The issue

There is general agreement that there should be an element of cost-sharing, i.e. that some of the costs of an RMS should be paid by the Commission who would then recover these costs through a 'factor' in the financial contributions assessed from Contracting Governments. The October 2002 private Commissioners' meeting established a small working group to explore and recommend to the Commission how this 'factor' might be defined, and in particular how a fair balance between the interests of whaling and non-whaling countries could be determined. The working group met in Antigua in May 2003 (IWC/55/COMMS 4). It agreed that there were four main elements to the costs of an RMS:

(1) national inspectors;
(2) international observers;
(3) vessel monitoring systems; and
(4) catch verification.

Cost estimates were developed for each element, although in relation to catch verification, estimates could only be developed for DNA registers/market sampling since no definite proposal for a Catch Document Scheme had been made.

The working group did not reach agreement on how costs might be apportioned among Contracting Governments, although there was general agreement that the costs of national inspectors should be paid by the flag state (with the exception where, as foreseen in the EDG proposal for the IOS, an individual acts as both national inspector and international observer when it may be appropriate for some cost sharing).

The working group also did not reach agreement on RMS costs and the overall financial contributions scheme. Two options were considered:

(a) factor them into the financial contributions scheme; or
(b) have them as a separate budget item.

The group did agree, however, that addressing the issue of RMS costs should not undermine the principles guiding the work of the Contributions Task Force (CTF) and its efforts to date, particularly with respect to reduced costs for developing countries.

The working group believed it had achieved as much as it could given the uncertainties involved.

In Berlin, Commissioners noted the usefulness of having broad cost estimates for the observer scheme and DNA registers/market sampling, even if both entailed considerable assumptions. All members recognised that the costs were significant in terms of the IWC budget, although some believed they were not large in the 'market' context. As with catch verification, there was no agreement in the Commissioners' meeting as to whether sufficient progress on this issue had been made, although the meeting noted that it is difficult to discuss the question of overall costs in isolation from the question of who shall pay.

Towards resolution

The issue of costs and how they might be apportioned was touched on during the discussions of the CSG, but was not discussed extensively. The group felt that the major cost elements of the RMS would be associated with:

- national inspectors;
- international observers;
- DNA registers and market sampling; and
- some sort of (trade) document scheme.

VMS was not included in this list since the small group is proposing that VMS is only required on small boats making only day-trips and with room for neither an inspector or observer aboard (see Section 5 and Appendix 1).

While further discussions are necessary about how costs are apportioned, the CSG considered that further consideration could be based on the general principle that costs for national activities be borne by relevant national governments, while international costs for securing transparency could be allocated in the context of the overall financial contributions scheme - as indicated in the following table.

Cost element	Who pays
National inspectors	Appropriate member countries
International observers	The Commission, in accordance with a Financial Contributions Scheme
VMS	Appropriate member countries
DNA registers + market sampling:	
set-up and running of systems	Member countries with DNA registers
oversight/review of national systems	The Commission, in accordance with a Financial Contributions Scheme
Checking	The country requesting the checking

3.4 Restricting whaling to national waters/area limitations

The issue

The proposal to restrict whaling to within EEZs, at least for a limited period prior to allowing 'full' whaling, was made principally as a measure to boost public confidence in IWC's ability to manage whaling successfully following the overexploitation of the past. While this proposal has been supported by some, possible difficulties have been raised by others. For example, some consider that a blanket closure of the high seas to exploitation may be contrary to UNCLOS. Concerns have also been expressed that in the present atmosphere of mistrust, any time-limit provision may be reminiscent of the 1990 'deadline' in paragraph 10(e) (i.e. that the restrictions would not be lifted at the appointed time). Others have noted that restricting catches to national waters in some circumstances would reduce yield and would be even more cautious than the already extremely cautious RMP. Finally some have observed that such a provision may also increase supervision and control difficulties since small-scale coastal activities can be more difficult to monitor than large-scale offshore operations.

Towards resolution

During the October 2002 Commissioners' RMS meeting, there had been the suggestion that the concept of area restrictions could be included as a recommendation embodied within a Resolution rather than a Schedule requirement and it was agreed to consider this approach further at a later date. During discussions of the CSG, the view was expressed that some sort of phased-in approach to commercial whaling could be useful and that this might be achieved through initial area limitations in the context of RMP *Implementation*s, such that in the first five years after the lifting of paragraph 10(e), catches are restricted to within national waters.

3.5 Trade restrictions

The issue

The proposal is to restrict trade in the meat and products of whales taken to local consumption only (i.e. no international trade to be allowed). Its reasons were two-fold:

(1) that past trade pressures were partly responsible for overexploitation of whale resources; and
(2) as part of the 'confidence-building' exercise.

Although initially proposed as a permanent measure, Ireland had indicated more recently that it could be time-limited.

Although there has been some support for this proposal, strong opposition has also been voiced. Those opposing the proposal believe that such a ban is:

(a) discriminatory against countries with small populations;
(b) against principles of free trade; and
(c) outside the competence of IWC.

They believed that public confidence should be built via other mechanisms.

Towards resolution

The potential problems with a blanket ban on all international trade were recognised by the CSG. However, it was noted that under some circumstances, certain trade measures might be appropriate, for example to combat IUU fishing, as is done by some fisheries management bodies (such as CCAMLR and ICCAT).

3.6 Animal welfare data

The issue

Currently, information on animal welfare (weapons used, time-to-death, etc.) is provided to the Commission on a voluntary basis. Some years ago however, the UK, with support from other member governments, proposed that the collection of animal welfare data should be a requirement of the RMS and included in the Schedule. It proposed a list of data to be collected. Other governments have raised three difficulties with this issue:

(1) the competency of IWC to address animal welfare;
(2) whether or not such information is necessary; and
(3) lack of trust.

With respect to the last point, some countries have noted that even the discussion of the data currently provided voluntarily are used in a wholly negative manner by some, rather than being used for constructive discussion on how to improve killing methods. Given this experience, they believed that the *status quo* of voluntary reporting should be continued.

Towards resolution
During discussions within the CSG, it was recognised that despite the opposing views, animal welfare is clearly an issue that needs to be addressed. The group noted that the principle that whaling should not inflict unnecessary suffering had already been agreed in discussions concerning the potential revised Schedule (see paragraph 13 of IWC/54/RMS 2). Two additional suggestions were made. One was that collection of data should not be considered mandatory as part of the 'package', but facilitated by including in the duties of international observers an item along the lines that they should 'collect such data that the Commission from time to time might request'. These data would not necessarily be the full list proposed by the UK. The other suggestion that received broad support, was that rather than requiring collection of comprehensive animal welfare data on all whaling vessels as a Schedule requirement under 'Information Required', there could be dedicated well-designed scientific programmes to improve whale killing methods, with the results being discussed at scientific workshops.

3.7 Special permits

The issue
In addition to area and trade restrictions, some have called for the phasing out of whaling under special permit. This aspect was touched upon briefly at the October 2002 private Commissioners' meeting. At that meeting, different views were expressed as to the need for any link/relationship between scientific permit catches and the RMS. While some Contracting Governments continue to support scientific whaling and its value for management and other important issues, others believe it to (1) be no longer necessary and (2) to be taking place on a larger scale than foreseen when the Convention was negotiated. Nevertheless, the right under Article VIII of the Convention for Contracting Governments to take whales for research purposes under scientific permit is not disputed and the suggestion was made at the October 2002 meeting that some sort of voluntary code of practice could be developed governing the conduct of scientific whaling. It was envisaged that this would not form part of the RMS but would be a document to which the IWC and others could refer.

Towards resolution
The concept of a voluntary Code of Conduct as a way to address the concern some governments have with special permit whaling was taken further during the discussions within the CSG. It was suggested that such a code might include certain features that research programmes should have and that it would need to be developed by scientists. This code might also increase the level of participation of scientists from other countries in the design and conduct of the research programmes. This could include, for example, holding an international workshop before designing a given research programme to improve the scientific review process and to avoid the research proposals, currently presented for review to the Scientific Committee a relatively short time before being implemented, being seen as a '*fait accompli*'.

The CSG identified two scenarios exist for special permit catches: (1) special permit catches upon species/stocks for which an RMP *Implementation* has been completed; and (2) those for which no *Implementation* has been completed. In the former case, the RMP explicitly takes into account catches under special permit by taking them off the 'commercial' catches as follows:

> 'Catch limits calculated under the Revised Management Procedure shall be adjusted downwards to account for human-induced mortalities caused by aboriginal subsistence whaling, scientific whaling, whaling outside IWC, bycatches and ship strikes.
>
> Each such adjustment shall be based on an estimate provided by the Scientific Committee of the size of the adjustment required to ensure that total removals over time from each population and area do not exceed the limits set by the Revised Management Procedure. Total removals include commercial catches and other human-induced mortalities caused by aboriginal subsistence whaling, scientific whaling, whaling outside IWC, bycatches and ship strikes, to the extent that these are known or can reasonably be estimated.' (*Ann. Rep. Int. Whaling Comm.* 2000: 32).

While a 'code of conduct' would be applicable for the first scenario, it would be particularly appropriate for the second.

3.8 Sanctuaries

The issue
The Irish Proposal called for sanctuaries to be respected, and concern is often expressed by some regarding the whaling that is occurring within existing sanctuaries. Others consider that sanctuaries within the IWC context are playing a different role than in other fora, i.e. they are seen as a way to achieve a global ban on commercial whaling rather than as a management tool. During discussions within the CSG, there was a suggestion that the existing IWC sanctuaries could be reviewed in the context of certain Marine Protected Areas (e.g. that had core areas, areas of limited use, etc), but in the end the general view was that sanctuaries would be a difficult issue to build into any 'package' and that it would be best to stick to the *status quo*.

4. DEVELOPING AN RMS 'PACKAGE'

Given the discussions held to date on the RMS, including the constructive and positive discussions held within the CSG, I believe the time is right for the Commission to make real and directed progress towards an RMS. The Preface to this document outlines what I believe is an incontrovertible case for the timely adoption of an RMS from the twin standpoints of conservation and wise management. I recognise that this will require an atmosphere of trust and mutual understanding that has appeared to be lacking in recent IWC meetings. I have been encouraged and heartened by the constructive nature of discussions within the CSG despite the very different opinions held on a number of key issues. Given that, I have developed what I believe to be a fair and realistic proposal for the essential ingredients of an RMS package for consideration now by the whole Commission. The proposal is, of course, open to discussion. As its cornerstone is the RMP that I believe still represents the most advanced and well-tested scientific approach to the management of natural resources; it is considerably more conservative than measures that we all accept in other national and international management regimes. Inevitably, not every detail of this package will satisfy every member nation – that is inherent in the concept of compromise. However, in my proposal I have endeavoured to respect to the extent possible the various viewpoints held by Commission members within a logical framework that ensures that the rules and regulations of the Commission are not only obeyed but also seen to be obeyed in an efficient and cost-effective manner.

4.1 Elements to include in the RMS 'package'

Following from the above, I would like to commend to the Commission the following as elements to include in an RMS 'package'. Some elements are appropriate to be incorporated as part of the Schedule, while others could be best addressed using voluntary measures such as Resolutions and codes of conduct. However, the proposal is for a package as a whole; it is the combination of all of these elements that I believe best meets the objectives for the RMS agreed by the EDG. It is my hope that such a package will be able to receive broad support from Commission members.

Elements to be incorporated as part of the Schedule

- The RMP (including survey guidelines and provisions for total catches over time).
- A phased-in approach to commercial whaling.
- A national inspection and International Observer Scheme.
- Additional catch verification measures.
- Compliance.
- A mechanism to apportion RMS costs among member countries.
- Measures for the lifting of Schedule paragraph 10(e).

Elements to be dealt with primarily via Resolutions and similar measures

- Whaling under special permit.
- Animal welfare considerations.

This 'package' of measures includes, in some way, almost all of the elements that have been discussed recently in the context of the RMS. The exceptions are blanket trade restrictions and sanctuaries. As indicated earlier, while noting that some trade restrictions might be appropriate in the context of deterring IUU whaling, I recognise the strength of the view that a blanket ban on international trade in whale products would:

(1) be discriminatory against countries with small populations;
(2) be against principles of free trade; and
(3) be outside the competence of IWC.

In addition, such a ban would not appear to further the conservation and wise management of whale stocks in addition to the RMS package proposed. With respect to sanctuaries, these are provided for under the Convention and should be reviewed on their conservation and management merits. They would therefore be difficult to build into any RMS 'package'.

An outline of the different elements and an indication of where significant further work is required is provided in the next section.

4.2 Description of RMS 'package' elements

4.2.1 The RMP

The RMP as agreed by the Scientific Committee and endorsed by the Commission should be used to set commercial whaling catch limits. In effect all catches will be zero until the Scientific Committee has completed an *Implementation* for a particular species and area. The Committee cannot begin an *Implementation* without instructions from the Commission. In the present atmosphere of mistrust, safeguards are needed to ensure that non-scientific methods are not used to delay/prevent *Implementation* work (in either the Commission or the Committee) as well as to ensure that it is carried out with appropriate scientific rigour.

FURTHER WORK

The Scientific Committee is already working on guidelines relating to the level of information needed to begin and complete an *Implementation* as well as the time such a process should take. I have asked the Secretariat to explore (with appropriate members of the Scientific Committee) how such provisions could be built into the RMP (and thus into the Schedule).

4.2.2 A phased-in approach to the resumption of commercial whaling

I believe that some sort of phased-in approach to commercial whaling could be useful in building public confidence in the IWC's ability to manage whaling and conserve whale stocks. This is not to imply either that the RMP is not safe or that there will be immediate widespread whaling on all species around the world. I suggest that the best approach would be by phasing-in the areas in which commercial whaling would be allowed and propose that when whaling resumed, it would initially (e.g. for a 5-year period) be within waters under national jurisdiction of member countries. Safeguards would be needed to make sure that this would only be a temporary measure, such as a clear sunset clause in the Schedule text. One option for such text might be:

> 'Notwithstanding the catch limits by Small Area shown in Table 2, whaling will be restricted to waters under the national jurisdiction of the relevant Contracting Governments until 1 January 200X. After that date, this restriction will no longer be in effect.'

4.2.3 A national inspection and International Observer Scheme

This would be as proposed by the EDG (where, in general, observers and inspectors are placed on all boats where practical), and include the proposals made by the CSG on VMS and observers on catcher vessels (see Annex), i.e. VMS on very small vessels with < 24hr trips and one observer per catch vessel attached to a factory ship.

4.2.4 Additional catch verification measures (involves Schedule amendments and a Resolution)

I propose that additional catch verification measures involving national diagnostic DNA registers/market sampling systems and import controls should be included in the RMS to ensure that IWC removal limits are not exceeded by IUU whaling and/or unreported bycatches.

DNA REGISTERS/MARKET SAMPLING

DNA registers/market sampling systems should form the major part of the catch verification system. They should have the following attributes:

- national diagnostic DNA register for each whaling country or group of countries (to agreed specifications) to avoid redundancy and additional costs; and
- designed market sampling system (to agreed specifications).

TRANSPARENCY

While DNA registers and market sampling (DNA/MSS) will meet the objective of regulations being obeyed, a level of transparency attached to these systems is required to meet the objective that regulations are seen to be obeyed. There are varying interpretations of the competency of the Commission with regard to international trade and the monitoring of domestic markets and, even though the objective of the catch verification scheme is not concerned with the monitoring of trade *per se*, any arrangement for securing the transparency of the catch verification system must take this into account to be broadly acceptable.

Transparency could be obtained in a number of ways. For example, the IWC Scientific Committee has already reviewed the specifications for the existing national registers and approved them. Formal specifications could thus be drawn up by the Committee in conjunction with those involved in the existing registers. National governments could agree voluntarily to provide relevant updated information on the registers. Similarly, national governments could allow outside review of the design of domestic market sampling programmes and protocols for voluntary submission of data. Further discussion on this matter is required (e.g. the nature of the outside review and the composition of any expert groups).

FURTHER WORK

Specifications for the DNA/MSS need to be developed and agreed, as does a system to provide transparency/oversight. For the former it is likely that an expert group will need to be established to develop proposals for review by the Scientific Committee and the Commission. For the latter, the Secretariat has been asked to draft a discussion paper outlining a series of options.

A system for submitting samples to the register(s) for 'checking' must be developed to prevent fraudulent claims of illegal products being found. In developing such a system, consideration must be given to whether such samples are checked against the national registers themselves, or whether Contracting Governments should provide the genetic profiles of each individual whale in their registers in confidence to an outside body in a pre-specified electronic format (a small technical group would be required to develop detailed specifications). The latter would allow the comparisons to be compared independently from the national database. Such a system could provide a simple yes/no answer to whether a sample is from an animal in a diagnostic register.

NO IMPORTATION OF WHALE PRODUCTS FROM NON-IWC COUNTRIES OR FROM ILLEGAL OPERATIONS

Preventing the import of whale products from non-IWC countries or from illegal operations of boats registered in IWC countries is an essential element of the catch verification approach. I suggest that this is done in two ways:

- a Resolution agreeing that Contracting Governments will institute national legislation prohibiting the import of whale products from non-IWC countries as well as from IWC countries that are non-whaling (such legislation already exists in some countries such as Japan); and
- a system of catch documentation to the point of entry/landing.

With respect to the latter it is clear that some form of documentation will be required by national governments at the point of entry to show that the products come from whales caught legally by an IWC country. Whale products not accompanied by such a document would not be allowed to be imported. While it is the responsibility of national governments to decide what documentation they would require when products are being imported, it would be valuable to develop an IWC *pro forma* that takes into account (1) the FAO harmonised trade document and CITES documentation (which is currently required), and (2) sensitivities regarding IWC's competency to address trade issues.

I do not believe that documentation/product labelling once a product has entered an IWC country is necessary given other measures in place.

FURTHER WORK

A new Resolution concerning national legislation prohibiting the import of whale meat from non-IWC countries as well as from IWC countries that are non-whaling needs to be drafted. The Secretariat has been asked to review existing relevant Resolutions and to draft a consolidated version.

With respect to catch documentation, the Secretariat has been asked to examine CITES documents and the FAO proposal for a harmonised trade document with the view to developing an IWC *pro forma* if considered necessary.

4.2.5 Compliance

A Compliance Review Committee would be established with the duties as developed by the EDG and agreed by the Commission (IWC/54/7 and IWC/55/COMMS 2). Under the Convention, it is clear that it is the responsibility of relevant Contracting Governments and not the IWC to impose penalties and I propose that the recommendations of the Compliance Working Group from IWC/55 be followed, i.e. that the following text be included in the Schedule: 'The Compliance Review Committee reports on infringements and the seriousness of these infringements to the Commission and advises the Commission what actions, if any, to be taken'.

4.2.6 Apportioning RMS costs among Contracting Governments

Clearly more discussion is needed on how RMS costs should be apportioned, but I recommend that it is based on the general principle that costs for national activities be borne by relevant national governments, while international costs for securing transparency could be allocated in the context of the overall financial contributions scheme - as indicated below.

Cost element	Who pays
National inspectors	Appropriate member countries
International observers	The Commission, in accordance with a Financial Contributions Scheme
VMS	Appropriate member countries
DNA registers and market sampling:	
set-up and running of systems	Member countries with DNA registers
oversight/review of national systems	The Commission, in accordance with a Financial Contributions Scheme
Checking	The country requesting the checking

FURTHER WORK

This is an issue that needs further discussion, as does the relationship with the work of the Contributions Task Force. The Commission has always recognised the interaction between the work of the Task Force and RMS cost discussions, but until now, the Task Force has been asked to develop a contributions formula that does not take future RMS costs into account. However, if the Commission reacts favourably to my proposals for an RMS 'package', there will be significant implications for any revised contributions formula. Consequently, while the development of a revised contributions formula remains high priority for the Commission, I believe that it would be prudent to delay further work of the Task Force until the Commission has discussed the RMS in Sorrento and assessed any implications for the work of the Task Force. The Task Force had been scheduled to meet before IWC/56 to try to finalise a proposal for a revised contributions formula. However, given the above and after consulting with the Task Force members and the Advisory Committee it has been decided to postpone the Task Force meeting.

4.2.7 Measures for the lifting of Schedule paragraph 10(e)

I do not believe that trying to finalise an RMS in isolation of discussions on paragraph 10(e) is appropriate, and consider that a way of linking agreement on an RMS with the lifting of paragraph 10(e) needs to be found. My preferred approach is to modify paragraph 10(e) such that it becomes invalid on a specific day whilst ensuring that any whaling operations are undertaken under the full RMS package as adopted by the Commission.

FURTHER WORK

Developing appropriate text to achieve this is not a simple task, and the Secretariat has been asked to develop some possible Schedule text and scenarios for consideration.

4.2.8 Whaling under special permit

Recognising:

(1) the right of governments under the Convention to issue special permits;
(2) concern expressed by some regarding scientific whaling; and
(3) the need to obtain as broad a consensus as possible on the RMS 'package'.

I believe that an appropriate approach would be to develop a voluntary 'code of conduct' for whaling under special permit as part of the RMS 'package'. Such a code might include certain features that research programmes should have, e.g. with respect to appropriate abundance estimates, improved participation of scientists from other countries in the design, review and conduct of research programmes, e.g. through international intersessional workshops.

FURTHER WORK

A draft code of conduct needs to be developed. I suggest that the group within the Scientific Committee that is already working to consolidate existing guidelines is requested to develop recommendations for such a code.

4.2.9 Animal welfare considerations

The differing opinions among Contracting Governments over the competency of IWC to address animal welfare issues should be recognised and taken into account.

I suggest that animal welfare considerations be addressed primarily through an initiative (perhaps by Resolution) to focus discussions within the Commission on improving the techniques to kill whales, based on (1) voluntary reporting of data as discussed at the Workshop in Berlin; and (2) the voluntary provision of information from existing research programmes (and/or the development of a co-operative research programme) at regular (e.g. triennial) specialist workshops).

In addition, the importance of taking animal welfare considerations into account should be explicitly recognised in the Schedule through the inclusion of text along the following lines:

> 'The hunting of whales shall be undertaken so that the hunted whale does not experience unnecessary suffering and so that people and property are not exposed to danger.'

5. POSSIBLE NEXT STEPS

A private Commissioners' meeting on the RMS is scheduled for the afternoon of Friday 16 July 2004 in Sorrento. This meeting will provide an opportunity for me to present and explain the rationale behind my proposals, for Commissioners to provide feedback and for the Commission to discuss next steps. I believe that the objective of these steps should be to work towards developing a draft final proposal for adoption at the meeting in 2005.

If the Commission wishes to take the work forward along the lines I propose, this will require substantial intersessional activity of both a technical and policy nature prior to the 2005 Annual Meeting. A number of intersessional meetings will be needed and could include a meeting of the CSG, meetings (2-3) of expert groups tasked with developing necessary details on certain aspects (as indicated above) and a private Commissioners' meeting. I believe that the intersessional work would best be progressed through private meetings. However, recognising the need for transparency to the wider IWC community and beyond, provision for an open meeting on the RMS (e.g. the RMS Working Group) should be included in the meeting schedule for IWC/57.

Appendix 1

Recommendations from the Chair's small RMS group concerning the International Observer Scheme

The small RMS group was able to address the two issues outstanding regarding the International Observer Scheme, i.e.:

1. Whether VMS is required on all vessels or, as proposed by the EDG, only on category (a) vessels, i.e. vessels that operate day trips (< 24 hours) only, carry out no substantial flensing on board and can accommodate neither a national inspector nor an international observer. For these vessels, the EDG agreed that a combination of VMS data transmitted in real-time to an observer at the point of landing is acceptable.
2. Whether, for pelagic operations, there should be observers on board each catcher vessel in addition to observers on board each factory ship.

The Chair's small RMS group recommends that:

- VMS is only required on category (a) vessels.
- One international observer would be deployed on each catcher boat attached to a factory ship. It was noted that as experience is gained, it may eventually be decided that observers are only needed on the factory ship.

Annex F

Statement from Henrik Fischer, Chair of the Commission, to the Private Meeting of Commissioners/Alternate Commissioners on the 16th July 2004

First of all I would like to express my deep regret and disappointment at not being able to attend and Chair the 56th Annual Meeting and in particular in being unable to present my proposal on the RMS to you in person and to work with you all to seek agreement on a way forward. I hope however, that you will permit me to communicate, via this statement, the great importance I give to completion of the RMS and what I would like the discussions on the RMS in Sorrento to achieve.

Given the lengthy discussions held to date on the RMS, and especially the constructive and positive discussions held within my small RMS group since last year's meeting in Berlin, I believe the time is right for the Commission to make real and directed progress towards an RMS. I fear that failure to put an RMS in place may not only jeopardise the future of the IWC, but perhaps more importantly serve neither the interests of whale conservation nor management – the dual mandates of our Convention.

The Preface to my proposal (IWC/56/COMMS 2) outlines what I believe is an incontrovertible case for the timely adoption of an RMS from the twin standpoints of conservation and wise management. I won't repeat the case here, but ask you to consider it very carefully indeed. I recognise that the completion and timely adoption of the RMS will require an atmosphere of trust and mutual understanding among member governments that has often appeared to be lacking in recent IWC meetings. However, I was encouraged and heartened by the constructive nature of discussions within my small group, despite the very different opinions held on a number of key issues, and hope that this spirit of co-operation and willingness to seek compromises will continue into the private Commissioners' meeting and indeed all aspects of the Commission's work this year.

I have developed what I believe to be a fair and realistic proposal for the essential ingredients of an RMS package for consideration now by the whole Commission. Inevitably, not every detail of this package will satisfy every member nation – that is inherent in the concept of compromise. However, I have endeavoured to respect, to the extent possible, the various viewpoints held by Commission members within a logical framework that ensures that the rules and regulations of the Commission are not only obeyed but also seen to be obeyed in an efficient and cost-effective manner.

The proposal is, of course, open to discussion. However, as the package includes, in some way, almost all of the elements that have been discussed recently in the context of the RMS, the exception being blanket trade restrictions and sanctuaries (for reasons explained in my document), I strongly urge you to concentrate on refinements to the package and not, unless deemed necessary by the great majority of Contracting Governments, entertain suggestions that would involve major changes and reconstruction of the entire package. If refinements and changes are considered necessary – and there no doubt will be some – then I believe it is essential to have a clear explanation of why they are needed, following the approach that I have used for my proposal.

If there is a generally favourable reaction to my proposals for an RMS, then I believe it should be possible to have firm proposals ready for adoption at the meeting in 2005. This will require substantial intersessional activity of both a technical and policy nature prior to the 2005 Annual Meeting.

In conclusion, I sincerely hope that you will be able to broadly accept my proposal for an RMS package and agree to the necessary intersessional activities. Once again, I stress my view that failure to put a workable RMS in place will serve neither the interests of whale conservation nor management – the dual mandates of our Convention.

Annex G

Information Provided by Contracting Governments regarding Whale Killing Methods and Associated Welfare Issues

DENMARK (GREENLAND)

1. Summary of Activities Related to the Action Plan on Whale Killing Methods (based on Resolution 1999-1)

Contracting Government	Denmark (Greenland)
Season	2003
Area	Greenland
Fishery type (e.g. commercial, aboriginal subsistence, scientific permit)	Aboriginal subsistence

Summary of primary and secondary whale killing methods used
(Note that the appropriate Method No. should be used throughout the form)

Method No.	Brief description of method (e.g. penthrite grenade, 'cold' grenade, rifle *of stated calibre*, etc). Put the most commonly used method first. Insert more rows if necessary.	Used as: (state whether primary killing method, secondary, or both)
1	Penthrite grenade	Primary (142 in West Greenland)
2	Rifle (minimum 30.06 cal. (7.62 mm) and cal. .375 or cal. 458	Primary (52 in West Greenland + 13 in East Greenland)

Summary of criteria used to indicate unconsciousness and death

[Include brief description here]
Criteria: when the whale does not move and the flippers are immovable.
Number of whales killed instantly are whales reported killed within 1 minute.

Summary of information providers

Percentage of data provided by:	
• Inspectors	0%
• Scientists	0%
• Hunters	100%
• Other (please specify)	0%

Summary of hunt

Item	Species 1 *Minke whale - West Greenland*		Species 2 *Minke whale - East Greenland*		Species 3 *Fin whale*	
	No.	%	No.	%	No.	%
Whale killing methods						
• Total no. killed (all methods summed)	185		13		9	
• Total killed using Method 1 only	133	72			9	100
• Total killed using Method 2 only	52	28	13	100		
• Total killed using Method 3 only						
• Total needing secondary harpoon or other secondary killing method						
• If bullets used:						
- minimum number						
- maximum number						
- median number						
Time to unconsciousness/death (TTD)*						
• Total for which information recorded	179		13	100	7	78
• Total estimated TTD to be instant	36		2	15	1	20
• Maximum estimated TTD	300 min.		60 min.		720 min.[1]	
• Mean time to TTD	14 min.		31 min.		114 min.[1]	
• Median Time to TTD	8 min.		25 min.		10 min.	
Other information						
• Total targeted and missed						
• Total struck and lost	7		1		3	

[1]The time to death of 720 minutes of one struck and lost fin whale was caused by bad weather conditions and the breaking of the harpoon string. When excluding this one whale the average time to death was 13 minutes.

***NB: The Resolution asks for TTD information for each whale not killed instantly. Please append these data, e.g. as Table or histogram.** [none]

Any other relevant information e.g. with information on technical assistance given to other fisheries or with respect to new studies to (a) improve methods and TTD, (b) develop new criteria for TTD. [none]

2. Report on improvements in ASW in Greenland

Referring to Resolution 1997-1 on improving the humaneness of aboriginal subsistence whaling, the Greenland Home Rule Government would like to report the following on the process of improvements:

- The harpoon-cannon renovating programme finished in 1998. 71 harpoon cannons were well functioning and safe. 37 vessels with a mounted harpoon cannon were active in the 2003-season, and approx. 575 skiffs were used in the collective hunt.
- A seminar on renewable resources was held 9-11 October 1998 in KATUAQ, the Greenlandic cultural centre in Nuuk. Representatives from all relevant Greenlandic parties were gathered to discuss future ways for sustainable harvest, the situation of the living natural resources, hunting ethics, sharing the resources, etc.
- On 9-11 February 1999 the North Atlantic Marine Mammal Commission (NAMMCO) held a workshop on hunting methods used for hunting marine mammals in NAMMCO member countries. As the workshop was held in Nuuk, Greenland, several Greenlandic hunters participated in this workshop and had the opportunity to share information on hunting methods with other hunters and whalers.
- From March to September 2000 several courses on the handling and instruction of the use of the new Norwegian penthrite grenade (Whale Grenade-99) were held for about 150 whalers, wildlife officers and the Greenland Trade Company (distributor of the grenade in Greenland). The whalers representing the 71 vessels with a mounted harpoon cannon. The courses were arranged in cooperation with Dr. Egil Ole Øen and the Greenland Home Rule ship consultant Mr Peter Siegstad and the Department of Industry.
- The harpoon-cannons are inspected every second year, thereby reducing the risks for the hunters to a minimum and maximising the efficiency when killing whales.
- In November 2001, NAMMCO held a weapons and ammunition workshop in Sandefjord, Norway, on ballistics related to hunting in the NAMMCO member countries of relevant mammals and marine mammals, including minke whales and fin whales.
- In January 2003, NAMMCO held a conference titled 'Users Knowledge and Scientific Knowledge in Management Decision Making' on how both user knowledge and scientific knowledge can be incorporated into management decisions. The recommendations and conclusions from the Conference will form the basis to further the work of integrating user knowledge into the management decision making process.
- From April to August 2003, 9 courses on the handling and instruction of the use of the Norwegian penthrite grenade (Whale Grenade-99) were held for about 75 whalers. The courses were arranged in cooperation with consultant Mr Peter Siegstad and the Department of Fisheries and Hunting.

3. A note regarding information encouraged in Resolution 1999-1

The following text contains comments to Resolution 1999-1 regarding the operative paragraphs 2-5:

Ad 2: Number of whales killed by each method:

- In West Greenland, the total minke whale quota was 190, including a carry-over quota. 135 (reallocation 133) minke whales were allocated to vessels with harpoon cannons and 55 (reallocation 57) to the collective hunt. In East Greenland, the quota of 15 minke whales was allocated to the collective hunt, including a carry-over quota.
- In West Greenland, the municipal collective hunt quota on minke whales varied from 2 to 6 animals. The municipal quota to vessels with harpoon cannons was a free quota. 37 of 65 vessels were active in 2003. The 2003 quota and catch of minke whales and the number of vessels with harpoon cannons can be seen in Appendix 1.
- In West Greenland, 133 minke whales were killed by harpoon whereas 52 minke whales were killed in the collective hunt. In East Greenland 13 minke whales were killed in the collective hunt.
- The fin whale quota of 19 animals was set free for vessels mounted with harpoon cannons. In the 2003 season, 9 fin whales were killed.

Number and proportion of total whales killed instantaneously; time-to-death for each animal not killed instantly:

- 36 minke whales were reported killed within 1 minute, the average time to death for minke whales was 14 minutes. 1 fin whale was reported killed within 1 minute. The average time to death for fin whales was 114 minutes, this caused by one struck and lost whale with a time to death of 720 minutes due to bad weather conditions and the breaking of the harpoon string. When excluding this one whale the average time to death was 13 minutes.

Number of whales targeted and missed; number of whales struck and lost:

- See Appendix 1.

Calibre of rifle used and number of bullets used:

- In the collective hunt on minke whales, a minimum of 30.06 cal. (7.62 mm) rifle and cal. .375 or cal. .458 are used. It is not an obligation to report the number of bullets used. It will require many resources to collect information from approx. 575 skiffs.

Methods used to determine unconsciousness/time to death:

- The information collected from the hunters is not scientifically based. There is an instruction on how to determine the time to death in the regulation; from the first shot to the time when the hunter measures that the whale is dead.

Ad 3: Development of more accurate indicators for determining the time to death other than cessation of movement:

- Greenland is lacking the assistance from veterinarians who, in a professional manner, are capable of collecting data on the time to death, and of developing more accurate indicators for determining the time to death.

Ad 4: 'Recognises the difficulty, in some aboriginal subsistence hunts, of obtaining time to death information….'

- See the comments in point 3.

Ad 5: 'Encourages all Contracting Governments to provide appropriate technical assistance to reduce cruelty in aboriginal subsistence whaling.'

- Greenland has a very good working relationship with the Norwegian government allowing Greenland to import the new whale grenade. Furthermore, Greenland gets very good assistance from Dr. Egil Ole Øen concerning the introduction and instruction of how to use the newly developed penthrite grenade used in the minke whale and fin whale hunt.
- Greenland also seeks advice on how to improve hunting gear and methods through the very fruitful working relationship via NAMMCO which arranged a workshop on hunting methods in February 1999, and a workshop on marine mammals: weapons, ammunition and ballistics, in November 2001.

4. Status for Greenland Action Plan on Whale Hunting Methods, 2003

Implementation of the Greenland Action Plan on Whale Hunting Methods was described in IWC/46/AS3. Recent development in Greenlandic Whaling was furthermore presented in IWC/49/AS3, IWC/51/WK6, IWC/51/WK7, IWC/51/WK8.

With reference to the 10 point Revised Action Plan recommended from the workshop on Whale Killing Methods, 1995, the status for the Greenland Action Plan on Whale Hunting Methods in 2003 is summarised as follows.

Re. Rev. Action Plan point 2: Continue improving accuracy of delivery of penthrite grenade harpoons, including assessment of refined sighting equipment suitable for rapid action under conditions encountered at sea. Support and encourage the development and implementation of programmes to provide training in the safe handling and effective use of killing devices including the penthrite grenade and in other aspects of the hunt.

In close co-operation with the Greenlandic Trade Company (Pilersuisoq A/S) detonating penthrite grenades are distributed according to the issued licenses on 14 places for sale throughout the whaling season. In the period 1991-1994, 147 persons (fishermen and hunters, distributors and shipyard workers) have passed the course in safe handling and firing of the detonating grenade and other hunting equipment. A further 48 persons finished the course in 1999.

The overhaul programme for the harpoon cannons was successfully concluded in 1998. In 2003 there were 65 harpoon cannons on the West coast of Greenland authorised to apply for a license to go whaling. The harpoon cannons are inspected every 2 years - reducing the risks for the hunters to a minimum and maximising the efficiency when killing whales.

From March to September 2000, 9 courses were held in Greenland on the handling and instruction in the use of the new Norwegian Whale Grenade-99. All persons who completed a course on the 1985-whale grenade proto-type and newcomers were offered places on the new course which included information on how to keep the harpoon cannons in good shape. The course also included items mentioned in the Action Plan points 2, 3, 4 and 8.

From April to August 2003 an additional 9 courses on the handling and instruction of the of the Norwegian penthrite grenade (Whale Grenade-99) were held for about 75 whalers. The course also included items mentioned in the Action Plan points 2, 3, 4 and 8.

Re. Rev. Action Plan point 3: Continue to review constraints on shooting distance and relative orientation of vessel and whale and encourage reducing times to death.

Shooting distances and shooting angle are dealt with in the course in safe handling and firing of the detonating grenade. Furthermore, maintenance of the harpoon cannons is reviewed.

Re. Rev. Action Plan point 4: Continue to review the effectiveness of secondary killing methods with a view to reducing time to death in whales and encourage the application of the most effective methods.

In fin whaling the secondary killing methods is - like the first - the penthrite grenade, while in the hunt for minke whales a minimum of a 30.06 cal. (7.62 mm) rifle has proven sufficient. Some hunters use cal. .375 or cal. .458 as well.

Re. Rev. Action Plan point 8: Encourage the collection and presentation of struck and lost rates and standardised time to death records in aboriginal subsistence catches of whales and undertake the assessment of requirements for controls on the use of rifles to kill unsecured whales.

In 1992, the Greenland Home Rule Government introduced time to death in the self-reporting system for catch reports in the hunt for fin and minke whales. The regulations and catch report system are also reviewed in the course on the handling of the penthrite grenade.

Re. Rev. Action Plan point 9: Encourage the incorporation of data collection and reduction of struck and lost rates in the initiatives in Greenland relating to the beluga and narwhal hunts.

The Greenland Home Rule Government and Denmark does not recognise IWC competence on small cetacean issues, and consequently Greenland will not provide any information as to point 9.

Appendix 1

2003 QUOTA ALLOCATION TO INDIVIDUAL MUNICIPALITIES

The numbers in the quota columns are given before 1 April, and reallocations of not-used licenses took place 30 August and 15 October. Consequently, the quota of each municipality can vary from the actual total catch.

Municipality	Harpoon cannon quota	Collective hunt (rifle) quota	Total quota	No. of harpoon cannons	Settlements without harpoon cannons	Harpoon cannon strikes	Collective strikes	Total strikes
Nanortalik		6		1	6	7	7	14
Qaqortoq		4		4	4	26	5	31
Narsaq		2		3	2	23	4	27
Paamiut		3		6	1	8	3	11
Nuuk		5		8	1	21	3	24
Maniitsoq		5		8	1	16	4	20
Sisimiut		4		9	2	20	5	25
Kangaatsiaq		5		5	4	1	3	4
Aasiaat		4		4	2	4	1	5
Qasigiannguit		2		3	1	0	2	2
Ilulissat		4		10	4	2	3	5
Qeqertarsuaq		4		3	1	5	5	10
Uummannaq		5		1	6	0	5	5
Upernavik		2		0	6	0	2	2
West Greenland total	**135**	**55**	**190**	**65**[1]	**35**	**133**	**52**	**185**
Tasiilaq	0	12	12	0	-	0	13	13
Ittoqqortoormiit	0	3	3	0	-	0	0	0
East Greenland total	**0**	**15**	**15**	**0**	**-**	**0**	**13**	**13**

Note: 7 struck and lost (Sisimiut: 3; Qasugiannguit: 1, 2; Qeqertarsuaq: 3). [1] 4 boat owners with 2 harpoon cannons each.

RUSSIAN FEDERATION

(On next page)

RUSSIAN FEDERATION

1. Summary of Activities Related to the Action Plan on Whale Killing Methods (based on Resolution 1999-1)

Contracting Government	Russian Federation
Season	2003
Area	Chukotka waters
Fishery type (e.g. commerical, aboriginal subsistence, scientific permit)	Aboriginal subsistence

Summary of primary and secondary whale killing methods used
(Note that the appropriate Method No. should be used throughout the form)

Method No.	Brief description of method (e.g. penthrite grenade, 'cold' grenade, rifle *of stated calibre*, etc). Put the most commonly used method first. Insert more rows if necessary.	Used as: (state whether primary killing method, secondary, or both)
1	Harpoon with float	
2	Darting gun	
3	Rifle (various)	

Summary of criteria used to indicate unconsciousness and death

[Include brief description here]

Criteria: Visual determination of unconsciousness and death. Rifles are utilised for control (final defining) shot that guarantees death.

Summary of information providers:

Percentage of data provided by:	
• Inspectors	100%
• Scientists	Approximately 50%
• Hunters	100%
• Other (please specify)	

Summary of hunt

Item	Species 1 *Gray whale*		Species 2 *Bowhead whale*		Species 3 *[insert name]*	
	No.	%	No.	%	No.	%
Whale killing methods						
• Total no. killed (all methods summed)	126		3			
• Total killed using Method 1 only	0		0			
• Total killed using Method 2 only	0		0			
• Total killed using Method 3 only	0		0			
• Total needing secondary harpoon or other secondary killing method	126**	100	3#	100		
• If bullets used:						
- minimum number	8		50			
- maximum number	97		60			
- median number	36.9		55			
Time to unconsciousness/death (TTD)*						
• Total for which information recorded						
• Total estimated TTD to be instant						
• Maximum estimated TTD	50 mins		40 mins			
• Mean time to TTD	28.7 mins		30 mins			
• Median Time to TTD						
Other information						
• Total targeted and missed						
• Total struck and lost	2					

**Gray whales: the harpoon (Method 1) and rifles (Method 3) were used in the kill of all 126 whales. In addition, the darting gun was used in the kill of 66 (52%) of these whales.
#Bowhead whales: The harpoon (Method 1) and darting gun (Method 2) were used to kill all 3 whales. In addition, the rifle (Method 3) was used in the kill of 2 of the whales.

****NB The Resolution asks for TTD information for each whale not killed instantly. Please append these data, e.g. as Table or histogram.*** [none]

Other: Any other relevant information e.g. with information on technical assistance given to other fisheries or with respect to new studies to (a) improve methods and TTD, (b) develop new criteria for TTD: [See table above]

UNITED STATES OF AMERICA

Data provided on 2003 Bowhead Subsistence Hunt

- In 2003, 35 bowhead whales were landed. All of those whales were taken using the traditional hand-thrown darting gun harpoon with the traditional shoulder gun used as the secondary killing method.
- Thirty-one whales were landed using darting gun harpoons firing a traditional black powder projectile. Four whales were taken in Barrow using the penthrite projectile that the AEWC has been working with Dr. Egil Øen of Norway to develop.
- Six whales were struck and lost. Therefore, for 2003, the rate of efficiency of the hunt was 85%. This rate is much higher than the previous year, but as we have explained previously, weather and ice conditions play a significant role in determining the efficiency of the aboriginal bowhead whale hunts.
- It should be noted in this regard that historically the rate of efficiency in this hunt was 50%. However, the AEWC made a commitment to this Commission to increase the hunt's efficiency rate to an annual average of 75%. As with every other commitment it has made, the AEWC has not only fulfilled this promise, in recent years, it has exceeded 75% as an annual average.
- Two initiatives of the AEWC have been largely responsible for this dramatic improvement in efficiency as well as an increase in the humaneness of this hunt. First, the AEWC early on instituted a practice at its annual meetings whereby the more experienced and successful captains share their hunting techniques with each other and with the younger and less experienced hunters. This 'Hunting Efficiency Workshop' is conducted using a replica of a bowhead whale so that participants can actually demonstrate techniques.
- The Whaling Captains' Associations in individual villages conduct similar workshops each year to that village's bowhead subsistence hunt.
- The second AEWC initiative to help improve the efficiency and humaneness of this hunt is the 'Weapons Improvement Program' overseen by the AEWC's 'Weapons Improvement Committee' which is comprised of hunters, weapons experts and scientists. It is through this Program and under the supervision of the Weapons Improvement Committee that the AEWC has achieved success in adapting the penthrite-exploding projectile for use in the traditional hand-held darting gun.
- Environmental conditions for the spring and fall hunt are treacherous and cause difficulty for subsistence hunters to determine time to death with precision. During the spring, the bowhead subsistence hunt is conducted from the edge of the shore-fast ice and in the spring ice lead system. Crews use small hand-made canoes (*umiaqs*) consisting of sealskin stretched over a wooden frame and designed to hold four to six people.
- In light of the circumstances of this hunt, it can be seen that in the bowhead subsistence hunt, visual observations simply cannot yield an accurate estimate of time-to-death.
- The AEWC has made extraordinary efforts over the years to cooperate with the Commission. This commitment continues. Therefore, working with the scientists at the North Slope Borough Department of Wildlife Management, the AEWC is preparing to collaborate with researchers at the Norwegian School of Veterinary Medicine on the development of techniques to recover brain tissue samples from landed bowhead whales. As in Norway, these tissue samples would be used to study brain trauma caused by the detonation of the penthrite projectile. The AEWC hopes to follow the success of Norway in using this information as a basis for estimating time to death in the bowhead subsistence hunt.

Annex H

Report of the Conservation Committee

Wednesday 14 July and Thursday 15 July 2004, Sorrento, Italy

1. INTRODUCTORY ITEMS

The meeting took place at the Hilton Sorrento Palace Hotel, Sorrento, Italy on the afternoon of 14 July and the morning of 15 July 2004 and was chaired by Horst Kleinschmidt (South Africa). A list of participants is given in Appendix 1.

1.1 Convener's opening remarks

Horst Kleinschmidt (South Africa) welcomed delegates and observers to the inaugural meeting of the Conservation Committee. He indicated that, upon the recent withdrawal from the Commission of Carlos Dominguez Diaz (Spain), who had agreed to convene the Committee, the IWC Chair had invited him to convene the Committee.

1.2 Election of Chair

Horst Kleinschmidt (South Africa) was elected Chair.

1.3 Appointment of rapporteur

Stephen Powell (Australia) was appointed rapporteur.

1.4 Review of documents

The following documents were relevant to the discussions of the Committee:

IWC/56/CC1: Revised Draft Agenda
IWC/56/CC2: Overview of collaboration with other organisations (Secretariat)
IWC/56/CC3: A proposal for voluntary national reports on cetacean conservation (Brazil)
IWC/56/CC4: Statement regarding the Scientific Committee (DeMaster and Donovan)
IWC/56/12: Funding considerations in relation to the Conservation Committee (Secretariat)
Appendix 3: Report of the small group on the Conservation Committee
Appendices I and II of CMS (CMS)

2. ADOPTION OF THE AGENDA

The agenda, as given in Appendix 2, was adopted without amendment.

As this was the inaugural meeting of the Conservation Committee, the Chair invited members to address general issues relating to the establishment and purpose of the new Committee before turning to specific agenda items. There was consensus that all members of the IWC should be and were committed to conservation, and that the new Committee should not supervise or duplicate the work of any other bodies of the Commission. However, a range of views were expressed about the appropriateness or otherwise of the steps taken to establish the Conservation Committee. It was agreed that efforts since IWC/55 to improve the level of communication between members in disagreement were important.

Many of the co-sponsors of Resolution 2003-1, by which the Committee was established, stated that the new body should be viewed as pro-conservation, not anti-whaling. These members recognised that the Convention provides for both conservation and management of whale stocks, and believed that the establishment of the Conservation Committee did not prevent the fulfilment of either of these objectives. The conservation of whale stocks was in the common interest.

These members held the view that the establishment of the Committee would not alter or in any way impinge upon the attributions or work of any of the Commission's active bodies, nor would it change any of the functions or terms of reference of such bodies, or of the Commission itself. Rather, the primary objective in setting up the Conservation Committee in their view was to rationalise the Commission's work on that part of its agenda that deals with conservation issues, as well as to institutionalise and better distribute the Commission's workload. They emphasised that the Conservation Committee would not have any supervisory function over the work of the Scientific Committee, which has its agenda and terms of reference clearly established by the Commission.

Those who had supported the establishment of the Committee looked forward to the Committee improving the way the IWC met its responsibility for managing whales, by addressing issues not only from the perspective of whaling. To date, conservation issues had been typically addressed late in the plenary, and the Committee would allow such issues to be discussed in detail several days before the plenary. The Committee could provide advice and guidelines on conservation-related functions that were currently dispersed, and serve as a central node to identify and prioritise topics. This might prevent overload on other bodies of the Commission.

Other members, who had opposed Resolution 2003-1, indicated that they still had reservations about the establishment of the Committee, especially because in their view it took the objective of the 'conservation of whale stocks' out of the context of the objective of making possible 'the orderly development of the whaling industry.' They were committed to the sustainable use of natural resources, and viewed completion of a Revised Management Scheme to prevent over-exploitation as a higher priority conservation measure than items that might be addressed under a Conservation Committee. Their participation in the first meeting should not be construed as change of position on the Resolution.

These members stated that the process used at IWC/55 to create a new body made no attempt to bring the members of the IWC together: a mechanism to address those conservation issues which are capable of attracting widespread support ought not to have been promoted in a manner which did not effectively consult nearly half of the members of the IWC. Some efforts to discuss alternative language had been rejected out of hand, which was not conducive to open and fair dealings.

Those who had opposed the establishment of the Committee noted that, even if nothing in Resolution 2003-1 defined conservation narrowly, the wording of the Resolution and its appendix of past decisions of the Commission made it clear that the initiative would alienate nearly half of the members of the IWC. Nonetheless, members present who had opposed the process had decided to attend the first meeting, expecting a change to the name of the Committee and amendment of the original Resolution, in order to reciprocate their goodwill.

The Committee discussed the question of how to define 'conservation,' and particularly whether that should be construed as including 'sustainable use'. It was noted that various definitions were available, both from dictionaries (though there was no equivalent term in some languages), and in the texts and agreements of other treaties. While it was agreed that conservation was of interest to all members, and that further discussion on its definition would be worthwhile, a definitive answer was beyond the capacity of the Committee's first meeting. Some indicated that they had envisaged the Committee addressing issues that did not fit the remit of 'sustainable use,' while others would welcome further discussion on this.

It was noted that many members of the Commission were absent. This could be viewed as an indication of dissatisfaction with the process by which the Committee was established. Supporters of the Committee indicated that they were engaged in a constructive dialogue with some of the absent members, in the interest of seeking broad participation, and hoped that the Committee's report might demonstrate to them the value of the Committee.

3. DEVELOPMENT OF TERMS OF REFERENCE AND WORKING METHODS

3.1 Relationship between the Conservation Committee and other bodies within the Commission

Relationships between the Conservation Committee and other bodies within the Commission will be vital to the success and effectiveness of the new Committee. Relationships should be based on the principle of complementarity, not duplication.

The Chair of the Scientific Committee introduced IWC/56/CC4, expressing the view that the actions and recommendations of the Conservation Committee will be of considerable interest to the Scientific Committee, and vice versa. The statement indicates that the proceedings of all of the Scientific Committee's sub-committees and working groups have relevance to conservation.

It was clarified that the paper was not discussed at or endorsed by the Scientific Committee. Rather, it was presented by DeMaster and Donovan to aid the Conservation Committee's discussions. The issue of relationships with the Conservation Committee had not been placed on the agenda of the Scientific Committee because it was not clear how this could occur until the 2004 meeting gave such guidance. Members viewed the table of conservation-related items addressed by the Scientific Committee as helpful (see Item 4.1 below), and some noted that the Conservation Committee presented an opportunity for the Commission to address the conservation-related advice provided by the Scientific Committee more fully than in the past.

The Committee agreed that interactions with the Scientific Committee would occur in the same way that the Scientific Committee interacts with other subsidiary bodies already established by the Commission. As with the Aboriginal Subsistence Whaling Sub-committee and the first meeting of the Conservation Committee, the Chair of the Scientific Committee would attend and provide information on scientific matters that are germane to that body's work.

Relationships with the Technical Committee were also addressed. Some members viewed the reference to 'conservation' in the Rules of Procedure that relate to the Technical Committee as evidence of potential overlap with the Conservation Committee. Rule of Procedure M7 might need to be changed to avoid duplication of functions. The alternative view was that appropriate delegation of responsibility could ensure complementarity: the Commission could refer to the Technical Committee the development of proposed management measures that the Commission considered for adoption into the Schedule (i.e. matters pertaining to Article V), while referring to the Conservation Committee the development of the conservation agenda and related proposed recommendations (i.e. matters pertaining to Article VI). There were also other views on these issues.

3.2 Proposed terms of reference

Resolution 2003-1 contained three terms of reference for the Conservation Committee:

(1) the preparation and recommendation to the Commission of its future Conservation Agenda;
(2) the implementation of those items in the Agenda that the Commission may refer to it; and
(3) making recommendations to the Commission in order to maintain and update the Conservation Agenda on a continuing basis.

Many felt that these should guide the initial work of the Committee. The Committee should begin its work under these terms, and should develop additional terms if and when required. Further drafting work should proceed in an open process under the auspices of the Commission as a whole or its Chair.

Others who would prefer alternative terms of reference or who had not commented were encouraged to make specific proposals. Terms of reference for committees were typically brief, while the list of items to be addressed in the standing agenda of the Committee, generated separately, would be much more detailed.

In light of the concerns raised by those who had opposed Resolution 2003-1, a small group was formed to examine the language of the Resolution and further discuss terms of reference, outside of the Committee meeting. The group comprised the Netherlands (Chair), Australia, Iceland, Republic of Korea, Mexico, New Zealand and South Africa, and discussed concepts of conservation, ways to move forward after Resolution 2003-1, and terms of reference. The group agreed to the importance of addressing conservation in the IWC and to respect different views on whaling. Furthermore the group offered for discussion a collection of possible ways forward, including different ways of defining the concept of conservation, and various alternatives, including resolutions, that could clarify the work of the new Committee, including addressing its connection to Resolution 2003-1 (Appendix 3). This discussion should be in an open process and should be open to all IWC members. Should intersessional discussion be required, this should occur via correspondence rather than intersessional meetings.

3.3 Proposed working methods

The Committee agreed to hold annual meetings, in line with the practice of other committees and working groups. The Conservation Committee would not normally meet intersessionally, other than by e-mail when necessary.

3.4 Funding considerations

Paragraph 8 of Resolution 2003-1 charged the Committee with beginning to explore the possibility of a trust fund to make resources available both to the Commission and to Contracting Governments to implement research related to the Conservation Agenda. Discussion indicated it was premature to discuss this in detail yet. Further, it would be up to the Commission to decide whether to establish such a fund.

The Committee noted that the Secretariat had, as requested, prepared a report on funding considerations, *inter alia* the implementation of Resolutions 1998-6 on Funding of Work on Environmental Concerns and 1995-5 on the Funding of High Priority Scientific Research. This report was available to the Conservation Committee as well as to the Commission (IWC/56/12).

4. CONSIDERATION OF ITEMS TO FALL UNDER THE AUSPICES OF THE CONSERVATION COMMITTEE

The Committee recognised the value of establishing a list of items to address as part of the 'extensive conservation agenda' mentioned in its founding Resolution. The following were proposed as initial items of common interest:

- endangered species and populations;
- human impacts (e.g. noise, vessel strike, bycatch, entanglements, strandings);
- habitat protection for cetacean conservation;
- whalewatching best practice guidelines;
- reporting systems for strandings, entanglements and bycatch; and
- legal and regulatory arrangements for cetacean conservation.

Some countries argued that the list is too general and too extensive. These countries argued that conservation issues are very important, but only for a small number of species and stocks of large whales. Many species and stocks of large whales are either quite numerous or rapidly growing, and for these, in their opinion, the items on the list above are not important for conservation.

4.1 Scientific issues

Of the conservation-related items currently addressed by the Scientific Committee (listed in IWC/56/CC4), the following were identified as most germane to the work of the Conservation Committee:

- highly endangered species and populations;
- scientific research related to development of techniques for improved assessment of status and mitigation measures to potential threats where identified;
- incidental takes of cetaceans including assessment of problems at the population level and development and evaluation of mitigation measures;
- non-consumptive utilisation of cetaceans;
- whales and their environment, with an emphasis on population level effects and interaction with interpreting abundance estimates;
- sanctuaries, in particular their value to the monitoring and recovery of depleted populations;
- scientific advice relevant to enforcement and compliance with conservation measures;
- collaboration with other organisations; and
- voluntary submission of national reports on cetacean conservation (IWC/56/CC3).

4.2 Collaboration with other organisations

The Conservation Committee is directed 'to explore how the Commission can co-ordinate its conservation agenda through greater collaboration with a wider range of other organisations and conventions.' Paper IWC/56/CC2 described the major existing points of cooperation between the Commission and other organisations and conventions, which include reciprocal observer arrangements on scientific committees. The Committee could centralise collaboration, maintain an overview of those who serve as ambassadors for the IWC, and identify opportunities for new and improved collaborations.

Under this item, the Committee agreed to invite Marco Barbieri of the Secretariat to the Convention on Migratory Species (CMS), to which many IWC members belong, to address this issue. Mr Barbieri reported that CMS has been following with interest the development of the new Committee and looks forward to continuing to work closely with the IWC. A CMS-IWC Memorandum of Cooperation is in place.

5. DEVELOPMENT OF A CONSERVATION AGENDA

The Committee viewed its discussion of terms of reference, relationships with other bodies, and items to fall under its auspices as the first steps towards the development of a conservation agenda.

Brazil and Argentina proposed, through paper IWC/56/CC3, to seek voluntary reports from Contracting Governments on national actions on cetacean conservation, to provide information to subsidise a conservation agenda, in the terms of non-whaling cetacean management. In response to concerns that this might need further work, the Committee agreed to include this topic in those items under 4.1 above. Some delegations considered it premature to enter into substantive discussions, until a conclusion has been reached regarding the nature of the Conservation Committee. Other delegations disagreed with this and felt it was appropriate to start substantive discussions at this time.

6. ADOPTION OF THE REPORT

The Committee adopted the report at 09:25 on Saturday 17 July 2004.

Appendix 1

LIST OF PARTICIPANTS

Argentina
Raul Comelli
Eduardo Iglesias
Miguel Iñiguez

Australia
Nicola Beynon
Pam Eiser
Connall O'Connell
Stephen Powell

Austria
Andrea Nouak
Michael Stachowitsch

Belgium
Alexandre de Lichtervelde
Koen Van Waerebeek

Brazil
Regis Pinto de Lima
Marcia Engel
Jose Truda Palazzo Jr.

Chile
Francisco Devia Aldunate

Denmark
Ole Heinrich
Amalie Jessen
Kim Mathiasen
Maj Friis Munk
Ole Samsing
Leif Fontaine

Finland
Esko Jaakkola

France
Vincent Ridoux

Germany
Peter Bradhering
Wolfgang Dinter
Karl-Herman Kock
Marlies Reimann

Iceland
Stefan Asmundsson
Ragnar Baldursson
Asta Einarsdottir
Gisli Vikingsson

Ireland
Christopher O'Grady

Italy
Giuseppe Notarbartolo di Sciara

Republic of Korea
Chang Myeng Byen
Zang Geun Kim
Oh Seung Kwon
Sung Kwon Soh

Mexico
Exequiel Ezcurra Real de Azua
Lorenzo Rojas Bracho

Monaco
Frederic Briand

Netherlands
Henk Eggink
Giuseppe Rapphorst
Anne-Marie van der Heijden

New Zealand
Chris Anderson
Mike Donoghue
Nigel Fyfe
Al Gillespie
Geoffrey Palmer

Norway
Halvard Johansen
Lars Walløe

Russian Federation
Rudolf Borodin
Valentin Ilyashenko

South Africa
Horst Kleinschmidt
Herman Oosthuizen

Spain
Carmen Asencio
Santiago Lens

Sweden
Bo Fernholm

Switzerland
Tom Althaus

UK
Richard Cowan
Geoff Jasinski
Laurence Kell
Jenny Lonsdale
Trevor Perfect
Mark Simmonds

USA
Nancy Azzam
Robert Brownell
Carole Carlson
Roger Eckert
Thomas Napageak
Gary Rankel
Jean Pierre Plé
Nathan Pamplin
Rollie Schmitten
Brad Smith
Michael Tillman
Chris Yates

Secretariat
Nicky Grandy
Greg Donovan

Appendix 2

AGENDA

1. Introductory items
   1.1 Convener's opening remarks
   1.2 Election of Chair
   1.3 Appointment of rapporteur
   1.4 Review of documents
2. Adoption of the Agenda
3. Development of terms of reference and working methods
   3.1 Relationship between the Conservation Committee and other bodies within the Commission
   3.2 Proposed terms of reference
   3.3 Proposed working methods
   3.4 Funding considerations
4. Consideration of items to fall under the auspices of the Conservation Committee
   4.1 Scientific issues
   4.2 Collaboration with other organisations
5. Development of a conservation agenda
6. Other matters
7. Adoption of the report

Appendix 3

REPORT OF THE SMALL GROUP ON THE CONSERVATION COMMITTEE

Participants: Australia, Iceland, Mexico, Netherlands (Chair and rapporteur), New Zealand, Republic of Korea, South Africa

Purpose of meeting

On request of the Conservation Committee (CC) meeting of 14 July 2004, to collect views with respect to the expectations of the work of the CC and to report back to the Committee.

The Chair identified the following subjects for discussion:

- concepts of conservation;
- ways to move forward after Resolution 2003-1;
- terms of reference of the CC; and
- possible way forward after reporting back to the CC.

Context in which we collected views

The group agreed to exchange views and opinions in an open manner, meaning no negotiation, respecting each other feelings, accepting all views expressed by the members of the informal group and defining the most broad range of options. It was discussed and accepted that existing different views with regard to whaling should be respected in trying to define common ground and possible ways to move forward.

1. Concepts of conservation

DISCUSSION

Everybody agreed with the importance of addressing conservation in the IWC.

It was further noted that the purpose of conservation can be looked at from different angles. One view is that conservation, unlike preservation, does not exclude sustainable use; another view is that conservation does not necessarily imply sustainable use but serves all kinds of purposes. A third view is that it explicitly includes sustainable use.

COLLECTED OPTIONS

(a) Define a specific IWC definition of conservation.
(b) Define conservation in relation to its different purposes: both preservation as well as sustainable use.
(c) Everyone can have their own interpretation of conservation without a fixed definition.
(d) No definition of conservation, but make explicit reference that it includes sustainable use.
(e) No definition of conservation, but make explicit reference that it includes sustainable use, specifying it by mentioning whaling, whale watching etc.
(f) No definition of conservation, but simply define a group of agenda-ideas which the committee could look at, e.g. starting with non-controversial issues like the most endangered species.
(g) A definition of conservation that is limited in specifying that conservation serves the purposes of the convention.

It was recognised that different combinations of above mentioned concepts could be made.

2. Ways to move forward with Resolution 2003-1

DISCUSSION

Everyone recognised that Resolution 2003-1 is a legal fact. It was further recognised that it is necessary to move beyond the existing *status quo* and to look at building bridges.

COLLECTED OPTIONS

(a) Accepting the *status quo* by which the CC moves forward under the present conditions.
(b) Drafting of a resolution with an instruction for work of the CC without reference to Resolution 2003-1.
(c) Drafting of a resolution in which it is clear that the work of the CC has no link with 2003-1.
(d) Drafting of a resolution with an instruction for work of the CC and which replaces 2003-1.
(e) Drafting of a resolution with an instruction for work of the CC which refers to all previous resolutions (instead of only to the ones in Annex I of 2003-1) and which recognises that conservation serves the purposes of the Convention.
(f) Drafting of a resolution which reconfirms the Conservation Committee and includes reference to a work plan.

Above mentioned options can be combined with the different options regarding the concept of conservation.

3. Terms of reference

DISCUSSION

Defining a ToR at this stage does not serve the purpose of the open discussion started on the functioning of the CC.

It was concluded that further drafting work on a ToR should proceed in an open process under auspices of the IWC or its Chair.

4. Possible way forward after reporting to the CC

DISCUSSION AND CONCLUSION

It was agreed that further discussions on the expectations of the work of the CC should be continued under the responsibility of the IWC or its Chair to ensure that all views will be taken into account in the further discussions.

Appendix 4

A PROPOSAL FOR VOLUNTARY NATIONAL REPORTS ON CETACEAN CONSERVATION

Submitted by Brazil

Introduction

The establishment of a Conservation Committee of the International Whaling Commission has opened new possibilities for the IWC to promote international cooperation and provide adequate advice for interested national governments on issues related to cetacean management and conservation.

To better assess the progress currently been made by national governments, identify cooperation opportunities and help develop the Conservation Agenda, it would be very useful to gather and analyse information provided by the governments themselves on the status of cetacean conservation and management initiatives they may wish to forward to the IWC. A parallel can be drawn with the National Progress Reports on Cetacean Research, which since their introduction in 1973 have been very useful as a Scientific Committee tool. In order to fulfil its mandate effectively, the Conservation Committee will likewise depend on the submission of information by Contracting Governments on progress with cetacean conservation.

Paragraph 31 of the Schedule already obliges Contracting Governments to transmit to the Commission copies of all their official laws and regulations relating to whales and whaling, and changes in such laws and regulations. Although this requirement is not limited to whaling-related measures, in practice not all members have transmitted their non-whaling laws and regulations affecting cetacean conservation, and these could be covered under a national cetacean conservation report. Issues such as the establishment of cetacean-related marine or freshwater protected areas, and particular management activities that could be of interest to other States facing similar challenges or willing to cooperate through either bilateral or international exchanges.

Even landlocked States, and other States with limited cetacean fauna, can and do contribute to cetacean conservation, for example through assistance with capacity building in cetacean conservation, especially in cooperation with developing States, as well as through active participation in biodiversity-related conventions other than the IWC.

National Cetacean Conservation Reports would be submitted annually for consideration by the Conservation Committee, and could subsidise its operational agenda as priority items of interest for member States are identified.

Brazil is mindful of the differing views and concerns regarding the initial operation of the Conservation Committee, and having taken these into account, would like to propose that the National Cetacean Conservation Reports be requested on a voluntary basis.

Proposal

We propose that a request be adopted by the Commission for the annual submission, on a voluntary basis, of National Cetacean Conservation Reports by Contracting Governments from 2005 onwards, to be considered by the Conservation Committee, and added to the IWC website.

These Reports should follow the format proposed in Adjunct 1 and contain information on:

- laws, regulations and other measures affecting the conservation of cetaceans;
- planning, design and designation/establishment of marine or freshwater protected areas of particular interest to cetacean conservation;
- information on whalewatching operations, its scale, target species and pertinent management issues;
- particular governmental programmes to enhance the conservation of endangered species and populations;
- data pertinent to the nature and scale of threats to cetacean conservation in their waters, and measures taken to address such threats, including, where appropriate, a summary of cooperation needs;
- systems in place for reporting of cetaceans injuries and mortality including stranding networks, incidental catch and collisions reporting frameworks;
- national activities pertaining to regional and bilateral agreements with other States relating to cetacean conservation;
- assistance to other States, especially to developing states, in the field of cetacean conservation, listing where appropriate future assistance opportunities that may become available; and
- any other information that the Conservation Committee may from time to time specify for inclusion.

The first such report should be submitted by interested parties to the Conservation Committee prior to the 57th Annual Meeting, and contain a comprehensive summary of existing laws, regulations and other measures in effect relevant to the conservation of cetaceans, and of the cetacean conservation work of the last few years. Subsequent annual reports need only contain new information.

Groups of Contracting Governments which have participated in cetacean conservation-related activities under the purview of regional organisations or agreements (such as CMS agreements) should seek to invite the organisation to submit a Cetacean Conservation Report documenting the relevant measures taken by that organisation.

The international organisations listed in Resolution 2003-1 (CMS, CCAMLR, IMO, IUCN, UNEP) should also be invited to submit regular information to the Conservation Committee on cetacean conservation issues and actions related to their field of work, preferably along the lines of the topics submitted to National Cetacean Conservation Reports.

Adjunct 1

Proposed Template for National Cetacean Conservation Reports

Country:

National Governmental Authority submitting the Report (full contact information)

1. Legal developments (laws, regulations and other regulatory measures related to cetaceans).
2. Information on whalewatching operations (scale, target species/populations and relevant management issues).
3. Current Government programs related to cetacean conservation.
4. Current threats to cetacean conservation and management measures taken/proposed.
5. Reporting systems for cetacean injuries/mortality/strandings.
6. International cooperation activities (includes bilateral or multilateral cooperation, assistance and funding programs and appropriate contact information, and other international activities of the Country submitting the Report).
7. Other (at the discretion of the Authority submitting the Report).

Annex I

Report of the Infractions Sub-Committee

Wednesday 14 July 2004, Sorrento, Italy

1. INTRODUCTORY ITEMS

The meeting took place at the Hilton Sorrento Palace Hotel, Sorrento, Italy on 14 July 2004. A list of participants is given in Appendix 1. The Infractions Sub-Committee considers matters and documents relating to the International Observer Scheme and Infractions insofar as they involve monitoring of compliance with the Schedule and penalties for infractions thereof (*Rep. int. Whal. Commn.* 29: 22).

1.1 Appointment of Chair

Sung Kwon Soh (Korea) was elected Chair.

1.2 Appointment of Rapporteur

Cherry Allison (Secretariat) was appointed rapporteur.

1.3 Review of documents

The following documents were available to the Sub-Committee.

IWC/56/Inf

1. Revised Draft Agenda
2. Secretariat: Expanded Revised Draft Agenda
3. Secretariat: National Legislation Details Supplied to the IWC
4. [Draft] Secretariat: Summary of Infraction Reports Received by the Commission in 2003
5. Quota monitoring on minke and fin whale hunting in Greenland, 2003

2. ADOPTION OF THE AGENDA

The Chair noted that in the past some delegations, including Norway and Japan, had referred to the terms of reference of this Sub-Committee and had stated their belief that Item 7.1, covering stockpiles of whale products and trade questions, was outside the scope of the Convention. Consequently, they had proposed that this item be deleted. Other delegations, including the USA and New Zealand had not agreed with this view. Nevertheless, as in previous years, it was agreed that an exchange of views might be useful and the draft agenda was adopted unchanged (Appendix 2).

3. INFRACTIONS REPORTS FROM CONTRACTING GOVERNMENTS, 2003

The Secretariat introduced IWC/56/Inf 3, the draft summary of infraction reports received by the Commission in 2003, which is given as Appendix 3 to this report.

The USA, on behalf of the Alaska Eskimo Whaling Commission, reported that 35 bowhead whales were landed in 2003, with 6 struck and lost. As explained in previous years, the weather and ice conditions play a significant role in determining the efficiency of the spring hunts. The USA reported two infractions in 2003, which occurred during an aboriginal subsistence hunt, when a female bowhead whale accompanied by a calf was taken. The female was landed whilst the status of the calf was unknown. The taking of cow-calf pairs is prohibited in Eskimo hunting tradition, and also under the regulations both of this Commission and of the AEWC Management plan. The AEWC has primary enforcement responsibility under a cooperative agreement with the Government of the USA. Following a hearing, the AEWC Commissioners concluded that the crew had not acted with proper caution and rescinded the bowhead subsistence captain's registration for two years. Further details are given in Appendix 3.

The Republic of Korea reported that the Ministry of Maritime Affairs and Fisheries and the marine police of Korea had exposed five illegal catches of minke whales in 2003 and had taken judicial and administrative measures as listed in Appendix 3. Four of the cases were deliberate, the catches being taken covertly with a spear by small fishing vessels and the fifth case was that of a dead whale found floating with spearheads stuck into it. The Korean authorities perceive these incidents to be a result of poachers trying to make money. The Government of Korea does not think poaching to be a major problem since all suspect poachers are listed and their movements watched by the police. The by-catch reporting system has proved useful in discriminating between illegal catches and by-catches. In addition, the authorities have continued to strengthen public awareness of poaching activities through the mass media. The Government of Korea will continue its efforts to bring an end to these illegal activities.

Switzerland asked whether it was legal for small harpoons to be carried on fishing vessels, as were reported to have been used in three of the infractions reported by the Republic of Korea. Korea replied that it was not permitted to carry harpoons on fishing vessels.

4. SURVEILLANCE OF WHALING OPERATIONS

The Infractions Reports submitted by the USA, the Russian Federation and St. Vincent and The Grenadines stated that 100% of their catches were under direct national inspection. Denmark (Greenland) reported on quota monitoring in IWC/56/Inf 5.

Following questions from New Zealand and the UK concerning internal legal requirements in Denmark for collection of DNA samples and actions in the event of the samples not being provided, Denmark reported that it was mandatory to supply samples, and that it had written to all municipal authorities in Greenland to inform them of this fact.

New Zealand considered that failure to collect samples should be reported as an Infraction since Article IX of the Convention requires each Contracting Government to 'take appropriate measures to ensure the application of the provisions of this Convention and the punishment of infractions against the said provisions in operations carried out by persons or by vessels under its jurisdiction' and Para 29b of the Schedule requires samples to be collected.

Denmark did not agree with New Zealand's interpretation, as Para 29b refers to small type whaling and not to aboriginal subsistence whaling. Denmark will try to take appropriate measures to ensure samples are collected in the future, but it considered that missing samples are not infractions in the sense of Article IX of the Convention. In addition, it would help if the hunters knew the samples would be put to good use, as at present many samples seem to be stored in freezers but not analysed. The Department of Fishing and Hunting will continue its efforts to collect samples.

New Zealand reiterated its opinion that collection of samples is obligatory under Para 29b of the Schedule and that failure to do so is an offence that should be reported as an infraction, particularly in view of the definition of 'small type whaling' in the Schedule and the strong language used by the Scientific Committee to express its concerns on this matter.

Following a suggestion from the Chair, New Zealand and Denmark agreed to discuss this matter further on a bilateral basis.

The UK noted that a bowhead whale was reported to have been killed in Greenland on 25 April 2004[1].

Australia expressed concern that since a new law had been enacted by Japan in 2001 allowing whales caught in nets to be killed, that the numbers of bycatch in Japan had increased dramatically, from 29 in 2000 to 79 in 2001, 109 in 2002 and to 125 in 2003. They cautioned that this could be considered an active hunt. Japan considered the question was not relevant to the Infractions Sub-Committee. Rather, the Scientific Committee is the right forum for such discussions and Japan had provided information on bycatch to that Committee. It would respond directly to Australia on this issue if asked.

The UK noted that other countries e.g. Iceland and Korea also have significant levels of bycatch. It recognised that some other countries have a different opinion as to whether bycatch should be regarded as an infraction. However, the UK believed that everyone should agree that numbers of bycaught whales should be taken off any quota and, since the quota was zero, bycatch constituted an infraction.

5. CHECKLIST OF INFORMATION REQUIRED OR REQUESTED UNDER SECTION VI OF THE SCHEDULE

This Checklist was developed as an administrative aid to the Sub-Committee in helping it to determine whether obligations under Section VI of the Schedule were being met. It is not compulsory for Contracting Governments to fill in the Checklist although, of course, they do have to fulfil their obligations under this Section of the Schedule.

The available information is summarised below:

Denmark: Information on date, position, species, length and sex is collected for between 83-100% of the catch, depending on the item. Other biological data and information on killing methods and struck and lost animals are also collected.

USA: Information on date, species, position, length, sex, whether a foetus is present, killing method and numbers struck and lost is collected for between 97-100% of the catch depending on the item. Biological samples are collected for about 50% of animals.

Russian Federation: Information on date, species, position, length, sex, whether a foetus is present, killing method and numbers struck and lost is collected for 100% of the catch.

St. Vincent and The Grenadines: Information on date, species, position, length, sex, killing method and numbers struck and lost is collected for 100% of the catch.

Norway: the required information has been submitted to the Secretariat as noted in the Scientific Committee report (IWC/56/Rep 1).

6. SUBMISSION OF NATIONAL LAWS AND REGULATIONS

A summary of national legislation supplied to the Commission is given in Table 1. The UK and the USA applauded St. Vincent and The Grenadines for adopting domestic legislation that governs the aboriginal take of humpback whales. Australia expressed similar sentiments and enquired whether the regulations met the requirements of Schedule Para 13b(4). The Secretariat believed that they do and noted that the regulations were available if Australia wished to confirm this.

7. OTHER MATTERS

7.1 Reports from Contracting Governments on availability, sources and trade in whale products

The Commission has adopted a number of Resolutions inviting Contracting Governments to report on the availability, sources and trade in whale products:

- 1994-7 on international trade in whale meat and products;
- 1995-7 on improving mechanisms to prevent illegal trade in whale meat;
- 1996-3 on improving mechanisms to restrict trade and prevent illegal trade in whale meat;
- 1997-2 on improved monitoring of whale product stockpiles; and
- 1998-8 *inter alia* reaffirmed the need for Contracting Governments to observe fully the above Resolutions addressing trade questions, in particular with regard to the problem of illegal trade in whale products, and urged all governments to provide the information specified in previous resolutions.

No reports were received by the Secretariat on these resolutions and no comments were made during the meeting.

[1] Denmark responded to a first question, which related to 2003, and said that no bowhead had been killed in 2003. It did not respond to the question of 2004 during the meeting, but subsequently reported that a bowhead whale had been seen in fishing nets in 2004 but that it had not been killed.

Table 1
National legislation details supplied to the IWC.[1]

Country	Date of most recent material	Country	Date of most recent material
Antigua & Barbuda	None	Monaco	None
Argentina	1984	Mongolia	None
Australia	2000	Morocco	None
Austria	1998	Netherlands, The	1978
Benin	None	New Zealand	1992
Brazil	1987	Norway	2000
Canada	1983	Oman	1981
Chile	1983	Palau, Republic of	None
China, People's Republic of	1983	Panama	None
Costa Rica	None	Peru	1984
Denmark (including Greenland)	1998	Portugal	None
Dominica	None	Russian Federation	1998
Ecuador	None	San Marino	None
Finland	1983	Saint Kitts & Nevis	None
France	1994	Saint Lucia	1984
Gabon	None	Saint Vincent & The Grenadines	2003
Germany	1982	Senegal	None
Grenada	None	Seychelles	1981
Guinea	None	Solomon Islands	None
Iceland	1985	South Africa	1998
India	1981	Spain	1987
Ireland	2000	Sweden	1987
Italy	None	Switzerland	1983
Japan	1983	Tonga	None
Kenya	None	UK	1981
Korea, Republic of	1985	USA	1995
Mexico	2001		

[1]Up to the middle of June 2004. Dates in the table refer to the date of the material not the date of submission. [2]Member states of the European Economic Community are subject also to relevant regulations established by the Commission of the European Community. The date of the most recent EEC legislation supplied to the International Whaling Commission is 1983. [3]Information on which pieces of legislation have been provided by the member countries is available on request from the Secretariat.

7.2 Other

The UK referred to six northern bottlenose whales killed in the Faroe Islands in 2002 and noted that the Scientific Committee had expressed concern over the status of this stock in the 1970s. The UK asked a series of questions requesting details of the incidents. It noted that this species is included in the Schedule (Table 3) with a zero catch limit, and believed that the killing of these whales constituted an infraction.

Denmark responded that six whales had died as a result of stranding and that such events were not infractions. Denmark has provided information on similar events on a bilateral basis on many occasions in the past and would be happy to do so again.

The UK repeated that, because the species is in the Schedule, the reasons for the kills need to be documented.

Australia notified the Sub-Committee of an alleged incident that occurred in 2004 in which a whale of unknown species was caught by an Australian fishing vessel, and the vessel returned to port with whale meat on board. The allegation has been referred to the Australian Federal Police for investigation. Australia will inform the IWC of the outcome of this matter once further details are available

No other issues were raised under this item.

8. ADOPTION OF REPORT

The report was adopted 'by post' on 18 July 2004.

Appendix 1

LIST OF PARTICIPANTS

Argentina
Raul Comelli
Miguel Iñiguez

Australia
Nicola Beynon
Pam Eiser
Connall O'Connell
Stephen Powell

Austria
Andrea Nouak
Michael Stachowitsch

Belize
Beverly Wade

Benin
Sogan Simplice
Bantole Yaba

Brazil
Marcia Engel
Regis Pinto de Lima
Jose Truda Palazzo

Denmark
Leif Fontaine
Ole Heinrich
Amalie Jessen
Kim Mathiasen

Maj Friis Munk
Ole Samsing
Kate Sanderson

Dominica
Andrew Magloire
Lloyd Pascal

Finland
Esko Jaakkola

Germany
Peter Bradhering
Marlies Reimann

Grenada
Frank Hester
Justin Rennie

Iceland
Stefan Asmundsson
Ragnar Baldursson
Asta Einarsdottir
Kristjan Loftsson

Ireland
Chris O'Grady

Italy
Rosa Caggiano
Riccardo Rigillo

Japan
Toshiyuki Iwado
Atsushi Kato
Mysayuki Komatsu
Minora Morimoto
Joji Morishita
Shuya Nakatsuka
Seiji Ohsumi
Midori Ota
Akiko Tomita

Republic Of Korea
Chang Myeng Byen
Zang Geun Kim
Oh Seung Kwon
Sung Kwon Soh (Chair)

Mexico
Lorenzo Rojas Bracho

Monaco
Frederic Briand

Netherlands
Henk Eggink
Giuseppe Raaphorst
Anne-Marie van der Heijden

New Zealand
Chris Anderson
Mike Donoghue
Nigel Fyfe
Al Gillespie
Geoffrey Palmer

Norway
Halvard Johansen
Egil Øen
Jan Skjervø
Hild Ynnesdal

Russian Federation
Rudolf Borodin
Vladimir Etylin
Inankeuyas Gennady
Olga Gogoleva
Valentin Ilyashenko
Olga Ipatova
Ivan Slugin
John Tichotsky

Saint Kitts and Nevis
Joseph Simmonds

Solomon Islands
Sylvester Diake
Paul Maenuu

South Africa
Herman Oosthuizen

Spain
Carmen Asencio

Sweden
Bo Fernholm
Anna Roos

Switzerland
Tom Althaus

UK
Richard Cowan
Geoff Jasinski
Laurence Kell
Jenny Lonsdale
Trevor Perfect
Mark Simmonds

USA
George Ahmaogak
Nancy Azzam
Harry Brower Jr.
Robert Brownell
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Keith Johnson
Thomas Napageak
Jean Pierre Plé
Gary Rankel
Rollie Schmitten
Brad Smith
Michael Tillman
Chris Yates

Secretariat
Cherry Allison
Greg Donovan

Appendix 2

AGENDA

1. Introductory items
   1.1 Appointment of Chairman
   1.2 Appointment of Rapporteur
   1.3 Review of Documents
2. Adoption of the Agenda
3. Infractions reports from Contracting Governments, 2003
4. Surveillance of whaling operations
5. Checklist of information required or requested under Section VI of the Schedule
6. Submission of national laws and regulations
7. Other matters
   7.1 Reports from Contracting Governments on availability, sources and trade in whale products
   7.2 Other
8. Adoption of the report

Appendix 3

SUMMARY OF INFRACTIONS REPORTS RECEIVED BY THE COMMISSION IN 2003

Under the terms of the Convention, each Contracting Government is required to transmit to the Commission full details of each infraction of the provisions of the Convention committed by persons and vessels under the jurisdiction of the Government. Note that although lost whales are traditionally reported, they are not intrinsically infractions.

Scientific permit catches were reported to the Scientific Committee (IWC/56/Rep 1). Catch and associated data for commercial and scientific permit catches were submitted to the IWC Secretariat (IWC/56/Rep 1). Norway reported no infractions from her commercial whaling operations. Aboriginal subsistence catches and infractions are summarised in the following table.

Country	Species	Males	Females	Total landed	Struck and lost	Total strikes	Infractions/ comments
Denmark							
West Greenland	Fin	2	4	6	3	9	None
	Minke	58	117	178[1]	7	185	None
	Humpback			1			1[3]
East Greenland	Minke	1	11	13[2]	1	14	None
St. Vincent and The Grenadines							
	Humpback	1	0	1	0	1	None
USA							
	Bowhead	17	17	35[2]	6	41	2[4]
Russian Federation	Gray	70	56	126	2	128	None
	Bowhead	3	0	3	0	3	None
Republic of Korea							
	Minke			5			5[5]

[1]Includes 3 animals of unknown sex.

[2]Includes 1 animal of unknown sex.

[3]On 12 August 2003, the wildlife officer in the municipality of Ilulissat reported that a male humpback whale calf of length 9.5m had been wounded in a rifle hunt and could not be rescued. After authorisation from the Department of Fisheries and Hunting the whale was killed by a harpoon vessel and meat, blubber and qiporaq was distributed to institutions in Ilulissat. The incident was reported to the police who informed the department that they consider the incident as unsolved due to lack of possibilities of further investigation.

[4]On approximately May 25, 2003, a female bowhead whale was taken in the Beaufort Sea off Barrow, Alaska, by the crew of an Alaska Eskimo Whaling Commission (AEWC) registered bowhead subsistence captain. On taking the whale, the crew realized it was accompanied by a calf, which then swam away. The USA has elected to report two infractions as the disposition of the calf is unknown. The taking of a whale calf or a cow accompanied by a calf is prohibited by Alaskan Eskimo hunting tradition. Such a taking is also prohibited by the AEWC management plan for the bowhead subsistence hunt and by the regulations of the IWC. The AEWC considers the taking of a whale calf or a cow with a calf to be a very serious infraction. Under the AEWC Management Plan, a captain whose crew takes a calf or a cow accompanied by a calf may have his AEWC registration revoked for up to five whaling seasons or be subject to a fine of up to $10,000. On May 30, 2003, the Commissioners of the AEWC convened a hearing to receive testimony from the members of the crew and from the members of other crews who were in the vicinity when the whale was taken. While testimony indicated that the taking might have been accidental, the Commissioners concluded that the crew knew a cow-calf pair was in the vicinity and did not act with proper caution under the circumstances. Therefore, the Commissioners voted to rescind the bowhead subsistence captain's registration with the AEWC for two years (four seasons) beginning with the fall 2003 bowhead subsistence hunt. The AEWC also confiscated the baleen taken from the whale and donated it to a local organisation that supports Native artists. Under the U.S. Whaling Convention Act, it is illegal for anyone who is not a registered captain with the AEWC, or a member of the crew of a registered captain, to hunt bowhead whales. Anyone attempting to take a bowhead whale without being properly registered with the AEWC, or being a crew member of a registered captain, is subject to penalties under U.S. law.

[5]The Government of the Republic of Korea reported 5 illegal direct catches of minke whales by its nationals in Korean waters in 2003. It identified and confirmed these as infractions. The details are as follows:

i) A minke whale of length 4m was caught on 23 April 2003 by a fishing vessel permitted for offshore pot fisheries. The take was done covertly with a small harpoon at about 19 nautical miles off the port of Onsan. Penalty: the meat and fishing gear were confiscated, a fine of 7 million won imposed and the fishing licence and seamanship licence revoked. The matter is under appeal.

ii) A minke whale of length 5m was caught on 25 April 2003 by a fishing vessel permitted for offshore gillnet fisheries. The take was done covertly with a small harpoon at about 15 nautical miles off the port of Jungja. The meat was transported by another fishing vessel. Penalty: the meat and fishing gear were confiscated. The fisherman was fined 7 million won and his fishing licence revoked. The transporter was fined 4 million won and his fishing licence and seamanship licence revoked

iii) A minke whale of length 5m was caught on 18 May 2003 by a fishing vessel permitted for offshore driftnet fisheries. The take was done covertly with a small harpoon at about 15 nautical miles off the port of Ulsan. Penalty: the whale carcass and fishing gear were confiscated, a 6 month prison sentence imposed with 2 years probation and the fishing licence and seamanship licence revoked.

iv) A minke whale of length 4.1m was found dead in a driftnet on 19 May 2003 about 1 nautical mile off Ulsan city. Four harpoon heads were in the back of the whale and its tail was entangled. The whale carcass and fishing gear were confiscated but investigation failed to find the culprit.

v) A minke whale of length 8.3m was caught on 24 May 2003, by a fishing vessel permitted for offshore driftnet fisheries, at about 23 nautical miles off Youngduk city. Penalty: the whale carcass and fishing gear were confiscated, an 8 month prison sentence imposed with 2 years probation and the fishing licence revoked.

Annex J

Catches by IWC Member Nations in the 2003 and 2003/2004 Seasons

	Fin	Humpback	Minke	Sperm	Bowhead	Gray	Sei	Bryde's	Operation
North Atlantic									
Denmark									
(West Greenland)	9[1]	1[2]	185[3]	-	-	-	-	-	Aboriginal subsistence
(East Greenland)	-	-	14[4]	-	-	-	-	-	Aboriginal subsistence
Iceland	-	-	37[4]	-	-	-	-	-	Special Permit
Norway	-	-	647[5]	-	-	-	-	-	Whaling under Objection
St. Vincent & The Grenadines	-	1	-	-	-	-	-	-	Aboriginal subsistence
North Pacific									
Japan	-	-	151[4]	10	-	-	50	50	Special Permit
Korea	-	-	5[6]	-	-	-	-	-	
Russian Federation	-	-	-	-	3	128[7]	-	-	Aboriginal subsistence
USA	-	-	-	-	41[8]	-	-	-	Aboriginal subsistence
Antarctic									
Japan	-	-	443[1]	-	-	-		-	Special Permit

[1]Including 3 struck and lost; [2]Denmark reported that a humpback was killed after being injured in a rifle hunt; [3]including 7 struck and lost; [4]including 1 struck and lost; [5]including 9 struck and lost; [6]the Republic of Korea reported that 5 minke whales had been taken deliberately (see IWC/56/Rep 4 for details); [7]including 2 struck and lost; [8] including 6 struck and lost.

Annex K

Report of the Finance and Administration Committee

Friday 16 July 2004, Sorrento, Italy

1. INTRODUCTORY ITEMS

The meeting took place at the Hilton Sorrento Palace Hotel, Sorrento, Italy on 16 July 2004. A list of participants is given in Appendix 1.

1.1 Appointment of Chair

Halvard Johansen (Norway) was appointed as Chair of the Committee.

The Chair noted that attendance at the Finance and Administration Committee was limited to delegates and that observers were not permitted to attend.

1.2 Appointment of Rapporteurs

The Secretariat agreed to act as rapporteurs.

1.3 Review of documents

The Chair indicated that most documents had been pre-circulated but that some additional papers were newly available. The Chair briefly reviewed all the documents available to the Committee (Appendix 2). Document IWC/56/Rep1 (Extracts from the) Report of the Scientific Committee was not available since summary information on the Scientific Committee's proposed research expenditure for 2004-2005 was included in the Report of the Budgetary Sub-committee (IWC/56/F&A 3).

2. ADOPTION OF THE AGENDA

The Chair noted that under Item 6 (Other Matters), the Advisory Committee had submitted a paper to explore possible changes to NGO participation and that Brazil had requested a new item be similarly added regarding the on-going costs for delegations attending the Annual Meeting. Noting all the above changes, the Finance and Administration Committee adopted the agenda (Appendix 3).

3. ADMINISTRATIVE MATTERS

3.1 Annual Meeting arrangements and procedures

3.1.1 Need for a Technical Committee

The Chair reminded the Committee that no provision had been made for the Technical Committee to meet at Annual Meetings since IWC/51. However, the Commission had agreed to keep the need for a Technical Committee under review. He suggested that it would be appropriate to maintain the *status quo*, i.e. keep this item on the agenda since, as previously noted, the Technical Committee may have a role to play when the RMS is completed and catch limits set. The Committee agreed.

3.1.2 Use of simultaneous translation

The Chair recalled that at last year's meeting the Commission adopted by consensus, Resolution 2003-4 on the use of simultaneous interpretation at Annual Meetings of the International Whaling Commission. He invited the Secretary to present the report of the Working Group established at IWC/55 (document IWC/56/F&A 2).

REPORT FROM THE WORKING GROUP ON SIMULTANEOUS INTERPRETATION

The Secretary reminded the Committee that through Resolution 2003-4, the Commission had decided to establish a Working Group to explore the various implications for the provision of technical components for simultaneous interpretation and to make recommendations on how provision of technical components for simultaneous interpretation may be provided at the IWC to accommodate the needs of contracting parties for whom English is a second language. The Working Group was to be guided by the following Terms of Reference:

(a) to review and consider the costs as set out in document IWC/55/F&A 2 and to identify ways in which these costs could be apportioned or reduced;
(b) to recommend options and scope for the provision of technical components for simultaneous interpretation;
(c) to determine the operations and costs of other international organisations providing such components; and
(d) to consult with member states on these issues.

It was agreed that the Working Group should be open to any Contracting Government, but that it should ideally remain small and conduct its work by email. After the meeting Antigua and Barbuda, Benin, France, Gabon, Republic of Guinea, Japan, Senegal and Spain indicated that they wished to join the group. To initiate the work required, the Secretariat developed a paper for review by the Group that included:

(a) information on interpretation facilities provided by other comparable intergovernmental organisations, and costs of such provision;
(b) descriptions of different possible arrangements for providing equipment for simultaneous interpretation at IWC Annual Meetings;
(c) cost estimates for providing the different arrangements (based on cost information from Berlin, Sorrento, Ulsan and a hypothetical venue in London); and
(d) options for how such costs for IWC meetings could be met.

Although the Working Group members expressed a wide range of views in response to the Secretariat's paper regarding the extent of the service that should be provided, it was able to develop a consensus proposal on the basis that facilities for simultaneous interpretation be introduced in a phased manner. In introducing the Working Group's proposal, the Secretary noted that in accordance with previous discussions within the Commission and with Resolution 2003-4, the proposal referred only to the provision of the technical components for simultaneous interpretation, and not provision of interpreters and document translation.

In summary, the Working Group proposed that:

- initially facilities for 3 languages be provided (French, Spanish and Japanese). Japanese was proposed since most Japanese delegates speak in their mother tongue at the meetings. French and Spanish were proposed since, out of IWC's membership as of 2 July 2004, 15 countries are French-speaking and 16 countries are Spanish-speaking. In addition, requests have been made in the past for interpretation into these languages. It was further proposed that provision for additional languages could be considered at a later date (e.g. after two years);
- initially, to help reduce costs, the technical set-up used would be that where headsets would be provided only for those national delegations using simultaneous interpretation, but with a view to moving toward the usual set up where headsets are provided to all delegates;
- initially simultaneous interpretation be provided only for the Commission plenary. Provision at other meetings (i.e. Commission sub-groups and private Commissioners' meetings) could be considered at a later date (e.g. after two years). It would seem prudent, both financially and technically, to have a phased approach to provision of simultaneous interpretation; and
- the Commission would meet most of the costs through an increase in the budget provision for the Annual Meeting (approx. 2% initially). If costs are in excess of this, then the host government would cover additional expenses. In the case where the Annual Meeting is arranged by the Secretariat in the UK (in the absence of an offer from a Contracting Government), the Working Group proposed that any additional costs to provide simultaneous interpretation equipment be met by drawing on the Commission's reserves.

The Chair thanked the Secretary for presenting the report and invited members of the Working Group to comment. In doing so, they stressed the importance of this issue so as to enable effective participation of all countries regardless of their mother tongue and urged that the Commission take action.

F&A COMMITTEE DISCUSSIONS

The Committee welcomed the Working Group report, recognised the importance of this issue and agreed that some action should be taken to facilitate the participation of delegates for whom English is not their first language so as to put all member countries on the same footing. There was general agreement that the costs of providing the technical facilities for simultaneous interpretation should be met by the Commission, although a suggestion was made that, in addition, the Commission may also wish to seek voluntary contributions to support this provision.

Some members supported the approach proposed by the Working Group, although the view was expressed that if possible (e.g. by restricting the number of languages for which interpretation facilities would be provided to two rather than three), it would be desirable to extend provision of simultaneous interpretation facilities to the Commission sub-groups (not including the Scientific Committee) and the private Commissioners' meetings. Others felt that, with the increasing membership and increasing number of languages spoken by members, it would be appropriate for the Commission to take broader steps, allocating a higher percentage of the budget so as to provide, for example (and perhaps even in time for IWC/57 in Ulsan), interpretation for a greater number of languages and the translation of documents - as is the case in some other intergovernmental organisations. A number of members, however, expressed concern regarding the proposal to include translation of documents before the implications, particularly of cost, could be properly assessed. They did not believe there was sufficient time to make this assessment during IWC/56.

After a further exchange of views, the Chair proposed the following compromise:

(1) that the Committee acknowledges the importance of facilitating the effective participation of all Contracting Governments in the work of the Commission and that no government should be disadvantaged by language;
(2) that in the first instance, equipment facilities for the provision of simultaneous interpretation facilities be provided for French and Spanish for the Commission's sub-groups (but not the Scientific Committee), the Commission plenary and private Commissioners' meetings. This would come into effect in time for IWC/57 in Ulsan next year;
(3) that the budget provision for the Annual Meeting would be increased by 2%, as recommended by the Working Group; and
(4) that the Secretariat should work intersessionally, with a small Task Force (composition to be decided), to develop cost estimates and implications for the provision of document translation at Annual Meetings and to report to the F&A Committee at IWC/57 in Ulsan for possible decision-making.

The Committee agreed to recommend this to the Commission.

3.2 Amendments to the Rules of Procedure

3.2.1 Election of the Chair and Vice-Chair of the Commission

Japan introduced the following proposals concerning Rules of Procedure F.1 and G.1:

> Amendment of Rule F.1: that the text be amended such that the Chair may be elected from among the Commissioners and Alternate Commissioners. The specific text of this proposal is that line 1 of rule F.1. be amended to read: ***The Chair of the Commission shall be elected from time to time from among the Commissioners and Alternate Commissioners and shall…***

> Amendment of Rule G.1.: that the text be amended such that the Vice-Chair may be elected from among the Commissioners and Alternate Commissioners. The specific text of this proposal is that line 1 of rule G.1 be amended to read: ***The Vice-Chair of the Commission shall be elected from time to time from among Commissioners and Alternate Commissioners and…***

A number of governments indicated that while they appreciated and understood the motivation behind the proposed amendments, they considered - as pointed out when this same matter was raised at IWC/54 in Shimonoseki - that the proposal was contrary to Article III.2 of the Convention and therefore illegal.

Japan noted this position. It indicated that it did not wish to pursue the matter any further now, but may raise it in the Plenary.

3.2.2 Other – appointment of the Chair and Vice-Chair of the Scientific Committee

PROPOSAL FROM THE SCIENTIFIC COMMITTEE

At the 2002 Scientific Committee meeting, the Scientific Committee developed a proposed procedure and amendment to the Rules of Procedure for the Scientific Committee regarding the appointment of its Chair and Vice-Chair. It was proposed that a second paragraph be added to Rule of Procedure C.5 of the Scientific Committee as follows (proposed new text in *italics*):

C. Organisation

5. The Committee shall elect from its members a Chair and Vice-Chair who will normally serve for a period of three years. They shall take office at the conclusion of the annual meeting at which they are elected. The Vice-Chair shall act for the Chair in his/her absence.

The election process shall be undertaken by the heads of national delegations who shall consult widely before nominating candidates. Under normal circumstances, the Vice-Chair will become Chair at the end of his/her term, and a new Vice-Chair will then be elected. If the election of the Chair or Vice-Chair is not by consensus, a vote shall be conducted by the Secretary and verified by the current Chair. A simple majority shall be decisive. In cases where a vote is tied, the Chair shall have the casting vote. If requested by a head of delegation, the vote shall proceed by secret ballot. In these circumstances, the results shall only be reported in terms of which nominee received the most votes, and the vote counts shall not be reported or retained.

The rationale of the Scientific Committee for this recommendation was that a reporting of the actual vote has the potential to erode the confidence the Scientific Committee would have for the new Chair. It was also recognised that where three or more candidates were nominated, the potential for multiple votes exists and again the potential exists to erode the confidence the Scientific Committee would have for the new Chair.

In the Scientific Committee Report, it was also noted that in years when elections are required, the Chair will indicate a provisional date for the election in the initial draft agenda circulated to the Scientific Committee. The election process, as noted above, will be undertaken by the heads of the national delegations (*J. Cetacean Res. Manage 5* (suppl.): 450).

In 2002 when the proposed amendments to the Scientific Committee's Rules of Procedure were submitted to the Commission's Finance and Administration Committee, concern was expressed by a number of governments regarding the proposal that results from secret ballots would only be reported in terms of which nominee received the most votes and that the vote count would not be reported or retained. Given that the F&A Committee was evenly divided on the issue and that another election was unlikely to arise in the next three years, it agreed to refer the issue back to the Scientific Committee for further consideration. The Commission agreed.

The Heads of Delegation met during the IWC/56 Scientific Committee meeting and reconfirmed by consensus the Committee's support for its earlier position regarding secret ballots. They also agreed that the proposed Rule of Procedure should be revised to indicate that it was expected that the Vice-Chair would become Chair at the end of his/her term unless he/she declined.

The Heads of Delegation to the Scientific Committee therefore recommend that the following amended text be put forward to the Commission via the F&A Committee for adoption (proposed new text in ***bold italics***):

The election process shall be undertaken by the heads of national delegations who shall consult widely before nominating candidates. ~~Under normal circumstances~~, ***T***he Vice-Chair will become Chair at the end of his/her term ***(unless he/she declines)***, and a new Vice-Chair will then be elected. ***If the Vice-Chair declines to become Chair, then a new Chair must also be elected.*** If the election of the Chair or Vice-Chair is not by consensus, a vote shall be conducted by the Secretary and verified by the current Chair. A simple majority shall be decisive. In cases where a vote is tied, the Chair shall have the casting vote. If requested by a head of delegation, the vote shall proceed by secret ballot. In these circumstances, the results shall only be reported in terms of which nominee received the most votes, and the vote counts shall not be reported or retained.

A notification of the proposed changes in the Rules of Procedure of the Scientific Committee was included in the draft agenda for the Scientific Committee and circulated to all Scientific Committee delegates in advance of the meeting. Therefore, if approved by the Commission, the proposed changes to the Scientific Committee Rules of Procedure would go into effect at SC/57.

F&A COMMITTEE DISCUSSIONS

The F&A Committee endorsed the Scientific Committee's proposal and recommends that it be adopted by the Commission.

4. FORMULA FOR CALCULATING CONTRIBUTIONS

The Chair recalled that at its meeting last year, the Commission agreed that the Contributions Task Force should meet again prior to IWC/56 to try to finalise a proposal for a revised contributions formula and that the Task Force had been scheduled to meet in late May 2004. He noted however, that the Commission had also agreed to allow Henrik Fischer, Chair of the Commission, to convene a small group to explore ways of taking the RMS process forward. This included a discussion on how RMS costs might be apportioned. It was noted that the Commission has always recognised the interaction between the work of the Task Force and RMS cost discussions, but that until now, the Task Force has been asked to develop a contributions formula that does not take future RMS costs into account. However, given the intersessional work of the Commission Chair and its potential implications for any revised contributions formula, Henrik Fischer believed that it would be prudent to delay further work of the Task Force until these implications could be assessed. Consequently, while continuing to recognise the high priority the Commission gives to the development of a revised contributions formula, it was decided to postpone the Task Force meeting after consultation with the Task Force members and with the Advisory Committee.

While recognising the sense of postponing the May 2004 Task Force meeting, a number of delegations stressed the importance of completing the work on a revised financial contributions formula expeditiously.

There was some discussion regarding the Chair of the Task Force, given that Daven Joseph (Antigua and Barbuda) was no longer Commissioner or representing Antigua and Barbuda. There was some debate as to whether Chairs are appointed as individuals or as countries and whether Task Force Chairs should be appointed by the Commission or elected by the group itself. Noting these different views, the F&A Committee Chair proposed that the new Commissioner for Antigua and Barbuda convene a meeting of Task Force members over lunch to elect a Chair. The Committee agreed with this proposed approach and, following the short Task Force meeting, the convenor was able to report that by consensus, the Task Force recommended that, if the Commission so wishes, the Task

Force continue with the Commissioner for Antigua and Barbuda (Anthony Liverpool) as Chair and with the Commissioner for Argentina (Eduardo Iglesias) as Vice-Chair.

The F&A Committee agreed to recommend this to the Commission.

5. FINANCIAL STATEMENTS, BUDGETS AND OTHER MATTERS ADDRESSED BY THE BUDGETARY SUB-COMMITTEE[1]

5.1 Review of the Provisional Financial Statement, 2003/2004

5.1.1 Report of the Budgetary Sub-committee

The report of the Budgetary Sub-committee (IWC/56/F&A 3) was introduced by its Chair Jean-Pierre Plé.

The Sub-committee had discussed intersessionally the Provisional Financial Statement presented in IWC/56/14.

The Secretariat introduced updated tables for IWC/56/14 and reviewed briefly the changes that had occurred to produce an updated out-turn for 2003/04. Total income has risen from £1.624m to £1.657m mainly due to financial contributions from new members and additional penalty interest. Operational expenditure has risen from £1.501m to £1.526m due to increases in Secretariat costs (£6.1k - mainly maintenance) and £19.1k in research expenditure (mainly items deferred from previous financial years which had already been funded). This gives an increase in the surplus of income over expenditure (before movement to/from reserves) from £78.6k to £86.0k (i.e. a net increase of £7.4k).

5.1.2 Secretary's report on the collection of financial contributions

The Secretariat referred to document IWC/56/F&A 4. Total financial contributions and interest outstanding amounted to £592k, of which £138k referred to former members and £453k referred to current members. The majority of the debt of current members relates to three countries, i.e. Costa Rica, Kenya and Senegal. The Secretariat reported that the majority of countries with arrears had made significant efforts to clear their debts with Kenya entering into a repayment schedule. The Secretariat stressed that the information in IWC/56/F&A 4 was subject to rapid change and was in fact already out of date since further funds had been received just prior to the meeting.

The Secretariat noted that approximately 90% of financial contributions for the Financial Year 2003-04 had been received by the due date for settlement (28 February 2004). The charging of penalty interest of 10% for late payments and the loss of voting rights has provided a strong incentive for members to pay on time.

5.1.3 F&A Committee discussions and recommendations

The Committee noted that the provisional statement shows a generally satisfactory situation and accordingly recommends to the Commission that the Provisional Financial Statement (Appendix 4) be approved subject to audit.

The Secretary's report on the collection of financial contributions was noted by the Committee. Concern was expressed that the 10% penalty interest charge presented difficulties to developing countries. The fixed rate of 10% interest was questioned at a time when market rates of interest are much lower. However, it was noted that the penalty interest provides a strong incentive to some national finance ministries to pay on time. The Chair commented that these conditions are included within the Financial Regulations, but noted the request from some Committee members that the continued use of penalty interest be reviewed by the Commission. An inquiry was received regarding the status of repayment schedules allowed by Financial Regulations, which allow members to regain voting rights. The Secretariat indicated that Financial Regulation F5(e) detailed the relevant procedures. It was noted that the relationship between financial contributions and voting rights would be one of the issues addressed at the private Commissioners' meeting on Sunday 18 July.

5.2 Consideration of estimated budgets, 2004/2005 and 2005/2006, including the budget for the Scientific Programme

5.2.1 Report of the Budgetary Sub-committee

REVIEW OF PROPOSED BUDGET 2004-2005 AND FORECAST 2005-2006

This aspect of the work done by the Budgetary Sub-committee was introduced by its Chair Jean-Pierre Plé. He highlighted the main factors affecting the formulation of the 2004/05 proposed budget which were as follows:

Income: The total amount required from Contracting Governments to 'balance' the budget does not necessarily mean a zero deficit or surplus for the year, rather that the resulting deficit or surplus is in line with the Commission's decisions.

Two scenarios were presented to the Budgetary Sub-committee intersessionally. An increase in financial contributions of 7.9% would have allowed income to equal expenditure (before transfers to/from reserves). An increase in financial contributions of 4.9% would result in expenditure exceeding income (before transfers to/from reserves) but would still leave the General Fund at the target level of 50% of operating costs. The lower increase was regarded more favourably and was used in the proposed 2004-2005 budget in document IWC/56/14.

Expenditure: The proposed 4.9% increase in Financial Contributions is due to necessary increases in expenditure on items deferred from previous years (e.g. essential repairs and renewals to fixtures and fittings and computer equipment) and scale increments allowed within staff contracts. It also includes costs for the construction of a new meeting room (to allow more intersessional meetings to be held at the Secretariat and so reduce costs for the Commission). Much of this expenditure is specific to 2004/05 only, which accounts for the reduction in expenditure in the 2005/06 forecast.

The Budgetary Sub-committee Chair noted that the response of the Sub-committee to these main items of income and expenditure in the 2004/05 proposed budget were as follows.

- The proposed increase in Financial Contributions of 4.9% (in the context of the proposed one off expenditure referred to previously) was regarded as being broadly acceptable. Attention was drawn to the fact that the total increase of 4.9% did not apply uniformly to contributing

[1] £k denotes thousands ('000); £m denotes millions ('000,000).

countries once the effects of the Interim Measure are taken into account. It was further noted that as 2004/05 completes the series of reductions put into effect by the Interim Measure, increases for 2005/06 onwards would affect all countries uniformly.

- The replacement of the boiler was considered essential.
- The concept of the meeting room was well received with the following observations being made:
  - (i) the immediate benefit of the meeting room will depend on the decisions reached in Plenary regarding the need for intersessional meetings in association with the Revised Management Scheme (RMS) and the Contributions Task Force;
  - (ii) construction of the meeting room, if approved, should commence as soon as possible;
  - (iii) all future intersessional meetings should be held in the new Secretariat meeting room, whenever possible, to maximise the use of the resource and thereby minimise costs to the Commission;
  - (iv) the lease of the Red House will be open to re-negotiation in 5 years time. Even if the meeting room is only used for those 5 years, the future savings would still far exceed the modest outlay of £8.75k in 2004/05;
  - (v) the Scientific Committee should be encouraged to use the new meeting room for its intersessional meetings when ever practicable; and
  - (vi) the new meeting room should be wired to take advantage of the new ASDL service (fast internet access) and thereby allow visitors access to an increasingly necessary facility.
- The Sub-committee recognised that the proposed budget did not reflect a potential 2% increase in the Annual Meeting budget proposed by the Working Group on Simultaneous Interpretation to cover costs for the provision of interpretation facilities.

Given the above, the Sub-committee considered that, pending detailed consideration of the funding request from the Scientific Committee for research, the proposed budget for 2004-2005 was acceptable. It also considered the forecast for the following year appropriate - the forecast budget for 2005/06 used the proposed budget for 2004/05 as its base, with expenditure increased by an assumed UK inflation rate of 3% where applicable. Financial Contributions were increased by 1.7% over the proposed 2004/05 level to produce a balanced budget (before transfers to/from reserves).

The Chair of the Sub-committee reminded the Finance & Administration Committee that it was required to make a specific recommendation on the level of NGO and media fees for 2004/05. The Secretariat had used levels of £590 and £35 respectively based on the procedure used in 2003/04 for determining the level of increase in these fees by linking them to the rate of UK inflation (3% used for budgeting purposes). The Sub-committee agreed that the levels originally outlined by the Secretariat should be adopted. Accordingly the Sub-committee **recommended** that for 2004/05 the NGO fee be set at £590 and the media fee at £35.

RESEARCH EXPENDITURE PROPOSED BY THE SCIENTIFIC COMMITTEE FOR 2004-2005

The Budgetary Sub-committee Chair explained that the Scientific Committee had identified projects totalling £374.35k, which it considered necessary to properly carry out the Commission's requirements. However, he noted that the Committee recognised the financial constraints that applied, and accordingly had prepared a reduced list of items to get as near as possible to the target, which had been set at £238k. The Scientific Committee had developed a reduced budget of £240.85k and 'strongly recommended that, at a minimum, the Commission accepts its reduced budget of £240.85k'.

The Budgetary Sub-committee Chair drew attention to the generous voluntary contribution from Japan of £32k towards the SOWER cruise series, without which key equipment would not be purchased or Invited Participants funded to attend an important intersessional meeting to review results to date and to plan future work. He further noted that the priorities of the Scientific Committee were accepted by the Sub-committee, and that the Sub-committee agreed to include the Scientific Committee's £240.85k 'package' in the proposed budget for 2004-2005 (Annex M).

The Sub-committee therefore **recommended** that the Finance and Administration Committee consider and forward the proposed budget for 2004-2005 (Annex L) to the Commission with a recommendation that it be adopted, together with the indicated level of financial contributions from Contracting Governments. (A preliminary estimate of the contribution to be requested from individual governments is given in Appendix 5. Note however, that this is indicative only and subject to adjustment and confirmation in the light of e.g. actual meeting attendance).

5.2.2 F&A Committee discussions and recommendations

2004-2005 PROPOSED BUDGET

The 2004-2005 proposed budget was generally acceptable to the Committee.

Norway considered that the proposed increase in contributions of 4.9% was too high while Germany regretted that the proposed budget showed any increase at all. The necessity for annual meetings was also questioned (Germany, Norway, Ireland) with bi-annual or even tri-annual meetings suggested as alternatives. Ireland noted its intention to submit a Resolution to Plenary on this matter. The need to build a meeting room was questioned by Norway who believed that intersessional meetings should be reduced as far as possible.

With regard to the 2004-2005 proposed budget for research expenditure, the inclusion of £14.5k to support a workshop on the use of market sampling to estimate bycatch was not supported by Japan and Norway. Others believed this to be a very important piece of work related to the RMS, and asked that the Scientific Committee Chair or Secretariat's Head of Science provide further explanation. The Head of Science noted that there is a requirement in the Scientific Committee when recommending a catch limit to adjust downwards the safe removals level calculated by the *Catch Limit Algorithm* by expected levels of anthropogenic removals such as bycatch. In recent years the Committee has received a number of papers using a market sampling approach and it has never been able to reach agreement over whether or not market based approaches are useful for estimating bycatch levels in an

RMP context. The Scientific Committee therefore believes it to be important to try to resolve this issue and that the best way to achieve this is through a dedicated workshop. The objectives of this methodological workshop are to:

(1) review available methods that have been used to provide estimates of large cetacean bycatches via market samples, including a consideration of their associated confidence intervals in the context of the RMP; and
(2) provide advice as to whether market-sampling-based methods can be used to reliably estimate bycatch for use in addressing the Commission's objectives regarding total removals over time and, if so, the requirements for such methods.

The Head of Science emphasised that the terms of reference for the proposed workshop limited interest in the question of markets to the context of an evaluation of whether or not market data can be used to provide reliable estimates of bycatches. However, Japan thought that what might start as a methodology might rapidly become unworkable. Japan also believed that the market approach would not be useful and in addition was outside the Terms of Reference of IWC.

NGO AND PRESS FEE

The recommendation to set fees for 2004-2005 of £590 for NGOs and £35 for media was agreed by the Committee. The Chair of the Budgetary Sub-committee clarified that these increases were based on the UK inflation rates used in the 2004-2005 budget.

2005-2006 FORECAST BUDGET

The 2005-2006 forecast budget was noted by the Committee.

SUMMARY OF RECOMMENDATIONS TO THE COMMISSION

The F&A Committee **recommends** that:

- the proposed budget for 2004-2005 (Annex L) be forward to the Commission for its consideration and with a recommendation that it be adopted, noting the reservations of Norway, Japan and Germany;
- for 2004-2005, the NGO fee be set at £590 and the media fee at £35; and
- the Commission takes note of the Forecast Budget for 2005-2006.

5.3 Secretariat offices

5.3.1 Report of the Budgetary Sub-committee

The Chair of the Budgetary Sub-committee reminded the Committee that at IWC/55, the Sub-committee had recommended that the Secretariat explore a range of alternatives, including:

(1) continuing to rent the Red House;
(2) purchasing the Red House or another suitable property in Cambridge or elsewhere in the UK; or
(3) relocation of the Secretariat to another member country;

and report back to the Budgetary Sub-committee. He noted that the background to this is that the cost of the Secretariat represents a significant percentage of the IWC's budget (i.e. £958k out of £1,623k of operating expenditure - as per the 2002-03 audited accounts). The rental of Red House (i.e. £69k) represents 4.3% of the £1,623k of operating expenditure, while salaries, and allowances (i.e. £622k) represent 38% of the £1,623k of expenditure.

The Red House is a large suburban house, which has been converted to office use with a warehouse added, giving a total area of 552 square metres (5,946 square feet). The building provides a functional environment for the work of the Secretariat. As this type of property has successfully met the needs of the organisation since 1976, the use of similar property in other parts of the world seemed an appropriate basis for comparison. Two countries were selected from each of the economic groupings used to assess capacity to pay as part of the calculation of Financial Contributions. Countries were further selected to reflect the geographical distribution of the membership. Properties in suburban locations of the capital cities of the selected countries were sought (or a comparable international location). A variety of property types and locations within the UK were selected to demonstrate the choice available and associated costs. The countries chosen for this comparison included: Argentina, Australia, Japan, Panama, Senegal, South Korea, Switzerland and the USA.

An assessment for the purchasing of property in the UK and other countries had not been included in the review. Differences in property law, methods of selling, availability and taxation made the accumulation of sufficient information very difficult to allow a meaningful comparison of property purchases to be made in the time available. In the case of renting property, there was sufficient information available to allow a broad comparison to be made.

The report examined the criteria for relocation within the UK and overseas and the associated variables (rents, wind-up costs, set-up costs, transition costs, loss of expertise and effects on organisational effectiveness etc). It concluded that:

- Currently there are savings to be made from relocating the IWC abroad, both in terms of lower rental costs and local salaries. The savings however may be sensitive to currency/economic fluctuations. Savings in expenditure in the early years of relocation could easily revert to additions to expenditure in later years.
- Over the transition period it is possible that transition costs (e.g. paying rent on two properties – if relocation occurred before the current lease expired) would equal or even exceed cost savings.
- If the current lease is continued until 2009, the rent will be capped at around £73,700 per annum from June 2005. This will give stability to costs and still provide a competitive rent in relation to alternative sites in the Cambridge area.
- The renewal of the lease in 2009 offers the chance to re-negotiate the current terms. The current lease only allows increases in rent. The chance to reduce the rent and allow rent decreases at each 5 yearly rent review could be explored.
- The focus of much of this paper has been on the relative costs of property and the relative costs of operating in various parts of the world. The costs associated with losing staff with the operational expertise and relationships that have been developed over many years should also be taken into consideration.
- The volatility of international markets make budgeting over a long time frame problematic. An effective Secretariat needs stability to function effectively and so its location should be considered within a long-term perspective. A country that can offer a stable cost base

allied to operational effectiveness should give an acceptable balance between value and performance in the face of fluctuations in the world economy.

The Sub-committee had acknowledged that rent represented approximately 4% of the total budget, and was not an excessive cost. The need to retain expertise within the Secretariat was recognised and that this would be lost if the Secretariat were moved away from the Cambridge area. As there is still over 5 years until the current lease expires, the Sub-committee recommended that the Secretariat explore alternatives within the Cambridge area which might include:

- To ask the NASCO (North Atlantic Salmon Conservation Organisation) Secretariat in Edinburgh, Scotland how it managed to purchase its Headquarters building in terms of funding and what effect their status as an International Organisation had in buying property. (Financing any purchase would have to be carefully considered in the context of minimising the effects on Financial Contributions).
- Near the date of renewal of the lease, to see if there might be any scope for the owners of Red House to 'gift' the property to the IWC. This might be an option if the inheritance tax status of the owner made this option advantageous.
- To keep the property market in Cambridge under active review to allow the early assessment of rental or purchase alternatives.
- If new property was acquired, to assess the possibility to renting part of that property as a means of minimising total property costs.

5.3.2 F&A Committee discussions and recommendations

The Committee accepted the report as presented and recommends to the Commission that the Secretariat be asked to investigate the feasibility and options for purchasing/acquiring premises suitable for office accommodation in the Cambridge area and to report back to the Budgetary Sub-committee next year.

5.4 Budgetary Sub-committee rota

5.4.1 Report of the Budgetary Sub-committee

The Sub-committee Chair recalled that at IWC/54 in Shimonoseki in 2002, the Commission adopted a rota for membership of the Budgetary Sub-committee. In summary:

- using the same country groupings as the Interim Measure for Financial Contributions[2], membership comprises:
  - 2 members from Group 1
  - 2 members from Group 2
  - 2 members from Group 3
  - Japan, USA + one other from Group 4
- membership is for 2 years (except for Japan and the USA who have a 'permanent' place since they are likely to be the two highest paying contributors under almost any formula for the calculation of financial contributions for the foreseeable future being the highest payers now and probably in the future);
- any member that declines to serve to be replaced by the next member in alphabetical sequence within its Group;
- new members of the Commission to be fitted into the cycle at the nearest alphabetical point after they have had a period in which to familiarise themselves with the organisation; and
- the appointment of the Sub-committee Chair should be handled by the Chair of the Commission and the Advisory Committee.

He noted that at its meeting at IWC/55 last year, the Commission agreed that the Secretariat review the current rota system with a view to:

(1) making it more attractive for countries to serve on the Sub-committee;
(2) providing greater continuity;
(3) improving the process for selection of the Sub-committee Chair; and
(4) reporting back to the Budgetary Sub-committee for further action as appropriate.

At its meeting this year, the Sub-committee reviewed a variety of options put forward by the Secretariat for consideration regarding items (1) to (3) above and recommended to the F&A Committee that the following be incorporated into the membership rota system:

TO ENCOURAGE PARTICIPATION IN THE SUB-COMMITTEE

A. When inviting countries to serve, stress not only the importance of the work of the Sub-committee (it really does make the job of the F&A Committee much easier and more efficient), but also that the workload is not high - either intersessionally or at Annual Meetings. The Sub-committee is only active during the period from March to when the annual meeting is held – and this only involves responding to documents/ proposals from the Secretariat. All intersessional work is done by email/fax and no intersessional meetings are involved. At annual meetings, the Sub-committee generally meets for only 1-2 sessions.

B. Undertake to schedule meetings of the Budgetary Sub-committee when other Commission sub-groups are not meeting and try to avoid scheduling the Budgetary Sub-committee at the beginning of the series of Commission sub-group meetings (because not all delegations arrive in time to otherwise participate).

C. Keep the four economic groups, but add two 'open seats' (i.e. for any interested countries) as a fifth category. Countries filling the two open seats would need to be identified and agreed at the meeting of the Finance and Administration Committee. Formalise the current informal arrangement allowing Contracting Governments not members of the Budgetary Sub-committee to attend meetings as observers.

TO PROVIDE GREATER CONTINUITY

D. Extend the term of members from 2 to 3 years.

E. Appoint not only a Sub-committee Chair but also a Vice-Chair. Under normal circumstances, the Vice-Chair would replace the outgoing Chair. This would have the effect of 2 Sub-committee members serving for either 4 years (under the

[2] It is recognised that these country groupings were developed solely for the purposes of the Interim Measure for calculating financial contributions and may need revision when a new formula is adopted.

current system) or 6 years if the term of all members was extended as proposed in D above.

IMPROVING THE PROCESS FOR THE SELECTION OF THE SUB-COMMITTEE CHAIR AND VICE-CHAIR

F. That the Sub-committee elects its own Chair (as is the case in other Commission sub-groups – and indeed the Commission itself).

5.4.2 F&A Committee discussions and recommendations

Several countries expressed an interest to join or continue participating in the work of the Budgetary Sub-committee. The question was raised as to how long an 'open seat' as proposed in C above might be open to an interested country and clarification was sought as to the status of observers. It was agreed that both these aspects required clarification and that the Budgetary Sub-committee should be asked to do this intersessionally (see recommendations below).

The F&A Committee therefore recommends to the Commission:

- That items A to F in section 5.4.1 above be incorporated into the membership rota system with the aim of: making it more attractive for countries to serve on the Sub-committee; providing greater continuity; and improving the process for the selection of the Sub-committee Chair (and now Vice-Chair).
- That Germany and Norway be invited to take the 'open seats' commencing immediately following IWC/56.
- That the Budgetary Sub-committee provide clearer guidelines for its operation and to report its conclusions back to the F&A Committee next year.

The proposed rota for the budgetary Sub-committee for 2004/05 onwards is given as Appendix 6.

6. OTHER MATTERS

6.1 NGO participation

6.1.1 Discussion document from the Advisory Committee

Richard Cowan (UK) introduced document IWC/56/F&A 6 'Discussion paper on rules governing participation of non-governmental organisations in the International Whaling Commission' on behalf of the Advisory Committee. He explained that in September last year, the Secretariat had been approached by a representative of one of the large environmental NGOs regarding changes that a number of them would like to rules of NGO accreditation in particular but also in their level of participation in Commission affairs. The Secretariat had brought this matter to the attention of the Advisory Committee to seek advice on the best way to proceed. The Advisory Committee agreed that this issue should be brought to the attention of the Finance and Administration Committee, and that the best way to do this was for it to develop a paper outlining the issues raised and the potential implications of these. He noted that the focus of the paper is on NGO participation in the Commission and its sub-groups excluding the Scientific Committee, and that the intention was for the F&A Committee to have a general discussion on the matter at this year's Annual Meeting and further that if changes are suggested, decisions could be taken at IWC/57 next year, as appropriate.

It was noted that the discussion document addressed the four following issues.

(1) Removal of the requirement that non-governmental organisations maintain offices in more than three countries.
(2) Allowing accredited NGOs to send up to [five?] representatives to IWC meetings as observers with the possibility of all observers being in the meeting room at any one time.
(3) Revising the fee structure for NGOs, such that the effect of the changes listed above is fee-neutral (cost-neutral?) in the year of its introduction and that thereafter, fees should not in general increase by more than such an amount as is necessary to keep pace with inflation in the UK (as host country to the IWC).
(4) Formally confirming the right of NGO representatives to speak at IWC meetings, but with some limitation on the number of interventions that could be made.

Richard Cowan stressed that, should the Commission decide to consider whether, and if so how, its Rules of Procedure might be amended to accommodate the wishes of some NGOs for more active participation, certain requirements are paramount, i.e. that changes in the rules should not:

- impede the orderly and timely conduct of business in meetings of the Commission or its subsidiary bodies;
- result in an increase in the IWCs costs nor a diminution in its income; or
- significantly increase either the number of NGO observers present at meetings, nor the volume of documentation which the IWC Secretariat is required to produce to accommodate them.

6.1.2 F&A Committee discussions

A range of views were expressed by members of the Committee. Some believed that NGOs have a valuable contribution to make, strongly supported a move to liberalise the rules for NGO participation in the IWC, and considered that each of items 1-4 listed above should be further investigated. They considered that transparency of decision-making at an international level is important and particularly important now with respect to IWC. Removal of the requirement for NGOs to have offices in at least four countries and allowing NGOs to have more than one observer present in the meeting room (items 1 and 2) were particularly supported as this should remove the tendency for some NGOs to participate under 'flags of convenience' organisations.

While not proposing to exclude NGOs, others noted that the IWC is an organisation of governments, that NGOs already have sufficient influence and that the current rules are adequate. They were concerned that the changes related to items 1 and 2 would lead to a significant increase in the numbers of NGO representatives attending meetings (with significant cost implications) and noted that governments are at liberty to include NGOs in their delegations. On this last point, others noted that since NGOs included on national delegations are required to abide by that government's position, it is important that NGOs also be allowed to attend as observer organisations.

Given the discussions, the Chair concluded that IWC is already transparent since it is open to observers from non-member governments, other intergovernmental organisations, NGOs and in the case of the Plenary, also to the media. He noted that some members had serious concerns regarding the granting of speaking rights to NGOs, but suggested that further consideration might be given to items

1 to 3 above. He therefore proposed that the Secretariat work with the Advisory Committee intersessionally to explore how items 1-3 might be implemented and to report to the F&A Committee next year, together with any recommendations as appropriate. He noted that it would be necessary for the Secretariat to consult with NGOs on this issue. He suggested that the issue of speaking rights be set aside for the time being. The Committee supported this proposed approach and agreed to recommend it to the Commission. The Committee also supported the suggestion that if Contracting Governments do not consider that the pre-conditions listed under the three bullet points above cover all of their concerns, they should be invited to contribute proposals for further pre-conditions that would help in limiting/better defining NGO attendance.

6.2 Costs involved in participation at Annual Meetings

Brazil briefly drew attention to its concern regarding the costs incurred to Contracting Governments, especially those of developing countries, of sending delegations to Annual Meetings, particularly given the length of the meeting series. It hoped that host governments and the Secretariat could take such concerns into account when determining the timing and location of Annual Meetings. This was supported by a number of other governments.

The Committee took note of this concern and agreed to draw it to the attention of the Commission.

At the end of the meeting, St Kitts and Nevis announced that it intends to offer to host the Annual Meeting in 2006.

Appendix 1

LIST OF PARTICIPANTS

Antigua and Barbuda
Anthony Liverpool

Argentina
Raul Comelli
Miguel Iñiguez
Eduardo Iglesias

Australia
Nicola Beynon
Pam Eiser
Conall O'Connell
Stephen Powell

Austria
Andrea Nouak

Belgium
Alexandre de Lichtervelde
Koen Van Waerebeek

Belize
Beverly Wade

Benin
Lucie Kouderin
Bantole Yaba
Sogan Simplice

Brazil
Regis Pinto de Pinto
Jose Truda Palazzo

Denmark
Amalie Jessen
Maj Friis Munk
Ole Samsing

Dominica
Andrew Magloire
Lloyd Pascal

Finland
Esko Jaakkola

Germany
Peter Bradhering
Marlies Reimann

Grenada
Justin Rennie
Frank Hester

Republic of Guinea
Amadou Telivel Diallo
Sidiki Diane

Iceland
Stefan Asmundsson
Ragnar Baldursson
Asta Einarsdottir

Ireland
Chris O'Grady

Italy
Rosa Caggiano

Japan
Dan Goodman
Yasuo Iino
Toshiyuki Iwado
Atsushi Kato
Hidehiro Kato
Masayuki Komatsu
Akihiro Mae
Minoru Morimoto
Joji Morishita
Shuya Nakatsuka
Kayo Ohmagari
Midori Ota
Hirohiko Shimizu
Akiko Tomita

Republic of Korea
Chang Moyeng Byen
Zang Geun Kim
Oh Seyng Kwon
Sung Kwon Soh

Mexico
Lorenzo Rojas-Bracho

Netherlands
Henk Eggink
Giuseppe Raaphorst
Anne-Marie van der Heijden

New Zealand
Chris Anderson
Mike Donoghue
Nigel Fyfe
Al Gillespie
Geoffrey Palmer

Nicaragua
Miguel Marenco

Norway
Turid Eusebio
Bengt Johansen
Halvard Johansen (Chair)
Hild Ynnesdal

Panama
Epimenides M. Diaz

Russian Federation
Rudolf Borodin
Olga Gogoleva

Valentin Ilyashenko
Valery Knyazev

St. Kitts and Nevis
Joseph Simmonds
Daven Joseph

St. Lucia
Vaughn Charles

St. Vincent & The Grenadines
Raymond Ryan

Solomon Islands
Sylvester Diake
Paul Maenuu

South Africa
Herman Oosthuizen

Spain
Carmen Asencio

Suriname
Deuwperkaas Jairam

Sweden
Bo Fernholm
Stellan Hamrin
Anna Roos

Switzerland
Tom Althaus
Martin Krebs

UK
Richard Cowan
Geoff Jasinski
Jenny Lonsdale
Trevor Perfect
Mark Simmonds

USA
Nancy Azzam
Robert Brownell
Roger Eckert
Jean-Pierre Plé
Mike Tillman
Chris Yates

Chair of SC
Doug DeMaster

Secretariat
Nicky Grandy
Sean Moran
Sue Morley
Greg Donovan

Appendix 2

LIST OF DOCUMENTS

IWC/56/F&A
1. Revised Draft Agenda
2. Report of the Working Group on Simultaneous Interpretation
3. Report of the Budgetary Sub-committee
4. Secretary's report on the collection of financial contributions
5. Reconsideration of Rules of Procedure for the appointment of Chair and Vice-Chair of the Scientific Committee
6. Discussion paper on rules governing participation of non-governmental organisations (NGOs) in the International Whaling Commission
7. Invited Participants to the Scientific Committee 2004

IWC/56/Rep 1 (Extracts from the) Report of the Scientific Committee

IWC/56/14 Financial Statements

Appendix 3

AGENDA

1. Introductory items
   - 1.1 Appointment of Chair
   - 1.2 Appointment of Rapporteur
   - 1.3 Review of Documents
2. Adoption of the Agenda
3. Administrative matters
   - 3.1 Annual Meeting Arrangements and Procedures
     - 3.1.1 Need for a Technical Committee
     - 3.1.2 Use of simultaneous translation
     - 3.1.3 Other
   - 3.2 Amendments to the Rules of Procedure, Financial Regulations and Rules of Debate
4. Formula for calculating contributions
   - 4.1 Report of the Contributions Task Force
   - 4.2 F&A Committee discussions and recommendations
5. Financial statements, budgets and other matters addressed by the Budgetary Sub-committee
   - 5.1 Review of the provisional financial statement, 2003/2004
     - 5.1.1 Report of the Budgetary Sub-committee
     - 5.1.2 Secretary's report on the collection of financial contributions
     - 5.1.3 F&A Committee discussions and recommendations
   - 5.2 Consideration of estimated budgets, 2004/2005 and 2005/2006, including the budget for the Scientific Programme
     - 5.2.1 Report of the Budgetary Sub-committee
     - 5.2.2 F&A Committee discussions and recommendations
   - 5.3 Secretariat offices
     - 5.3.1 Report of the Budgetary Sub-committee
     - 5.3.2 F&A Committee discussions and recommendations
   - 5.4 Budgetary Sub-committee membership rota
     - 5.4.1 Report of the Budgetary Sub-committee
     - 5.4.2 F&A Committee discussions and recommendations
6. Other matters
7. Adoption of the Report

Appendix 4

PROVISIONAL FINANCIAL STATEMENT 2003 -2004

Income and Expenditure Account

	Approved Budget		Projected Out-turn	
Income	**£**	**£**	**£**	**£**
Contracting Government contributions		1,274,000		**1,282,189**
Recovery of arrears		28,400		**0**
Interest on overdue financial contributions		0		**44,049**
Voluntary contributions for research, small cetaceans work and publications		16,000		**62,183**
Sales of publications		12,500		**10,000**
Sales of sponsored publications		4,100		**2,000**
Observers registration fees		60,200		**60,200**
UK taxes recoverable		18,730		**29,979**
Staff assessments		130,600		**128,579**
Interest receivable		40,000		**38,160**
Sundry income		0		**0**
		1,584,530		**1,657,340**
Expenditure				
Secretariat	907,300		**908,675**	
Publications	50,200		**50,200**	
Annual meetings	300,000		**300,400**	
Other meetings	0		**827**	
Research expenditure	231,073		**263,748**	
Small cetaceans	23,000		**2,300**	
Sundry	0		**400**	
	1,511,573		**1,526,150**	
Provisions				
Unpaid contributions	36,750		**0**	
Unpaid interest on overdue contributions	0		**24,464**	
Severance pay provision	32,500		**28,112**	
Provision for other doubtful debts	0		**-7,356**	
		1,580,823		**1,571,370**
Surplus of income over expenditure		**3,707**		**85,970**
Net transfers from or to (-):				
Sponsored publications fund		-2,280		**448**
Small cetaceans fund		6,600		**31,027**
Research fund		11,727		**264**
Surplus/Deficit (-) for the year after transfers		**19,754**		**54,230**

Appendix 5

PROVISIONAL ESTIMATE OF FINANCIAL CONTRIBUTIONS 2004-2005*

		Current scheme	Capacity to pay Group	Red'n Stage 1	Red'n Stage 2	Red'n £	Add-on whaling	Add on Group 3 £	Add on Group 4 £	Total (£)
1	Antigua and Barbuda	19,096	1	-9,548	-2,387	-11,935	0	0	0	7,161
2	Argentina	19,096	2	-4,774	-1,432	-6,206	0	0	0	12,890
3	Australia	25,461	3	0	0	0	0	6,418	0	31,879
4	Austria	19,096	3	0	0	0	0	6,418	0	25,514
5	Belize	19,096	1	-9,548	-2,387	-11,935	0	0	0	7,161
6	Benin	19,096	1	-9,548	-2,387	-11,935	0	0	0	7,161
7	Brazil	25,461	2	-6,365	-1,910	-8,275	0	0	0	17,186
8	Chile	19,096	2	-4,774	-1,432	-6,206	0	0	0	12,890
9	China, P.R. of	19,096	2	-4,774	-1,432	-6,206	0	0	0	12,890
10	Costa Rica	12,730	2	-3,183	-955	-4,137	0	0	0	8,593
11	Denmark	38,191	3	0	0	0	5,705	6,418	0	50,314
12	Dominica	19,096	1	-9,548	-2,387	-11,935	0	0	0	7,161
13	Finland	19,096	3	0	0	0	0	6,418	0	25,514
14	France	19,096	4	0	0	0	0	0	34,229	53,325
15	Gabon	19,096	1	-9,548	-2,387	-11,935	0	0	0	7,161
16	Germany	25,461	4	0	0	0	0	0	34,229	59,690
17	Grenada	19,096	1	-9,548	-2,387	-11,935	0	0	0	7,161
18	Guinea	19,096	1	-9,548	-2,387	-11,935	0	0	0	7,161
19	Iceland	31,826	3	0	0	0	0	6,418	0	38,244
20	India	19,096	2	-4,774	-1,432	-6,206	0	0	0	12,890
21	Ireland	19,096	3	0	0	0	0	6,418	0	25,514
22	Italy	25,461	4	0	0	0	0	0	34,229	59,690
23	Japan	89,113	4	0	0	0	5,705	0	34,229	129,047
24	Kenya	12,730	2	-3,183	-955	-4,137	0	0	0	8,593
25	Korea, Rep. of	38,191	2	-9,548	-2,864	-12,412	0	0	0	25,779
26	Mexico	19,096	2	-4,774	-1,432	-6,206	0	0	0	12,890
27	Monaco	19,096	3	0	0	0	0	6,418	0	25,514
28	Mongolia	19,096	1	-9,548	-2,387	-11,935	0	0	0	7,161
29	Morocco	19,096	2	-4,774	-1,432	-6,206	0	0	0	12,890
30	Netherlands	25,461	3	0	0	0	0	6,418	0	31,879
31	New Zealand	31,826	3	0	0	0	0	6,418	0	38,244
32	Nicaragua	19,096	1	-9,548	-2,387	-11,935	0	0	0	7,161
33	Norway	50,922	3	0	0	0	5,705	6,418	0	63,045
34	Oman	19,096	2	-4,774	-1,432	-6,206	0	0	0	12,890
35	Palau	19,096	1	-9,548	-2,387	-11,935	0	0	0	7,161
36	Panama	19,096	2	-4,774	-1,432	-6,206	0	0	0	12,890
37	Peru	19,096	2	-4,774	-1,432	-6,206	0	0	0	12,890
38	Portugal	19,096	3	0	0	0	0	6,418	0	25,514
39	Russian Federation	31,826	2	-7,957	-2,387	-11,935	5,705	0	0	27,188
40	St. Kitts and Nevis	19,096	1	-9,548	-2,387	-11,935	0	0	0	7,161
41	St. Lucia	19,096	1	-9,548	-2,387	-11,935	0	0	0	7,161
42	St. Vincent & The G.	31,826	1	-15,913	-3,978	-19,891	5,705	0	0	17,640
43	San Marino	19,096	3	0	0	0	0	6,418	0	25,514
44	Senegal	19,096	1	-9,548	-2,387	-11,935	0	0	0	7,161
45	Solomon Islands	19,096	1	-9,548	-2,387	-11,935	0	0	0	7,161
46	South Africa	19,096	2	-4,774	-1,432	-6,206	0	0	0	12,890
47	Spain	19,096	3	0	0	0	0	6,418	0	25,514
48	Sweden	25,461	3	0	0	0	0	6,418	0	31,879
49	Switzerland	19,096	3	0	0	0	0	6,418	0	25,514
50	United Kingdom	25,461	4	0	0	0	0	0	34,229	59,690
51	USA	44,557	4	0	0	0	5,705	0	34,229	84,491
52	Hungary	19,096	2	-4,774	-1,432	-6,206	0	0	0	12,890
53	Mauritania	19,096	1	-9,548	-2,387	-11,935	0	0	0	7,161
54	Belgium	19,096	3	0	0	0	0	6,418	0	25,514
55	Tuvalu	19,096	1	-9,548	-2,387	-11,935	0	0	0	7,161
56	Cote d'Ivoire	19,096	2	-9,548	-2,387	-11,935	0	0	0	7,161
57	Suriname	19,096	1	-9,548	-2,387	-11,935	0	0	0	7,161
		1,336,700		**-270,523**	**-71,768**	**-342,291**	**34,229**	**102,687**	**205,374**	**1,336,700**

Shortfall for re-distribution -329,332

Group 1	19	Whaling	**10%**	34,229
Group 2	16	Group 3	**30%**	102,687
Group 3	16	Group 4	**60%**	205,374
Group 4	6			342,291
	57			

*Secretariat note: In this provisional estimate, Iceland was omitted by mistake from whaling countries.

Appendix 6

PROPOSED BUDGETARY SUB-COMMITTEE ROTA FOR 2004/05 ONWARDS

The table below shows a possible rota that would result from the proposals made in section 5.4.1 of the F&A report. This rota incorporates the existing structure as modified by the proposed changes.

Membership would consist of:

- 2 members from Group 1;
- 2 members from Group 2;
- 2 members from Group 3; and
- Japan, USA + one other from Group 4.

- Membership is for 3 years (except for Japan and the USA who have a 'permanent' place since they are likely to be the two highest paying contributors under almost any formula for the calculation of financial contributions for the foreseeable future, being the highest payers now and probably in the future).
- Any member that declines to serve to be replaced by the next member in alphabetical sequence within its Group.
- New members of the Commission to be fitted into the cycle at the nearest alphabetical point after they have had a period in which to familiarise themselves with the organisation.
- Keep the four economic groups, but add two 'open seats' (i.e. for any interested countries) as a fifth category. Countries filling the two open seats would need to be identified and agreed at the meeting of the F&A Committee.

The table below shows the provisional rota for the Budgetary Sub-committee membership for 2004-05 to 2007-08 (assuming no-one declines to serve).

2004-2005 (current year)	2005-2006	2006-2007	2007-2008
Group 1			
Antigua and Barbuda	Belize	Belize	Belize
Dominica	Benin	Benin	Benin
Group 2			
Korea, Republic of	Korea, Republic of	Hungary	Kenya
Hungary	Hungary	Kenya	Mexico
Group 3			
Austria	Belgium	Belgium	Belgium
Finland	Finland	Denmark	Denmark
Norway*			
Group 4			
France	Germany	Germany	Germany
Japan	Japan	Japan	Japan
USA	USA	USA	USA
Germany*			

*Open seats for Norway and Germany have been proposed. Determination of the period the open seats will be open to interested parties, will be clarified by the Budgetary Sub-committee intersessionally.

Annex L

Approved Budget for 2004/2005 and Forecast Budget for 2005/2006

Income and Expenditure Account

	Proposed Budget 2004-2005		***Forecast Budget 2005-2006***	
Income	**£**	**£**	***£***	***£***
Contracting Government contributions		1,336,700		*1,359,200*
Recovery of Arrears		0		*0*
Interest on late financial contributions		0		*0*
Voluntary contributions		13,700		*0*
Sales of publications		10,300		*10,700*
Sales of sponsored publications		2,000		*2,100*
Observers registration fees		62,200		*64,100*
UK taxes recoverable		30,200		*27,400*
Staff assessments		138,300		*146,600*
Interest receivable		30,800		*31,700*
Sundry income		0		*0*
		1,624,200		*1,641,800*
Expenditure				
Secretariat	974,900		*1,006,200*	
Publications	47,600		*49,000*	
Annual meetings	308,900		*318,100*	
Other meetings	5,500		*5,700*	
Research expenditure	265,000		*245,200*	
Small cetaceans	46,900		*0*	
Sundry	0		*0*	
	1,648,800		*1,624,200*	
Provisions				
Unpaid contributions	0		*0*	
Unpaid interest on overdue contributions	0		*0*	
Severance pay provision	16,600		*17,600*	
Provision for other doubtful debts	0		*0*	
		1,665,400		*1,641,800*
Excess of expenditure over income		-41,200		*0*
Net Transfers from or to (-):				
Sponsored publications fund		-800		*-800*
Research fund		20,500		*-3,400*
Small cetaceans fund		32,600		*-700*
Surplus/Deficit (-) for the year after transfers		11,100		*-4,900*

Annex M

Approved Research Budget for 2004/2005 and Forecast Budget for 2005/2006

	Budget	
	Recommended	Reduced
RMP (Annex D)		
Intersessional Workshop on North Pacific Bryde's whales	£10,000	£8,000
AWMP (Annex E)		
AWMP developers fund	£10,000	£8,500
Genetic simulation studies	£12,000	£10,000
Intersessional workshop on Greenlandic issues	£10,000	£10,000
IA (Annex G)		
SOWER 2004/5	£88,500	£66,000
Beyond SOWER 2004/5	£9,000	£0
Estimating abundance of Antarctic minke whales - new methods and standard	£3,000	£3,000
Estimating abundance of Antarctic minke whales - DESS	£20,100	£12,100
Estimating trend in abundance of Antarctic minke whales – VPA analysis	£20,000	£18,000
E/IA/BRG (Annexes F, G and K)		
Sea-ice and whale habitat	£4,050	£4,050
E (Annex K)		
Porphyrin analyses POLLUTION 2000+, Phase I	£4,500	£0
SO-collaboration field work	£22,000	}
SO-collaboration, data validation, analysis, preparation of grant proposals	£30,000	} £45,000
SO-collaboration, spatial modelling development, data analysis	£25,000	}
Training scholarship, integrated data	£22,000	£0
SOCER, coordination, literature search and editing	£3,000	£0
SH (Annex H)		
Antarctic humpback whale photo catalogue	£5,200	£5,200
BC (Annex J)		
Coordination with FAO	£1,500	£1,500
Workshop on the use of market sampling to estimate bycatch	£14,500	£14,500
SM/BC (Annexes J and L)		
Workshop on mitigation of franciscana bycatches, Buenos Aires, 2005**	£20,000	£0
ALL		
Invited participants	£40,000	£35,000
TOTAL	£374,350	£240,850

** This money is to come out of the small cetaceans fund.
Note: The funding allocation included in the forecast budget for 2005-06 is £245,200.

Annex N

Amendments to the Schedule Adopted at the 56th Annual Meeting

Paragraphs 11 and 12, and Tables 1, 2 and 3:

Substitute the dates ***2004/2005*** pelagic season, ***2005*** coastal season, ***2005*** season, or ***2005*** as appropriate.

Paragraph 13:

Delete the words in 13 (b) (2): '…whose traditional aboriginal subsistence and cultural needs have been recognized.'

Add a new paragraph 13 (a) (4) to read: ***13 (a) (4) For aboriginal whaling conducted under subparagraphs (b) (1), (b) (2), and (b) (3) of this paragraph, it is forbidden to strike, take or kill calves or any whale accompanied by a calf. For aboriginal whaling conducted under subparagraphs (b) (4) of this paragraph, it is forbidden to strike, take or kill suckling calves or female whales accompanied by calves.***

Delete items 13 (b) (1) (ii) and 13 (b) (2) (ii).

Add a new paragraph 13 (a) (5) to read: ***13 (a) (5) All aboriginal whaling shall be conducted under national legislation that accords with this paragraph.***

Delete the words in paragraph 13 (b) (4):

Such whaling must be conducted under formal legislation that accords with the submission of the Government of St. Vincent and The Grenadines (IWC/54/AS 8 rev. 2).

Financial Statements for the Year ended 31 August 2004

Financial Statements for the year ended 31 August 2004

Independent Auditors' Report to the Commission

We have audited the financial statements of the International Whaling Commission which comprise the accounting policies, the income and expenditure account, the analysis of expenditure, the balance sheet and the related notes 1 to 8. These financial statements have been prepared under the accounting policies set out therein. This report is made solely to the Commission. Our audit work has been undertaken so that we might state to the Commission those matters we are required to state to them in an auditors' report and for no other purpose. To the fullest extent permitted by law, we do not accept or assume responsibility to anyone other than the Commission for our audit work, for this report, or for the opinions we have formed.

Respective Responsibilities of the Secretary and Auditors
As described in the statement of the Secretary's responsibilities, the Secretary is responsible for the preparation of financial statements.

Neither statute nor the Commission has prescribed that the financial statements should give a true and fair view of the Commission's state of affairs at the end of each year within the specialised meaning of that expression in relation to financial statements. This recognised terminology signifies in accounting terms that statements are generally accepted as true and fair only if they comply in all material aspects with accepted accounting principles. These are embodied in accounting standards issued by the Accounting Standards Board. The Commission has adopted certain accounting policies which represent departures from accounting standards:

- fixed assets are not capitalised within the Commission's accounts. Instead fixed assets are charged to the income and expenditure account in the year of acquisition. Hence, the residual values of the furniture, fixtures and fittings and equipment are not reflected in the accounts;
- publications stocks are charged to the income and expenditure account in the year of acquisition and their year end valuation is not reflected in the accounts.
- provision is made for the severance pay which would be payable should the Commission cease to function.

This is permissible as the financial statements are not required to give a true and fair view.

It is our responsibility to form an independent opinion, based on our audit, on those statements and to report our opinion to you. We also report if the Commission has not kept proper accounting records or if we have not received all the information and explanations we require for our audit.

Basis of Opinion
We conducted our audit in accordance with United Kingdom Auditing Standards issued by the Auditing Practices Board. An audit includes examination, on a test basis, of evidence relevant to the amounts and disclosures in the financial statements. It also includes an assessment of the significant estimates and judgements made by the Secretary in the preparation of the financial statements, and of whether the accounting policies are appropriate to the Commission's circumstances, consistently applied and adequately disclosed.

We planned and performed our audit so as to obtain all the information and explanations which we considered necessary in order to provide us with sufficient evidence to give reasonable assurance that the financial statements are free from material misstatement whether caused by fraud or other irregularity or error. In forming our opinion, we also evaluated the overall adequacy of the presentation of information in the financial statements.

Added Emphasis
In forming our opinion we have taken account of the absence of a requirement for the financial statements to give a true and fair view as described above.

Opinion
In our opinion the financial statements have been properly prepared in accordance with the accounting policies and present a proper record of the transactions of the Commission for the year ended 31 August 2004.

D A Green & Sons, Chartered Certified Accountants, St Ives, 1 February 2005

The Secretary's Responsibilities

The financial responsibilities of the Secretary to the Commission are set out in its Rules of Procedure and Financial Regulations. Fulfilment of those responsibilities requires the Secretary to prepare financial statements for each financial year which set out the state of affairs of the Commission as at the end of the financial year and the surplus or deficit of the Commission for that period. In preparing those financial statements, the Secretary should:

- Select suitable accounting policies and then apply them consistently;
- Make judgements and estimates that are reasonable and prudent;
- Prepare the financial statements on the going concern basis unless it is inappropriate to presume that the Commission will continue in operation.

The Secretary is responsible for keeping proper accounting records which disclose with reasonable accuracy at any time the financial position of the Commission. The Secretary is also responsible for safeguarding the assets of the Commission and hence for taking reasonable steps for the prevention and detection of fraud and other irregularities.

Accounting Policies - Year ended 31 August 2004

The accounting policies adopted by the Commission in the preparation of these financial statements are as set out below. The departures from generally accepted accounting practice are considered not to be significant for the reasons stated.

Convention
These accounts are prepared under the historical cost convention (i.e. assets and liabilities are stated at cost and not re-valued).

Fixed Assets
The full cost of furniture and equipment is written off in the income and expenditure account in the year in which it is incurred. The total cost of equipment owned by the Commission is some £171,000 and its realisable value is not significant. Proposed expenditure on new items is included in budgets and raised by contributions for the year.

Publications
The full cost of printing publications is written off in the year. No account is taken of stocks which remain unsold at the balance sheet date.

Most sales occur shortly after publication and so stocks held are unlikely to result in many sales, consequently their net realisable value is not significant.

Severance Pay Provision
The Commission provides for an indemnity to members of staff in the event of their appointment being terminated on the abolition of their posts. The indemnity varies according to length of service and therefore an annual provision is made to bring the total provision up to the maximum liability. This liability is calculated after adjusting for staff assessments since they would not form part of the Commission's liability.

Interest on Overdue Contributions
Interest is included in the income and expenditure account on the accruals basis and provision is made where its recoverability is in doubt.

Leases
The costs of operating leases are charged to the income and expenditure account as they accrue.

Foreign Exchange
Transactions dominated in foreign currencies are translated into sterling at rates ruling at the date of the transactions. Monetary assets and liabilities denominated in foreign currencies at the balance sheet date are translated at the rates ruling at that date. These translation differences are dealt with in the income and expenditure account.

Retirement Benefits Scheme
The Commission operates a defined contribution retirement benefits scheme. The costs represent the amount of the Commission's contributions payable to the scheme in respect of the accounting period.

Income and Expenditure Account (year ended 31 August 2004)

	[Note]	2004 £	£	2003 £	£
Income: continuing operations					
Contributions from member governments			1,298,789		1,251,073
Interest on overdue financial contributions			45,045		33,019
Voluntary contributions for research, small cetaceans work and publications			64,359		38,143
Sales of publications			17,852		17,342
Sales of sponsored publications	[1]		1,737		2,074
Observers' registration fees			55,240		65,847
UK taxes recoverable			23,103		32,418
Staff assessments			132,632		137,486
Interest receivable			48,811		36,928
Sundry income			1,230		1,396
			1,688,798		1,615,726
Expenditure					
Secretariat		882,190		958,284	
Publications		47,165		45,549	
Annual meetings		300,800		301,904	
Other meetings		1,556		30,698	
Research expenditure		251,062		265,572	
Small cetaceans	[3]	2,721		14,627	
Sundry		2,033		6,284	
		1,487,527		1,622,918	
Provisions made for:					
Unpaid contributions		(43,865)		(9,585)	
Unpaid interest on overdue contributions		(12,457)		(5,838)	
Severance pay	[5]	28,600		(24,100)	
Other doubtful debts		(964)	1,458,841	4,000	1,587,395
Surplus of income:					
Continuing operations	[7]		229,957		28,331
Net transfers from /(to) funds:					
Publications fund	[1]	(1,958)		(3,122)	
Research Fund	[2]	(46,834)		44,503	
Small cetaceans fund	[3]	(467)	(49,259)	(17,546)	23,835
Surplus for the year after transfers	[4]		180,698		52,166

There are no recognised gains or losses for the current financial year and the preceding financial year other than as stated in the income and expenditure account.

Analysis of Expenditure (year ended 31 August 2004)

	2004 £	2003 £
SECRETARIAT		
Salaries, national insurance and allowances	586,146	622,150
Retirement and Other Benefit Schemes	108,963	132,187
Travelling expenses	2,749	2,589
Office rent, heating and maintenance	96,479	90,844
Insurance	3,702	5,651
Postage and telecommunications	21,829	21,376
Office equipment and consumables	52,594	62,065
Professional fees	7,688	6,795
Training & Recruitment	765	14,287
Photocopying	1,275	340
	882,190	958,284
PUBLICATIONS		
Annual Report	8,730	6,294
Journal Cetacean Research and Management	38,435	39,234
Sponsored publications	0	21
	47,165	45,549
RESEARCH		
Invited participants	27,544	21,862
SOWER:		
2002/2003 SOWER cruise	0	80,283
2003/2004 SOWER cruise	84,199	0
Contract 14 Analysis support including DESS maintenance/development	11,750	32,472
Contract 16 Southern Hemisphere Humpback catalogue	5,105	6,800
SO-GLOBEC	34,839	33,614
Pollution 2000+	29,137	13,786
AWMP fund for developers	0	7,523
AWMP intersessional workshop	12,531	0
Fishery Cetacean Workshop	0	820
IA Development support	7,946	8,014
Gray Whale Workshop	0	9,634
Gray Whales USA/Russia Workshop	2,253	33,767
RMP (SC) Intersessional Workshop	0	8,266
SD Intersessional Workshop	0	7,612
FAO Fisheries statistics	606	0
AS Greenland Research	17,984	0
SOS Review	6,746	0
TOSSM Project	9,511	0
Other (including exchange differences)	911	1,119
	251,062	265,572
SMALL CETACEANS		
Invited participants	2,702	10,498
Common Dolphins in South America	0	3,934
Other (including exchange losses)	19	195
	2,721	14,627

Balance Sheet 31 August 2004

	[Note]	2004 £	2004 £	2003 £	2003 £
CURRENT ASSETS					
Cash on short term deposit					
General fund		1,313,771		1,376,254	
Research fund		124,455		39,881	
Publications fund		29,986		28,091	
Small Cetaceans fund		31,063	1,499,275	28,735	1,472,961
Cash at bank on current account					
Research fund		815		1,000	
Publications fund		1,000		1,000	
Small Cetaceans fund		1,000		1,000	
Cash in hand		120	2,935	89	3,089
			1,502,210		1,476,050
Outstanding contributions from members, including interest		573,674		616,614	
Less provision for doubtful debts		(560,277)	13,397	(616,599)	15
Other debtors and prepayments			82,538		64,280
			1,598,145		1,540,345
CREDITORS:					
Amounts falling due within one year	[6]		(93,303)		(294,060)
NET CURRENT ASSETS			1,504,842		1,246,285
PROVISION FOR SEVERANCE PAY	[5]		(331,500)		(302,900)
			1,173,342		943,385
Financed by					
Publications fund	[1]		31,209		29,251
Research fund	[2]		148,847		102,013
Small cetaceans fund	[3]		33,655		33,188
General fund	[4]		959,631		778,933
	[7]		1,173,342		943,385

Approved on behalf of the Commission
Nicola J Grandy, Secretary
31 January 2005

Notes to the Accounts

	2004 £	2003 £
1. Publications fund		
Interest receivable	221	1,069
Receipts from sales of sponsored publications	1,737	2,074
Expenditure	(0)	(21)
Net transfers to income and expenditure account	1,958	3,122
Opening balances at 1 September 2003	29,251	26,129
Closing balances at 31 August 2004	31,209	29,251
2. Research fund		
Allocation for research	231,073	206,822
UK taxes recoverable	2,665	4,658
Voluntary contributions received	61,616	6,349
Interest receivable	2,542	3,240
Expenditure	(251,062)	(265,572)
Net transfers (to) income and expenditure account	46,834	(44,503)
Opening balances at 1 September 2003	102,013	146,516
Closing balances at 31 August 2004	148,847	102,013
3. Small cetaceans fund		
Voluntary contributions received	2,743	31,795
Interest receivable	445	378
Expenditure	(2,721)	(14,627)
Net transfer from/(to) income and expenditure account	467	17,546
Opening balances at 1 September 2003	33,188	15,642
Closing balances at 31 August 2004	33,655	33,188
4. General fund		
Opening balances at 1 September 2003	778,933	726,767
Surplus transferred from income and expenditure account	180,698	52,166
Closing balances at 31 August 2004	959,631	778,933
5. Provision for severance pay		
Opening balances at 1 September 2003	302,900	327,000
Transfer (to) from income and expenditure account, being:		
Allocation	19,760	(32,245)
Interest received	8,840	8,145
Closing balances at 31 August 2004	331,500	302,900
6. Creditors: Amounts falling due within one year		
Deferred contributions income	53,554	252,295
Other creditors and accruals	39,749	41,765
	93,303	294,060
7. Reconciliation of movement in funds		
Surplus of income over expenditure	229,957	28,331
Opening funds	943,385	915,054
	1,173,342	943,385

8. Financial commitments

The Commission had annual commitments at 31 August 2004 under non-cancellable operating leases as set out below and which expire:

	2004		2003	
	Land and buildings £	Office equipment £	Land and buildings £	Office equipment £
Within 2 to 5 years	0	22,078	0	26,376
After five years	69,500	0	69,500	0
	69,500	22,078	69,500	26,376

International Convention
for the
Regulation of Whaling, 1946

signed at Washington, 2 December 1946

and its

Protocol

signed at Washington, 19 November 1956

The Schedule which is attached to the Convention and under Article I forms an integral part thereof is amended regularly by the Commission. The most recent version begins on p. 143 of this volume.

International Convention for the Regulation of Whaling

Washington, 2nd December, 1946

The Governments whose duly authorised representatives have subscribed hereto,

Recognizing the interest of the nations of the world in safeguarding for future generations the great natural resources represented by the whale stocks;

Considering that the history of whaling has seen over-fishing of one area after another and of one species of whale after another to such a degree that it is essential to protect all species of whales from further over-fishing;

Recognizing that the whale stocks are susceptible of natural increases if whaling is properly regulated, and that increases in the size of whale stocks will permit increases in the number of whales which may be captured without endangering these natural resources;

Recognizing that it is in the common interest to achieve the optimum level of whale stocks as rapidly as possible without causing widespread economic and nutritional distress;

Recognizing that in the course of achieving these objectives, whaling operations should be confined to those species best able to sustain exploitation in order to give an interval for recovery to certain species of whales now depleted in numbers;

Desiring to establish a system of international regulation for the whale fisheries to ensure proper and effective conservation and development of whale stocks on the basis of the principles embodied in the provisions of the International Agreement for the Regulation of Whaling, signed in London on 8th June, 1937, and the protocols to that Agreement signed in London on 24th June, 1938, and 26th November, 1945; and

Having decided to conclude a convention to provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry;

Have agreed as follows:-

Article I

1. This Convention includes the Schedule attached thereto which forms an integral part thereof. All references to "Convention" shall be understood as including the said Schedule either in its present terms or as amended in accordance with the provisions of Article V.
2. This Convention applies to factory ships, land stations, and whale catchers under the jurisdiction of the Contracting Governments and to all waters in which whaling is prosecuted by such factory ships, land stations, and whale catchers.

Article II

As used in this Convention:-

1. "Factory ship" means a ship in which or on which whales are treated either wholly or in part;
2. "Land station" means a factory on the land at which whales are treated either wholly or in part;
3. "Whale catcher" means a ship used for the purpose of hunting, taking, towing, holding on to, or scouting for whales;
4. "Contracting Government" means any Government which has deposited an instrument of ratification or has given notice of adherence to this Convention.

Article III

1. The Contracting Governments agree to establish an International Whaling Commission, hereinafter referred to as the Commission, to be composed of one member from each Contracting Government. Each member shall have one vote and may be accompanied by one or more experts and advisers.
2. The Commission shall elect from its own members a Chairman and Vice-Chairman and shall determine its own Rules of Procedure. Decisions of the Commission shall be taken by a simple majority of those members voting except that a three-fourths majority of those members voting shall be required for action in pursuance of Article V. The Rules of Procedure may provide for decisions otherwise than at meetings of the Commission.
3. The Commission may appoint its own Secretary and staff.
4. The Commission may set up, from among its own members and experts or advisers, such committees as it considers desirable to perform such functions as it may authorize.
5. The expenses of each member of the Commission and of his experts and advisers shall be determined by his own Government.
6. Recognizing that specialized agencies related to the United Nations will be concerned with the conservation and development of whale fisheries and the products arising therefrom and desiring to avoid duplication of functions, the Contracting Governments will consult among themselves within two years after the coming into force of this Convention to decide whether the Commission shall be brought within the framework of a specialized agency related to the United Nations.
7. In the meantime the Government of the United Kingdom of Great Britain and Northern Ireland shall arrange, in consultation with the other Contracting Governments, to convene the first meeting of the Commission, and shall initiate the consultation referred to in paragraph 6 above.
8. Subsequent meetings of the Commission shall be convened as the Commission may determine.

Article IV

1. The Commission may either in collaboration with or through independent agencies of the Contracting Governments or other public or private agencies, establishments, or organizations, or independently

(a) encourage, recommend, or if necessary, organize studies and investigations relating to whales and whaling;
(b) collect and analyze statistical information concerning the current condition and trend of the whale stocks and the effects of whaling activities thereon;
(c) study, appraise, and disseminate information concerning methods of maintaining and increasing the populations of whale stocks.

2. The Commission shall arrange for the publication of reports of its activities, and it may publish independently or in collaboration with the International Bureau for Whaling Statistics at Sandefjord in Norway and other organizations and agencies such reports as it deems appropriate, as well as statistical, scientific, and other pertinent information relating to whales and whaling.

Article V

1. The Commission may amend from time to time the provisions of the Schedule by adopting regulations with respect to the conservation and utilization of whale resources, fixing *(a)* protected and unprotected species; *(b)* open and closed seasons; *(c)* open and closed waters, including the designation of sanctuary areas; *(d)* size limits for each species; *(e)* time, methods, and intensity of whaling (including the maximum catch of whales to be taken in any one season); *(f)* types and specifications of gear and apparatus and appliances which may be used; *(g)* methods of measurement; and *(h)* catch returns and other statistical and biological records.
2. These amendments of the Schedule *(a)* shall be such as are necessary to carry out the objectives and purposes of this Convention and to provide for the conservation, development, and optimum utilization of the whale resources; *(b)* shall be based on scientific findings; *(c)* shall not involve restrictions on the number or nationality of factory ships or land stations, nor allocate specific quotas to any factory or ship or land station or to any group of factory ships or land stations; and *(d)* shall take into consideration the interests of the consumers of whale products and the whaling industry.
3. Each of such amendments shall become effective with respect to the Contracting Governments ninety days following notification of the amendment by the Commission to each of the Contracting Governments, except that *(a)* if any Government presents to the Commission objection to any amendment prior to the expiration of this ninety-day period, the amendment shall not become effective with respect to any of the Governments for an additional ninety days; *(b)* thereupon, any other Contracting Government may present objection to the amendment at any time prior to the expiration of the additional ninety-day period, or before the expiration of thirty days from the date of receipt of the last objection received during such additional ninety-day period, whichever date shall be the later; and *(c)* thereafter, the amendment shall become effective with respect to all Contracting Governments which have not presented objection but shall not become effective with respect to any Government which has so objected until such date as the objection is withdrawn. The Commission shall notify each Contracting Government immediately upon receipt of each objection and withdrawal and each Contracting Government shall acknowledge receipt of all notifications of amendments, objections, and withdrawals.
4. No amendments shall become effective before 1st July, 1949.

Article VI

The Commission may from time to time make recommendations to any or all Contracting Governments on any matters which relate to whales or whaling and to the objectives and purposes of this Convention.

Article VII

The Contracting Government shall ensure prompt transmission to the International Bureau for Whaling Statistics at Sandefjord in Norway, or to such other body as the Commission may designate, of notifications and statistical and other information required by this Convention in such form and manner as may be prescribed by the Commission.

Article VIII

1. Notwithstanding anything contained in this Convention any Contracting Government may grant to any of its nationals a special permit authorizing that national to kill, take and treat whales for purposes of scientific research subject to such restrictions as to number and subject to such other conditions as the Contracting Government thinks fit, and the killing, taking, and treating of whales in accordance with the provisions of this Article shall be exempt from the operation of this Convention. Each Contracting Government shall report at once to the Commission all such authorizations which it has granted. Each Contracting Government may at any time revoke any such special permit which it has granted.
2. Any whales taken under these special permits shall so far as practicable be processed and the proceeds shall be dealt with in accordance with directions issued by the Government by which the permit was granted.
3. Each Contracting Government shall transmit to such body as may be designated by the Commission, in so far as practicable, and at intervals of not more than one year, scientific information available to that Government with respect to whales and whaling, including the results of research conducted pursuant to paragraph 1 of this Article and to Article IV.
4. Recognizing that continuous collection and analysis of biological data in connection with the operations of factory ships and land stations are indispensable to sound and constructive management of the whale fisheries, the Contracting Governments will take all practicable measures to obtain such data.

Article IX

1. Each Contracting Government shall take appropriate measures to ensure the application of the provisions of this Convention and the punishment of infractions against the said provisions in operations carried out by persons or by vessels under its jurisdiction.
2. No bonus or other remuneration calculated with relation to the results of their work shall be paid to the gunners and crews of whale catchers in respect of any whales the taking of which is forbidden by this Convention.
3. Prosecution for infractions against or contraventions of this Convention shall be instituted by the Government having jurisdiction over the offence.
4. Each Contracting Government shall transmit to the Commission full details of each infraction of the provisions of this Convention by persons or vessels under the jurisdiction of that Government as reported by its

inspectors. This information shall include a statement of measures taken for dealing with the infraction and of penalties imposed.

Article X

1. This Convention shall be ratified and the instruments of ratifications shall be deposited with the Government of the United States of America.
2. Any Government which has not signed this Convention may adhere thereto after it enters into force by a notification in writing to the Government of the United States of America.
3. The Government of the United States of America shall inform all other signatory Governments and all adhering Governments of all ratifications deposited and adherences received.
4. This Convention shall, when instruments of ratification have been deposited by at least six signatory Governments, which shall include the Governments of the Netherlands, Norway, the Union of Soviet Socialist Republics, the United Kingdom of Great Britain and Northern Ireland, and the United States of America, enter into force with respect to those Governments and shall enter into force with respect to each Government which subsequently ratifies or adheres on the date of the deposit of its instrument of ratification or the receipt of its notification of adherence.
5. The provisions of the Schedule shall not apply prior to 1st July, 1948. Amendments to the Schedule adopted pursuant to Article V shall not apply prior to 1st July, 1949.

Article XI

Any Contracting Government may withdraw from this Convention on 30th June, of any year by giving notice on or before 1st January, of the same year to the depository Government, which upon receipt of such a notice shall at once communicate it to the other Contracting Governments. Any other Contracting Government may, in like manner, within one month of the receipt of a copy of such a notice from the depository Government give notice of withdrawal, so that the Convention shall cease to be in force on 30th June, of the same year with respect to the Government giving such notice of withdrawal.

The Convention shall bear the date on which it is opened for signature and shall remain open for signature for a period of fourteen days thereafter.

In witness whereof the undersigned, being duly authorized, have signed this Convention.

Done in Washington this second day of December, 1946, in the English language, the original of which shall be deposited in the archives of the Government of the United States of America. The Government of the United States of America shall transmit certified copies thereof to all the other signatory and adhering Governments.

Protocol

to the International Convention for the Regulation of Whaling, Signed at Washington Under Date of December 2, 1946

The Contracting Governments to the International Convention for the Regulation of Whaling signed at Washington under date of 2nd December, 1946 which Convention is hereinafter referred to as the 1946 Whaling Convention, desiring to extend the application of that Convention to helicopters and other aircraft and to include provisions on methods of inspection among those Schedule provisions which may be amended by the Commission, agree as follows:

Article I

Subparagraph 3 of the Article II of the 1946 Whaling Convention shall be amended to read as follows:

"3. 'whale catcher' means a helicopter, or other aircraft, or a ship, used for the purpose of hunting, taking, killing, towing, holding on to, or scouting for whales."

Article II

Paragraph 1 of Article V of the 1946 Whaling Convention shall be amended by deleting the word "and" preceding clause (h), substituting a semicolon for the period at the end of the paragraph, and adding the following language: "and (i) methods of inspection".

Article III

1. This Protocol shall be open for signature and ratification or for adherence on behalf of any Contracting Government to the 1946 Whaling Convention.
2. This Protocol shall enter into force on the date upon which instruments of ratification have been deposited with, or written notifications of adherence have been received by, the Government of the United States of America on behalf of all the Contracting Governments to the 1946 Whaling Convention.
3. The Government of the United States of America shall inform all Governments signatory or adhering to the 1946 Whaling Convention of all ratifications deposited and adherences received.
4. This Protocol shall bear the date on which it is opened for signature and shall remain open for signature for a period of fourteen days thereafter, following which period it shall be open for adherence.

IN WITNESS WHEREOF the undersigned, being duly authorized, have signed this Protocol.

DONE in Washington this nineteenth day of November, 1956, in the English Language, the original of which shall be deposited in the archives of the Government of the United States of America. The Government of the United States of America shall transmit certified copies thereof to all Governments signatory or adhering to the 1946 Whaling Convention.

International Convention

for the

Regulation of Whaling, 1946

Schedule

As amended by the Commission at the 56th Annual Meeting
Sorrento, Italy, 19-22 July 2004

International Convention for the Regulation of Whaling, 1946

Schedule

EXPLANATORY NOTES

The Schedule printed on the following pages contains the amendments made by the Commission at its 56th Annual Meeting in July 2004. It also contains an additional editorial footnote to paragraph 10(*e*). The amendments, which are shown in ***italic bold*** type, came into effect on 28 October 2004.

In Tables 1, 2 and 3 unclassified stocks are indicated by a dash. Other positions in the Tables have been filled with a dot to aid legibility.

Numbered footnotes are integral parts of the Schedule formally adopted by the Commission. Other footnotes are editorial.

The Commission was informed in June 1992 by the ambassador in London that the membership of the Union of Soviet Socialist Republics in the International Convention for the Regulation of Whaling from 1948 is continued by the Russian Federation.

The Commission recorded at its 39th (1987) meeting the fact that references to names of native inhabitants in Schedule paragraph 13(*b*)(4) would be for geographical purposes alone, so as not to be in contravention of Article V.2(*c*) of the Convention (*Rep. int. Whal. Commn* 38:21).

I. INTERPRETATION

1. The following expressions have the meanings respectively assigned to them, that is to say:

A. Baleen whales

"baleen whale" means any whale which has baleen or whale bone in the mouth, i.e. any whale other than a toothed whale.

"blue whale" (*Balaenoptera musculus*) means any whale known as blue whale, Sibbald's rorqual, or sulphur bottom, and including pygmy blue whale.

"bowhead whale" (*Balaena mysticetus*) means any whale known as bowhead, Arctic right whale, great polar whale, Greenland right whale, Greenland whale.

"Bryde's whale" (*Balaenoptera edeni*, *B. brydei*) means any whale known as Bryde's whale.

"fin whale" (*Balaenoptera physalus*) means any whale known as common finback, common rorqual, fin whale, herring whale, or true fin whale.

"gray whale" (Eschrichtius robustus) means any whale known as gray whale, California gray, devil fish, hard head, mussel digger, gray back, or rip sack.

"humpback whale" (*Megaptera novaeangliae*) means any whale known as bunch, humpback, humpback whale, humpbacked whale, hump whale or hunchbacked whale.

"minke whale" (*Balaenoptera acutorostrata*, *B. bonaerensis*) means any whale known as lesser rorqual, little piked whale, minke whale, pike-headed whale or sharp headed finner.

"pygmy right whale" (*Caperea marginata*) means any whale known as southern pygmy right whale or pygmy right whale.

"right whale" (*Eubalaena glacialis*, *E. australis*) means any whale known as Atlantic right whale, Arctic right whale, Biscayan right whale, Nordkaper, North Atlantic right whale, North Cape whale, Pacific right whale, or southern right whale.

"sei whale" (*Balaenoptera borealis*) means any whale known as sei whale, Rudolphi's rorqual, pollack whale, or coalfish whale.

B. Toothed whales

"toothed whale" means any whale which has teeth in the jaws.

"beaked whale" means any whale belonging to the genus Mesoplodon, or any whale known as Cuvier's beaked whale (*Ziphius cavirostris*), or Shepherd's beaked whale (*Tasmacetus shepherdi*).

"bottlenose whale" means any whale known as Baird's beaked whale (*Berardius bairdii*), Arnoux's whale (*Berardius arnuxii*), southern bottlenose whale (*Hyperoodon planifrons*), or northern bottlenose whale (*Hyperoodon ampullatus*).

"killer whale" (*Orcinus orca*) means any whale known as killer whale or orca.

"pilot whale" means any whale known as long-finned pilot whale (*Globicephala melaena*) or short-finned pilot whale (*G. macrorhynchus*).

"sperm whale" (*Physeter macrocephalus*) means any whale known as sperm whale, spermacet whale, cachalot or pot whale.

C. General

"strike" means to penetrate with a weapon used for whaling.

"land" means to retrieve to a factory ship, land station, or other place where a whale can be treated.

"take" means to flag, buoy or make fast to a whale catcher.

"lose" means to either strike or take but not to land.

"dauhval" means any unclaimed dead whale found floating.

"lactating whale" means (a) with respect to baleen whales - a female which has any milk present in a mammary gland, (b) with respect to sperm whales - a female which has milk present in a mammary gland the maximum thickness (depth) of which is 10cm or more. This measurement shall be at the mid ventral point of the mammary gland perpendicular to the body axis, and shall be logged to the nearest centimetre; that is to say, any gland between 9.5cm and 10.5cm shall be logged as 10cm. The measurement of any gland which falls on an exact 0.5 centimetre shall be logged at the next 0.5 centimetre, e.g. 10.5cm shall be logged as 11.0cm. However, notwithstanding these criteria, a whale shall not be considered a lactating whale if scientific (histological or other biological) evidence is presented to the appropriate national authority establishing that the whale could not at that point in its physical cycle have had a calf dependent on it for milk.

"small-type whaling" means catching operations using powered vessels with mounted harpoon guns hunting exclusively for minke, bottlenose, beaked, pilot or killer whales.

II. SEASONS

Factory Ship Operations

2. (*a*) It is forbidden to use a factory ship or whale catcher attached thereto for the purpose of taking or treating baleen whales except minke whales, in any waters south of 40° South Latitude except during the period from 12th December to 7th April following, both days inclusive.

(*b*) It is forbidden to use a factory ship or whale catcher attached thereto for the purpose of taking or treating sperm or minke whales, except as permitted by the Contracting Governments in accordance with sub-paragraphs (c) and (d) of this paragraph, and paragraph 5.

(*c*) Each Contracting Government shall declare for all factory ships and whale catchers attached thereto under its jurisdiction, an open season or seasons not to exceed eight months out of any period of twelve months during which the taking or killing of sperm whales by whale catchers may be permitted; provided that a separate open season may be declared for each factory ship and the whale catchers attached thereto.

(*d*) Each Contracting Government shall declare for all factory ships and whale catchers attached thereto under its jurisdiction one continuous open season not to exceed six months out of any period of twelve months during which the taking or killing of minke whales by the whale catchers may be permitted provided that:

(1) a separate open season may be declared for each factory ship and the whale catchers attached thereto;

(2) the open season need not necessarily include the whole or any part of the period declared for other baleen whales pursuant to sub-paragraph (*a*) of this paragraph.

3. It is forbidden to use a factory ship which has been used during a season in any waters south of 40° South Latitude for the purpose of treating baleen whales, except minke whales, in any other area except the North Pacific Ocean and its dependent waters north of the Equator for the same purpose within a period of one year from the termination of that season; provided that catch limits in the North Pacific Ocean and dependent waters are established as provided in paragraphs 12 and 16 of this Schedule and provided that this paragraph shall not apply to a ship which has been used during the season solely for freezing or salting the meat and entrails of whales intended for human food or feeding animals.

Land Station Operations

4. (*a*) It is forbidden to use a whale catcher attached to a land station for the purpose of killing or attempting to kill baleen and sperm whales except as permitted by the Contracting Government in accordance with sub-paragraphs (*b*), (*c*) and (*d*) of this paragraph.

(*b*) Each Contracting Government shall declare for all land stations under its jurisdiction, and whale catchers attached to such land stations, one open season during which the taking or killing of baleen whales, except minke whales, by the whale catchers shall be permitted. Such open season shall be for a period of not more than six consecutive months in any period of twelve months and shall apply to all land stations under the jurisdiction of the Contracting Government: provided that a separate open season may be declared for any land station used for the taking or treating of baleen whales, except minke whales, which is more than 1,000 miles from the nearest land station used for the taking or treating of baleen whales, except minke whales, under the jurisdiction of the same Contracting Government.

(*c*) Each Contracting Government shall declare for all land stations under its jurisdiction and for whale catchers attached to such land stations, one open season not to exceed eight continuous months in any one period of twelve months, during which the taking or killing of sperm whales by the whale catchers shall be permitted, provided that a separate open season may be declared for any land station used for the taking or treating of sperm whales which is more than 1,000 miles from the nearest land station used for the taking or treating of sperm whales under the jurisdiction of the same Contracting Government.

(*d*) Each Contracting Government shall declare for all land stations under its jurisdiction and for whale catchers attached to such land stations one open season not to exceed six continuous months in any period of twelve months during which the taking or killing of minke whales by the whale catchers shall be permitted (such period not being necessarily concurrent with the period declared for other baleen whales, as provided for in sub-paragraph (b) of this paragraph); provided that a separate open season may be declared for any land station used for the taking or treating of minke whales which is more than 1,000 miles from the nearest land station used for the taking or treating of minke whales under the jurisdiction of the same Contracting Government.

Except that a separate open season may be declared for any land station used for the taking or treating of minke whales which is located in an area having oceanographic conditions clearly distinguishable from those of the area in which are located the other land stations used for the taking or treating of minke whales under the jurisdiction of the same Contracting Government; but the declaration of a separate open season by virtue of the provisions of this sub-paragraph shall not cause thereby the period of time covering the open seasons declared by the same Contracting Government to exceed nine continuous months of any twelve months.

(*e*) The prohibitions contained in this paragraph shall apply to all land stations as defined in Article II of the Whaling Convention of 1946.

Other Operations

5. Each Contracting Government shall declare for all whale catchers under its jurisdiction not operating in conjunction with a factory ship or land station one continuous open season not to exceed six months out of any period of twelve months during which the taking or killing of minke whales by such whale catchers may be permitted. Notwithstanding this paragraph one continuous open season not to exceed nine months may be implemented so far as Greenland is concerned.

III. CAPTURE

6. The killing for commercial purposes of whales, except minke whales using the cold grenade harpoon shall be forbidden from the beginning of the 1980/81 pelagic and 1981 coastal seasons. The killing for commercial purposes of minke whales using the cold grenade harpoon shall be forbidden from the beginning of the 1982/83 pelagic and the 1983 coastal seasons.*

7. (*a*) In accordance with Article V(1)(c) of the Convention, commercial whaling, whether by pelagic operations or from land stations, is prohibited in a region designated as the Indian Ocean Sanctuary. This comprises the waters of the Northern Hemisphere from the coast of Africa to 100°E, including the Red and Arabian Seas and the Gulf of Oman; and the waters of the Southern Hemisphere in the sector from 20°E to 130°E, with the Southern boundary set at 55°S. This prohibition applies irrespective of such catch limits for baleen or toothed whales as may from time to time be determined by the Commission. This prohibition shall be reviewed by the Commission at its Annual Meeting in 2002.☼

(*b*) In accordance with Article V(1)(c) of the Convention, commercial whaling, whether by pelagic operations or from land stations, is prohibited in a region designated as the Southern Ocean Sanctuary. This Sanctuary comprises the waters of the Southern Hemisphere southwards of the following line: starting from 40 degrees S, 50 degrees W; thence due east to 20 degrees E; thence due south to 55 degrees S; thence due east to 130 degrees E; thence due north to 40 degrees S; thence due east to 130 degrees W; thence due south to 60 degrees S; thence due east to 50 degrees W; thence due north to the point of beginning. This prohibition applies irrespective of the conservation status of baleen and toothed whale stocks in this Sanctuary, as may from time to time be determined by the Commission. However, this prohibition shall be reviewed ten years after its initial adoption and at succeeding ten year intervals, and could be revised at such times by the Commission. Nothing in this sub-paragraph is intended to prejudice the special legal and political status of Antarctica.**+

Area Limits for Factory Ships

8. It is forbidden to use a factory ship or whale catcher attached thereto, for the purpose of taking or treating baleen whales, except minke whales, in any of the following areas:
   (*a*) in the waters north of 66°N, except that from 150°E eastwards as far as 140°W, the taking or killing of baleen whales by a factory ship or whale catcher shall be permitted between 66°N and 72°N;
   (*b*) in the Atlantic Ocean and its dependent waters north of 40°S;
   (*c*) in the Pacific Ocean and its dependent waters east of 150°W between 40°S and 35°N;
   (*d*) in the Pacific Ocean and its dependent waters west of 150°W between 40°S and 20°N; and
   (*e*) in the Indian Ocean and its dependent waters north of 40°S.

Classification of Areas and Divisions

9. (*a*) *Classification of Areas*
   Areas relating to Southern Hemisphere baleen whales except Bryde's whales are those waters between the ice-edge and the Equator and between the meridians of longitude listed in Table 1.
   (*b*) *Classification of Divisions*
   Divisions relating to Southern Hemisphere sperm whales are those waters between the ice-edge and the Equator and between the meridians of longitude listed in Table 3.
   (*c*) *Geographical boundaries in the North Atlantic*
   The geographical boundaries for the fin, minke and sei whale stocks in the North Atlantic are:

FIN WHALE STOCKS

NOVA SCOTIA
South and West of a line through:
47°N 54°W, 46°N 54°30'W,
46°N 42°W, 20°N 42°W.

NEWFOUNDLAND-LABRADOR
West of a line through:
75°N 73°30'W, 69°N 59°W, 61°N 59°W
52°20'N 42°W, 46°N 42°W and
North of a line through:
46°N 42°W, 46°N 54°30'W, 47°N 54°W.

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*The Governments of Brazil, Iceland, Japan, Norway and the Union of Soviet Socialist Republics lodged objections to the second sentence of paragraph 6 within the prescribed period. For all other Contracting Governments this sentence came into force on 8 March 1982. Norway withdrew its objection on 9 July 1985 and Brazil on 8 January 1992. Iceland withdrew from the Convention with effect from 30 June 1992. The objections of Japan and the Russian Federation not having been withdrawn, this sentence is not binding upon these governments.

☼At its 54th Annual Meeting in 2002, the Commission agreed to continue this prohibition but did not discuss whether or not it should set a time when it should be reviewed again.

** The Government of Japan lodged an objection within the prescribed period to paragraph 7(b) to the extent that it applies to the Antarctic minke whale stocks. The Government of the Russian Federation also lodged an objection to paragraph 7(b) within the prescribed period but withdrew it on 26 October 1994. For all Contracting Governments except Japan paragraph 7(b) came into force on 6 December 1994.

+Paragraph 7(*b*) contains a provision for review of the Southern Ocean Sanctuary "ten years after its initial adoption". Paragraph 7(*b*) was adopted at the 46th (1994) Annual Meeting. Therefore, the first review is due in 2004.

WEST GREENLAND
East of a line through:
75°N 73°30'W, 69°N 59°W,
61°N 59°W, 52°20'N 42°W,
and West of a line through
52°20'N 42°W, 59°N 42°W,
59°N 44°W, Kap Farvel.

EAST GREENLAND-ICELAND
East of a line through:
Kap Farvel (South Greenland),
59°N 44°W, 59°N 42°W, 20°N 42°W
and West of a line through:
20°N 18°W, 60°N 18°W, 68°N 3°E,
74°N 3°E, and South of 74°N.

NORTH NORWAY
North and East of a line through:
74°N 22°W, 74°N 3°E, 68°N 3°E,
67°N 0°, 67°N 14°E.

WEST NORWAY-FAROE ISLANDS
South of a line through:
67°N 14°E, 67°N 0°, 60°N 18°W, and
North of a line through:
61°N 16°W, 61°N 0°, Thyborøn (Western entrance to Limfjorden, Denmark).

SPAIN-PORTUGAL-BRITISH ISLES
South of a line through:
Thyborøn (Denmark), 61°N 0°, 61°N 16°W,
and East of a line through:
63°N 11°W, 60°N 18°W, 22°N 18°W.

MINKE WHALE STOCKS

CANADIAN EAST COAST
West of a line through:
75°N 73°30'W, 69°N 59°W, 61°N 59°W,
52°20'N 42°W, 20°N 42°W.

CENTRAL
East of a line through:
Kap Farvel (South Greenland),
59°N 44°W, 59°N 42°W, 20°N 42°W,
and West of a line through:
20°N 18°W, 60°N 18°W, 68°N 3°E,
74°N 3°E, and South of 74°N.

WEST GREENLAND
East of a line through:
75°N 73°30'W, 69°N 59°W, 61°N 59°W
52°20'N 42°W, and
West of a line through:
52°20'N 42°W, 59°N 42°W,
59°N 44°W, Kap Farvel.

NORTHEASTERN
East of a line through:
20°N 18°W, 60°N 18°W, 68°N 3°E, 74°N 3°E,
and North of a line through:
74°N 3°E, 74°N 22°W.

SEI WHALE STOCKS

NOVA SCOTIA
South and West of a line through:
47°N 54°W, 46°N 54°30'W, 46°N 42°W,
20°N 42°W.

ICELAND-DENMARK STRAIT
East of a line through:
Kap Farvel (South Greenland),
59°N 44°W, 59°N 42°W, 20°N 42°W,
and West of a line through:
20°N 18°W, 60°N 18°W, 68°N 3°E,
74°N 3°E, and South of 74°N.

EASTERN
East of a line through:
20°N 18°W, 60°N 18°W, 68°N 3°E, 74°N 3°E,
and North of a line through:
74°N 3°E, 74°N 22°W.

(*d*) *Geographical boundaries in the North Pacific*

The geographical boundaries for the sperm, Bryde's and minke whale stocks in the North Pacific are:

SPERM WHALE STOCKS

WESTERN DIVISION
West of a line from the ice-edge south along the 180° meridian of longitude to 180°, 50°N, then east along the 50°N parallel of latitude to 160°W, 50°N, then south along the 160°W meridian of longitude to 160°W, 40°N, then east along the 40°N parallel of latitude to 150°W, 40°N, then south along the 150°W meridian of longitude to the Equator.

EASTERN DIVISION
East of the line described above.

BRYDE'S WHALE STOCKS

EAST CHINA SEA
West of the Ryukyu Island chain.

EASTERN
East of 160°W (excluding the Peruvian stock area).

WESTERN
West of 160°W (excluding the East China Sea stock area).

MINKE WHALE STOCKS

SEA OF JAPAN-YELLOW SEA- EAST CHINA SEA
West of a line through the Philippine Islands, Taiwan, Ryukyu Islands, Kyushu, Honshu, Hokkaido and Sakhalin Island, north of the Equator.

OKHOTSK SEA-WEST PACIFIC
East of the Sea of Japan-Yellow Sea- East China Sea stock and west of 180°, north of the Equator.

REMAINDER
East of the Okhotsk Sea-West Pacific stock, north of the Equator.

(*e*) *Geographical boundaries for Bryde's whale stocks in the Southern Hemisphere*

SOUTHERN INDIAN OCEAN
20°E to 130°E,
South of the Equator.

SOLOMON ISLANDS
150°E to 170°E,
20°S to the Equator.

PERUVIAN
110°W to the South American coast,
10°S to 10°N.

EASTERN SOUTH PACIFIC
150°W to 70°W,
South of the Equator (excluding the Peruvian stock area).

WESTERN SOUTH PACIFIC
130°E to 150°W,
South of the Equator (excluding the Solomon Islands stock area).

SOUTH ATLANTIC
70°W to 20°E,
South of the Equator (excluding the South African inshore stock area).

SOUTH AFRICAN INSHORE
South African coast west of 27°E and out to the 200 metre isobath.

Table 1

BALEEN WHALE STOCK CLASSIFICATIONS AND CATCH LIMITS+ (excluding Bryde's whales)

	SEI		MINKE		FIN		BLUE		RIGHT, BOWHEAD, HUMPBACK		PYGMY RIGHT		GRAY	
	Classi-fication	Catch limit	Classi-fication	Catch limit	Classi-fication	Catch limit	Classi-fication	Catch limit	Classi-fication	Catch limit	Classi-fication	Catch limit	Classi-fication	Catch limit
SOUTHERN HEMISPHERE-***2004/2005*** pelagic season and ***2005*** coastal season														
Area														.
I 120°W-60°W	PS	0	-	0	PS	0	PS	0	PS	0	PS	0	.	.
II 60°W- 0°	PS	0	-	0	PS	0	PS	0	PS	0	PS	0	.	.
III 0°- 70°E	PS	0	-	0	PS	0	PS	0	PS	0	PS	0	.	.
IV 70°E-130°E	PS	0	-	0	PS	0	PS	0	PS	0	PS	0	.	.
V 130°E- 170°W	PS	0	-	0	PS	0	PS	0	PS	0	PS	0	.	.
VI 170°W-120°W	PS	0	-	0	PS	0	PS	0	PS	0	PS	0	.	.
Total catch not to exceed:						0		0		0		0		
NORTHERN HEMISPHERE-***2005*** season														
ARCTIC	.	.	.	.	.	.	.	.	.	.	PS	0	.	.
NORTH PACIFIC														
Whole region	PS	0	.	.	PS	0	PS	0	PS	0	PS	0	.	.
Okhotsk Sea-West Pacific Stock	.	.	-	0	.	.	.	.	.	.	.	.	.	.
Sea of Japan-Yellow Sea- East China Sea Stock	.	.	PS	0	.	.	.	.	.	.	.	.	.	.
Remainder	.	.	IMS	0	.	.	.	.	.	.	.	.	.	.
Eastern Stock	.	.	.	.	.	.	.	.	.	.	.	.	SMS	.[1]
Western Stock	.	.	.	.	.	.	.	.	.	.	.	.	PS	0
NORTH ATLANTIC														
Whole region	.	.	.	.	.	.	PS	0	PS	0	PS	0	.	.
West Greenland Stock	.	.	PS	0	-	19[2]	.	.	.	.	.	.	.	.
Newfoundland-Labrador Stock	.	.	.	.	-	0	.	.	.	.	.	.	.	.
Canadian East Coast Stock	.	.	-	0	.	.	.	.	.	.	.	.	.	.
Nova Scotia Stock	PS	0	.	.	PS	0	.	.	.	.	.	.	.	.
Central Stock	.	.	-	.	.	.	.	.	.	.	.	.	.	.
East Greenland-Iceland Stock	.	.	.	.	SMS	0	.	.	.	.	.	.	.	.
Iceland-Denmark Strait Stock	-	0	.	.	.	.	.	.	.	.	.	.	.	.
Spain-Portugal-British Isles Stock	.	.	.	.	-	0	.	.	.	.	.	.	.	.
Northeastern Stock	.	.	PS*	0	.	.	.	.	.	.	.	.	.	.
West Norway-Faroe Islands Stock	.	.	.	.	PS	0	.	.	.	.	.	.	.	.
North Norway Stock	.	.	.	.	-	0	.	.	.	.	.	.	.	.
Eastern Stock	-	0	.	.	.	.	.	.	.	.	.	.	.	.
NORTHERN INDIAN OCEAN	.	.	IMS	0	.	.	PS	0	PS	0	PS	0	.	.

[1] Available to be taken by aborigines or a Contracting Government on behalf of aborigines pursuant to paragraph 13*(b)*2. [2] Available to be taken by aborigines pursuant to paragraph 13*(b)*3. Catch limit for each of the years 2003, 2004, 2005, 2006 and 2007. + The catch limits of zero introduced into Table 1 as editorial amendments as a result of the coming into effect of paragraph 10*(e)* are not binding upon the governments of the countries which lodged and have not withdrawn objections to the said paragraph. *The Government of Norway presented objection to the classification of the Northeastern Atlantic stock of minke whales as a Protection Stock within the prescribed period. This classification came into force on 30 January 1986 but is not binding on the Government of Norway.

Classification of Stocks

10. All stocks of whales shall be classified in one of three categories according to the advice of the Scientific Committee as follows:

(*a*) A Sustained Management Stock (SMS) is a stock which is not more than 10 per cent of Maximum Sustainable Yield (hereinafter referred to as MSY) stock level below MSY stock level, and not more than 20 per cent above that level; MSY being determined on the basis of the number of whales.

When a stock has remained at a stable level for a considerable period under a regime of approximately constant catches, it shall be classified as a Sustained Management Stock in the absence of any positive evidence that it should be otherwise classified.

Commercial whaling shall be permitted on Sustained Management Stocks according to the advice of the Scientific Committee. These stocks are listed in Tables 1, 2 and 3 of this Schedule.

For stocks at or above the MSY stock level, the permitted catch shall not exceed 90 per cent of the MSY. For stocks between the MSY stock level and 10 per cent below that level, the permitted catch shall not exceed the number of whales obtained by taking 90 per cent of the MSY and reducing that number by 10 per cent for every 1 per cent by which the stock falls short of the MSY stock level.

(*b*) An Initial Management Stock (IMS) is a stock more than 20 per cent of MSY stock level above MSY stock level. Commercial whaling shall be permitted on Initial Management Stocks according to the advice of the Scientific Committee as to measures necessary to bring the stocks to the MSY stock level and then optimum level in an efficient manner and without risk of reducing them below this level. The permitted catch for such stocks will not be more than 90 per cent of MSY as far as this is known, or, where it will be more appropriate, catching effort shall be limited to that which will take 90 per cent of MSY in a stock at MSY stock level.

In the absence of any positive evidence that a continuing higher percentage will not reduce the stock below the MSY stock level no more than 5 per cent of the estimated initial exploitable stock shall be taken in any one year. Exploitation should not commence until an estimate of stock size has been obtained which is satisfactory in the view of the Scientific Committee. Stocks classified as Initial Management Stock are listed in Tables 1, 2 and 3 of this Schedule.

(*c*) A Protection Stock (PS) is a stock which is below 10 per cent of MSY stock level below MSY stock level.

There shall be no commercial whaling on Protection Stocks. Stocks so classified are listed in Tables 1, 2 and 3 of this Schedule.

(*d*) Notwithstanding the other provisions of paragraph 10 there shall be a moratorium on the taking, killing or treating of whales, except minke whales, by factory ships or whale catchers attached to factory ships. This moratorium applies to sperm whales, killer whales and baleen whales, except minke whales.

(*e*) Notwithstanding the other provisions of paragraph 10, catch limits for the killing for commercial purposes of whales from all stocks for the 1986 coastal and the 1985/86 pelagic seasons and thereafter shall be zero. This provision will be kept under review, based upon the best scientific advice, and by 1990 at the latest the Commission will undertake a comprehensive assessment of the effects of this decision on whale stocks and consider modification of this provision and the establishment of other catch limits.* • #

Table 2

Bryde's whale stock classifications and catch limits[+].

	Classification	Catch limit
SOUTHERN HEMISPHERE-***2004/2005*** pelagic season and ***2005*** coastal season		
South Atlantic Stock	-	0
Southern Indian Ocean Stock	IMS	0
South African Inshore Stock	-	0
Solomon Islands Stock	IMS	0
Western South Pacific Stock	IMS	0
Eastern South Pacific Stock	IMS	0
Peruvian Stock	-	0
NORTH PACIFIC-***2005*** season		
Eastern Stock	IMS	0
Western Stock	IMS	0
East China Sea Stock	PS	0
NORTH ATLANTIC-***2005*** season	IMS	0
NORTHERN INDIAN OCEAN-***2005*** season	-	0

[+] The catch limits of zero introduced in Table 2 as editorial amendments as a result of the coming into effect of paragraph 10*(e)* are not binding upon the governments of the countries which lodged and have not withdrawn objections to the said paragraph.

*The Governments of Japan, Norway, Peru and the Union of Soviet Socialist Republics lodged objection to paragraph 10(e) within the prescribed period. For all other Contracting Governments this paragraph came into force on 3 February 1983. Peru withdrew its objection on 22 July 1983. The Government of Japan withdrew its objections with effect from 1 May 1987 with respect to commercial pelagic whaling; from 1 October 1987 with respect to commercial coastal whaling for minke and Bryde's whales; and from 1 April 1988 with respect to commercial coastal sperm whaling. The objections of Norway and the Russian Federation not having been withdrawn, the paragraph is not binding upon these Governments.

•Iceland's instrument of adherence to the International Convention for the Regulation of Whaling and the Protocol to the Convention deposited on 10 October 2002 states that Iceland 'adheres to the aforesaid Convention and Protocol with a reservation with respect to paragraph 10(e) of the Schedule attached to the Convention'. The instrument further states the following:

'Notwithstanding this, the Government of Iceland will not authorise whaling for commercial purposes by Icelandic vessels before 2006 and, thereafter, will not authorise such whaling while progress is being made in negotiations within the IWC on the RMS. This does not apply, however, in case of the so-called moratorium on whaling for commercial purposes, contained in paragraph 10(e) of the Schedule not being lifted within a reasonable time after the completion of the RMS. Under no circumstances will whaling for commercial purposes be authorised without a sound scientific basis and an effective management and enforcement scheme.'

[#]The Governments of Argentina, Australia, Brazil, Chile, Finland, France, Germany, Italy, Mexico, Monaco, the Netherlands, New Zealand, Peru, San Marino, Spain, Sweden, UK and the USA have lodged objections to Iceland's reservation to paragraph 10(e).

Table 3

Toothed whale stock classifications and catch limits [+]

SOUTHERN HEMISPHERE-***2004/2005*** pelagic season and ***2005*** coastal season			
		SPERM	
Division	Longitudes	Classification	Catch limit
1	60°W-30°W	-	0
2	30°W-20°E	-	0
3	20°E-60°E	-	0
4	60°E-90°E	-	0
5	90°-130°E	-	0
6	130°E-160°E	-	0
7	160°E-170°W	-	0
8	170°W-100°W	-	0
9	100°W-60°W	-	0
NORTHERN HEMISPHERE-***2005*** season			
NORTH PACIFIC			
Western Division		PS	0[1]
Eastern Division		-	0
NORTH ATLANTIC		-	0
NORTHERN INDIAN OCEAN		-	0
		BOTTLENOSE	
NORTH ATLANTIC		PS	0

[1] No whales may be taken from this stock until catch limits including any limitations on size and sex are established by the Commission.

[+] The catch limits of zero introduced in Table 3 as editorial amendments as a result of the coming into effect of paragraph 10*(e)* are not binding upon the governments of the countries which lodged and have not withdrawn objections to the said paragraph.

Baleen Whale Catch Limits

11. The number of baleen whales taken in the Southern Hemisphere in the ***2004/2005*** pelagic season and the 2005 coastal season shall not exceed the limits shown in Tables 1 and 2.

12. The number of baleen whales taken in the North Pacific Ocean and dependent waters in ***2005*** and in the North Atlantic Ocean in ***2005*** shall not exceed the limits shown in Tables 1 and 2.

13. (*a*) Notwithstanding the provisions of paragraph 10, catch limits for aboriginal subsistence whaling to satisfy aboriginal subsistence need for the 1984 whaling season and each whaling season thereafter shall be established in accordance with the following principles:

(1) For stocks at or above MSY level, aboriginal subsistence catches shall be permitted so long as total removals do not exceed 90 per cent of MSY.

(2) For stocks below the MSY level but above a certain minimum level, aboriginal subsistence catches shall be permitted so long as they are set at levels which will allow whale stocks to move to the MSY level.[1]

(3) The above provisions will be kept under review, based upon the best scientific advice, and by 1990 at the latest the Commission will undertake a comprehensive assessment of the effects of these provisions on whale stocks and consider modification.

(4) For aboriginal whaling conducted under sub-paragraphs (b)(1), (b)(2), and (b)(3) of this paragraph, it is forbidden to strike, take or kill calves or any whale accompanied by a calf. For aboriginal whaling conducted under subparagraphs (b)(4) of this paragraph, it is forbidden to strike, take or kill suckling calves or female whales accompanied by calves.

(5) All aboriginal whaling shall be conducted under national legislation that accords with this paragraph.

(*b*) Catch limits for aboriginal subsistence whaling are as follows:

(1) The taking of bowhead whales from the Bering-Chukchi-Beaufort Seas stock by aborigines is permitted, but only when the meat and products of such whales are to be used exclusively for local consumption by the aborigines and further provided that:

(i) For the years 2003, 2004, 2005, 2006 and 2007, the number of bowhead whales landed shall not exceed 280. For each of these years the number of bowhead whales struck shall not exceed 67, except that any unused portion of a strike quota from any year (including 15 unused strikes from the 1998 – 2002 quota) shall be carried forward and added to the strike quotas of any subsequent years, provided that no more than 15 strikes shall be added to the strike quota for any one year. ***[ ]***

(ii) This provision shall be reviewed annually by the Commission in light of the advice of the Scientific Committee.

(iii) The findings and recommendations of the Scientific Committee's in-depth assessment

[1]The Commission, on advice of the Scientific Committee, shall establish as far as possible (a) a minimum stock level for each stock below which whales shall not be taken, and (b) a rate of increase towards the MSY level for each stock. The Scientific Committee shall advise on a minimum stock level and on a range of rates of increase towards the MSY level under different catch regimes.

for 2004 shall be binding on the parties involved and they shall modify the hunt accordingly.

(2) The taking of gray whales from the Eastern stock in the North Pacific is permitted, but only by aborigines or a Contracting Government on behalf of aborigines, and then only when the meat and products of such whales are to be used exclusively for local consumption by the aborigines. ***[ ]***

(i) For the years 2003, 2004, 2005, 2006 and 2007, the number of gray whales taken in accordance with this sub-paragraph shall not exceed 620, provided that the number of gray whales taken in any one of the years 2003, 2004, 2005, 2006 and 2007 shall not exceed 140. ***[ ]***

(ii) This provision shall be reviewed annually by the Commission in light of the advice of the Scientific Committee.

(3) The taking by aborigines of minke whales from the West Greenland and Central stocks and fin whales from the West Greenland stock is permitted and then only when the meat and products are to be used exclusively for local consumption.

(i) The number of fin whales from the West Greenland stock taken in accordance with this sub-paragraph shall not exceed the limits shown in Table 1.

(ii) The number of minke whales from the Central stock taken in accordance with this sub-paragraph shall not exceed 12 in each of the years 2003, 2004, 2005, 2006 and 2007, except that any unused portion of the quota for each year shall be carried forward from that year and added to the quota of any subsequent years, provided that no more than 3 shall be added to the quota for any one year.

(iii) The number of minke whales struck from the West Greenland stock shall not exceed 175 in each of the years 2003, 2004, 2005, 2006 and 2007, except that any unused portion of the strike quota for each year shall be carried forward from that year and added to the strike quota of any subsequent years, provided that no more than 15 strikes shall be added to the strike quota for any one year. This provision will be reviewed if new scientific data become available within the 5 year period and if necessary amended on the basis of the advice of the Scientific Committee.

(4) For the seasons 2003-2007 the number of humpback whales to be taken by the Bequians of St. Vincent and The Grenadines shall not exceed 20. The meat and products of such whales are to be used exclusively for local consumption in St. Vincent and The Grenadines. ***[ ]*** The quota for the seasons 2006 and 2007 shall only become operative after the Commission has received advice from the Scientific Committee that the take of 4 humpback whales for each season is unlikely to endanger the stock.

14. It is forbidden to take or kill suckling calves or female whales accompanied by calves.

Baleen Whale Size Limits

15. (*a*) It is forbidden to take or kill any sei or Bryde's whales below 40 feet (12.2 metres) in length except that sei and Bryde's whales of not less than 35 feet (10.7 metres) may be taken for delivery to land stations, provided that the meat of such whales is to be used for local consumption as human or animal food.

(*b*) It is forbidden to take or kill any fin whales below 57 feet (17.4 metres) in length in the Southern Hemisphere, and it is forbidden to take or kill fin whales below 55 feet (16.8 metres) in the Northern Hemisphere; except that fin whales of not less than 55 feet (16.8 metres) may be taken in the Southern Hemisphere for delivery to land stations and fin whales of not less than 50 feet (15.2 metres) may be taken in the Northern Hemisphere for delivery to land stations, provided that, in each case the meat of such whales is to be used for local consumption as human or animal food.

Sperm Whale Catch Limits

16. Catch limits for sperm whales of both sexes shall be set at zero in the Southern Hemisphere for the 1981/82 pelagic season and 1982 coastal seasons and following seasons, and at zero in the Northern Hemisphere for the 1982 and following coastal seasons; except that the catch limits for the 1982 coastal season and following seasons in the Western Division of the North Pacific shall remain undetermined and subject to decision by the Commission following special or annual meetings of the Scientific Committee. These limits shall remain in force until such time as the Commission, on the basis of the scientific information which will be reviewed annually, decides otherwise in accordance with the procedures followed at that time by the Commission.

17. It is forbidden to take or kill suckling calves or female whales accompanied by calves.

Sperm Whale Size Limits

18. (*a*) It is forbidden to take or kill any sperm whales below 30 feet (9.2 metres) in length except in the North Atlantic Ocean where it is forbidden to take or kill any sperm whales below 35 feet (10.7 metres).

(*b*) It is forbidden to take or kill any sperm whale over 45 feet (13.7 metres) in length in the Southern Hemisphere north of 40° South Latitude during the months of October to January inclusive.

(*c*) It is forbidden to take or kill any sperm whale over 45 feet (13.7 metres) in length in the North Pacific Ocean and dependent water south of 40° North Latitude during the months of March to June inclusive.

IV. TREATMENT

19. (*a*) It is forbidden to use a factory ship or a land station for the purpose of treating any whales which are

classified as Protection Stocks in paragraph 10 or are taken in contravention of paragraphs 2, 3, 4, 5, 6, 7, 8, 11, 12, 14, 16 and 17 of this Schedule, whether or not taken by whale catchers under the jurisdiction of a Contracting Government.

(*b*) All other whales taken, except minke whales, shall be delivered to the factory ship or land station and all parts of such whales shall be processed by boiling or otherwise, except the internal organs, whale bone and flippers of all whales, the meat of sperm whales and parts of whales intended for human food or feeding animals. A Contracting Government may in less developed regions exceptionally permit treating of whales without use of land stations, provided that such whales are fully utilised in accordance with this paragraph.

(*c*) Complete treatment of the carcases of "dauhval" and of whales used as fenders will not be required in cases where the meat or bone of such whales is in bad condition.

20. (*a*) The taking of whales for treatment by a factory ship shall be so regulated or restricted by the master or person in charge of the factory ship that no whale carcase (except of a whale used as a fender, which shall be processed as soon as is reasonably practicable) shall remain in the sea for a longer period than thirty-three hours from the time of killing to the time when it is hauled up for treatment.

(*b*) Whales taken by all whale catchers, whether for factory ships or land stations, shall be clearly marked so as to identify the catcher and to indicate the order of catching.

V. SUPERVISION AND CONTROL

21. (*a*) There shall be maintained on each factory ship at least two inspectors of whaling for the purpose of maintaining twenty-four hour inspection provided that at least one such inspector shall be maintained on each catcher functioning as a factory ship. These inspectors shall be appointed and paid by the Government having jurisdiction over the factory ship; provided that inspectors need not be appointed to ships which, apart from the storage of products, are used during the season solely for freezing or salting the meat and entrails of whales intended for human food or feeding animals.

(*b*) Adequate inspection shall be maintained at each land station. The inspectors serving at each land station shall be appointed and paid by the Government having jurisdiction over the land station.

(*c*) There shall be received such observers as the member countries may arrange to place on factory ships and land stations or groups of land stations of other member countries. The observers shall be appointed by the Commission acting through its Secretary and paid by the Government nominating them.

22. Gunners and crews of factory ships, land stations, and whale catchers, shall be engaged on such terms that their remuneration shall depend to a considerable extent upon such factors as the species, size and yield of whales and not merely upon the number of the whales taken. No bonus or other remuneration shall be paid to the gunners or crews of whale catchers in respect of the taking of lactating whales.

23. Whales must be measured when at rest on deck or platform after the hauling out wire and grasping device have been released, by means of a tape-measure made of a non-stretching material. The zero end of the tape-measure shall be attached to a spike or stable device to be positioned on the deck or platform abreast of one end of the whale. Alternatively the spike may be stuck into the tail fluke abreast of the apex of the notch. The tape-measure shall be held taut in a straight line parallel to the deck and the whale's body, and other than in exceptional circumstances along the whale's back, and read abreast of the other end of the whale. The ends of the whale for measurement purposes shall be the tip of the upper jaw, or in sperm whales the most forward part of the head, and the apex of the notch between the tail flukes.

Measurements shall be logged to the nearest foot or 0.1 metre. That is to say, any whale between 75 feet 6 inches and 76 feet 6 inches shall be logged as 76 feet, and any whale between 76 feet 6 inches and 77 feet 6 inches shall be logged as 77 feet. Similarly, any whale between 10.15 metres and 10.25 metres shall be logged as 10.2 metres, and any whale between 10.25 metres and 10.35 metres shall be logged as 10.3 metres. The measurement of any whale which falls on an exact half foot or 0.05 metre shall be logged at the next half foot or 0.05 metre, e.g. 76 feet 6 inches precisely shall be logged as 77 feet and 10.25 metres precisely shall be logged as 10.3 metres.

VI. INFORMATION REQUIRED

24. (*a*) All whale catchers operating in conjunction with a factory ship shall report by radio to the factory ship:
(1) the time when each whale is taken
(2) its species, and
(3) its marking effected pursuant to paragraph 20(b)

(*b*) The information specified in sub-paragraph (a) of this paragraph shall be entered immediately by a factory ship in a permanent record which shall be available at all times for examination by the whaling inspectors; and in addition there shall be entered in such permanent record the following information as soon as it becomes available:
(1) time of hauling up for treatment
(2) length, measured pursuant to paragraph 23
(3) sex
(4) if female, whether lactating
(5) length and sex of foetus, if present, and
(6) a full explanation of each infraction.

(*c*) A record similar to that described in sub-paragraph (*b*) of this paragraph shall be maintained by land stations, and all of the information mentioned in the said sub-paragraph shall be entered therein as soon as available.

(*d*) A record similar to that described in sub-paragraph (*b*) of this paragraph shall be maintained by "small-type whaling" operations conducted from shore or by pelagic fleets, and all of this information mentioned in the said sub-paragraph shall be entered therein as soon as available.

25. (*a*) All Contracting Governments shall report to the Commission for all whale catchers operating in conjunction with factory ships and land stations the following information:
    (1) methods used to kill each whale, other than a harpoon, and in particular compressed air
    (2) number of whales struck but lost.

    (*b*) A record similar to that described in sub-paragraph (*a*) of this paragraph shall be maintained by vessels engaged in "small-type whaling" operations and by native peoples taking species listed in paragraph 1, and all the information mentioned in the said sub-paragraph shall be entered therein as soon as available, and forwarded by Contracting Governments to the Commission.

26. (*a*) Notification shall be given in accordance with the provisions of Article VII of the Convention, within two days after the end of each calendar week, of data on the number of baleen whales by species taken in any waters south of 40° South Latitude by all factory ships or whale catchers attached thereto under the jurisdiction of each Contracting Government, provided that when the number of each of these species taken is deemed by the Secretary to the International Whaling Commission to have reached 85 per cent of whatever total catch limit is imposed by the Commission notification shall be given as aforesaid at the end of each day of data on the number of each of these species taken.

    (*b*) If it appears that the maximum catches of whales permitted by paragraph 11 may be reached before 7 April of any year, the Secretary to the International Whaling Commission shall determine, on the basis of the data provided, the date on which the maximum catch of each of these species shall be deemed to have been reached and shall notify the master of each factory ship and each Contracting Government of that date not less than four days in advance thereof. The taking or attempting to take baleen whales, so notified, by factory ships or whale catchers attached thereto shall be illegal in any waters south of 40° South Latitude after midnight of the date so determined.

    (*c*) Notification shall be given in accordance with the provisions of Article VII of the Convention of each factory ship intending to engage in whaling operations in any waters south of 40° South Latitude.

27. Notification shall be given in accordance with the provisions of Article VII of the Convention with regard to all factory ships and catcher ships of the following statistical information:
    (*a*) concerning the number of whales of each species taken, the number thereof lost, and the number treated at each factory ship or land station, and
    (*b*) as to the aggregate amounts of oil of each grade and quantities of meal, fertiliser (guano), and other products derived from them, together with
    (*c*) particulars with respect to each whale treated in the factory ship, land station or "small-type whaling" operations as to the date and approximate latitude and longitude of taking, the species and sex of the whale, its length and, if it contains a foetus, the length and sex, if ascertainable, of the foetus.

    The data referred to in (*a*) and (*c*) above shall be verified at the time of the tally and there shall also be notification to the Commission of any information which may be collected or obtained concerning the calving grounds and migration of whales.

28. (*a*) Notification shall be given in accordance with the provisions of Article VII of the Convention with regard to all factory ships and catcher ships of the following statistical information:
    (1) the name and gross tonnage of each factory ship,
    (2) for each catcher ship attached to a factory ship or land station:
        (i) the dates on which each is commissioned and ceases whaling for the season,
        (ii) the number of days on which each is at sea on the whaling grounds each season,
        (iii) the gross tonnage, horsepower, length and other characteristics of each; vessels used only as tow boats should be specified.
    (3) A list of the land stations which were in operation during the period concerned, and the number of miles searched per day by aircraft, if any.

    (*b*) The information required under paragraph (*a*)(2)(iii) should also be recorded together with the following information, in the log book format shown in Appendix A, and forwarded to the Commission:
    (1) where possible the time spent each day on different components of the catching operation,
    (2) any modifications of the measures in paragraphs (*a*)(2)(i)-(iii) or (*b*)(1) or data from other suitable indicators of fishing effort for "small-type whaling" operations.

29. (*a*) Where possible all factory ships and land stations shall collect from each whale taken and report on:
    (1) both ovaries or the combined weight of both testes,
    (2) at least one ear plug, or one tooth (preferably first mandibular).

    (*b*) Where possible similar collections to those described in sub-paragraph (a) of this paragraph shall be undertaken and reported by "small-type whaling" operations conducted from shore or by pelagic fleets.

    (*c*) All specimens collected under sub-paragraphs (a) and (b) shall be properly labelled with platform or other identification number of the whale and be appropriately preserved.

    (*d*) Contracting Governments shall arrange for the analysis as soon as possible of the tissue samples and specimens collected under sub-paragraphs (a) and (b) and report to the Commission on the results of such analyses.

30. A Contracting Government shall provide the Secretary to the International Whaling Commission with proposed scientific permits before they are issued and in sufficient time to allow the Scientific Committee to review and comment on them. The proposed permits should specify:
    (*a*) objectives of the research;
    (*b*) number, sex, size and stock of the animals to be taken;

(*c*) opportunities for participation in the research by scientists of other nations; and

(*d*) possible effect on conservation of stock.

Proposed permits shall be reviewed and commented on by the Scientific Committee at Annual Meetings when possible. When permits would be granted prior to the next Annual Meeting, the Secretary shall send the proposed permits to members of the Scientific Committee by mail for their comment and review. Preliminary results of any research resulting from the permits should be made available at the next Annual Meeting of the Scientific Committee.

31. A Contracting Government shall transmit to the Commission copies of all its official laws and regulations relating to whales and whaling and changes in such laws and regulations.

INTERNATIONAL CONVENTION FOR THE REGULATION OF WHALING, 1946, SCHEDULE APPENDIX A

TITLE PAGE
(one logbook per catcher per season)

Catcher name …………………………………………………… Year built ………………………………….

Attached to expedition/land station ……………………………………………………………………………..

Season …………………………………………………………..

Overall length ....………………………….......... Wooden/steel hull …………………………

Gross tonnage ....……………………………

Type of engine ....…………….…………. H.P. ....………………..

Maximum speed ....……………………………...... Average searching speed ....……………

Asdic set, make and model no. ....…………………………...…...……………..

Date of installation ....…………………………

Make and size of cannon ....…………………………………………….

Type of first harpoon used ....………………………..... explosive/electric/non-explosive

Type of killer harpoon used ………………………………………………………………………………..

Length and type of forerunner ……………………………………………………………………………..

Type of whaleline ………………………………………………………………………………………….

Height of barrel above sea level …………………………………

Speedboat used, Yes/No

Name of Captain …………………………………………………………………………………………...

Number of years experience ……………………………………..

Name of gunner …………………………………………………………………………………………

Number of years experience ……………………………………..

Number of crew ………………………………………………….

INTERNATIONAL CONVENTION FOR THE REGULATION OF WHALING, 1946

DAILY RECORD SHEET TABLE 1

Date .... Catcher name .... Sheet No.................................

Searching:	Time started (or resumed) searching	....	....	....	....	....
	*Time whales seen or reported to catcher	....	....	....	....	....
	Whale species	....	....	....	....	....
	Number seen and no. of groups	....	....	....	....	....
	Position found	....	....	....	....	....
	Name of catcher that found whales	....	....	....	....	....
Chasing:	Time started chasing (or confirmed whales)	....	....	....	....	....
	Time whale shot or chasing discontinued	....	....	....	....	....
	Asdic used (Yes/No)	....	....	....	....	....
Handling:	Time whale flagged or alongside for towing	....	....	....	....	....
	Serial No. of catch	....	....	....	....	....
Towing:	Time started picking up	....	....	....	....	....
	Time finished picking up or started towing	....	....	....	....	....
	Date and time delivered to factory	....	....	....	....	....
Resting:	Time stopped (for drifting or resting)	....	....	....	....	....
	Time finished drifting/resting	....	....	....	....	....
	Time ceased operations	....	....	....	....	....

	WEATHER CONDITIONS			
	Time	Sea state	Wind force and direction	Visibility
Total searching time..........................				
Total chasing time				
A) with asdic				
B) without asdic	....	....	....	....
Total handling time				
Total towing time	....	....	....	....
Total resting time				
Other time (e.g. bunkering, in port)	....	....	....	....

Whales Seen (No. and No. of schools)

Blue..	Bryde's ....
Fin..	Minke ....
Humpback..	Sperm ....
Right..	Others (specify) ....
Sei..	....
Signed..	....

*Time whales reported to catcher means the time when the catcher is told of the position of a school and starts to move towards it to chase it.

SCHEDULE APPENDIX A

SCHOOLING REPORT TABLE 2

To be completed by pelagic expedition or coastal station for each sperm whale school chased. A separate form to be used each day.

Name of expedition or coastal station ....

Date .... Noon position of factory ship ....

Time School Found ....

Total Number of Whales in School ....

Number of Takeable Whales in School ....

Number of Whales Caught from School by each Catcher ....

Name of Catcher ....

Name of Catcher ....

Name of Catcher ....

Name of Catcher ....

Total Number Caught from School ....

Remarks:

Explanatory Notes

A. Fill in one column for each school chased with number of whales caught by each catcher taking part in the chase; if catchers chase the school but do not catch from it, enter 0; for catchers in fleet which do not chase that school enter X.

B. A school on this form means a group of whales which are sufficiently close together that a catcher having completed handling one whale can start chasing another whale almost immediately without spending time searching. A solitary whale should be entered as a school of 1 whale.

C. A takeable whale is a whale of a size or kind which the catchers would take if possible. It does not necessarily include all whales above legal size, e.g. if catchers are concentrating on large whales only these would be counted as takeable.

D. Information about catchers from other expeditions or companies operating on the same school should be recorded under Remarks.

Rules of Procedure
and
Financial Regulations

As amended by the Commission at the 56th Annual Meeting, July 2004
(amendments are shown in *bold italics*)

Rules of Procedure

A. Representation

1. A Government party to the International Convention for the Regulation of Whaling, 1946 (hereafter referred to as the Convention) shall have the right to appoint one Commissioner and shall furnish the Secretary of the Commission with the name of its Commissioner and his/her designation and notify the Secretary promptly of any changes in the appointment. The Secretary shall inform other Commissioners of such appointment.

B. Meetings

1. The Commission shall hold a regular Annual Meeting in such place as the Commission may determine. Any Contracting Government desiring to extend an invitation to the Commission to meet in that country shall give formal notice two years in advance. A formal offer should include:
   (a) which meetings it covers, i.e. Scientific Committee, Commission sub-groups, Annual Commission meeting;
   (b) a proposed time window within which the meeting will take place; and
   (c) a timetable for finalising details of the exact timing and location of the meeting.

   Attendance by a majority of the members of the Commission shall constitute a quorum. Special Meetings of the Commission may be called at the direction of the Chair after consultation with the Contracting Governments and Commissioners.
2. Before the end of each Annual Meeting, the Commission shall decide on: (1) the length of the Annual Commission Meeting and associated meetings the following year; and (2) which of the Commission's sub-groups need to meet.

C. Observers

1. (a) Any Government not a party to the Convention or any intergovernmental organisation may be represented at meetings of the Commission by an observer or observers, if such non-party government or intergovernmental organisation has previously attended any meeting of the Commission, or if it submits its request in writing to the Commission 60 days prior to the start of the meeting, or if the Commission issues an invitation to attend.
   (b) Any international organisation with offices in more than three countries may be represented at meetings of the Commission by an observer:
   - if such international organisation has previously attended any meeting of the Commission,

   or
   - if it submits its request in writing to the Commission 60 days prior to the start of the meeting and the Commission issues an invitation with respect to such request.

   Once an international organisation is accredited, it remains accredited until the Commission decides otherwise.
   (c) The Commission shall levy a registration fee and determine rules of conduct, and may define other conditions for the attendance of observers accredited in accordance with Rule C.1.(a) and (b). The registration fee will be treated as an annual fee covering attendance at the Annual Meeting to which it relates and any other meeting of the Commission or its subsidiary groups as provided in Rule C.2 in the interval before the next Annual Meeting.
2. Observers accredited in accordance with Rule C.1. (a) and (b) are admitted to all meetings of the Commission and the Technical Committee, and to any meetings of subsidiary groups of the Commission and the Technical Committee, except the Commissioners-only meetings and the meetings of the Finance and Administration Committee.

D. Credentials

1. (a) The names of all representatives of member and non-member governments and observer organisations to any meeting of the Commission or committees, as specified in the Rules of Procedure of the Commission, Technical and Scientific Committees, shall be notified to the Secretary in writing before their participation and/or attendance at each meeting. For member governments, the notification shall indicate the Commissioner, his/her alternate(s) and advisers, and the head of the national delegation to the Scientific Committee and any alternate(s) as appropriate.

   The written notification shall be made by governments or the heads of organisations as the case may be. In this context, 'governments' means the Head of State, the Head of Government, the Minister of Foreign Affairs (including: on behalf of the Minister of Foreign Affairs), the Minister responsible for whaling or whale conservation (including: on behalf of this Minister), the Head of the Diplomatic Mission accredited to the seat of the Commission or to the host country of the meeting in question, or the Commissioner appointed under Rule A.1.
   (b) Credentials for a Commissioner appointed for the duration of a meeting must be issued as in D.1(a). Thereafter, until the end of the meeting in question, that Commissioner assumes all the powers of a Commissioner appointed under A.1., including that of issuing credentials for his/her delegation.
   (c) In the case of members of delegations who will attend the Annual Commission Meeting and its associated meetings, the notification may be made en bloc by submitting a list of the members who will attend any of these meetings.

(d) The Secretary, or his/her representative, shall report on the received notifications at the beginning of a meeting.

(e) In case of any doubt as to the authenticity of notification or in case of apparent delay in their delivery, the Chair of the meeting shall convene an *ad hoc* group of no more than one representative from any Contracting Government present to decide upon the question of participation in the meeting.

E. Decision-making

The Commission should seek to reach its decisions by consensus. Otherwise, the following Rules of Procedure shall apply:

1. Each Commissioner shall have the right to vote at Plenary Meetings of the Commission and in his/her absence his/her deputy or alternate shall have such right. Experts and advisers may address Plenary Meetings of the Commission but shall not be entitled to vote. They may vote at the meetings of any committee to which they have been appointed, provided that when such vote is taken, representatives of any Contracting Government shall only exercise one vote.

2. (a) The right to vote of representatives of any Contracting Government whose annual payments including any interest due have not been received by the Commission within 3 months of the due date prescribed in Regulation E.2 of the Financial Regulations or by the day before the first day of the next Annual or Special Meeting of the Commission following the due date, or, in the case of a vote by postal or other means, by the date upon which votes must be received, whichever date occurs first, shall be automatically suspended until payment is received by the Commission, unless the Commission decides otherwise.

(b) The Commissioner of a new Contracting Government shall not exercise the right to vote either at meetings or by postal or other means unless the Commission has received the Government's financial contribution or part contribution for the year prescribed in Financial Regulation E.3.

3. (a) Where a vote is taken on any matter before the Commission, a simple majority of those casting an affirmative or negative vote shall be decisive, except that a three-fourths majority of those casting an affirmative or negative vote shall be required for action in pursuance of Article V of the Convention.

(b) Action in pursuance of Article V shall contain the text of the regulations proposed to amend the Schedule. A proposal that does not contain such regulatory text does not constitute an amendment to the Schedule and therefore requires only a simple majority vote. A proposal that does not contain such regulatory text to revise the Schedule but would commit the Commission to amend the Schedule in the future can neither be put to a vote nor adopted.

(c) At meetings of committees appointed by the Commission, a simple majority of those casting an affirmative or negative vote shall also be decisive. The committee shall report to the Commission if the decision has been arrived at as a result of the vote.

(d) Votes shall be taken by show of hands, or by roll call, as in the opinion of the Chair, appears to be most suitable. The election of the Chair, Vice-Chair, the appointment of the Secretary of the Commission, and the selection of IWC Annual Meeting venues shall, upon request by a Commissioner, all proceed by secret ballot.

4. Between meetings of the Commission or in the case of emergency, a vote of the Commissioners may be taken by post, or other means of communication in which case the necessary simple, or where required three-fourths majority, shall be of the total number of Contracting Governments whose right to vote has not been suspended under paragraph 2.

F. Chair

1. The Chair of the Commission shall be elected from time to time from among the Commissioners and shall take office at the conclusion of the Annual Meeting at which he/she is elected. The Chair shall serve for a period of three years and shall not be eligible for re-election as Chair until a further period of three years has elapsed. The Chair shall, however, remain in office until a successor is elected.

2. The duties of the Chair shall be:

(a) to preside at all meetings of the Commission;

(b) to decide all questions of order raised at meetings of the Commission, subject to the right of any Commissioner to request that any ruling by the Chair shall be submitted to the Commission for decision by vote;

(c) to call for votes and to announce the result of the vote to the Commission;

(d) to develop, with appropriate consultation, draft agenda for meetings of the Commission;

(i) for Annual Meetings:

- in consultation with the Secretary, to develop a draft agenda based on decisions and recommendations made at the previous Annual Meeting for circulation to all Contracting Governments and Commissioners for review and comment not less than 100 days in advance of the meeting;
- on the basis of comments and proposals received from Contracting Governments and Commissioners under d(i) above, to develop with the Secretary, an annotated provisional agenda for circulation to all Contracting Governments not less than 60 days in advance of the meeting;

(ii) for Special Meetings, the two-stage procedure described in (i) above will be followed whenever practicable, recognising that Rule of Procedure J.1 still applies with respect to any item of business involving amendment of the Schedule or recommendations under Article VI of the Convention;

(e) to sign, on behalf of the Commission, a report of the proceedings of each annual or other meeting of the Commission, for transmission to Contracting Governments and others concerned as an authoritative record of what transpired;

(f) generally, to make such decisions and give such directions to the Secretary as will ensure, especially in the interval between the meetings of the Commission, that the business of the Commission is carried out efficiently and in accordance with its decision.

G. Vice-Chair

1. The Vice-Chair of the Commission shall be elected from time to time from among the Commissioners and shall preside at meetings of the Commission, or between them, in the absence or in the event of the Chair being unable to act. He/she shall on those occasions exercise the powers and duties prescribed for the Chair. The Vice-Chair shall be elected for a period of three years and shall not be eligible for re-election as Vice-Chair until a further period of three years has elapsed. He/she shall, however, remain in office until a successor is elected.

H. Secretary

1. The Commission shall appoint a Secretary and shall designate staff positions to be filled through appointments made by the Secretary. The Commission shall fix the terms of employment, rate of remuneration including tax assessment and superannuation and travelling expenses for the members of the Secretariat.
2. The Secretary is the executive officer of the Commission and shall:
   (a) be responsible to the Commission for the control and supervision of the staff and management of its office and for the receipt and disbursement of all monies received by the Commission;
   (b) make arrangements for all meetings of the Commission and its committees and provide necessary secretarial assistance;
   (c) prepare and submit to the Chair a draft of the Commission's budget for each year and shall subsequently submit the budget to all Contracting Governments and Commissioners as early as possible before the Annual Meeting;
   (d) despatch by the most expeditious means available:
      (i) a draft agenda for the Annual Commission Meeting to all Contracting Governments and Commissioners 100 days in advance of the meeting for comment and any additions with annotations they wish to propose;
      (ii) an annotated provisional agenda to all Contracting Governments and Commissioners not less than 60 days in advance of the Annual Commission Meeting. Included in the annotations should be a brief description of each item, and in so far as possible, documentation relevant to agenda items should be referred to in the annotation and sent to member nations at the earliest possible date;
   (e) receive, tabulate and publish notifications and other information required by the Convention in such form and manner as may be prescribed by the Commission;
   (f) perform such other functions as may be assigned to him/her by the Commission or its Chair;
   (g) where appropriate, provide copies or availability to a copy of reports of the Commission including reports of Observers under the International Observer Scheme, upon request after such reports have been considered by the Commission.

I. Chair of Scientific Committee

1. The Chair of the Scientific Committee may attend meetings of the Commission and Technical Committee in an *ex officio* capacity without vote, at the invitation of the Chair of the Commission or Technical Committee respectively in order to represent the views of the Scientific Committee.

J. Schedule amendments and recommendations under Article VI

1. No item of business which involves amendment of the Schedule to the Convention, or recommendations under Article VI of the Convention, shall be the subject of decisive action by the Commission unless the subject matter has been included in the annotated provisional agenda circulated to the Commissioners at least 60 days in advance of the meeting at which the matter is to be discussed.

K. Financial

1. The financial year of the Commission shall be from 1st September to 31st August.
2. Any request to Contracting Governments for financial contributions shall be accompanied by a statement of the Commission's expenditure for the appropriate year, actual or estimated.
3. Annual payments and other financial contributions by Contracting Governments shall be made payable to the Commission and shall be in pounds sterling.

L. Offices

1. The seat of the Commission shall be located in the United Kingdom.

M. Committees

1. The Commission shall establish a Scientific Committee, a Technical Committee and a Finance and Administration Committee. Commissioners shall notify their desire to be represented on the Scientific, Technical and Finance and Administration Committees 28 days prior to the meetings, and shall designate the approximate size of their delegations.
2. The Chair may constitute such *ad hoc* committees as may be necessary from time to time, with similar arrangements for notification of the numbers of participants as in paragraph 1 above where appropriate. Each committee shall elect its Chair. The Secretary shall furnish appropriate secretarial services to each committee.
3. Sub-committees and working groups may be designated by the Commission to consider technical issues as appropriate, and each will report to the Technical Committee or the plenary session of the Commission as the Commission may decide.
4. The Scientific Committee shall review the current scientific and statistical information with respect to whales and whaling, shall review current scientific research programmes of Governments, other international organisations or of private organisations, shall review the scientific permits and scientific programmes for which Contracting Governments plan

to issue scientific permits, shall consider such additional matters as may be referred to it by the Commission or by the Chair of the Commission, and shall submit reports and recommendations to the Commission.
5. The preliminary report of the Scientific Committee should be completed and available to all Commissioners by the opening date of the Annual Commission Meeting.
6. The Secretary shall be an *ex officio* member of the Scientific Committee without vote.
7. The Technical Committee shall, as directed by the Commission or the Chair of the Commission, prepare reports and make recommendations on:
   (a) Management principles, categories, criteria and definitions, taking into account the recommendations of the Scientific Committee, as a means of helping the Commission to deal with management issues as they arise;
   (b) technical and practical options for implementation of conservation measures based on Scientific Committee advice;
   (c) the implementation of decisions taken by the Commission through resolutions and through Schedule provisions;
   (d) Commission agenda items assigned to it;
   (e) any other matters.
8. The Finance and Administration Committee shall advise the Commission on expenditure, budgets, scale of contributions, financial regulations, staff questions, and such other matters as the Commission may refer to it from time to time.
9. The Commission shall establish an Advisory Committee. This Committee shall comprise the Chair, Vice-Chair, Chair of the Finance and Administration Committee, Secretary and two Commissioners to broadly represent the interests within the IWC forum. The appointment of the Commissioners shall be for two years on alternative years.
   The role of the Committee shall be to assist and advise the Secretariat on administrative matters upon request by the Secretariat or agreement in the Commission. The Committee is not a decision-making forum and shall not deal with policy matters or administrative matters that are within the scope of the Finance and Administration Committee other than making recommendations to this Committee.

N. Language of the Commission

1. English shall be the official and working language of the Commission but Commissioners may speak in any other language, if desired, it being understood that Commissioners doing so will provide their own interpreters. All official publications and communications of the Commission shall be in English.

O. Records of Meetings

1. The proceedings of the meetings of the Commission and those of its committees shall be recorded in summary form.

P. Reports

1. Commissioners should arrange for reports on the subject of whaling published in their own countries to be sent to the Commission for record purposes.
2. The Chair's Report of the most recent Annual Commission Meeting shall be published in the Annual Report of the year just completed.

Q. Commission Documents

1. Reports of meetings of all committees, sub-committees and working groups of the Commission are confidential (i.e. reporting of discussions, conclusions and recommendations made during a meeting is prohibited) until the opening plenary session of the Commission meeting to which they are submitted, or in the case of intersessional meetings, until after they have been dispatched by the Secretary to Contracting Governments and Commissioners. This applies equally to member governments and observers. Such reports, with the exception of the report of the Finance and Administration Committee, shall be distributed to Commissioners, Contracting Governments and accredited observers at the same time. Procedures applying to the Scientific Committee are contained in its Rules of Procedure E.5.(a) and E.5.(b).
2. Any document submitted to the Commission for distribution to Commissioners, Contracting Governments or members of the Scientific Committee is considered to be in the public domain unless it is designated by the author or government submitting it to be restricted. Such restriction is automatically lifted when the report of the meeting to which it is submitted becomes publicly available under 1. above.
3. Observers admitted under Rule of Procedure C.1.(a) and (b) may submit Opening Statements which will be included in the official documentation of the Annual or other Meeting concerned. They shall be presented in the format and the quantities determined by the Secretariat for meeting documentation.
   The content of the Opening Statements shall be relevant to matters under consideration by the Commission, and shall be in the form of views and comments made to the Commission in general rather than directed to any individual or group of Contracting Governments[1].
4. All meeting documents shall be included in the Commission's archives in the form in which they were considered at the meeting.

R. Amendment of Rules

1. These Rules of Procedure may be amended from time to time by a simple majority of the Commissioners voting, but notice of any proposed amendment shall be despatched by the most expeditious means available to the Commissioners by the Secretary to the Commission not less than 60 days in advance of the meeting at which the matter is to be discussed.

[1] [There is no intention that the Secretariat could conduct advance or *ex-ante* reviews of such statements.]

Financial Regulations

A. Applicability

1. These regulations shall govern the financial administration of the International Whaling Commission.
2. They shall become effective as from the date decided by the Commission and shall be read with and in addition to the Rules of Procedure. They may be amended in the same way as provided under Rule R.1 of the Rules of Procedure in respect of those Rules.
3. In case of doubt as to the interpretation and application of any of these regulations, the Chair is authorised to give a ruling.

B. Financial Year

1. The financial year of the Commission shall be from 1st September to 31st August (Rules of Procedure, Rule K.1).

C. General Financial Arrangements

1. There shall be established a Research Fund and a General Fund, and a Voluntary Fund for Small Cetaceans.
   (a) The Research Fund shall be credited with voluntary contributions and any such monies as the Commission may allocate for research and scientific investigation and charged with specific expenditure of this nature.
   (b) The General Fund shall, subject to the establishment of any other funds that the Commission may determine, be credited or charged with all other income and expenditure.
   (c) The details of the Voluntary Fund for Small Cetaceans are given in Appendix 1.

   The General Fund shall be credited or debited with the balance on the Commission's Income and Expenditure Account at the end of each financial year.
2. Subject to the restrictions and limitations of the following paragraphs, the Commission may accept funds from outside the regular contributions of Contracting Governments.
   (a) The Commission may accept such funds to carry out programmes or activities decided upon by the Commission and/or to advance programmes and activities which are consistent with the objectives and provisions of the Convention.
   (b) The Commission shall not accept external funds from any of the following:
      (i) Sources that are known, through evidence available to the Commission, to have been involved in illegal activities, or activities contrary to the provisions of the Convention;
      (ii) Individual companies directly involved in legal commercial whaling under the Convention;
      (iii) Organisations which have deliberately brought the Commission into public disrepute.
3. Monies in any of the Funds that are not expected to be required for disbursement within a reasonable period may be invested in appropriate Government or similar loans by the Secretary in consultation with the Chair.
4. The Secretary shall:
   (a) establish detailed financial procedures and accounting records as are necessary to ensure effective financial administration and control and the exercise of economy;
   (b) deposit and maintain the funds of the Commission in an account in the name of the Commission in a bank to be approved by the Chair;
   (c) cause all payments to be made on the basis of supporting vouchers and other documents which ensure that the services or goods have been received, and that payment has not previously been made;
   (d) designate the officers of the Secretariat who may receive monies, incur obligations and make payments on behalf of the Commission;
   (e) authorise the writing off of losses of cash, stores and other assets and submit a statement of such amounts written off to the Commission and the auditors with the annual accounts.
5. The accounts of the Commission shall be audited annually by a firm of qualified accountants selected by the Commission. The auditors shall certify that the financial statements are in accord with the books and records of the Commission, that the financial transactions reflected in them have been in accordance with the rules and regulations and that the monies on deposit and in hand have been verified.

D. Yearly Statements

1. At each Annual Meeting, there shall be laid before the Commission two financial statements:
   (a) a provisional statement dealing with the actual and estimated expenditure and income in respect of the current financial year;
   (b) the budget estimate of expenditure and income for the ensuing year including the estimated amount of the individual annual payment to be requested of each Contracting Government.

   Expenditure and income shall be shown under appropriate sub-heads accompanied by such explanations as the Commission may determine.
2. The two financial statements identified in Regulation D.1 shall be despatched by the most expeditious means available to each Contracting Government and each Commissioner not less than 60 days in advance of the Annual Commission Meeting. They shall require the Commission's approval after having been referred to the Finance and Administration Committee for consideration and recommendations. A copy of the final accounts shall be sent to all Contracting Governments after they have been audited.
3. Supplementary estimates may be submitted to the Commission, as and when may be deemed necessary, in a form consistent with the Annual Estimates. Any supplementary estimate shall require the approval of the Commission after being referred to the Finance and Administration Committee for consideration and recommendation.

E. Contributions

1. As soon as the Commission has approved the budget for any year, the Secretary shall send a copy thereof to each Contracting Government (in compliance with Rules of Procedure, Rule K.2), and shall request it to remit its annual payment.
2. Payment shall be in pounds sterling, drafts being made payable to the International Whaling Commission and shall be payable within 90 days of the said request from the Secretary or by the following 28 February, the "due date" whichever is the later. It shall be open to any Contracting Government to postpone the payment of any increased portion of the amount which shall be payable in full by the following 31 August, which then becomes the "due date".
3. New Contracting Governments whose adherence to the Convention becomes effective during the first six months of any financial year shall be liable to pay the full amount of the annual payment for that year, but only half that amount if their adherence falls within the second half of the financial year. The due date for the first payment by new Contracting Governments shall be defined as 6 months from the date of adherence to the Convention or before the first day of its participation in any Annual or Special Meeting of the Commission whichever is the earlier.
   Subsequent annual payments shall be paid in accordance with Financial Regulation E.2.
4. The Secretary shall report at each Annual Meeting the position as regards the collection of annual payments.

F. Arrears of Contributions[2]

1. If a Contracting Government's annual payments have not been received by the Commission by the due date referred to under Regulation E.2. a penalty charge of 10% shall be added to the outstanding annual payment on the day following the due date. If the payment remains outstanding for a further 12 months compound interest shall be added on the anniversary of that day and each subsequent anniversary thereafter at the rate of 2% above the base rate quoted by the Commission's bankers on the day. The interest, calculated to the nearest pound, shall by payable in respect of complete years and continue to be payable in respect of any outstanding balance until such time as the amount in arrears, including interest, is settled in full.
2. If a Contracting Government's annual payments, including any interest due, have not been received by the Commission within 3 months of the due date or by the day before the first day of the next Annual or Special Meeting of the Commission following the due date, or, in the case of a vote by postal or other means, by the date upon which votes must be received, whichever date occurs first, the right to vote of the Contracting Government concerned shall be suspended as provided under Rule E.2 of the Rules of Procedure.
3. Any interest paid by a Contracting Government to the Commission in respect of late annual payments shall be credited to the General Fund.
4. Any payment to the Commission by a Contracting Government in arrears with annual payments shall be used to pay off debts to the Commission, including interest due, in the order in which they were incurred.
5. If a Contracting Government's annual payments, including any interest due, have not been received by the Commission in respect of a period of 3 financial years;
   (a) no further annual contribution will be charged;
   (b) interest will continue to be applied annually in accordance with Financial Regulation F.1.;
   (c) the provisions of this Regulation apply to the Contracting Government for as long as the provisions of Financial Regulations F.1. and F.2. remain in effect for that Government;
   (d) the Contracting Government concerned will be entitled to attend meetings on payment of a fee per delegate at the same level as Non-Member Government observers;
   (e) the provisions of this Regulation and of Financial Regulations F.1. and F.2. will cease to have effect for a Contracting Government if it makes a payment of 2 years outstanding contributions and provides an undertaking to pay the balance of arrears and the interest within a further 2 years;
   (f) interest applied to arrears in accordance with this Regulation will accrue indefinitely except that, if a Government withdraws from the Convention, no further charges shall accrue after the date upon which the withdrawal takes effect.
6. Unless the Commission decides otherwise, a Government which adheres to the Convention without having paid to the Commission any financial obligations incurred prior to its adherence shall, with effect from the date of adherence, be subject to all the penalties prescribed by the Rules of Procedure and Financial Regulations relating to arrears of financial contributions and interest thereon. The penalties shall remain in force until the arrears, including any newly-charged interest, have been paid in full.

[2] For the purposes of the Financial Regulations the expression 'received by the Commission' means either (1) that confirmation has been received from the Commission's bankers that the correct amount has been credited to the Commission's account or (2) that the Secretariat has in its possession cash, a cheque, bankers draft or other valid instrument of the correct value.

Appendix 1

VOLUNTARY FUND FOR SMALL CETACEANS

Purpose

The Commission decided at its 46th Annual Meeting in 1994 to establish an IWC voluntary fund to allow for the participation from developing countries in future small cetacean work and requested the Secretary to make arrangements for the creation of such a fund whereby contributions in cash and in kind can be registered and utilised by the Commission.

Contributions

The Commission has called on Contracting Governments and non-contracting Governments, intergovernmental organisations and other entities as appropriate, in particular those most interested in scientific research on small cetaceans, to contribute to the IWC voluntary fund for small cetaceans.

Acceptance of contributions from entities other than Governments will be subject to the Commission's procedures for voluntary contributions. Where funds or support in kind are to be made available through the Voluntary Fund, the donation will registered and administered by the Secretariat in accordance with Commission procedures.

The Secretariat will notify all members of the Commission on receipt of such voluntary contributions.

Where expenditure is incurred using these voluntary funds the Secretariat will inform the donors of their utilisation.

Distribution of Funds

1. Recognising that there are differences of view on the legal competence of the Commission in relation to small cetaceans, but aware of the need to promote the development of increased participation by developing countries, the following primary forms of disbursement will be supported in accordance with the purpose of the Voluntary Fund:
   (a) provision of support for attendance of invited participants at meetings of the Scientific Committee;
   (b) provision of support for research in areas, species or populations or research methodology in small cetacean work identified as of direct interest or priority in the advice provided by the Scientific Committee to the Commission;
   (c) other small cetacean work in developing countries that may be identified from time to time by the Commission and in consultation with inter-governmental agencies as requiring, or likely to benefit from support through the Fund.
2. Where expenditure is proposed in support of invited participants, the following will apply:
   (a) invited participants will be selected through consultation between the Chair of the Scientific Committee, the Convenor of the appropriate sub-committee and the Secretary;
   (b) the government of the country where the scientists work will be advised of the invitation and asked if it can provide financial support.
3. Where expenditure involves research activity, the following will apply:
   (a) the normal procedures for review of proposals and recommendations by the Scientific Committee will be followed;
   (b) appropriate procedures for reporting of progress and outcomes will be applied and the work reviewed;
   (c) the Secretariat shall solicit the involvement, as appropriate, of governments in the regions where the research activity is undertaken.

Rules of Debate

A. Right to Speak

1. The Chair shall call upon speakers in the order in which they signify their desire to speak.
2. A Commissioner or Observer may speak only if called upon by the Chair, who may call a speaker to order if his/her remarks are not relevant to the subject under discussion.
3. A speaker shall not be interrupted except on a point of order. He/she may, however, with the permission of the Chair, give way during his/her speech to allow any other Commissioner to request elucidation on a particular point in that speech.
4. The Chair of a committee or working group may be accorded precedence for the purpose of explaining the conclusion arrived at by his/her committee or group.

B. Submission of Motions

1. Proposals and amendments shall normally be introduced in writing in the working language of the meeting and shall be submitted to the Secretariat which shall circulate copies to all delegations in the session. As a general rule, no proposal shall be discussed at any plenary session unless copies of it have been circulated to all delegations normally no later than 6pm, or earlier if so determined by the Chair in consultation with the Commissioners, on the day preceding the plenary session. The presiding officer may, however, permit the discussion and consideration of amendments, or motions, as to procedure, even though such amendments, or motions have not been circulated previously.

C. Procedural Motions

1. During the discussion of any matter, a Commissioner may rise to a point of order, and the point of order shall be immediately decided by the Chair in accordance with these Rules of Procedure. A Commissioner may appeal against any ruling of the Chair. The appeal shall be immediately put to the vote and the Chair's ruling shall stand unless a majority of the Commissioners present and voting otherwise decide. A Commissioner rising to a point of order may not speak on the substance of the matter under discussion.
2. The following motions shall have precedence in the following order over all other proposals or motions before the Commission:
   (a) to adjourn the session;
   (b) to adjourn the debate on the particular subject or question under discussion;
   (c) to close the debate on the particular subject or question under discussion.

D. Arrangements for Debate

1. The Commission may, in a proposal by the Chair or by a Commissioner, limit the time to be allowed to each speaker and the number of times the members of a delegation may speak on any question. When the debate is subject to such limits, and a speaker has spoken for his allotted time, the Chair shall call him/her to order without delay.
2. During the course of a debate the Chair may announce the list of speakers, and with the consent of the Commission, declare the list closed. The Chair may, however, accord the right of reply to any Commissioner if a speech delivered after he/she has declared the list closed makes this desirable.
3. During the discussion of any matter, a Commissioner may move the adjournment of the debate on the particular subject or question under discussion. In addition to the proposer of the motion, a Commissioner may speak in favour of, and two Commissioners may speak against the motion, after which the motion shall immediately be put to the vote. The Chair may limit the time to be allowed to speakers under this rule.
4. A Commissioner may at any time move the closure of the debate on the particular subject or question under discussion, whether or not any other Commissioner has signified the wish to speak. Permission to speak on the motion for the closure of the debate shall be accorded only to two Commissioners wishing to speak against the motion, after which the motion shall immediately be put to the vote. The Chair may limit the time to be allowed to speakers under this rule.

E. Procedure for Voting on Motions and Amendments

1. A Commissioner may move that parts of a proposal or of an amendment shall be voted on separately. If objection is made to the request of such division, the motion for division shall be voted upon. Permission to speak on the motion for division shall be accorded only to two Commissioners wishing to speak in favour of, and two Commissioners wishing to speak against, the motion. If the motion for division is carried, those parts of the proposal or amendments which are subsequently approved shall be put to the vote as a whole. If all operative parts of the proposal or of the amendment have been rejected, the proposal or the amendment shall be considered to have been rejected as a whole.
2. When the amendment is moved to a proposal, the amendment shall be voted on first. When two or more amendments are moved to a proposal, the Commission shall first vote on the last amendment moved and then on the next to last, and so on until all amendments have been put to the vote. When, however, the adoption of one amendment necessarily implies the rejection of another amendment, the latter amendment shall not be put to the vote. If one or more amendments are adopted, the amended proposal shall then be voted upon. A motion is considered an amendment to a proposal if it merely adds to, deletes from or revises part of that proposal.
3. If two or more proposals relate to the same question, the Commission shall, unless it otherwise decides, vote on the proposals in the order in which they have been submitted. The Commission may, after voting on a proposal, decide whether to vote on the next proposal.

Rules of Procedure of the Technical Committee

A. Participation

1. Membership shall consist of those member nations that elect to be represented on the Technical Committee. Delegations shall consist of Commissioners, or their nominees, who may be accompanied by technical experts.
2. The Secretary of the Commission or a deputy shall be an *ex officio* non-voting member of the Committee.
3. Observers may attend Committee meetings in accordance with the Rules of the Commission.

B. Organisation

1. Normally the Vice-Chair of the Commission is the Chair of the Technical Committee. Otherwise the Chair shall be elected from among the members of the Committee.
2. A provisional agenda for the Technical Committee and each sub-committee and working group shall be prepared by the Technical Committee Chair with the assistance of the Secretary. After agreement by the Chair of the Commission they shall be distributed to Commissioners 30 days in advance of the Annual Meeting.

C. Meetings

1. The Annual Meeting shall be held between the Scientific Committee and Commission meetings with reasonable overlap of meetings as appropriate to agenda requirements. Special meetings may be held as agreed by the Commission or the Chair of the Commission.
2. Rules of conduct for observers shall conform with rules established by the Commission for meetings of all committees and plenary sessions.

D. Reports

1. Reports and recommendations shall, as far as possible, be developed on the basis of consensus. However, if a consensus is not achievable, the committee, sub-committee or working group shall report the different views expressed. The Chair or any national delegation may request a vote on any issue. Resulting recommendations shall be based on a simple majority of those nations casting an affirmative or negative vote.
2. Documents on which recommendations are based should be available on demand immediately following each committee, sub-committee or working group meeting.
3. Technical papers produced for the Commission may be reviewed by the Committee for publication by the Commission.

Rules of Procedure of the Scientific Committee

TERMS OF REFERENCE

The Scientific Committee, established in accordance with the Commission's Rule of Procedure M.1, has the general terms of reference defined in Rule of Procedure M.4.

In this regard, the DUTIES of the Scientific Committee, can be seen as a progression from the scientific investigation of whales and their environment, leading to assessment of the status of the whale stocks and the impact of catches upon them, and then to provision of management advice on the regulation of whaling. This can be defined in the following terms for the Scientific Committee to:

Encourage, recommend, or if necessary, organise studies and investigations related to whales and whaling [Convention Article IV.1(a)]
Collect and analyse statistical information concerning the current condition and trend of whale stocks and the effects of whaling activities on them [Article IV.1 (b)]
Study, appraise, and disseminate information concerning methods of maintaining and increasing the population of whale stocks [Article IV.1 (c)]
Provide scientific findings on which amendments to the Schedule shall be based to carry out the objectives of the Convention and to provide for the conservation, development and optimum utilization of the whale resources [Article V.2 (a) and (b)]
Publish reports of its activities and findings [Article IV.2]

In addition, specific FUNCTIONS of the Scientific Committee are to:
Receive, review and comment on Special Permits issued for scientific research [Article VIII.3 and Schedule paragraph 30]
Review research programmes of Contracting Governments and other bodies [Rule of Procedure M.4]

SPECIFIC TOPICS of current concern to the Commission include:

Comprehensive Assessment of whale stocks [*Rep. int. Whal. Commn* 34:30]
Implementation of the Revised Management Procedure [*Rep. int. Whal. Commn* 45:43]
Assessment of stocks subject to aboriginal subsistence whaling [Schedule paragraph 13(b)]
Development of the Aboriginal Subsistence Whaling Management Procedure [*Rep. int. Whal. Commn* 45:42-3]
Effects of environmental change on cetaceans [*Rep. int. Whal. Commn* 43:39-40; 44:35; 45:49]
Scientific aspects of whale sanctuaries [*Rep. int. Whal. Commn* 33:21-2; 45:63]
Scientific aspects of small cetaceans [*Rep. int. Whal. Commn* 41:48; 42:48; 43:51; 45:41]
Scientific aspects of whalewatching [*Rep. int. Whal. Commn* 45:49-50]

A. Membership and Observers

1. The Scientific Committee shall be composed of scientists nominated by the Commissioner of each Contracting Government which indicates that it wishes to be represented on that Committee. Commissioners shall identify the head of delegation and any alternate(s) when making nominations to the Scientific Committee. The Secretary of the Commission and relevant members of the Secretariat shall be ex officio non-voting members of the Scientific Committee.
2. The Scientific Committee recognises that representatives of Inter-Governmental Organisations with particular relevance to the work of the Scientific Committee may also participate as non-voting members, subject to the agreement of the Chair of the Committee acting according to such policy as the Commission may decide.
3. Further to paragraph 2 above the World Conservation Union (IUCN) shall have similar status in the Scientific Committee.
4. Non-member governments may be represented by observers at meetings of the Scientific Committee, subject to the arrangements given in Rule C.1(a) of the Commission's Rules of Procedure.
5. Any other international organisation sending an accredited observer to a meeting of the Commission may nominate a scientifically qualified observer to be present at meetings of the Scientific Committee. Any such nomination must reach the Secretary not less than 60 days before the start of the meeting in question and must specify the scientific qualifications and relevant experience of the nominee. The Chair of the Scientific Committee shall decide upon the acceptability of any nomination but may reject it only after consultation with the Chair and Vice-Chair of the Commission. Observers admitted under this rule shall not participate in discussions but the papers and documents of the Scientific Committee shall be made available to them at the same time as to members of the Committee.
6. The Chair of the Committee, acting according to such policy as the Commission or the Scientific Committee may decide, may invite qualified scientists not nominated by a Commissioner to participate by invitation or otherwise in committee meetings as non-voting contributors. They may present and discuss documents and papers for consideration by the Scientific Committee, participate on sub-committees, and they shall receive all Committee documents and papers.
   (a) Convenors will submit suggestions for Invited Participants (including the period of time they would like them to attend) to the Chair (copied to the Secretariat) not less than four months before the meeting in question. The Convenors will base their suggestions on the priorities and initial agenda identified by the Committee and Commission at the previous meeting. The Chair may also consider offers from suitably qualified scientists to contribute to priority items on the Committee's agenda if they submit such an offer to the Secretariat not less than four months before the meeting in question, providing information on the contribution they believe that they can make. Within two weeks of this, the Chair, in consultation with the Convenors and Secretariat, will develop a list of invitees.
   (b) The Secretary will then promptly issue a letter of invitation to those potential Invited Participants suggested by the Chair and Convenors. That letter will state that there may be financial support available, although invitees will be encouraged to find their own support. Invitees who wish to be

considered for travel and subsistence will be asked to submit an estimated airfare (incl. travel to and from the airport) to the Secretariat, within 2 weeks. Under certain circumstances (e.g. the absence of a potential participant from their institute), the Secretariat will determine the likely airfare.

At the same time as (b) a letter will be sent to the government of the country where the scientists is domiciled for the primary purpose of enquiring whether that Government would be prepared to pay for the scientist's participation. If it is, the scientist is no longer an Invited Participant but becomes a national delegate.

(c) At least three months before the meeting, the Secretariat will supply the Chair with a list of participants and the estimated expenditure for each, based on (1) the estimated airfare, (2) the period of time the Chair has indicated the IP should be present and (3) a daily subsistence rate based on the actual cost of the hotel deemed most suitable by the Secretary and Chair[1], plus an appropriate daily allowance.

At the same time as (c) a provisional list of the proposed Invited Participants will be circulated to Commissioners, with a final list attached to the Report of the Scientific Committee.

(d) The Chair will review the estimated total cost for all suggested participants against the money available in the Commission's budget. Should there be insufficient funds, the Chair, in consultation with the Secretariat and Convenors where necessary, will decide on the basis of the identified priorities, which participants should be offered financial support and the period of the meeting for which that support will be provided. Invited Participants without IWC support, and those not supported for the full period, may attend the remainder of the meeting at their own expense.

(e) At least two months before the meeting, the Secretary will send out formal confirmation of the invitations to all the selected scientists, in accordance with the Commission's Guidelines, indicating where appropriate that financial support will be given and the nature of that support.

(f) In exceptional circumstances, the Chair, in consultation with the Convenors and Secretariat, may waive the above time restrictions.

(g) The letter of invitation to Invited Participants will include the following ideas:

(h) Under the Committee's Rules of Procedure, Invited Participants may present and discuss papers, and participate in meetings (including those of subgroups). They are entitled to receive all Committee documents and papers. They may participate fully in discussions pertaining to their area of expertise. However, discussions of Scientific Committee procedures and policies are in principle limited to Committee members nominated by member governments. Such issues will be identified by the Chair of the Committee during discussions. Invited Participants are also urged to use their discretion as regards their involvement in the formulation of potentially controversial recommendations to the Commission; the Chair may at his/her discretion rule them out of order.

(i) After an Invited Participant has his/her participation confirmed through the procedures set up above, a Contracting Government may grant this person national delegate status, thereby entitling him/her to full participation in Committee proceedings, without prejudice to funding arrangements previously agreed upon to support the attendance of the scientist in question.

7. A small number of interested local scientists may be permitted to observe at meetings of the Scientific Committee on application to, and at the discretion of, the Chair. Such scientists should be connected with the local Universities, other scientific institutions or organisations, and should provide the Chair with a note of their scientific qualifications and relevant experience at the time of their application.

B. Agenda

1. The initial agenda for the Committee meeting of the following year shall be developed by the Committee prior to adjournment each year. The agenda should identify, as far as possible, key issues to be discussed at the next meeting and specific papers on issues should be requested by the Committee as appropriate.
2. The provisional agenda for the Committee meeting shall be circulated for comment 60 days prior to the Annual Meeting of the Committee. Comments will normally be considered for incorporation into the draft agenda presented to the opening plenary only if received by the Chair 21 days prior to the beginning of the Annual Meeting.

C. Organisation

1. The Scientific Committee shall include standing sub-committees and working groups by area or species, or other subject, and a standing sub-committee on small cetaceans. The Committee shall decide at each meeting on sub-committees for the coming year.
2. The sub-committees and working groups shall prepare the basic documents on the identification, status and trends of stocks, including biological parameters, and related matters as necessary, for the early consideration of the full Committee.
3. The sub-committees, except for the sub-committee on small cetaceans, shall concentrate their efforts on stocks of large cetaceans, particularly those which are currently exploited or for which exploitation is under consideration, or for which there is concern over their status, but they may examine matters relevant to all cetaceans where appropriate.
4. The Chair may appoint other sub-committees as appropriate.
5. The Committee shall elect from among its members a Chair and Vice-Chair who will normally serve for a period of three years. They shall take office at the conclusion of the annual meeting at which they are elected. The Vice-Chair shall act for the Chair in his/her absence.

[1] [Invited Participants who choose to stay at a cheaper hotel will receive the actual rate for their hotel plus the same daily allowance.]

The election process shall be undertaken by the heads of national delegations who shall consult widely before nominating candidates. The Vice-Chair will become Chair at the end of his/her term (unless he/she declines), and a new Vice-Chair will then be elected. If the Vice-Chair declines to become Chair, then a new Chair must also be elected. If the election of the Chair or Vice-Chair is not by consensus, a vote shall be conducted by the Secretary and verified by the current Chair. A simple majority shall be decisive. In cases where a vote is tied, the Chair shall have the casting vote. If requested by a head of delegation, the vote shall proceed by secret ballot. In these circumstances, the results shall only be reported in terms of which nominee received the most votes, and the vote counts shall not be reported or retained.

D. Meetings

1. Meetings of the Scientific Committee as used in these rules include all meetings of subgroups of the Committee, e.g. sub-committees, working groups, workshops, etc.
2. The Scientific Committee shall meet prior to the Annual Meeting of the Commission. Special meetings of the Scientific Committee or its subgroups may be held as agreed by the Commission or the Chair of the Commission.
3. The Scientific Committee will organise its work in accordance with a schedule determined by the Chair with the advice of a group comprising sub-committee/working group chairs and relevant members of the Secretariat.

E. Scientific Papers and Documents

The following documents and papers will be considered by the Scientific Committee for discussion and inclusion in its report to the Commission:

1. Progress Reports. Each nation having information on the biology of cetaceans, cetacean research, the taking of cetaceans, or other matters it deems appropriate should prepare a brief progress report following in the format agreed by the Committee.
2. Special Reports. The Committee may request special reports as necessary on matters to be considered by the Committee for the following year.
3. Sub-committee Reports. Reports of the sub-committees or working groups shall be included as annexes to the Report to the Commission. Recommendations contained therein shall be subject to modification by the full Committee before inclusion in its Report.
4. Scientific and Working Papers.
   (a) Any scientist may submit a scientific paper for consideration by the Committee. The format and submission procedure shall be in accordance with guidelines established by the Secretariat with the concurrence of the Committee. Papers published elsewhere may be distributed to Committee members for information as relevant to specific topics under consideration.
   (b) Scientific papers will be considered for discussion and inclusion in the papers of the Committee only if the paper is received by the Secretariat on or by the first day of the annual Committee meeting, intersessional meeting or any sub-group. Exceptions to this rule can be granted by the Chair of the Committee where there are exceptional extenuating circumstances.
   (c) Working papers will be distributed for discussion only if prior permission is given by the Chair of the committee or relevant sub-group. They will be archived only if they are appended to the meeting report.
   (d) The Scientific Committee may receive and consider unpublished scientific documents from non-members of the Committee (including observers) and may invite them to introduce their documents at a meeting of the Committee provided that they are received under the same conditions (with regard to timing etc.) that apply to members.
5. Publication of Scientific Papers and Reports.
   (a) Scientific papers and reports considered by the Committee that are not already published shall be included in the Commission's archives in the form in which they were considered by the Committee or its sub-committees. Papers submitted to meetings shall be available on request at the same time as the report of the meeting concerned (see (b) below).
   (b) The report of the Annual Meeting of the Scientific Committee shall be distributed to the Commission no later than the beginning of the opening plenary of the Annual Commission Meeting and is confidential until this time.

   Reports of intersessional Workshops or Special Committee Meetings are confidential until they have been dispatched by the Secretary to the full Committee, Commissioners and Contracting Governments.

   Reports of intersessional Steering Groups or Sub-committees are confidential until they have been discussed by the Scientific Committee, normally at an Annual Meeting.

   In this context, 'confidential' means that reporting of discussions, conclusions and recommendations is prohibited. This applies equally to Scientific Committee members, invited participants and observers. Reports shall be distributed to Commissioners, Contracting Governments and accredited observers at the same time.

   The Scientific Committee should identify the category of any intersessional meetings at the time they are recommended.
   (c) Scientific papers and reports (revised as necessary) may be considered for publication by the Commission. Papers shall be subject to peer review before publication. Papers submitted shall follow the Guidelines for Authors published by the Commission.

F. Review of Scientific Permits

1. When proposed scientific permits are sent to the Secretariat before they are issued by national governments the Scientific Committee shall review the scientific aspects of the proposed research at its annual meeting, or during a special meeting called for that purpose and comment on them to the Commission.

2. The review process shall take into account guidelines issued by the Commission.
3. The proposed permits and supporting documents should include specifics as to the objectives of the research, number, sex, size, and stock of the animals to be taken, opportunities for participation in the research by scientists of other nations, and the possible effect on conservation of the stock resulting from granting the permits.
4. Preliminary results of any research resulting from the permits should be made available for the next meeting of the Scientific Committee as part of the national progress report or as a special report, paper or series of papers.

G. Financial Support for Research Proposals

1. The Scientific Committee shall identify research needs.
2. It shall consider unsolicited research proposals seeking financial support from the Commission to address these needs. A sub-committee shall be established to review and rank research proposals received 4 months in advance of the Annual Meeting and shall make recommendations to the full Committee.
3. The Scientific Committee shall recommend in priority order those research proposals for Commission financial support as it judges best meet its objectives.

H. Availability of data

The Scientific Committee shall work with the Secretariat to ensure that catch and scientific data that the Commission holds are archived and accessible using modern computer data handling techniques. Access to such data shall be subject to the following rules.

1. Information identified in Section VI of the Schedule that shall be notified or forwarded to the IWC or other body designated under Article VII of the Convention. This information is available on request through the Secretariat to any interested persons with a legitimate claim relative to the aims and purposes of the Convention[2].
2. Information and reports provided where possible under Section VI of the Schedule.
   When such information is forwarded to the IWC a covering letter should make it clear that the information or report is being made available, and it should identify the pertinent Schedule paragraph under which the information or report is being submitted.
   Information made available to the IWC under this provision is accessible to accredited persons as defined under 4. below, and additionally to other interested persons subject to the agreement of the government submitting the information or report.
   Such information already held by the Commission is not regarded as having been forwarded until such clarification of its status is received from the government concerned.
3. Information neither required nor requested under the Schedule but which has been or might be made available to the Commission on a voluntary basis.
   This information is of a substantially different status from the previous two types. It can be further divided into two categories:

(a) Information collected under International Schemes.

  (i) Data from the IWC sponsored projects.
  (ii) Data from the International Marking Scheme.
  (iii) Data obtained from international collaborative activities which are offered by the sponsors and accepted as contributions to the Comprehensive Assessment, or proposed by the Scientific Committee itself.

  Information collected as the result of IWC sponsored activities and/or on a collaborative basis with other organisations, governments, institutions or individuals is available within those contributing bodies either immediately, or, after mutual agreement between the IWC and the relevant body/person, after a suitable time interval to allow 'first use' rights to the primary contributors.

(b) Information collected under national programmes, or other than in (a). Information in this category is likely to be provided by governments under special conditions and would hence be subject to some degree of restriction of access. This information can only be held under the following conditions:

  (i) A minimum level of access should be that such data could be used by accredited persons during the Scientific Committee meetings using validated techniques or methods agreed by the Scientific Committee. After the meeting, at the request of the Scientific Committee, such data could be accessed by the Secretariat for use with previously specified techniques or validated programs. Information thus made available to accredited persons should not be passed on to third parties but governments might be asked to consider making such records more widely available or accessible.
  (ii) The restrictions should be specified at the time the information is provided and these should be the only restrictions.
  (iii) Restrictions on access should not discriminate amongst accredited persons.
  (iv) All information held should be documented (i.e. described) so that accredited persons know what is held, along with stated restrictions on the access to it and the procedures needed to obtain permission for access.

4. Accredited persons are those scientists defined under sections A.1, 2, 3 and 6 of the Rules of Procedure of the Scientific Committee. Invited participants are also considered as 'accredited' during the intersessional period following the meeting which they attend.

[2][The Government of Norway notes that for reasons of domestic legislation it is only able to agree that data it provided under this paragraph are made available to accredited persons.]

The International Whaling Commission
The Red House, 135 Station Road, Impington, Cambridge CB4 9NP UK
Tel: +44 (0)1223 233971 Fax: +44 (0)1223 232876
Subscriptions e-mail: *subscriptions@iwcoffice.org*
Web page: http://www.iwcoffice.org

Report of the Scientific Committee

The meeting was held at Centre de Congrès, Les Dunes d'Or, Agadir, Morocco from 30 May-11 June 2010 and was chaired by Debra Palka. A list of participants is given as Annex A.

1. INTRODUCTORY ITEMS

1.1 Chair's welcome and opening remarks

Palka welcomed the participants to the meeting. She thanked the Government of Morocco for hosting the meeting and for providing excellent facilities along with fabulous weather. She also expressed thanks for the beautiful artwork exhibited throughout the meeting venue.

With sadness, the Committee noted that Sidney Brown had passed away since the 2009 meeting. Sidney was a long-standing member of the Committee from the early 1960s to the mid 1980s. He was particularly involved in the Discovery Whale Marking Scheme, for which he was responsible for maintaining records of marks fired and recovered, ordering supplies and ensuring their availability for relevant whaling and scientific operations, and writing up the results. His advice on all things cetacean was much sought and greatly respected. His modest English manner belied a shrewd intellect and wide range of interests in maritime history and exploration. A minute of silence was observed in his memory.

1.2 Appointment of rapporteurs

Donovan was appointed rapporteur with assistance from various members of the Committee as appropriate. The Committee gave particular thanks to Butterworth for rapporteuring Item 20. Chairs of sub-committees and Working Groups appointed rapporteurs for their individual meetings.

1.3 Meeting procedures and time schedule

Grandy summarised the meeting arrangements and information for participants. The Committee agreed to follow the work schedule prepared by the Chair.

1.4 Establishment of sub-committees and Working Groups

Two pre-meetings preceded the start of the Scientific Committee. The Working Group on the *pre-Implementation assessment* of Western North Pacific Common Minke Whales (NPM) and the correspondence Working Group on Abundance Analysis Methods for Southern Hemisphere Minke Whales met from 28-29 May, during which agenda items covered were incorporated into their main agendas and reports (Annexes D1 and G respectively).

A number of sub-committees and Working Groups were established. Their reports were either made annexes (see below) or subsumed into this report.

Annex D – Sub-Committee on the Revised Management Procedure (RMP);
Annex D1 – Working Group on the *pre-Implementation assessment* of Western North Pacific common minke whales (NPM);
Annex E – Standing Working Group on an Aboriginal Whaling Management Procedure (AWMP);
Annex F – Sub-Committee on Bowhead, Right and Gray Whales (BRG);
Annex G – Sub-Committee on In-Depth Assessments (IA);
Annex H – Sub-Committee on Other Southern Hemisphere Whale Stocks (SH);
Annex I – Working Group on Stock Definition (SD);
Annex J – Working Group on Estimation of Bycatch and other Human-Induced Mortality (BC);
Annex K – Standing Working Group on Environmental Concerns (E);
Annex K1 – Working Group to Address Multi-species and Ecosystem Modelling Approaches (EM);
Annex L – Standing Sub-Committee on Small Cetaceans (SM);
Annex M – Sub-Committee on Whalewatching (WW); and
Annex N – Working Group on DNA (DNA).

1.5 Computing arrangements

Allison outlined the computing and printing facilities available for delegate use. Requests for Secretariat computing are addressed according to the priority assigned by the Convenors.

2. ADOPTION OF AGENDA

The adopted Agenda is given as Annex B1. Statements on the Agenda are given as Annex U. The Agenda took into account the priority items agreed last year and approved by the Commission (IWC, 2010c). Annex B2 links the Committee's Agenda with that of the Commission.

3. REVIEW OF AVAILABLE DATA, DOCUMENTS AND REPORTS

3.1 Documents submitted

Donovan noted that the pre-registration procedure, coupled with the availability of electronic papers, had again been successful. With such a large number of documents, pre-specifying papers had reduced the amount of photocopying and unnecessary paper dramatically. He was pleased to note that this year, the percentage of people opting to receive their primary papers entirely electronically (27%) was almost triple that of last year (10%) and he hoped that this percentage would continue to grow in future years. The list of documents is given as Annex C.

3.2 National Progress Reports on research

National Progress Reports presented at the 2002-10 meetings are accessible on the IWC website. Reports from previous years will also become available in this format in the future.

The Committee reaffirmed its view of the importance of national Progress Reports and **recommends** that the Commission continues to urge member nations to submit them following the approved guidelines (IWC, 1993). Non-member nations wishing to submit progress reports are welcome to do so. The Secretariat is looking into the possibility of online submission of the data included in national Progress Reports; a simplified progress report template has also been developed (see Annex P).

A summary of the information included in the reports presented this year is given as Annex O; the report template,

Table 1
List of data and programs received by the IWC Secretariat since the 2009 meeting.

Date	From	IWC ref.	Details
Catch data from the previous season:			
03/05/10	Norway: N. Øien	E84 Cat09	Individual minke catch records from the Norwegian 2009 commercial catch. Access restricted (specified 14-11-00).
31/05/10	Iceland: G. Víkingsson	E87 Cat09	Individual catch records from the Icelandic commercial catch 2009.
31/05/10	Japan: H. Okada	E88 Cat09	Individual catch records from the Japanese 2009 North Pacific special permit catch (JARPN II) and 2009/10 Antarctic special permit catch (JARPA II).
31/05/10	Russia: R.G. Borodin	E89 Cat09	Individual catch records from the aboriginal harvest in the Russian Federation in 2009.
03/06/10	St.Vincent: L. Edwards	E90 Cat10	Individual catch records from St. Vincent and The Grenadines for the 2010 humpback harvest.
Sightings data/programs:			
22/02/10	K. Sekiguchi	E86 CD92a-n	2009/10 SOWER cruise photographs and data including sightings, effort, waypoint, ice edge, weather.
00/04/10	L. Burt	CD93	DESS Version 3.63 2010.
30/05/10	Japan: K. Matsuoka	CD94	ICR blue whale photo-id pictures from JARPA 1987/88-2004/05 submitted under IWC data access Procedure B.

is available on the IWC website (*http://www.iwcoffice.org/sci_com/scprogress/htm*). The importance of using the agreed template was **emphasised** by the Committee.

3.3 Data collection, storage and manipulation

3.3.1 Catch data and other statistical material

Table 1 lists data received by the Secretariat since the 2009 meeting.

3.3.2 Progress of data coding projects and computing tasks

Allison reported that work has continued on the entry of catch data into both the IWC individual and summary catch databases, including data received from the 2008 season. Work has focused on updating data for eastern North Pacific gray whales (see Item 9.2) and data from the North Atlantic in the period 1897-1930. Version 5.0 of the catch databases will be available shortly. Entry of data into the bycatch database developed by Simon Northridge has continued with data from the 2004 and 2008 seasons being added. Data from the 2008/09 SOWER sightings cruise have been validated and incorporated into the DESS database and work on encoding and validation of data from the 2009/10 cruise has begun. Burt and Hughes began an audit of the Western North Pacific Bryde's whale survey data intersessionally and this work was completed during the course of the meeting.

Programming work during the past year is discussed later under the relevant agenda items.

4. COOPERATION WITH OTHER ORGANISATIONS

4.1 Convention on the Conservation of Migratory Species (CMS)

4.1.1 Scientific Council

There were no meetings of the Scientific Council during the intersessional period. Perrin will represent the IWC at its next meeting.

4.1.2 Conference of Parties (COP)

There were no meetings of the Conference of Parties during the intersessional period. The Secretariat will represent the IWC at the next COP.

4.1.3 Agreement on Small Cetaceans of the Baltic and North Seas (ASCOBANS)

The report of the IWC observer at the 6th Meeting of the Parties to ASCOBANS held in Bonn, Germany from 16-18 September 2009 is given as IWC/62/4D. The main topics of relevance to the IWC are summarised as follows:

(1) a new version of the Recovery Plan for Baltic Harbour Porpoises was adopted;
(2) a new Conservation Plan for the Harbour Porpoise in the North Sea was adopted; and
(3) the meeting agreed on guidelines to address the adverse affects of underwater noise on marine mammals during offshore construction activities for renewable energy production.

The 17th meeting of the Advisory Committee to ASCOBANS had been scheduled to take place from 21-23 April 2010 in Cornwall. This was postponed due to flight restrictions caused by volcanic eruptions in Iceland. It has been rescheduled for 4-6 October 2010 in Bonn, Germany.

The Committee thanked Scheidat for her report and **agrees** that she should represent the Committee as an observer at the next ASCOBANS Advisory Committee meeting and Meeting of Parties. Further information can be found at *http://www.ascobans.org*.

4.1.4 Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS)

The ACCOBAMS Scientific Committee met in Casablanca from the 11-13 January 2010, primarily to prepare information for the forthcoming Meeting of Parties that will be held from 9-12 November 2010 in Monaco. It was attended by members of the Scientific Committee, representatives from the Sub-Regional Coordination Units, representatives from International Organisations and observers including partners of ACCOBAMS. The report of the IWC observer is given as IWC/62/4M.

Nine recommendations and a Declaration expressing the Committee's concern about the slow and/or limited level of implementation of the Agreement to effectively address the conservation problems affecting cetaceans in the Agreement area were adopted by the Committee during the meeting:

Recommendation	Topic
6.1	ACCOBAMS Survey Initiative
6.2	Programme of work on population structure
6.3	Conservation of Mediterranean common dolphins
6.4	Ship strikes
6.5	Marine Protected Areas
6.6	Anthropogenic noise
6.7	Monitoring, assessment and reducing cetacean bycatch in the Black Sea
6.8	Climate change
6.9	Minimum funding for the Scientific Committee

The next meeting of the Scientific Committee is planned for early 2011. The full report of the Scientific Committee can be found on the ACCOBAMS website *http://www.accobams.org*. The Committee thanked Donovan for his report and **agrees** that he should represent the IWC at the forthcoming Meeting of the Parties and Scientific Committee meetings.

4.1.5 Memorandum of Understanding (MoU) on the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia

There was no report related to the MoU on the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia. Perrin will represent the Committee at future activities.

4.1.6 Memorandum of Understanding (MoU) for the Conservation of Cetaceans and Their Habitats in the Pacific Islands Region (MoU for Pacific Islands Cetaceans)

The report of the IWC observer at the 2nd meeting of the MoU for Pacific Islands Cetaceans held 28-29 July 2009 in Auckland, New Zealand is given as IWC/62/4E. The meeting was attended by most of the signatories (Australia, Cook Islands, Fiji, French Polynesia, New Caledonia, New Zealand, Niue, Papua New Guinea, Samoa and the Solomon Islands). Federated States of Micronesia was unable to attend, and Tonga attended as an observer. The UK, on behalf of the Pitcairn Islands, signed the MoU at the meeting, bringing the total number of signatories to twelve.

The meeting, *inter alia*, reviewed progress in cetacean conservation in the region, endorsed a proposal to develop an Oceania Humpback Whale Recovery Plan and adopted an Action Plan for the MoU. An offer by the Whale and Dolphin Conservation Society (WDCS) to convene a Pacific Cetaceans MoU Technical Advisory Group was gratefully accepted. The meeting also noted with appreciation the continued support by WDCS for the development of the CMS Pacific MoU website: *http://www.pacificcetaceans.org*. The Committee thanked Donohue for his report and **agrees** that he should represent the Committee at the next meeting of the MoU for Pacific Islands. Further information can be found at *http://www.cms.int/species/pacific_cet/pacific_cet_bkrd.htm*.

4.2 International Council for the Exploration of the Sea (ICES)

The report of the IWC observer documenting the 2009 activities of ICES is given as IWC/62/4B. The ICES Working Group on Marine Mammal Ecology (WGMME) met in February 2009. Issues considered included management procedures for estimating bycatch limits for small cetaceans, assessing population and stock structure in small cetaceans, improvements in the procedure for reporting on favourable Conservation Status (FSC) under the EU habitats Directive, and developing a framework for monitoring and surveillance of European marine mammal populations.

A review of the ASCOBANS/HELCOM Working Group (WG) on common dolphin population structure in the Northeast Atlantic was conducted. The WGMME concurred with the recommendation that only one common dolphin population inhabits the Northeast Atlantic, although the distributional range of the population is unknown. A separate Iberian harbour porpoise population has recently been identified using genetic analysis and the WGMME strongly recommended that this population be given a high priority for conservation. The WGMME also strongly recommended immediate action by the Spanish and Portuguese governments in monitoring and conserving the Iberian harbour porpoise population.

New data from the SCANS II and CODA projects were reviewed and the WGMME concurred with the recommendation to use the *Catch Limit Algorithm* approach for estimating bycatch limits for small cetaceans.

The WG noted that the continuation and establishment of national observer bycatch programmes is extremely important in order to obtain current estimates of incidental capture for all marine mammal species. The WG also noted the need for the continuation of surveys such as SCANS II and CODA at least every 5-10 years in order to estimate absolute abundance.

Initial development of a European framework for surveillance and monitoring of marine mammals was undertaken. While it is clear that monitoring of abundance, bycatch and health status may reasonably form the core of surveillance for cetaceans, the importance of other types of information (e.g. life history data) and monitoring of specific threats (e.g. offshore construction) should also be recognised when designing a surveillance strategy. Further, monitoring programme design should take account of new findings on the target stock's structure.

The 2009 ICES Annual Science Conference (ASC) was held in Berlin, Germany, 21-25 September 2009. Some sessions were designed with marine mammals included as an integral part. A number of sessions were of relevance to the Committee, including those describing:

(1) advances in marine ecosystem research;
(2) comparative study of climate impact on coastal and continental shelf ecosystems in the ICES area;
(3) habitat science to support stock assessment;
(4) avoidance of bycatch and discards; and
(5) ecological foodweb and network analysis.

The Committee thanked Haug for the report and **agrees** that he should represent the Committee as an observer at the next ICES meeting.

4.3 Inter-American Tropical Tuna Commission (IATTC)

No observer for the IWC attended the 2009 meeting of IATTC.

4.4 International Commission for the Conservation of Atlantic Tunas (ICCAT)

The report of the IWC observer to the 21st meeting of ICCAT is given as IWC/62/4J. The critical status of some stocks was highlighted, including the bluefin tuna, and measures adopted to allow the rebuilding of stocks as well as measures to improve the management frameworks and status for swordfish and albacore. The Committee thanked Corrêa for attaneding the meeting on its behalf.

4.5 Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR)

The report of the IWC observer at the 28th Meeting of the CCAMLR Scientific Committee (CCAMLR-SC), held in Hobart, Australia from 23-27 October 2009 is given as IWC/61/4A. The main items considered at the CCAMLR meeting of relevance to the IWC included: (1) fishery status and trends of Antarctic fish stocks, krill, squid and stone crabs; (2) incidental mortality of seabirds and marine mammals in fisheries in the CCAMLR Convention Area; (3) harvested species (krill, fish, and stone crabs and their assessment); (4) ecosystem monitoring and management; (5) management under conditions of uncertainty about stock size and sustainable yield; (6) scientific research exemption; (7) CCAMLR Scheme of International Scientific Observation; (8) new and exploratory fisheries; (9) joint CCAMLR-IWC workshop with respect to ecosystem modelling in the Southern Ocean; and (10) the CCAMLR performance review.

Marine Protected Areas were discussed in detail. The area of the southern South Orkney shelf and the Seasonal Pack-ice Zone and part of the Fast Ice Zone south of the Shelf was the first MPA designated by CCAMLR. The following milestones were previously agreed: (1) by 2010, collate relevant data for as many of the 11 priority regions as possible; (2) by 2010, submit proposals on a representative system of MPAs to the CCAMLR Commission; (3) by early 2011, convene a workshop to review progress, share experience and determine a work programme for the identification of MPAs; and (4) by 2011, submit proposals for areas for protection to the CCAMLR-SC.

Two reports of cetacean-fisheries interactions in the Southern Ocean were received by CCAMLR in 2009: (1) a killer whale hooked on a line was dead when brought to the surface; and (2) a sperm whale hauled up dead after being caught in discarded fishing gear on the seabed.

The Committee thanked Kock for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next CCAMLR-SC meeting.

4.6 Southern Ocean GLOBEC (SO-GLOBEC)

The synthesis and analysis process under SO-GLOBEC has continued and has produced a number of papers relating cetacean distribution to prey and other environmental variables. There is no active work with respect to SO-GLOBEC at this time.

4.7 North Atlantic Marine Mammal Commission (NAMMCO)

Scientific Committee

The report of the IWC observer at the 16th meeting of the NAMMCO Scientific Committee held in Reykjavik, Iceland 19-22 April 2009 is given as IWC/62/4L.

The Working Group on Marine Mammals-Fisheries (MMFI WG) considered: (1) new developments in the quantitative description of marine mammal diet by species; (2) new developments in the estimation of energy consumption; and (3) recent developments in multi-species modelling. In light of the report of the WG, the NAMMCO SC agreed that multi-species modelling is a valid approach for understanding ecological relations between species. However, it was noted that ecosystem models have significant data requirements, many of which are currently unavailable. In order to improve the understanding of such modelling, an exercise is planned in which four different modelling approaches are used to describe the same ecosystem.

A successful survey of narwhals was conducted in East Greenland during August 2008. The abundance estimates developed from this are the first for the Scoresby Sound fjord system south to Ammassalik. The abundance estimate for narwhals in Melville Bay, developed from the 2007 survey is the first estimate from this locality. The NAMMCO SC recommended catches be set so that there is at least a 70% probability that management objectives be met for West and East Greenland narwhals, i.e. maximum total removals of 310 and 85 narwhals in West and East Greenland respectively.

At the last NAMMCO SC meeting it was recognised that the preliminary data on abundance of narwhals and white whales show higher estimates and encouraged Greenland to submit fully corrected estimates. These were submitted to and endorsed by the NAMMCO/JCNB Joint Working Group in February 2009.

The Committee thanked Walløe for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next NAMMCO SC meeting.

Council

The report of the IWC observer at the 17th Annual Meeting of NAMMCO held in Tromso, Norway in September 2009 is given as IWC/61/4F. The whaling and sealing nations in the North Atlantic confirmed their commitment to ensuring the sustainable utilisation of marine mammals through science-bases management decisions, stressing the vital importance marine mammals have as renewable resources for economies and cultures across the region.

Key conclusions from the meeting relevant to IWC included:

(1) welcoming Greenland's multi-annual catch quotas for white whales and narwhal stocks;
(2) a recommendation from the NAMMCO SC that a quota of 10 humpback whales in West Greenland, including struck and lost animals, would be sustainable;
(3) initiation of an ecosystem modelling programme; and
(4) agreement to convene an expert working group to undertake a review and evaluate the whale killing data submitted to NAMMCO by Japan and to look at data and information on recent and ongoing research on improvements and technical innovations in hunting methods and gears used for the hunting of large whales in NAMMCO countries.

The Committee thanked Goodman for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next NAMMCO Council meeting. Further information on NAMMCO can be found at *http://www.nammco.no.*

4.8 International Union for the Conservation of Nature (IUCN)

Cooke and Larsen, the IWC observers, reported on the considerable cooperation with IUCN that had occurred during the past year and this is given as IWC/62/4K.

Western gray whales (see also Item 10.4)

The IUCN Western Gray Whale Advisory Panel has continued its work (*http://www.iucn.org/wgwap*). The Panel had earlier advised that a seismic survey commissioned by Sakhalin Energy and scheduled for 2009 in the Astokh area be postponed, in view of the anomalous (and possibly disturbance-related) distribution of gray whales off Sakhalin in 2008. Given the apparent return to normal gray whale distribution in the area in 2009, the Panel agreed that carrying out of the survey in 2010 was acceptable, particularly in the light of the jointly developed, improved monitoring and mitigation measures and completion of the survey early in the season before large numbers of whales arrive in the Piltun feeding area.

The Panel was extremely concerned to learn that a further seismic survey is planned for July-September 2010 by the company Rosneft Shelf - Far East, to cover the Lebedenskoie field which underlies the northern part of the prime near-shore feeding ground of western gray whales The IUCN Director General has written to Prime Minister Putin urging the Russian government to order the postponement of the survey at least until 2011 to enable satisfactory mitigation measures to be put in place to minimise the disturbance to whales[1]. A draft Western Gray Whale Conservation Plan has been developed with the help of the IUCN Marine Programme as part of its Range-Wide Conservation Initiative for western Gray Whales (SC/62/BRG24).

Red List updates
Following the comprehensive updating of the Red List entries for cetaceans in 2008, the Cetacean Specialist Group has completed separate assessments of the two species of *Sotalia*, the freshwater tucuxi and the coastal marine and estuarine Guiana dolphin. Draft assessments of a number of Mediterranean subpopulations (fin whale, sperm whale, long-finned pilot whale, Risso's dolphin, striped dolphin, common bottlenose dolphin and Cuvier's beaked whale) are in review.

Asian freshwater cetaceans (see also Item 14.3)
The Cetacean Specialist Group has undertaken several initiatives in Asia over the past year. These have included, most notably a workshop in Samarinda, East Kalimantan, Indonesia in October 2009 on freshwater protected areas for dolphins; a special meeting in Phnom Penh, Cambodia in November 2009 on the conservation of Irrawaddy dolphins in the Mekong River; and a meeting in Patna, India in February 2010 to assist in the development of a national action plan for the conservation of Ganges river dolphins (*Susus*).

The Committee thanked Cooke and Larsen for their report and **agrees** that they should continue to act as observers to IUCN for the IWC. Further information on IUCN can be found at *http://www.iucn.org.*

4.9 Food and Agriculture Organisation (FAO) related meetings – Committee on Fisheries (COFI)
There was no meeting of COFI in 2010. Further information on FAO can be found at *http://www.fao.org*.

4.10 Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)
The report of the IWC observer at the 15th meeting of the CITES Conference of the Parties held 13-25 March 2010 in, Doha, Qatar is given as IWC/62/4H. There were no proposals for changing the listing of whale stocks from Appendix I to Appendix II (downlisting). There were also no proposals for changing the listing of a dolphin or whale species from Appendix II to Appendix I (uplisting).

The CITES Secretariat reviewed all of the Decisions that were in effect after the 14th meeting of the Conference of the Parties, including a recommendation to delete Decision 14.81 relating to great whales. Decision 14.81 states that 'No periodic review of any great whale, including the fin whale, should occur while the moratorium by the International Whaling Commission is in place'. The CITES Secretariat recommendation also noted that if the substance of this Decision should remain in effect, it should be considered in the context of the draft resolution on the periodic review of the Appendices.

A number of Parties opposed its deletion on the basis that the draft resolution on the periodic review had not been accepted. After a vote, the recommendation to delete the Decision was rejected.

The Committee thanked the US Government for attending on its behalf and **agrees** that it should represent the Committee as an observer at the next CITES meeting. Information on CITES can be found at *http://www.cites.org.*

4.11 North Pacific Marine Science Organisation (PICES)
The report of the IWC observer at the 18th annual meeting of PICES held 23 October-1 November 2009 in Jeju, Republic of Korea is given as IWC/62/4G. The Marine Birds and Mammals Advisory Group (AP-MBM), cosponsored by ICES held a theme session on 'integrating marine mammal populations and rates of prey consumption in models and forecasts of climate change-ecosystem change in the North Pacific and North Atlantic Oceans'. A diverse range of topics were covered, including population trends, diet, estimates of prey consumption and models of trophic impact. AP-MBM reviewed aspects of the new PICES science programme (FUTURE), specifically: (1) understanding climate change and anthropogenic impacts on marine ecosystems; (2) forecasting future ecosystem change; and (3) better communication with society. The AP reiterated its primary mission to provide advice to the PICES community about the role of marine birds and mammals in marine ecosystems. Based on its role in FUTURE the AP-MBM defined its focal points as: (1) spatial ecology of predators in marine ecosystems; (2) models of prey consumption of top predators; (3) marine birds and mammals as indicators of ecosystem change; (4) marine mammals as autonomous oceanographic sampling devices; and (5) providing advice to the PICES community.

The Committee thanked Kato for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next PICES meeting. Further information on PICES can be found at *http://www.pices.int*.

4.12 Eastern Caribbean Cetacean Commission (ECCO)
No information on the activities of ECCO was provided.

4.13 Protocol on Specially Protected Areas and Wildlife (SPAW) of the Cartagena Convention for the Wider Caribbean
There were no meetings of SPAW during the intersessional period. Carlson will represent the IWC at its next meeting. Further information on SPAW can be found at *http://www.cep.unep.org/cartagena-convention*.

4.14 Indian Ocean Commission (IOC)
No information on the activities of IOC was provided. Further information on the IOC can be found at *http://www.coi-ioc.org*.

4.15 Permanent Commission for the South Pacific (CPPS)
No information on the activities of CPPS was provided. Further information on CPPS can be found at *http://www.cpps-int.org*.

4.16 International Maritime Organisation (IMO)
The report of the IWC observer at the General Assembly of the IMO held 23 November-4 December 2009 is given as IWC/62/4I. The proposed Agreement of Cooperation between IMO and IWC was approved, which means that the IWC now has definitive IMO observer status. While the impetus for closer co-operation between IMO and IWC was in relation to ship strikes on cetaceans, there are a number of other issues of potential mutual relevance including habitat degradation and noise from shipping. Discussions on

[1]See *http://www.iucn.org/wgwap/wgwap/public_statements/* for the text of this and other letters.

collisions with whales and underwater noise from shipping took place within the Marine Environment Protection Committee (MEPC) at its 59th session held in July 2009 and 60th session held in March 2010.

The MEPC has had 'noise from commercial shipping and its adverse impact on marine life' on its work programme since 2008. A correspondence group was established to identify and address ways to minimise the introduction of incidental noise into the marine environment from commercial shipping to reduce the potential adverse impact on marine life and in particular develop voluntary technical guidelines for ship-quieting technologies as well as potential navigation and operational practices. The IWC Secretariat is a member of this group.

The Committee thanked the IWC Secretariat for its report and **agrees** that it should represent the Committee at the next IMO meeting. Further information on IMO can be found at *http://www.imo.org.*

4.17 Other

An update was received on conservation in the Southeast Pacific under the framework of the Lima Convention and is given as IWC/62/4C. In January 2010 the 16th Meeting to the Parties to the Lima Convention was held in Guayaquil, Ecuador. The five member countries (Chile, Colombia, Ecuador, Panama and Chile) reviewed the activities regarding implementation of a Plan of Action for the Conservation of Marine Mammals in the Southeast Pacific (PAMM). The PAMM was formed to help countries to improve their policies on marine mammals' conservation and to develop activities that require regional cooperation.

In 2009 five pilot projects to mitigate the impacts of fishing activities were conducted: (1) implementation of actions for the conservation of the Chilean dolphin in the zone of Constitucion; (2) study to mitigate impact of the incidental entanglement of coastal cetaceans in the Columbia Pacific; (3) preliminary assessment of the interaction of cetaceans with artisanal fisheries in the Machalilla National Park, Ecuador; (4) reduction of the impact of gillnets on cetaceans in coastal waters within the Gulf of Chiriqui; and (5) study to test the use of pingers to reduce the incidental bycatch of small cetaceans in Peru.

As a result of these projects, a document entitled 'Efforts to mitigate the impact of fishing activities on cetaceans in the Southeast Pacific countries' will be published.

The first phase of a biodiversity and MCPA information system (SIBIMAP-PSE) was finalised. This is an online tool for searching and downloading information crucial for management and conservation of cetaceans, sea turtles and MCPA in the Southeast Pacific. The module on cetaceans is now complete.

A workshop on legal aspects of whalewatching was planned for March 2010, but was postponed until late 2010 due to an earthquake in Chile.

The Committee thanked Felix for his report and **agrees** that he should represent the Committee at future activities related to cetacean conservation in the Southeast Pacific under the framework of the Lima Convention.

5. REVISED MANAGEMENT PROCEDURE (RMP) – GENERAL ISSUES

5.1 Review MSY rates

5.1.1 Report of the intersessional workshop

The Committee has been discussing maximum sustainable yield rates (MSYR) for some time in the context of a general reconsideration of the plausible range to be used in population models used for testing the *Catch Limit Algorithm* (*CLA*) of the RMP (and see Item 5.1.2 below). At present, this range is 1% to 7% when expressed in terms of the mature component of the population. As part of the review process, information on observed population growth rates at low population sizes is being considered because Cooke (2007) noted that in circumstances where variability and/or temporal autocorrelation in the effects of environmental variability on population growth rates is high, simple use of such observed population growth rates could lead to incorrect inferences being drawn concerning the lower end of the range of plausible values for MSYR.

A Third Workshop was held intersessionally to examine whether the observed levels of variation in baleen whale reproduction and annual survival rate parameters were sufficiently large that biases of the nature identified from population models incorporating environmentally-induced variability might be of concern (SC/62/Rep2; Annex D, item 2.1.1).

At the Workshop, an analytical approach was developed and followed to estimate the coefficient of variation (CV) and temporal autocorrelation for the selected time series of calving proportion indices and calving interval data. This information, modified appropriately, provides input for a method developed to relate variability in calving proportion to variability in the annual growth rate of a population using a population dynamics model (see SC/62/Rep2). The model can take into account environmentally-induced variability in population abundance arising from variation in annual survival rate.

The Workshop identified two further steps needed before results from this model can be used to draw inferences about the plausible ranges for the CV and temporal autocorrelation parameters describing the effects of environmental variability on population dynamics in the model of Cooke (2007). The Committee incorporated these into its work plan under this item (see Annex D, item 2.1.2).

The Workshop received a revised approach for a meta-analysis of population growth rates previously discussed (IWC, 2010b) and suggested some additional work to be completed before the 2010 Annual Meeting. Item 5.1.2 and Annex D, item 2.1.1 describe progress made on three other issues listed in the work plan for completion of the MSYR review at last year's meeting.

5.1.2 Issues arising

The Committee received SC/62/RMP3 in response to the Workshop recommendations to: (1) apply the age-structured model of SC/62/Rep2, Annex D to all of the datasets assembled during the Workshop to estimate the resultant CV and temporal auto-correlation in growth rate; and (2) to conduct further tests of the Bayesian meta-analysis approach. More details are given in Annex D, item 2.1.2.

The Committee **agrees** that this Bayesian approach was an acceptable basis to compute a posterior distribution for r_0, once the inputs needed to apply it become available. It also **agrees** that account will need to be taken that the estimates of lower posterior percentiles from this method are positively biased, before making recommendations regarding appropriate values for MSYR for use in trials.

SC/62/RMP2 and SC/62/RMP4 responded to recommendations to use the environmental variability model of Cooke (2007) to provide CVs and temporal autocorrelation estimates for the growth of the population from one year to the next for the standard set of scenarios and to use this model to determine the predicted relationship between the length of series and the estimated level of variability in the population rate of increase. More details are given in Annex D, item 2.1.2. The Committee **agrees** that it now has a basis to link variability in demographic processes with the inputs of the Cooke (2007) model.

Efforts to fit models that account for both process and observation error to the data on calving rates and calving intervals had encountered numerical problems intersessionally The Committee **endorses** a work plan to address this (Annex D, Appendix 2) and looks forward to seeing the results of this work next year.

The Committee discussed how to relate variation in net recruitment rate, which depends on variation in both survival and reproduction, to variation in reproductive rates alone. Details are given in Annex D, item 2.1.2. The Committee considered the question of correlations between survival and reproductive rates to be potentially important for the question of estimating typical levels of variation in net recruitment rate for baleen whales, but **agrees** that more analysis is required before any general inference can be drawn. It **requests** in particular:

(1) a literature review with regard to the question of the circumstances under which correlations between survival and reproductive rates would be negative or positive;
(2) more extensive modelling to cover the full range of parameter values deemed to be plausible for baleen whales in order to determine whether general inferences can be drawn, or at least to identify the circumstances where substantial correlations of a specific sign would be expected;
(3) direct estimation of variability in survival rates to the extent that this is possible.

The Committee **agrees** that if results from this work are available at its next meeting, then they should be taken into account in its deliberations with respect to the level of variability in baleen whale demography. However, that lack of results will not preclude the Committee from completing its review of MSY rates next year.

The Committee considered the extent to which genetic data could place bounds on fluctuations in population size for some examples of trajectories arising for the environmental variation model of Cooke (2007). It recognised the potential of genetic methods to inform its deliberations on the plausible range of MSYR values, but **agrees** that these methods could not be used during the current review. However, it **recommends** that the number of haplotypes in whale populations, along with other population and demographic measures should be assembled since this might inform the current review. The Committee **encourages** completion of a compilation already initiated by Brownell.

The Committee also **agrees** that although the use of time-series of abundance estimates for species other than whales to make inferences regarding the extent of variation and the temporal auto-correlation of the rate of growth remained a good idea, the lack of such time-series at present means that this source of information cannot be pursued during the current review.

In conclusion, although considerable progress was made during the current meeting, the Committee was once again not in position to complete the review. It established a work plan (see Annex D, item 2.5) to address the final issues that need to be examined to complete the review at next year's meeting.

It **agrees** that the review will be completed at next year's meeting on the basis of the data and analyses available. It **accepts** that it is not appropriate to keep extending the time available for the review, particularly given its importance to Item 5.2 below.

5.2 Finalise the approach for evaluating proposed amendments to the *CLA*

The Committee noted that it could not complete discussions on amendments to the *CLA* until the range for MSYR values in the RMP was completed. Regarding the Norwegian proposal for amending the *CLA*, it was noted that all of the relevant trials/results had been presented in Aldrin and Huseby (2007), but that evaluation of this proposal could not occur until the review of MSY rates was complete.

5.3 Version of *CLA* to be used in trials

SC/62/RMP10 examined the sensitivity of catch limits to the level of accuracy when computing posterior distributions using the *CLA*. Four versions of programs used to implement the *CLA* were discussed. More details are given in Annex D, item 2.1.2.

The Committee **endorses** the recommendations in SC/62/RMP10 that: (a) only the Norwegian version of the *CLA* should be used when conducting future trials; (b) the Second Intersessional Workshop in an *Implementation* or *Implementation Review* will need to be carefully scheduled to ensure that all trials can be run before it takes place; (c) if special circumstances arise when it becomes necessary to run additional trials during a meeting (e.g. during the Second Intersessional Workshop), the 'intermediate' version of the Cooke implementation that is more accurate than the 'trials' version (but less accurate than the 'accurate' or Norwegian version) be used for this purpose and the results confirmed using the Norwegian 'CatchLimit' program after the meeting; and (d) a full set of revised results from the trials for North Atlantic fin whales, Western North Pacific Bryde's whales; and North Atlantic minke whales should be run using the Norwegian 'CatchLimit' program and the results placed on the IWC website.

5.4 Updates to RMP specification and annotations

In the context of applying the RMP pursuant to Item 20, the Committee identified some issues where updating and clarification of the specifications of the RMP and the accompanying annotations and guidelines was warranted (see Annex D, item 2.4).

(1) The provision for the adjustment for sources of human-caused mortality other than commercial catches, as recommended by the Scientific Committee in 2000 (IWC, 2001f, p.91), should be included in the RMP with the qualification specified by the Commission (IWC, 2001b) that the provision be limited to mortality due to bycatches, ship strikes, non-IWC whaling, scientific permit catches, and indigenous subsistence whaling. A new annotation should be added to provide the Committee with operational guidelines to implement this provision.
(2) The maximum period of validity of catch limit calculations should be extended from five to six years to be consistent with the six-year cycle of surveying specified in section 3.2.2 of the RMP, as currently implemented for minke whales in the North Atlantic.
(3) The rule for rounding of catch limits to a whole number of whales should be clarified.

(4) The guidelines for conducting surveys under the RMP and those for *Implementing* the RMP (IWC, 2005b; 2005c) should be modified to clarify that changes to the guidelines are not retroactive. That is, results from surveys conducted in accordance with earlier version of the guidelines would not become inadmissible for use in the RMP when the guidelines are changed.

Proposed amendments to the RMP and its annotations to address these issues are given in Annex D, Appendix 5, along with some background information. The Committee **recommends** adoption of these amendments to the RMP specification and annotations. The Committee further **requests** the Secretariat to prepare a proposal to next year's meeting to update the guidelines for conducting surveys and for *Implementations* to accommodate point (4) in Annex D, item 2.4.

Several amendments to the RMP specifications and annotations had been adopted since the most recent published version (IWC, 1999e). These are listed in Annex D, Appendix 5. The Committee **agrees** that the consolidated revised version be published in full in the next supplement to *J. Cetacean Res. Manage.*

6. RMP – *IMPLEMENTATIONS* AND *IMPLEMENTATION REVIEWS*

6.1 Western North Pacific Bryde's whales

6.1.1 Complete Implementation

6.1.1.1 RESEARCH PROPOSAL FOR THE 'VARIANT WITH RESEARCH'

The Committee had agreed in 2007 (IWC, 2008b) that three of the four RMP variants (1, 3 and 4) considered during the *Implementation* for western North Pacific Bryde's whales performed acceptably from a conservation perspective and recommended that those variants could be implemented without a research programme. It also agreed that variant 2 was only 'acceptable with research' because conservation performance was 'unacceptable' on three 'medium' plausibility trials incorporating stock structure hypothesis 4 i.e. two stocks of Bryde's whales in the western North Pacific, one of which consists of two sub-stocks (stock structure hypothesis 4).

In 2008, the Committee reviewed a research proposal (Pastene *et al.*, 2008) that aimed to determine whether or not sub-stocks occur in sub-area 1. Based on this review, the Committee had recommended that the *Implementation Simulation Trials* for the western North Pacific Bryde's whales be used to determine whether differences in age-compositions between sub-areas 1W and 1E could be used to resolve whether there are sub-stocks in these sub-areas and that results from previous (and any new) power analyses that assess the use of genetic methods to evaluate stock structure hypothesis 4 be included in the revised proposal.

This year, the Committee received a revised research plan (Annex D, Appendix 6) and welcomed work done to address several of its earlier recommendations. The results of the *Implementation Simulation Trials* showed that recent age structure data would not be able to distinguish between scenarios in which there is or is not age-structuring in sub-areas 1W and 1E.

The Committee **recommends** that the proposal be revised further and, in particular, that the power analyses focus more clearly on the specific hypotheses for the Western North Pacific Bryde's whales. The Committee was informed that a revised proposal will be presented next year that will focus to a greater extent on the use of genetic data.

6.1.2 Recommendations and work plan

The Committee **agrees** that its work plan for the 2011 Annual Meeting would be to review the revised research proposal for the 'variant with research'.

6.2 North Atlantic fin whales

6.2.1 Complete Implementation

Last year, the Committee had agreed that if the RMP is implemented for this species in this Region, variants 1, 3, 4, 5 and 6 (see Table 4 of IWC, 2010d) can be implemented without an associated research programme but that variant 2 (sub-areas WI+EG are a Small Area) was only acceptable with research.

This year, comparison of results from different versions of the *CLA* (see Item 5.2) revealed that variant 3 (sub-areas WI+WG+EI/F are a *Small Area*) does not have 'acceptable' performance for some of the trials and can no longer be considered to be acceptable without research but is rather only 'acceptable with research'.

Last year, the Committee had confirmed that use of variant 2 for ten years followed by variant 1 (sub-area WI is a *Small Area*) led to performance which was 'acceptable' for all trials and consequently that the requirements for stage 1 of the process for implementing a 'variant with research' had been met. The second stage of the process was for Iceland to demonstrate to the satisfaction of the Committee that a research programme has a good chance (within a 10-year period) of being able to confirm or deny that stock structure hypothesis IV is implausible.

The Committee received a research proposal (SC/62/RMP1) that followed the *pro forma* agreed by the Committee in 2007. Details are given in Annex D, item 3.2.2.

The Committee welcomed the proposal, noting that it was not final and that Iceland was inviting suggestions for how it can be improved. In discussion, it noted that the aim of the proposal should be to assess the probability of hypothesis IV relative to the probabilities for the other stock structure hypotheses. It noted that the *Implementation Simulation Trials* could be used to assess the effect sizes on which the power analyses are based.

In particular, the Committee **recommends** that the lowest rate at which the C sub-stocks mix in sub-areas EC, WG, EG, WI, EI+F, and N and the performance of variant 2 is 'acceptable' for all trials should be calculated and used when conducting power analyses. It further **recommends** that quantitative analyses along the lines of Appendix 3 of SC/62/RMP1 be conducted for each of the stock structure hypotheses.

6.2.2 Recommendations and work plan

The Committee **agrees** that its work plan for the 2011 Annual Meeting would be to review a revised research proposal for the 'variant with research' and to review any abundance estimates for use in the *CLA*.

6.3 North Pacific common minke whales

6.3.1 Initiate pre-Implementation assessment

In 2009, the Commission had agreed that the Scientific Committee should follow the option in its report (IWC, 2010e) that specified completing a full *Implementation Review* as soon as possible, ideally by the 2012 meeting. This timeline will be possible only if the *pre-Implementation assessment* can be completed this year. The Committee was undertaking a *pre-implementation assessment*, rather than immediately commencing an *Implementation Review*, because the 2003 *Implementation* had been conducted before the existing guidelines for *Implementations* had been developed and had focused primarily on 'O' stock.

Committee guidelines for *Implementations* (IWC, 2005b) state that the main focus of a *pre-Implementation assessment* is:

> 'the establishment of plausible stock hypotheses consistent with the data that are inclusive enough that it is deemed unlikely that the collection of new data during the *Implementation* process will suggest a major novel hypothesis (e.g. a different number of stocks) not already specified in the basic *Implementation Simulation Trial* structure.'

Additional foci are examination of available abundance estimates and information on the geographical and temporal nature of 'likely' whaling operations and future levels of anthropogenic removals other than due to commercial whaling.

The importance of creating a document that lists the various datasets and other information available for the *pre-implementation assessment* was recognised (this is normally provided by national scientists in the case of a new request for a *pre-Implementation assessment)*. This will be a living document, at least until the deadline is established for the consideration of no new data for the *Implementation Review* (this occurs at the First Intersessional Workshop although new *analyses* may be presented at the First Annual Meeting). A table containing this information is given in Annex D1, Appendix 2.

6.3.1.1 STOCK STRUCTURE

The goals for the *pre-Implementation assessment* with respect to stock structure were to agree to a set of inclusive plausible hypotheses consistent with the data, and to ensure that the types of information needed for the *Implementation Review* were available. Assessing the relative plausibility of alternative hypotheses regarding stock structure will be considered at the First Annual Meeting of the *Implementation Review*.

The Committee briefly discussed minimum standards for plausibility. It **agrees**, as it has in the past, that the most reasonable approach is to use best professional judgment and common sense, after considering all relevant information.

The Committee first reviewed past discussions on stock structure for western North Pacific minke whales. Details are given in Annex D1, item 5.1.

The Committee then received a number of papers providing new information relevant to stock structure. Details of these and the considerable discussions that ensued are given in Annex D1, item 5.3. The following summary focuses on issues where the Committee made specific statements.

SC/62/NMP22 provided results of a biopsy skin-sampling survey in July-August 2009 in the Okhotsk Sea. Unfortunately, none of the five biopsy samples taken could be removed from Russian waters because of CITES-related restrictions. This is discussed further under Annex D1, item 7.6. In spite of this, the Committee was pleased that that this research had been conducted within the Russian EEZ, and that it had been possible to collect biopsy samples from minke whales on the feeding grounds. The Committee **encourages** future collaborations and **strongly urges** all concerned to find ways to solve these CITES-related issues.

SC/62/NPM10 estimated the mixing proportion of 'O' and 'J' stocks in the Sea of Okhotsk using cookie-cutter shark scars from 22 animals. Based on previous research in sub-area 11 in 1996 and 1999, the maximum likelihood estimate for the proportion of 'J' stock in sub-area 12 was 0. The Committee welcomed this valuable new information, but **agrees** that the method used to estimate mixing proportions needed some refinement.

SC/62/NPM13 reviewed non-genetic biological information relevant to the stock structure of minke whales in the Yellow Sea, Sea of Japan (East Sea), and western Pacific Ocean. The review was structured to examine four key comparisons between: (1) the Yellow Sea and the Korean coast of the Sea of Japan; (2) the Korean and Japanese coasts in the Sea of Japan; (3) the Sea of Japan and Pacific coasts of Japan; and (4) coastal and offshore areas of the Pacific Ocean. The Committee welcomed this attempt to synthesise diverse types of non-genetic information that potentially can inform discussions of stock structure and found the idea of orienting the analyses around four key questions useful. The authors acknowledged that although they had attempted to be exhaustive, they might have missed some relevant biological information, particularly if it was reported outside the IWC context, and requested that any such information be forwarded to them. The Committee in particular supported the collation of information in table 3 in SC/62/NPM13 and **encourages** members to work together to complete this and provide it to the First Intersessional Meeting of the *Implementation Review*.

The Committee reconsidered Hatanaka and Miyashita (1997) that investigated feeding migration based on length data. It was pointed out that these data are consistent with the generic concept of an 'O' stock, and that the length data might be useful for mature/immature determinations to condition different migration patterns for one or more 'O' stocks. The Committee **agrees** to include these data in Annex D1, Appendix 2.

SC/62/NPM11 had two major objectives: (1) to determine the status of whales that could not be identified reliably to 'O' or 'J' stock based on analyses described in Kanda *et al.* (2009); and (2) to examine stock structure of the 'J' stock in the Sea of Japan and Yellow Sea. The Committee **appreciates** the efforts of the authors to respond to some of the suggestions for additional analyses made last year.

Two papers presented new analyses of mtDNA data. SC/62/NPM21 examined genetic variation at the mtDNA control region to evaluate the plausibility of proposed stock structure scenarios for the 'J' and 'O' stocks. SC/62/NPM20 reported on differences in mtDNA sequences and sex ratios in western North Pacific minke whales by combining information from samples collected in Korean market surveys with three Japanese datasets made available through the IWC Data Availability Agreement. SC/62/NPM27 commented on the analyses conducted in SC/62/NPM20. In discussion, it was clarified that although SC/62/NPM20 and SC/62/NPM27 largely considered the same group of samples, there were two important differences: (1) SC/62/NPM20 used market samples for Korean samples, while SC/62/NPM21 used bycatch; and (2) SC/62/NPM21 used mtDNA data that had been error-corrected subsequently whereas due to time constraints and the agreed deadlines for *pre-Implementation assessment*. SC/62/NPM20 used the original data and grouped haplotypes into haplogroups to minimize influence of the sequencing errors.

In further discussion of standards for establishing/rejecting hypotheses, the Committee **agrees** that it is important but challenging to try to find a balance between two potential errors: (1) interpreting minor differences that might be artefacts or not biologically meaningful as evidence for separate stocks; and (2) failing to recognise true stock structure because power to resolve closely related populations is low.

Discussion of these issues highlighted divergent opinions within the Committee regarding how best to deal with the inability to sample populations on their breeding grounds. In one view, the best way to approach this problem is to use results of the program *STRUCTURE* (Pritchard *et al.*, 2000) which is designed to deal with situations in which there are no reliable *a priori* ways of grouping individuals into putative populations. The other view was that this approach has elements of circularity and can result in a false sense of confidence in model results and that *STRUCTURE* has a documented inability to provide reliable results when dealing with mixtures of closely related populations. These issues have arisen previously regarding earlier versions of the genetic data analyses for North Pacific minke whales (IWC, 2010e).

The Committee **agrees** on the potential value of trying to collect samples in areas where a single stock is believed to occur, but recognises the difficulty in identifying the location of these.

Following presentation and discussion of new information, the Committee reviewed and discussed two independent attempts to generate plausible stock-structure hypotheses that synthesised both genetic and non-genetic information. The summaries of these papers and the ensuing discussion are below.

SC/62/NPM12 examined recent progress in the development of stock structure hypotheses for western North Pacific common minke whale ('O' and 'J' stocks), and conducted a preliminary evaluation of these hypotheses in the context of the available scientific information, mainly genetics, presented and discussed by the Committee in recent years. The aim was to identify stock structure scenarios that are consistent with the data. The authors of SC/62/NPM12 considered that the best available scientific evidence is consistent with the hypothesis that there is a single 'J' stock distributed in the Yellow Sea, Sea of Japan and Pacific side of Japan and a single 'O' stock in sub-areas 7, 8 and 9. They considered this hypothesis the most plausible. It is consistent with the pattern of mixing between 'J' and 'O' stocks along the Japanese coast as proposed by Kanda *et al.* (2009), the migration patterns of adult and juvenile 'J' stock whales as suggested by SC/62/NPM1, and the migration of 'O' stock whales as suggested by Hatanaka and Miyashita (1997). SC/62/NPM12 postulated three less plausible hypotheses which modify the most plausible scenario as follows:

(1) a W-stock sporadically intrudes into sub-area 9;
(2) a different stock (Y-stock) resides in the Yellow Sea and overlaps with 'J' stock in the southern part of sub-area 6; and
(3) a W-stock sporadically intrudes into sub-area 9 and a Y-stock resides in the Yellow Sea, and overlaps with 'J' stock in the southern part of sub-area 6.

These four hypotheses are further described and shown graphically in Annex D1, Appendix 3.

SC/62/NPM15 reviewed genetic and non-genetic data regarding stock structure; the authors summarised their conclusions in the context of addressing four key questions, as follows.

(1) Are whales in the Yellow Sea part of a population that migrates into the Sea of Japan?
SC/62/NPM15 summarised that migration north into the Yellow Sea, the presence of mature whales and cow/calf pairs there, and the fact that Yellow Sea whales have only autumn conception dates (*n*=124), provides evidence that a separate stock exists there. The Korean coast of the Sea of Japan showed some evidence for a mixture of two stocks, and microsatellite DNA showed seasonal differences that might be explained by a Yellow Sea stock moving along the Korean coast only in summer. In summary, the authors consider that the available data suggest that Yellow Sea whales may not be a part of the Sea of Japan stock.

(2) Are whales along the Korean coast part of the same population as whales along the western Japanese coast?
SC/62/NPM15 summarized that there is no obvious hiatus in distribution between the two coasts, and that genetic analyses showed mixed results (haplogroup and *STRUCTURE* found no difference, pair-wise mtDNA and microsatellite DNA found differences). A small sample (*n*=8) from the Sea of Japan showed a bimodal distribution of conception dates and a larger sample (*n*=63) showed two different flipper colour patterns, but these data could be explained by a mixture of whales coming into the northeast Sea of Japan from the Sea of Okhotsk. No sex bias or haplogroup-by-sex differences were found for Japanese Sea of Japan bycatch, suggesting a possible year-round presence of a non-migratory coastal stock. In summary, the authors consider that it is plausible there are different stocks on either side of the Sea of Japan, but the data are somewhat contradictory or are lacking in sufficient resolution or spatial extent to make definitive conclusions. Some genetic evidence suggesting a second stock could be most simply explained by whales from a Yellow Sea stock appearing along the coast of Korea in summer.

(3) Are so-called 'J-type' whales on the east coast of Japan the same population as on the west coast of Japan?
The majority of whales bycaught on the southern Pacific coast of Japan (sub-area 2) are assigned to be J-type and so are either part of a Sea of Japan stock or are a coastal stock separate from a Pacific Ocean ('O') stock. Whales caught in the Pacific Ocean, even from sub-area 7 coastal areas, only have winter conception dates (*n*=68) and a single flipper colour type (*n*=77); if coastal sub-area 7 had a mixture of stocks there should be autumn conception dates and a mixture of flipper colour types. There are differences in microsatellite DNA and mtDNA between the two coasts of Japan when all samples are used. Additionally, the southern Pacific coast bycatch (sub-area 2) is genetically different from bycatch along the northern Pacific coast of Japan (sub-area 7), suggesting a Pacific coastal stock might be distributed only in the Kuroshio current, and does not occur further north in the Oyashio current. In summary, the authors consider that it is plausible that there are different coastal stocks on either coast of Japan, and/or longitudinally along the Pacific coast.

(4) Is there a coastal population in Subarea 7 (east of Hokkaido and northern Honshu) that is different from offshore minke whales in the Pacific Ocean, even after accounting for Sea of Japan whales that might migrate into this area?
One hypothesis is that there is a 'pure' Sea of Japan stock (J-type whales) and Pacific Ocean stock (O-type whales). Under that hypothesis, genetic differences between Pacific coastal waters (sub-area 7W) and other areas have been interpreted to be a mixture of these two stocks. An alternate hypothesis is that this area contains a distinct stock characterised by intermediate haplotype frequencies, as seen in humpback whales, for example. Again, the lack of evidence of autumn conception dates (*n*=68) and a mixture of flipper colour types (*n*=77) in the Pacific Ocean argues

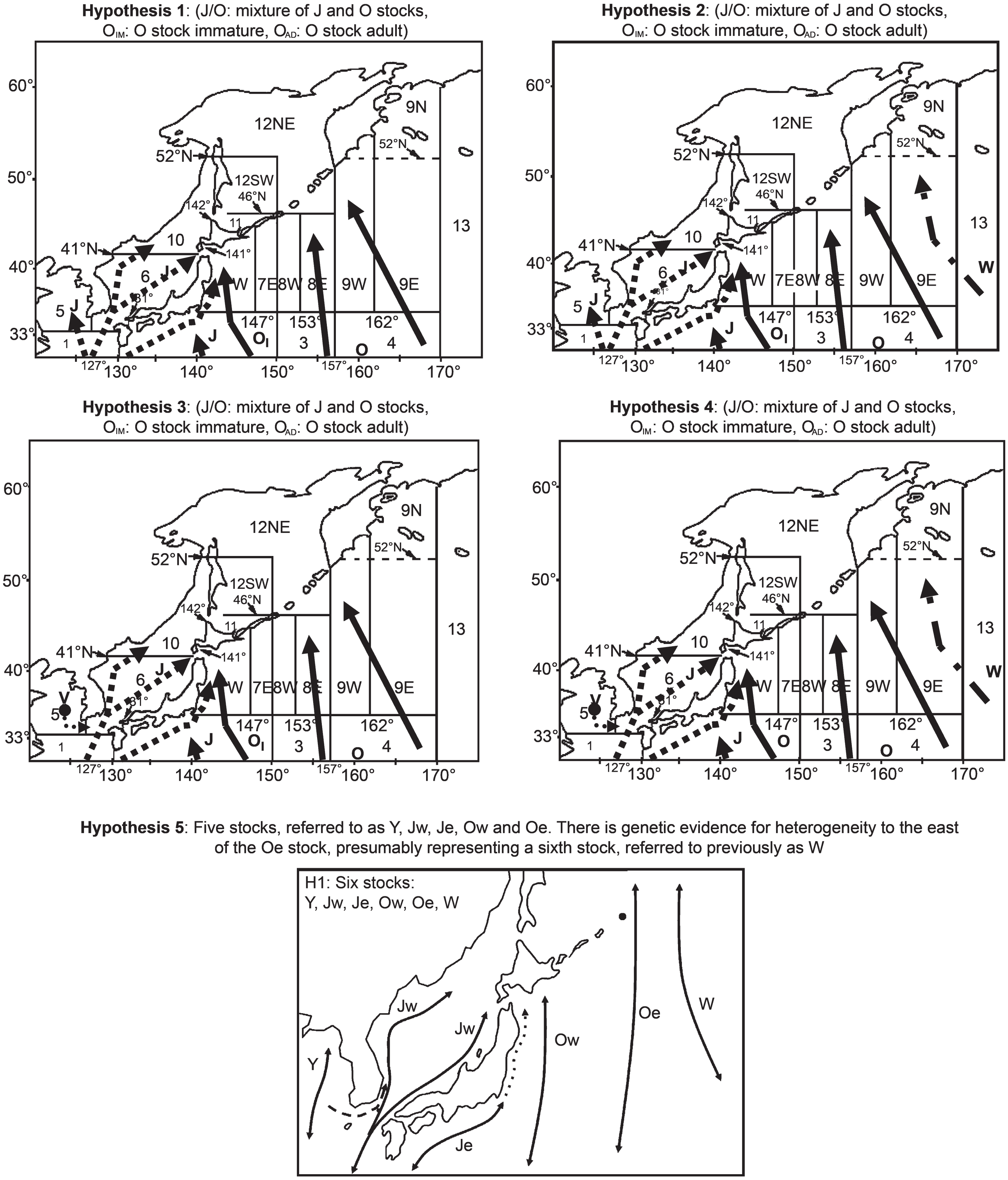


Fig.1. Five plausible stock structure hypotheses for North Pacific minke whales.

against there being a mixture of stocks in coastal Pacific areas. Although it is possible that the haplotype frequencies of sub-area 7W could be explained by a complex seasonal, sex- and age-biased mixing of 2 stocks, e.g. a 'core J' and a 'core O', it is not as parsimonious as the hypothesis of a distinct stock with intermediate haplogroup frequencies. The absence of a strong haplogroup-by-sex interaction in coastal waters is inconsistent with the prediction of a sex-biased mixing of two stocks. SC/62/NPM30 concluded that there was genetic heterogeneity in the Pacific Ocean, with a strong signal in the coastal area east of Hokkaido. In summary, the authors consider that it is plausible that the unique genetic signals seen in coastal waters of the Pacific coast of Japan are due to the existence of a distinct coastal stock or stocks, rather than a mixture of a 'pure J' and a 'pure O' stock.

An additional stock-structure hypothesis based on consideration of the four questions posed above is that there are six stocks (Y, J_W, J_E, O_W, O_E, and W); this is described and shown graphically in Annex D1, Appendix 4.

In discussion, there was general agreement on answers to two of the key questions posed by SC/62/NPM15: (1) a separate J-like stock (denoted Y-stock) occurs in the Yellow

Sea and in at least some years some Y-stock whales are found in the Sea of Japan; and (2) minke whales on the east coast of Korea and on the west coast of Japan are generally part of a single stock.

In contrast, substantial disagreements remained concerning the other two questions. These disagreements centred on how to interpret results of statistical tests showing heterogeneity of allele frequencies. In one view, the results can be explained by overlapping distributions of 'O' and 'J' stock, which leads to different mixing proportions (and hence different allele and haplotypic frequencies) in different geographic areas. Under this hypothesis, it would not be surprising that comparisons of samples from areas having different fractions of the two stocks often produce statistically significant results. An alternative view to an explanation that requires complex mixing patterns is the hypothesis that the statistically significant differences reflect a distinct stock with intermediate gene frequencies.

In conclusion, in spite of the disagreements noted above, the Committee **agrees** that the set of stock-structure hypotheses based on the four proposed in Annex D1, Appendix 3 and the fifth proposed in Annex D1, Appendix 4 were inclusive and sufficiently plausible at least to take forward to the next step in the *Implementation* process (see Fig. 1).

6.3.1.2 CATCHES

The Committee noted that information was available on commercial catches for those countries that have taken the largest catches of western North Pacific minke whales. There are, however, limited data on catches for the People's Republic of China and no catch data for North Korea (if North Korea has taken western North Pacific minke whales).

The Committee reviewed information regarding incidental catches.

SC/62/NPM4 provided information on incidental catches of common minke whales off Japan and Korea. Some suggestions were made on how plausible estimates of future incidental catches can be made, as well as to how past series, now considered erroneous, can be constructed. The Committee noted that it would be useful if estimates were presented to the Preparatory Meeting for the First Intersessional Meeting of the *Implementation Review* (see Item 6.3.2 and Annex D1, item 11.2).

SC/62/NPM19 provided information on bycatch of minke whales in Korean waters from 1996 to 2008. The authors collected bycatch data from the 14 local branch offices of the Korea Coast Guard which investigates the bycatch of cetaceans. A total of 1,156 minke whales were bycaught of which 83.7% were bycaught in the East Sea; 363 animals were entangled or trapped by set nets, 316 and 303 were entangled by fish pots and gillnets, respectively.

SC/62/NPM26 provided information on incidental catches off Korea based on DNA profiling of market products (discussed under Annex J, item 9.4), which suggested that reported bycatch totals may be underestimated. The Committee was informed that the large majority of the incidental catch off Japan was taken in set nets; 119 common minke whales were bycaught in set nets and one animal in a gill net during 2009 (SC/62/ProgRepJapan).

The Committee **recommends** that available data on incidental catches and the associated effort should be analysed to develop CPUE series for possible use during the *Implementation Review*. The Committee **agrees** that sufficient information is available that alternative hypotheses regarding time-series of historical commercial and incidental catches can be developed during the *Implementation Review*. The Committee **agrees** that during the *Implementation Review* there is sufficient information to disaggregate the historical commercial and incidental catches to sub-areas and periods during the year.

The Committee received information on likely future whaling operations for minke whales in the western North Pacific. Japan aims to conduct land-based and pelagic whaling. Land-based whaling will be restricted to close to Japan while pelagic whaling will occur mainly in offshore areas. Temporal and spatial restrictions will be imposed on both types of whaling to try to reduce catching J-type animals. Korea intends to conduct land-based whaling to the east and west of Korea from March to November. These whaling plans will need to be elaborated further during the First Intersessional Workshop of the *Implementation Review*.

The work related to catches that needs to be completed prior to the Preparatory Meeting for the First Intersessional Workshop of the *Implementation Review* is:

(1) construction and GLM standardisation of CPUE series using the incidental catches and the associated fishing effort (see also Annex D1, item 8.3);
(2) development of a format for reporting incidental catches by Japanese and Korean scientists to the Secretariat and the provision of these data in the agreed format to the Secretariat; and
(3) development of alternative hypotheses regarding time-series of past and future commercial and incidental catches.

6.3.1.3 ABUNDANCE ESTIMATES

The Committee reviewed information available on abundance surveys and estimates of abundance.

SC/62/NPM2 provided estimates of abundance for the JARPN II survey area (sub-areas 7, 8 and 9, excluding the Russian EEZ) for the early (May and June) and late (July and August) seasons for 2006 and 2007. SC/62/NPM16 analyzed sightings data from recent surveys conducted by Korea in the Yellow Sea (sub-area 5) and the East Sea (sub-area 6) to estimate the abundance of common minke whales. Details are given in Annex D1, item 7.1.

SC/62/NPM24 reported on a sighting survey for minke whales and other cetaceans in the East Sea from 21 April to 30 May, 2009. An provided oversight on behalf of the Scientific Committee and the survey was undertaken in accordance with IWC guidelines. The plan had been presented to the 2008 Annual Meeting (Choi *et al.*, 2008) and was endorsed by the Committee. Details are given in Annex D1, item 7.1. The Committee expressed its appreciation to the Government of Korea for its continued commitment to surveys for minke whales in Korean waters, and to An for his role of oversight on behalf of the Committee. The Committee **agrees** that data from the 2009 survey off Korea are suitable for use in the RMP.

SC/62/NPM7 summarised the sighting surveys for minke whales in the western North Pacific conducted by Japan and Korea since 2000. The survey period for 'J' stock was April-June, and that for 'O' stock July-September. The areas covered were the Korean EEZ in sub-areas 5 and 6, the Japanese EEZ in sub-areas 6 and 10, the Russian EEZ in sub-area 10, the Sea of Okhotsk (sub-areas 11 and 12) and east of the Kurile archipelago and Kamchatka (sub-areas 8, 9 and 12), including the Russian EEZ. A total of 505 minke whale schools (560 animals) were sighted on 27,045 n.miles on primary search effort in 22 cruises.

SC/62/NPM8 updated the integrated abundance estimates for minke whales in sub-areas 5, 6 and 10 using new information on abundance and *g*(0). SC/62/NPM14 reviewed the proposed method in SC/62/NPM8 for integrating surveys for use in the *Implementation Simulation Trials*. Details are given in Annex D1, items 7.1 and 7.3.

The Committee **endorses** the method used to combine sightings data over time to estimate the extent of additional variance, but not necessarily the methods proposed for dealing with abundance across spatial areas in this case because of concerns over migration during the survey and extrapolation (see also Annex D1, item 7.3). The Committee did not review the abundance estimates in SC/62/NPM8 *inter alia* because it is unclear whether the sub-areas used for reporting abundance estimates will be used in the *Implementation Simulation Trials* developed during the First Intersessional Meeting. It was noted that although models can be used to interpolate abundance for unsurveyed regions, if a region has never been surveyed, the abundance estimate for that region should be set to zero when calculating catch limits under the RMP.

The Committee discussed possible migration patterns of 'J' stock minke whales in the Sea of Japan, as well as whether some component of the 'J' stock may not migrate to a substantial extent, in relation to how abundance estimates are computed and used in *Implementation Simulation Trials* and when applying the *CLA*. The Committee **agrees** that care needs to be taken to avoid double-counting animals when computing abundance estimates. In relation to animals in the Sea of Japan and the Yellow Sea, the Committee **agrees** that the *Implementation Simulation Trials* will capture hypotheses regarding the migration patterns of western North Pacific minke whales and that the models underlying these trials would be specified accordingly. The abundance estimates used for conditioning will be allocated to the appropriate time periods to avoid double counting.

The Committee **agrees** that there are several abundance estimates available for possible use when conditioning trials. Annex D1, table 1 provides a summary of the sightings surveys for the sub-areas used in the last set of *Implementation Simulation Trials* and those conducted since. The Committee did not discuss the acceptability or otherwise of the use of these surveys for conditioning the *Implementation Simulations Trials*.

The Committee noted that it was not necessary to select the abundance estimates for use in the *CLA* at the present meeting; this will take place during the First Intersessional Meeting of the *Implementation Review*. The selection of abundance estimates for use in *CLA* will need to take account of whether or not the surveys and their analysis followed the Requirements and Guidelines for Conducting Surveys and Analysing Data within the RMP (IWC, 2005c). Some of these surveys (e.g. those from JARPN II) have not been reviewed by the Committee for use in the RMP.

SC/62/NPM9 provided revised estimates of *g*(0) and abundance for western North Pacific common minke whales. The main changes from the previous analyses were the addition of new data, particularly for the Okhotsk Sea for 2003 and 2005. Details are given in Annex D1, item 7.5. The Committee welcomed this analysis which substantially reduced the previous range for *g*(0) but there was insufficient time for an in-depth review. The Committee **agrees** to review the method used to estimate *g*(0) and the resultant estimates further at the First Intersessional Workshop.

The Committee received information on plans for future sighting surveys by Korea and Japan (SC/62/NPM17 and SC/62/NPM4). Japan noted that it was not currently planning to conduct surveys in sub-areas 6 and 10, but may revise that decision in future. It was noted that the results of the *Implementation Simulation Trials* may provide information on which programme of surveys will lead to the best performance of the RMP, and that Japan and Korea may wish to modify their survey plans once the results of initial trials become available.

More specifically, SC/62/NPM25 described plans for a sighting survey in the Yellow Sea in April-May 2011, with the objective to obtain information on the distribution and abundance of minke whales. Details are given in Annex D1, item 7.6. The Committee was pleased to see that distance and angle estimation will be tested and **requests** that the results of analyses of these and previous data be presented to future meetings. It was noted that the survey could be conducted to eliminate the possible implications of migration during the survey. The Committee appointed An to provide oversight on behalf of the Committee.

SC/62/NPM23 described plans for a sighting and biopsy sampling survey for common minke whales in the Okhotsk Sea during summer 2010. The aim of the survey is to collect sightings data for abundance estimation and information on stock identification. To overcome CITES-related issues, genetic analysis using biopsied skin samples will be conducted on the research vessel. The Committee noted the importance of estimating the proportion of 'J' and 'O' stock animals in the survey area. It **recommends** that Japan explore ways that are not constrained by CITES to facilitate extracting relevant information from biopsy samples collected from the EEZ of Russia which could be used to examine stock structure and mixing. Specific suggestions for this are given in Annex D1, item 7.6. The Committee appointed Miyashita to provide oversight on behalf of the Committee.

6.3.1.4 OTHER ISSUES

Regarding information for estimating dispersal rates and mixing proportions, the Committee noted that SC/62/O30 outlined an approach for estimating mixing rates between stocks using microsatellite data.

Values for the biological parameters for use in *Implementation Simulation Trials* for the western North Pacific common minke whales had been assembled for the previous *Implementation* (IWC, 2004).

The previous trials were based on values for MSYR(mat) of 1% and 4%. These values should be used in any new trials unless the current review of MSY rates (Annex D, item 2) leads to a recommendation for a change to this range.

The Committee noted that CPUE data had been assembled and used to compare alternative stock structure hypotheses (Yasunaga *et al.*, 2009, Appendix II). It **recommends** that relevant commercial and incidental catch and effort data, along with the information identified by the 1987 CPUE Workshop (IWC, 1989), should be assembled, GLM standardised where possible, and be available at the First Intersessional Workshop of the *Implementation Review*. Data on flipper colour and conception dates should also be assembled and presented to the Preparatory Meeting of the First Intersessional Workshop of the *Implementation Review*. Initial discussions of future experimental and analytical ways to distinguish among competing hypotheses are given in Annex D1, item 10.

6.3.2 Recommendations

The Committee **agrees** that it has successfully addressed all of the items required for a *pre-Implementation assessment* and therefore **agrees** that the *pre-Implementation assessment* is completed.

The Committee **recognises** that there is a considerable amount of work that needs to be done to complete the *Implementation Review*. Specifically, there is a need: (a) to assemble the data so that they can be used when conditioning the operating models on which the *Implementation Simulation Trials* are based; (b) to specify and code the operating models themselves; and (c) to fit the operating models to the agreed data sets (conditioning).

The Committee **agrees** that it is infeasible to conduct all of the work in a single meeting (the First Intersessional Meeting). Rather, it **agrees** that the probability of completing the work during the first year of the *Implementation Review* will be maximised if two meetings occur. The main objective of the first (the Preparatory Meeting) would be to determine the structure (time-steps, sub-areas and population components) of the operating models so that all relevant data can be assembled at the appropriate spatial and temporal resolutions in time for the First Intersessional Workshop, and to start to specify the operating models and how they will be conditioned. The second step would be to complete work scheduled at the First Intersessional Workshop.

Annex D1, Appendix 9 outlines the work plan in more detail, including tentative dates for deadlines and holding the Preparatory Meeting and the First Intersessional Workshop.

6.4 North Atlantic common minke whales

6.4.1 New information on stock boundaries and abundance estimates

Some of the *Small Areas* boundaries for North Atlantic minke whales were changed during the 2003 *Implementation Review* but not all boundaries were fully specified. The Committee **recommends** that a point at 63°N, 12°W be introduced to fill the 'hole' between the CM and CIP *Small Area*, and that boundaries around the southern tip of Greenland be defined as shown in Annex D, fig. 1. It also **recommends** that the *Small Areas* in Annex D, fig. 1 be adopted for use when the applying the RMP for North Atlantic minke whales.

SC/62/RMP6 presented a method for estimating *g*(0) from single platform line transect data in which both the forward and perpendicular distances have been recorded. More details are given in Annex D, item 3.3.2. The Committee noted that attempts had been made in the past to estimate *g*(0) using data from a single platform. It **encourages** efforts to develop methods to achieve this. The Committee **recommends** that the robustness of the method proposed in SC/62/RMP6 to model structure uncertainty, measurement error, and diving pattern be examined.

SC/62/RMP7 summarised a sightings survey conducted in the North Sea area within *Small Area EN* during summer 2009. More details are given in Annex D, item 3.3.2. The Committee **welcomes** this information and noted that these data would be included in a future abundance estimate for the North Atlantic common minke whales.

SC/62/RMP5 presented estimates of abundance for common minke whales in the Central Atlantic from the North Atlantic Sightings Survey conducted by Icelandic and Faroese vessels during June/July 2007. More details are given in Annex D, item 3.3.2.

The Committee **agrees** that the methods in SC/62/RMP5 followed the relevant RMP Guidelines. Annex D, table 1 lists the estimates of abundance in SC/62/RMP5.

The Committee **agrees** to adopt the estimates of abundance for 2007 for the CG and CIP *Small Areas* presented in Annex D, table 1 for use in the RMP.

The Committee **endorses** abundance estimates for the CM *Small Area* and for the Eastern *Medium Area*, by *Small Area*, for use in the RMP given in Annex D, table 2.

6.4.2 Recommendations and work plan

The Committee **recommends** that the boundaries in Annex D, fig. 1 be adopted for use when applying the RMP for North Atlantic minke whales. It also **recommends** that abundance estimates in Annex D, tables 1 and 2 be adopted for use in the RMP. The Committee **agrees** that its work plan for the 2011 Annual Meeting will include the review of any new abundance estimates.

7. ESTIMATION OF BYCATCH AND OTHER HUMAN-INDUCED MORTALITY (BC)

The report of the Working Group on Estimation of Bycatch and Other Human-Induced Mortality is given as Annex J. This subject was introduced onto the Agenda in 2002 (IWC, 2003c) because as part of the Revised Management Procedure, recommended catch limits must take into account estimates of mortality due to *inter alia* bycatch, ship strikes and other human factors in accordance with Commission discussions at the 2000 Annual Meeting (IWC, 2001a), although of course such mortality can be of conservation and management importance to populations of large whales other than those to which the RMP might be applied. Subsequently, the issue of ship strikes has become of interest to the Commission's Conservation Committee (IWC, 2006a).

7.1 Collaboration with FAO on collation of relevant fisheries data

The effort to compile a comprehensive database of entanglement data in the national progress reports, an element of collaboration with FAO, has continued; the IWC Secretariat has now entered data from 2004-09.

7.2 Progress on joining the Fisheries Resource Monitoring System (FIRMS)

The information potentially to be developed in collaboration with FIRMS includes an inventory of fisheries, including gear characteristics and some indicators of fishing effort. The IWC will be eligible to move from observer status to full partnership in FIRMS after completion of the entanglement database (see Item 7.1, above). Details are provided in Annex J.

7.3 Estimation of bycatch mortality of large whales

7.3.1 Mortality in longline fisheries

The Committee received a global review of operational interactions between cetaceans and longline fisheries (SC/62/BC6). It reported deaths of humpback and Bryde's whales. In addition, mortality of southern right whales has been recorded elsewhere (Best *et al.*, 2001). Depredation by some species of cetaceans such as sperm and killer whales (Kock *et al.*, 2008; Kock *et al.*, 2006; Purves *et al.*, 2005) is of economic importance to some fisheries. Research to mitigate depredation and mortality can potentially contribute to estimating both fish and cetacean mortality rates.

7.3.2 Bycatches in Korea and Japan

Genetic analysis of samples of cetacean meat collected in markets in Korea in 2004-05 suggested that 90 common minke whales were represented (SC/62/NPM26). Details of the analyses are given in Annex J. The small number of samples from the same individuals suggests that the whales pass through the market rapidly. The reported bycatch for Korea for 2004 was 61. The detection of a minimum of 90 whales in the market indicates that the true bycatch was greater than reported. The reported bycatch for 2009 is 54. The results of the 2004-05 market survey analyses suggest that this is likely an underestimate.

The Committee welcomed publication of a recent paper describing incidental entanglement of minke whales in the Republic of Korea (Song *et al.*, 2010). This contained information that had been previously been requested of Korea by the Committee.

The Committee noted the need for time series of bycatch for the *Implementation Simulation Trials* for North Pacific common minke whales (see Item 6.3) for Japan and the Republic of Korea. The Committee reviewed the method presented in SC/62/NPM4 to estimate past incidental catches of minke whales in Japan (details are given in Annex J). Concern was raised regarding the multiplicative factor used to adjust reported catch figures for the period 1979-2000. It was noted that there was considerably more variability in the early reported figures, with CVs for the 1980s and 1990s three to six times higher than since 2001. For this reason, some members suggested that a multiplicative adjustment was not appropriate and that the reports of zero bycatch for some years, (which also resulted in zero estimates) were implausible. Other members considered that estimates in SC/62/NPM4 are an improvement compared to the previous assumption of 100 animals each year over a 100-year period. Butterworth commented that point estimates of zero for some years did not necessarily invalidate the method as a basis for estimating cumulative bycatch mortalities over time, which was the primary input required for *Implementation Simulation Trials*; nevertheless he encouraged refinement of the method presented.

In conclusion, the Committee **recommends** that additional analyses to arrive at time-series of bycatches in the region be undertaken for presentation to the preparatory meeting for the first intersessional workshop. In response to a suggestion from some members that bycatch in fisheries other than set nets warrants further examination, including historical information on past fisheries, e.g. the Japanese squid driftnet fishery of 1978-1992 (Yatsu *et al.*, 1994); it was noted that bycatches occur only rarely in types of gear other than set nets in Japanese waters, as reported in the national progress reports of Japan.

7.4 Estimation of risks and rates of entanglement

7.4.1 Report of intersessional workshop

The Committee noted relevant information on entanglement mortality in an advance copy of the report of the Commission's intersessional Workshop on Welfare Issues Associated with the Entanglement of Large Whales (IWC/62/15). The Workshop concluded that:

(1) all species of large whales are at risk of entanglement to varying degree, but common minke, humpback, right (both North Atlantic and southern) and gray whales are the most frequently reported;
(2) all types of stationary or drifting gear (i.e. not actively towed) pose potential risk to entangle, but pound, set and fyke-type nets, along with gill nets and various pot-type gear were most frequently implicated;
(3) entanglements can occur wherever this type of gear and large whales overlap in distribution, and isnot limited to feeding grounds but also includes breeding grounds as well as migratory pathways;
(4) given the cryptic nature of large whale entanglements in combination with the paucity of experienced observers and lack of formal reporting networks, entangled whales are severely underreported globally; and
(5) regional shifts in fisheries and gear types can produce major differences in the character of entanglements and reporting frequency (e.g. coastal versus offshore gear placement).

Based on these conclusions, the Workshop made the following relevant recommendations:

(1) that coastal nations establish adequate programmes for monitoring entanglement of whales; and
(2) that member countries improve reporting to the IWC through National Progress Reports.

The Committee **endorses** these recommendations. In addition it **recommends** that:

(1) all member countries which have coastal fishing operations be encouraged to more accurately report the occurrence and nature of large whale entanglements and establish entanglement response programmes where applicable;
(2) existing and new programmes communicate with each other to standardise the data collected to maximise their usefulness; and
(3) members be encouraged to facilitate thorough examinations of carcasses, at a minimum to record whether fishing gear is present, or fresh scars which might have resulted in mortality are visible, as well as facilitating necropsies on all large whales whenever possible. Such investigations should be conducted irrespective of population status, since this will be required to better estimate entanglement mortality rates including for species and populations that may be subject to whaling.

Additional details reported concerning the entanglement response networks of various nations are given in Annex J.

7.4.2 Entanglement mortality in Oman

An analysis of scars in the peduncle region indicates that 30-40% of whales observed in the isolated and severely depleted population of humpback whales in the western Arabian Sea (known as Breeding Stock X) were likely to have been involved in entanglements (SC/62/SH20). Of 10 stranded baleen whales, three were entangled in gill nets. Fishing effort, including use of drifting and set gillnets and fish traps, is increasing rapidly in the region. The Committee **welcomes** the establishment of a national stranding committee by the Government of Oman, and **recommends** that all member states that do not have national stranding networks to establish these. The importance of indications of fishing effort was also emphasised. The possibility of this population being considered as a candidate for a conservation management plan is discussed under Item 11.2.2.4.

7.5 Progress on including information in National Progress Reports

The data on entanglements and ship strikes reported in this year's National Progress Reports are summarised in Appendix 2 to Annex J. The Committee last year considered a proposal for developing a mechanism for online submission of the information; progress on issues related to online submission of bycatch and other information is discussed further under Item 3.2 and 25 and in Annex P.

7.6 Review of methods to estimate mortality from ship strikes

7.6.1 New data on ship strikes

The Committee received a report on ship strikes affecting southern right whales in Uruguayan waters (SC/62/BC2); between 2003 and 2007, seven whales were observed with large wounds due to collision and five were stranded dead. The Committee **welcomes** this information, noting that this is the type of information requested to be included in the national progress reports; in combination with data on shipping traffic, it may allow comparative analysis of ship-strike rates along the Atlantic coast of South America.

After consideration of a report of a 'near miss' between a humpback whale and a cruise ship in the Antarctic (see Annex J, item 10.1), it was **agreed** that a study of near-miss data (it is known that ferry operators in Hawaii collected such data) may yield additional insight into the dynamics of ship strikes and provide input for modelling risk (see below).

7.6.2 Progress in modelling risk

A report was received on progress in a series of winter and summer surveys of fin whale distribution and abundance in the Mediterranean Sea especially near the Italian coast and in the Pelagos Sanctuary. These surveys are in part intended to improve evaluation of population level effects of human-induced mortality including ship strikes. Details of the results are in Annex J. Plans to collect data on ship traffic were also detailed. The Committee **encourages** continuation of this effort that makes an important contribution towards the modelling of risk and assessing population level effects.

7.7 Progress in developing global database of ship strikes

This effort has been underway since 2007, with associated activities by IMO and ACCOBAMS. Tasks identified at last year's meeting have been completed or are nearly completed. Progress has relied on informal arrangements among the Secretariat, members of the data review group, and an external contractor. In view of the increasing workload and proposed intersessional tasks, detailed in Annex J, Appendix 3, the Committee **recommends** that consideration be given to the appointment of a dedicated coordinator; this is the practice for other similar successful databases of this scale. Funding requested to support intersessional work including data validation, the creation of a handbook and for work on data entry is discussed under Item 24.

The Committee **endorses** the policy on release of information in the database in response to requests from the public detailed in Annex J, Appendix 3. Information from nine fields in the database will be eligible for release on a down-loadable basis. Only data on confirmed ship strikes will be released. Requests for full access will be dealt with on an individual basis.

The Committee noted that IWC and ACCOBAMS will hold a joint workshop in Monaco from 21-24 September 2010 on reducing risk of ship strike and that some agenda items will be relevant to data gathering and estimating numbers of collisions. The IWC also continues to collaborate with IMO on efforts to minimise the risk of ships strikes and to reduce underwater noise from commercial shipping (Annex K, item 9.4).

7.8 Other issues

7.8.1 Methods for assessing mortality from acoustic sources

There was no new information on this topic. However, the Committee noted development of an improved method for handling and analysis of gas embolisms found in stranded cetaceans (Bernaldo de Quiros *et al.*, 2010); such embolisms may be linked with acoustic sources. A workshop entitled 'Diving marine mammals gas kinetics' was held in Woods Hole, MA, USA in April 2010 and the Committee looks forward to receiving the report at next year's meeting.

7.8.2 Methods for assessing mortality from marine debris

Methods used in a study modelling co-occurrence of debris and cetaceans (SC/62/BC5) have potential value for assessing mortality from debris. The Committee **recommends** that full necropsies be conducted on all stranded large whales, irrespective of population status, to detect incidents of mortality associated with ingested debris (and see the earlier recommendation on entanglement).

7.8.3 Other potential sources of human-induced mortality

The Committee noted that while there have been no confirmed reports of whale mortality due to collisions with marine renewable energy developments, the potential exists for such (SC/62/E7 and E8) and see Carter *et al.* (2008).

7.8.4 Actions arising from intersessional requests from the Commission

The Committee was asked to review Annex {DNA} of IWC/62/7rev. This contains a section on market sampling. Although the proposed scheme has the purpose of acting as a deterrent to illegal activity, the Committee noted that it might also potentially provide information for estimating bycatch. A workshop and simulation studies were conducted in the past by the Committee to assess the possibilities for developing a market sampling system to estimate bycatch (details in Annex J).

8. ABORIGINAL SUBSISTENCE WHALING MANAGEMENT PROCEDURE (AWMP)

This item continues to be discussed as a result of Resolution 1994-4 of the Commission (IWC, 1995a). The report of the SWG on the development of an aboriginal whaling management procedure (AWMP) is given as Annex E. The Committee's deliberations, as reported below, are largely a summary of that Annex, and the interested reader is referred to it for a more detailed discussion. The primary issues at this year's meeting comprised: (1) *Implementation Review* of eastern gray whales; (2) various aspects of providing management advice for Greenlandic hunts; and (3) review of management advice for the humpback whale fishery of St. Vincent and The Grenadines. This represented a significant workload. The Chair of the SWG noted that its work this year had been considerably assisted by the progress made at the intersessional Workshop on Greenland fisheries held in Roskilde, Denmark (SC/62/Rep3).

In addition, he recalled that two years ago (IWC, 2009c), the Committee had tested and agreed a safe method to provide interim advice (i.e. catch limits for up to two 5-year blocks) such that the catch limit is 2% of the lower 5th percentile of the most recent estimate of abundance.

8.1 Sex ratio methods for common minke whales off West Greenland

The Committee has been evaluating assessment methods for common minke whales off West Greenland that rely on the relationship between the observed sex ratio of catches and that inferred from population models parameterised in terms of carrying capacity, productivity and how the distribution of males may have changed relative to that of females. This concept was introduced in 2005 (IWC, 2006b; Witting, 2005). The major factor which suggests that sex-ratio data may be informative about population size is that catches have consistently been female-dominated. 'Best' estimates of population size from sex ratio based methods are infinite, in effect indicating that any level of past catches would not have impacted this population of minke whales. However, it is standard Scientific Committee practice, in accordance with a precautionary approach, to base management advice primarily on lower confidence bounds for such estimates. The Committee has therefore focussed attention on developing the novel assessment approach required to calculate these bounds.

Considerable technical work was undertaken by the SWG during the intersessional period with a view to being able to test the approach with an initial set of robustness trials as described in SC/62/Rep3. However, implementation of the new method is proving extremely difficult. The details of this are complex and can be found in Annex E, item 3.1.3 but in short can be said to be due to the continued difficulties the SWG has faced with the likelihood function that underlies the sex-ratio approach.

Several remedies were considered by the SWG. The most promising of these was to re-parameterise the analysis by replacing *K* (carrying capacity) with a suitable transformation. This can be thought of as a high-risk/high-reward option: it could provide an adequate basis for estimation thereby eliminating many of the intricacies that continue to plague the current framework, but it may introduce new difficulties.

The Committee **endorses** the SWG recommendation that this approach receive the highest priority during the next intersessional period. If a transformed analysis could be completed and agreed at the 2011 Scientific Committee meeting, the sex-ratio method could be used as a basis for abundance estimation and submitted to appropriate simulation trials to test performance and robustness. If these trials are passed, the approach could then be used for providing management advice and as a basis for a long-term *SLA* (Item 8.3).

The SWG also considered a number of other options which would not require such a drastic change but which it considered had less chance of being successful, as can be seen in Annex E. An option to try raising the current truncation point was shown not to solve the issue as a result of runs undertaken after the SWG had completed its work.

The SWG had agreed that the continued difficulties in successfully implementing a sex-ratio approach required a re-evaluation of its work plan. The original motivation for this work had been the Committee's inability to provide management advice for this hunt. Thus, reflecting the priorities of the Scientific Committee and the Commission, work on a sex ratio estimation of abundance for West Greenland common minke whales has been the dominant focus of SWG effort for a number of annual meetings and three intersessional workshops.The participants have devoted considerable research effort to this task, the work has been scientifically challenging and methodologically innovative and the potential gain in terms of providing adequate management advice extremely high. However, despite enormous effort, no satisfactory conclusion has been achieved to date. Last year, the Committee had agreed an abundance estimate for common minke whales off West Greenland that, in conjunction with the agreed approach to provide safe interim advice for up to two five-year blocks, meant that the Committee was able to provide satisfactory management advice for the first time.

Therefore, the SWG had concluded that it would no longer prioritise development of the sex ratio approach unless a comprehensive final analysis could be endorsed at the 2011 Scientific Committee meeting. Although it would be regrettable to abandon the sex ratio effort without obtaining an agreed abundance estimate, there are many other urgent issues to which the SWG must turn its focus. The Committee **concurs** with this view.

8.2 Conduct *Implementation Review* of eastern North Pacific gray whales

In 2004, (IWC, 2005d), the Committee presented the Commission with its recommended Gray Whale *Strike Limit Algorithm* (the *Gray Whale SLA*) and this was endorsed by the Commission. The scheduled 2009 *Implementation Review* had been postponed because a number of key analyses would not be ready in time.

The purpose of an *Implementation Review* is to update information on catch history and abundance and to determine whether any other new information that has become available in the intervening (normally) 5-year period indicates that the present situation is outside the region of parameter space tested during *SLA* development. If this is the case, additional trials will need to be developed to test the performance of the *SLA* in this new region. If performance is found to be unacceptable under these new trials, revisions to the *SLA* will be required.

Full details of the parameter space investigated in the development of the *Gray Whale SLA* can be found in IWC (2005d). In practical terms, the most important issues relevant to the present *Implementation Review* relate to the issues of stock structure and updated information on abundance/trends.

8.2.1 The issue of the DAA and the conduct of this Implementation Review

Implementation Reviews are subject to the Committee's Data Availability Agreement incorporating a timetable of events. Although many datasets and analyses were completed within the appropriate timelines, unfortunately, just before adoption of its report, the SWG had realised that the photo-id and genetics data central to its discussions of stock structure and movements had not formally been submitted to the IWC under the DAA (although the papers themselves had met the appropriate deadlines). The same is also true for the telemetry data that, while not central to the conclusions reached, was also discussed under that Agenda Item; in this case the paper also did not meet the appropriate deadline.

The Committee recognised that discussions of these data cannot be considered as part of the *Implementation Review.* Thus although the *Implementation Review* is considered complete with respect to the discussions involving the data properly made available under the DAA, it **recommends** that a new *Implementation Review* takes place at the next Annual Meeting. This is to enable the SWG to take properly into account the important new information received this year that had not met the DAA timeline and that could indicate that the original trial structure was not sufficiently broad (see Item 8.2.7). This issue is referred to, where appropriate, in other parts of this report. A mechanism to ensure that this unfortunate event does not happen again is discussed under Item 8.2.8.

8.2.2 Stock structure

In the development process for the *Gray Whale SLA*, the possibility of a summer feeding aggregation along the Pacific coast between California and southeast Alaska was noted (e.g. IWC, 2001h) but the Committee had agreed that a single stock scenario was the most appropriate (IWC, 2002d).

Considerable new information has been collected since that time on the animals feeding along the Pacific coast and the SWG received three papers of relevance to stock structure at this meeting (unfortunately, as noted above, these did not meet all of the DAA requirements). Although different names have been used in the past by different authors (e.g. the southern feeding group, the Pacific Coast Feeding aggregation), the Committee **agrees** to refer to the animals that spend the spring, summer and autumn feeding in coastal waters of the Pacific coast of North America from California to southeast Alaska as the Pacific Coast Feeding Group or PCFG.

SC/62/AWMP1 presented an analysis of the genetic differentiation between the PCFG (using samples from Vancouver Island) and the larger population (using samples from Baja California). The authors concluded that their results suggest that the matrilines of the southern feeding group are demographically independent from those of the rest of the population, and therefore require separate management consideration.

SC/62/BRG32 reported the results of an 11-year (1998-2008) photo-id study examining the abundance and the population structure of eastern gray whales that spend the spring, summer and autumn feeding in coastal waters of the Pacific Northwest. With respect to stock structure, it concluded that there is one group of whales that return frequently and account for the majority of the sightings in the Pacific northwest during summer and autumn (i.e. the PCFG) and a second group of whales are apparent 'stragglers' encountered in this region after the main migration.

The discussion was also informed by consideration of telemetry data (SC/62/BRG21) and the details can be found in Annex E, item 2.2.

The Committee thanked the authors for these comprehensive papers. There was considerable discussion of them and their implications for stock structure. Despite some differences in interpretation and recognising that further analyses could be carried out, the Committee **endorses** the SWG's conclusion that the hypothesis of a demographically distinct PCFG was plausible and warranted further investigation. The implications of this for the *Implementation Review* are discussed under Item 8.2.7.

Telemetry data may provide the best estimator of residency times for PCFG gray whales in order to evaluate their relative vulnerability with respect to the spatial and temporal characteristics being considered for the Makah hunt. Analogous data from non-PCFG whales may also help determine if there are differences between PCFG and non-PCFG whales with regard to their migrations (distances from shore, water depths or timing) or other behaviours. Therefore, the Committee **recommends** that the satellite tagging work should continue and that these data be analysed with the goal of providing input (e.g. as required in mixing matrices, etc.) for any future trials of the *Gray Whale SLA*.

8.2.3 Catch data

Allison informed the SWG that the catch series had been updated to incorporate new information. The complete series can be found in Annex E, table 1.

8.2.4 Abundance and trends

Two papers relating to calf counts were considered, one from migration and one from the breeding grounds.

SC/62/BRG1 presented calf counts from shore-based surveys of northbound eastern North Pacific gray whales that have been conducted each spring between 1994 and 2009 in central California. Estimates were highly variable between years, with no sign of a positive or negative trend. Calf production indices, ranged between 1.6 - 8.8% with an overall average of 4.2%. The authors hypothesised that a late retreat of seasonal ice may delay access to the feeding areas for pregnant females and reduce the probability that existing pregnancies will be carried to term.

SC/62/BRG36 reported on changes in the abundance of gray whales inferred from boat surveys at Laguna Ojo de Liebre and Laguna San Ignacio between the late 1970s to the present. There was a decrease in the numbers of cow-calf pairs in both lagoons during 2007 to 2009, similar to the results from shore-based surveys at Piedras Blancas during the northbound migration. The counts of cow-calf pairs in both lagoons in 2010 were the lowest over the last 15 years.

In discussion, it was noted that the calf production indices were particularly low (<3%) during two periods (1999-2001 and 2007-09). During the first period, calf counts were low and high numbers of strandings also occurred. However, although the calf counts were low during 2007-09, there is no evidence for higher numbers of strandings during these years. The Committee noted that the calf production indices are being used in its discussion of MSY rates (see Item 5.1). Although the time-series of calf counts is now 16 years long, this is only just long enough to allow estimation of these parameters.

The Committee therefore **recommends** that these data continue to be collected and are reviewed during future *Implementation Reviews*. The series of cow-calf counts in lagoons, which provide a relative index not absolute estimates, are consistent with the calf counts given in SC/62/BRG1.

The Committee noted that the calf count data had been used during the initial development and *Implementation* for eastern gray whales and **agrees** that the new information did not indicate a need to modify the trials structure.

The Committee had two new papers relating to total abundance estimates. The first, SC/62/BRG8 reported a promising new approach that has recently been adopted for the counts of southbound migrating whales at Granite Canyon, California, which form the basis of abundance estimation for the eastern gray whales. The authors recognised the need for new calibration data to evaluate the different biases of new counting methods and new observers before count data can be reliably rescaled to estimate abundance.

The Committee welcomed this report, noting the importance of ensuring comparability among years in any long-term monitoring effort. It **recommends** that data be collected to re-evaluate pod size bias given the change in survey protocol and that variance estimates for future survey estimates of abundance account for the uncertainty associated with calibration of abundance estimates computed using different survey protocols.

The second paper, Laake *et al.* (2009), re-evaluated the data from all 23 seasons of shore-based counts for the Eastern North Pacific stock of gray whales conducted throughout all or most of the southbound migration near Carmel, California using a common estimation procedure and an improved method for treatment of error in pod size and detection probability estimation.

In addition to these papers, the Committee noted that the telemetric information in SC/62/BRG21 provided the first confirmation of day/night migration rates since the original

Table 2
Time-series of agreed abundance estimates of eastern gray whales for use in the *Gray Whale SLA* (taken from Laake *et al.*, 2009).

Year	Estimate	CV	Year	Estimate	CV
1967/68	13,426	0.094	1979/80	19,763	0.083
1968/69	14,548	0.080	1984/85	23,499	0.089
1969/70	14,553	0.083	1985/86	22,921	0.081
1970/71	12,771	0.081	1987/88	26,916	0.058
1971/72	11,079	0.092	1992/93	15,762	0.067
1972/73	17,365	0.079	1993/94	20,103	0.055
1973/74	17,375	0.082	1995/96	20,944	0.061
1974/75	15,290	0.084	1997/98	21,135	0.068
1975/76	17,564	0.086	2000/01	16,369	0.061
1976/77	18,377	0.080	2001/02	16,033	0.069
1977/78	19,538	0.088	2006/07	19,126	0.071
1978/79	15,384	0.080			

radio tag information that has been used when estimating abundance from the southbound census. The Committee thanked the authors for this comprehensive and careful review of this extremely valuable time-series of absolute abundance estimates. It **recommends** that the estimates of abundance given in Table 2 be **adopted** for use in the *Implementation Review* and for use when applying the *Gray Whale SLA*.

SC/62/BRG32 referred to under Item 8.2.2, also used the photo-id data to estimate the abundance of the PCFG. Abundance estimates for whales present in summer and autumn were estimated using both open and closed population models. Methods were proposed to remove the 'stragglers' from both types of analyses, to estimate abundance only of regularly returning whales. Three methods and four geographic scales revealed the abundance of animals that regularly return to the Pacific Northwest to be at most a few hundred individuals.

The Committee **agrees** that these data will be extremely useful during the proposed 2011 *Implementation Review*, along with telemetry data, to determine the probability that animals from the putative feeding aggregation in the Pacific Northwest are at risk of being caught during hunts in that area (see Annex E, item 2.6). The estimates in SC/62/BRG32 will also be useful to condition any trials developed to examine the performance of *SLA* variants for this feeding aggregation.

8.2.5 Assessment
SC/62/AWMP2 fitted an age- and sex-structured population dynamics model to data on the catches and abundance estimates for the ENP stock of gray whales using Bayesian methods. The prior distributions used for these analyses incorporated the revised the estimates of abundance in Laake *et al.* (2009) and SC/62/BRG1, and account explicitly for the drop in abundance caused by the 1999-2000 mortality event. A series of sensitivity analyses were conducted. The baseline analysis estimated the population to be above MSYL and the 2009 population size (posterior mean of 21,911) to be at 85% of its carrying capacity (posterior mean of 25,808); conclusions were consistent across all the model runs. SC/62/AWMP2 only estimated an extra mortality parameter for 1999-2000 based both on calf and strandings data and the analysis of Brandon and Punt (2009a; 2009b) in which annual parameters were estimated for reproduction and survival.

The Committee thanked the authors of SC/62/AWMP2 for the updated assessment. It **agrees** that the results of the assessment are within the bounds considered during the *Implementation*. Although the base operating model used to estimate the *Gray Whale SLA* did not explicitly include the 1999-2000 event, robustness tests involving catastrophic mortality events were conducted and the *Gray Whale SLA* performed adequately for these tests.

8.2.6 Strandings data
SC/62/BRG25 provided a summary of all gray whale strandings in California, Oregon and Washington between 1 January 2010 and 31 May 2010. The Committee welcomes this information, **agrees** that it showed that stranding levels were now similar to 'normal' years, and **recommends** that these data continue to be collected and presented to the Committee.

8.2.7 Consideration of need for new trials (and, if applicable, results of those)
The Committee refers to its earlier comments on the situation with respect to the DAA and the need for an *Implementation Review*.

Although some of the papers/data available could not be considered in terms of the 2010 *Implementation Review*, the Committee **agrees** that the information provided on the PCFG was such that its existence represents a plausible hypothesis, not considered in the original *Implementation*. In accord with Committee guidelines for this process (IWC, 2005b), this is sufficient to trigger a new *Implementation Review* in 2011. The reason that this hypothesis is important from an AWMP perspective relates to the potential harvesting in this region by the Makah Tribe and thus the need for the SWG to provide advice/develop an *SLA* to fulfil both the 'conservation' and 'user' objectives given by the Commission. It noted that the situation for PCFG is not the same as for the Greenlandic feeding aggregation of humpback whales; the latter case involves a feeding aggregation that does not occur (even in the short-term during migration) with animals from other feeding aggregations in the waters where the hunt takes place. In the case of the proposed area for the Makah hunt, both PCFG and migrating whales from the other feeding areas co-occur at least some of the time. In fact the situation is more similar to that of Gulf of Maine humpback whales.

The Committee therefore **agrees** that the information on stock structure and hunting warranted the development of trials to evaluate the performance of *SLA*s for hunting in the Pacific northwest at the 2011 *Implementation Review*. The Committee also noted that the assessment work discussed above (Item 8.2.5) showed that the population as a whole is in a healthy state. It **agrees** that for the purposes of the 2011 *Implementation Review*, the primary focus should be the PCFG.

That being said, it also **agrees** that over the next few years (i.e. in time for an *Implementation Review* in about 2016), further work should be undertaken to investigate the possibility of structure on the northern feeding grounds, especially in the region of the Chukotkan hunts. It **recommends** that relevant information be collected from the Chukotkan region, in particular, where possible, including genetic samples and photographs from the hunt). In addition, the collation of information on the geographical and temporal distribution of the hunt will be valuable.

Annex E, item 2.6 provides some general guidance for the 2011 *Implementation* Review. The Committee **agrees** that any acceptable future *SLA* for the hunt in the Pacific northwest must include a feedback mechanism. It also requests that the Chair of the SWG discuss its requirements for need envelopes with the hunters and members of the

US delegation. The Committee **agrees** that the following would assist, but are not required for beginning, the trial development process:

(1) Collection/analysis of genetic data that would allow more robust comparison of such data from animals in the northern and southern feeding areas;
(2) Collection/analysis of genetic data from Kodiak Island to California to further examine the probable range of the PCFG;
(3) Collection/analysis of genetic data to compare further animals seen in only one year ('stragglers' in SC/62/BRG32) with animals that are frequently seen within the hunting area;
(4) Collection/analysis of additional information (including telemetry data) on the relative temporal 'availability' of PCFG animals within the hunting area (e.g. by month); and
(5) An updated analysis of any additional data to obtain the most recent abundance estimate for the PCFG at the time of the 2011 *Implementation Review.*

8.2.8 Conclusions and recommendations

In light of the DAA difficulties discussed earlier, the Committee **agrees** that it has completed the *Implementation Review* on the basis of the data that had been made available to it in accord with the DAA. However, given the new information available that did not meet the DAA conditions, it **agrees** that a new *Implementation Review* should occur in 2011 to take into account information provided on the PCFG which was presented outside the DAA as noted under Items 8.2.2 and 8.2.7. The Chair of the SWG **agrees** to ensure that all likely contributors to the review are made aware of the DAA requirements as well as the guidelines for genetic analyses and data. The draft guidelines for *Implementation Reviews* referred to under Item 8.4 will also assist this process. The Committee also **agrees** that preparatory discussions for the 2011 *Implementation Review* take place at the proposed intersessional workshop (see Item 21). Management advice for this population can be found under Item 9.2.2.

8.3 Continue work on developing *SLA*s for the Greenlandic fisheries

In 2009, the Committee agreed an approach for providing safe interim advice on catch limits that is valid for up to two five-year blocks. In doing so, this provides time for the SWG to develop long-term *SLA*s for the Greenlandic fisheries. Work on this has progressed in general terms (e.g. see discussion in SC/62/Rep3 and Annex E, items 3.3 and 4.2). However, particularly given the complexity of the multispecies hunt in Greenland, the Committee **agrees** that this must be given high priority for the future work of the SWG, such that suitable *SLA*s can be developed and tested before the interim advice expires.

Simulation evaluation of *SLA*s requires the development and parameterisation of a set of operating models. Unlike the situation for West Greenland common minke whales, the SWG has an assessment for West Greenland fin whales which means that it is in a better position to develop an *SLA* for fin whales. Last year, it was agreed that the set of RMP trials developed to evaluate variants of the RMP for North Atlantic fin whales would be an appropriate starting point for developing such trials and this year the SWG was presented with a summary of the stock structure hypotheses underlying those trials. These will need to be modified to focus more on the uncertainties pertinent to West Greenland if they are to form the basis for evaluation of *SLA*s for fin whales. Unfortunately, the SWG did not have time to consider this further at the present meeting.

With respect to common minke whales off West Greenland, the SWG had previously been awaiting the outcome of the evaluation of a sex ratio method approach before addressing the issue of long-term *SLA*s; the decision potentially to cease work on a sex-ratio abundance estimate in 2011 (see Item 8.1) does not affect the need to begin work on an *SLA* as soon as possible. As noted in SC/62/Rep3, consideration of existing RMP trials for North Atlantic common minke whales may again prove a useful starting point for discussions.

In conclusion, the Committee **re-emphasises** the importance of developing *SLA*s for Greenlandic fisheries as soon as possible. It **agrees** that this should form the primary item for discussion at the intersessional workshop.

8.4 Consider lessons learned from the bowhead whale *Implementation Review*

Two main issues arising from the bowhead *Implementation Review* relating to: (1) stock structure and in particular genetic samples; and (2) data availability. In relation to the first of these two issues, the Committee noted that there are now guidelines for DNA data quality (IWC, 2009h).

In relation to the general question of data availability, a number of issues were raised in the SWG (see Annex E, item 8). One reason for the difficulties encountered was the lack of explicit guidelines for conducting *Implementations* and *Implementation Reviews* for the AWMP process, noting how valuable these had proved for the RMP process. The Committee **agrees** that Donovan should develop a draft of such a document for consideration at next year's meeting.

8.5 Aboriginal Whaling Scheme (AWS)

In 2002, the Committee strongly recommended that the Commission adopt the Aboriginal Subsistence Whaling Scheme (IWC, 2003a, pp.22-23). This covers a number of practical issues such as survey intervals, carryover, and guidelines for surveys. The Committee has stated in the past the AWS provisions constitute an important and necessary component of safe management under AWMP *SLAs* and it **reaffirms** this view. It noted that discussions within the Commission of some aspects such as the 'grace period' are not yet complete.

8.6 Other

8.6.1 Conversion factors for edible products for Greenland fisheries

IWC/62/9 is the report of a Small Working Group (Donovan, Palka, George, Hammond, Levermann and Witting) established by the Chair of the Commission to provide advice on conversion factors for the Greenlandic hunt. The report of the group was presented to the intersessional Commission meeting to consider Greenlandic strike limits. In discussion of the report at that meeting, it was agreed that there was no need for the report to be reviewed in detail by the Scientific Committee but that individual scientists should send comments to the authors so that the report could be revised, if necessary, by the Commission meeting in Agadir. That request and the document itself was circulated to the Scientific Committee with a request for comments by 6 June 2010. However, it had been agreed that this issue would be added to the SWG agenda.

A short summary of the report, which has been available on the IWC website since February 2010, is given in Annex E, item 9.1[2].

[2]The full 52 page report can be found at *http://www.iwcoffice.org/_documents/commission/IWC62docs/62-9.pdf.*

In discussion of IWC/62/9 during the present meeting, one member provided a number of comments on the underlying approach to calculating conversion factors, as well as to the quality of the data used by the authors. Points raised included whether conversion factors should be based only upon what product yield has been achieved in the past, or whether it should consider what could be achieved with significant improvements in processing efficiency. He also commented on the likely inaccuracy and unreliability of the hunter collected data. He suggested that Greenland be asked to come back next year with data of verifiable quality on length and product yield, and/or that the Committee be given details of the new data collection methods, together with information on the process by which the reliability of the product yield data is verified. In response, the authors noted that they had spent considerable time and effort in investigating the original data, recognising that it had not been collected by scientists for the purposes of estimating conversion factors. The large sample size and the consistency with edible product information collected by scientists in the North Pacific, revealed that the data for common minke whales were sufficient to calculate a robust conversion factor (as well as showing the flensing process to be efficient). The limitations of the conversion factors provided for the other species were recognised in the report and considered interim pending the recommended collection of additional data on length correction and edible products. They had offered to assist in appropriate experimental design. They also noted that it would take some time to obtain sufficient sample sizes for some species. They concluded that matters of efficiency were appropriate for discussion by the Commission.

The Committee endorsed the **recommendations** of the report. In particular, it supported the recommendations for further work that data on both 'curved' and 'standard' measurements are obtained during the coming season for common minke whales, fin whales and bowhead whales and that new data on edible products be collected using properly-design protocols, analysed appropriately and reviewed. It also supported the recommendation that the work be undertaken by scientists, hunters and wildlife officers since this would improve the ability of hunters, particularly those in remote areas, to obtain more accurate length and weight measurements. The Committee was informed that Greenland has already begun to implement some of the recommendations of the Small Working Group and they will be implementing all of them in the next season. There is now increased collaboration between hunters, scientists and managers and improved estimates of the three types of edible product should be possible by having each product stored in separate bins and weighed. It was also noted that collaboration between hunters from Alaska and Greenland was underway with the respect to flensing techniques for bowhead whales. Finally, the Committee **requests** Greenland to provide information on its sampling scheme and data validation protocols to next year's meeting.

9. ABORIGINAL SUBSISTENCE WHALING MANAGEMENT ADVICE

9.1 Eastern Canada and West Greenland bowhead whales

9.1.1 Assess stock structure and abundance of Eastern Canada and West Greenland bowhead whales

The Committee has agreed at the previous three Annual Meetings to consider a single stock of bowhead whales in this region as the 'working hypothesis' while acknowledging that there is still some uncertainty about the population structure of bowhead whales in eastern Canada and western Greenland (e.g. IWC, 2009d). Last year, the Committee had expressed some disappointment that the expected genetic analyses had not materialised to take discussions further. It had noted that use of the term 'working' hypothesis implies that alternative hypotheses can still be considered and thus there should be consideration of both one stock and two stock hypotheses. The Committee was therefore pleased to receive this year a number of stock structure papers, some of which include the use of genetic data.

SC/62/BRG26 presented work on genetic differentiation of bowhead whales in Eastern Canada and Western Greenland. The study included sequence data for 346 individuals from Baffin-Bay-Davis-Strait and 197 individuals from Hudson-Bay-Foxe-Basin. There was a slight but significant genetic difference between the two areas in terms of F_{ST} based on haplotype frequencies. However, there was no differentiation between Hudson Bay-Foxe Basin and Cumberland Sound, an area presumed to be within the range of the putative Baffin Bay-Davis-Strait stock. In the context of other biological information available (SC/62/BRG23 and SC/62/ BRG25), the authors consider the observed F_{ST} to be consistent with the one stock hypothesis.

SC/62/BRG25 reported on the re-identification patterns of genetic markers from bowhead whales sampled in Eastern Canada and West Greenland. From the total of 647 identified individuals, 91 were re-identified within the same location and year. Of the remaining 556 individuals (208 males and 348 females), the authors found 16 re-identifications between years. Three of these were between sampling areas and all three had moved from the Hudson Bay-Foxe Basin area to the Baffin Bay-Davis Strait area. In addition, of the 20 new satellite tags put out in 2009 in Disko Bay, four animals had crossed assumed boundaries between putative stocks. The authors concluded that: (i) the low number of re-identifications between years indicates that the population is relatively large; and (ii) the high proportion of re-identifications and movements of satellite tagged animals between areas indicate a high rate of movement between the areas. In the authors' view, these results indicate that there is only one stock of bowhead whales in Eastern Canada and Western Greenland.

SC/62/BRG23 reported on the sexual segregation of bowhead whales sampled in Eastern Canada and West Greenland. Genetic samples (the same as used in the previous two papers) were obtained from one location in West Greenland: Disko Bay (April-June 2000-09) and four locations in Eastern Canada: Pelly Bay (September 2000-02), Cumberland Sound (June-August 1997-2006), Foxe Basin (July-August 1994-2007) and Repulse Bay (September 1995-2005). The sex-ratio was significantly different from 1:1 in Disko Bay (76% females), but this was not the case in the remaining areas. The authors also reviewed available field observations and historical whaling records in the region, which provided further evidence of segregation. They concluded that Baffin Bay is mainly used by adult males and resting/pregnant females, whereas the Prince Regent, Gulf of Boothia, Foxe Basin and northwestern Hudson Bay areas are used by nursing females, calves and sub-adults. The Committee noted that the available information is consistent with some form of structured movement, but that this movement is still not well understood.

There was considerable discussion of these papers and their strengths and weaknesses in their ability to distinguish among stock structure hypotheses as can be seen in Annex F, item 4.2. Some members of the Committee interpreted the seasonal movements and resighting patterns between the two areas to mean that there is a single stock whilst others believed that these movements and the observed shallow population structure between some areas are still consistent with the two-stock hypothesis. The Committee **agrees** that the degree of population structure requires further work with additional molecular markers (nuclear loci) before a final conclusion can be reached and it also **recognises** the importance of the successful satellite tracking study. It **encourages** the continuation of work on structure in order to allow it to conduct a more in-depth analysis next year.

The Committee also received two papers on abundance (Annex F, item 4.2.2). SC/62/BRG28 reported the results of an aerial survey of the late-summer concentration of bowhead whales in Isabella Bay, Nunavut, Canada in September 2009. The resulting abundance of 1,105 (95% CI: 532-2,294) was corrected for whales that were submerged during the passage of the survey plane, but not for whales missed by the observers because >90% of the sightings were detected by both platforms.

SC/62/BRG34 summarised a preliminary evaluation of the potential to use photographs and capture-recapture analyses to estimate the size of the Eastern Canada-West Greenland stock(s) of bowhead whales. The large and often remote summer range of these animals makes it difficult to obtain an aerial survey estimate of abundance. On the other hand, photographic surveys benefit from mixing among the separate sampling areas and have been successfully used to estimate abundance of the B-C-B stock of bowhead whales. The authors proposed that photographic surveys be directed at areas of known summer aggregations. Photography methods and analyses for the proposed surveys would follow methods used for the 2004 B-C-B bowhead population estimate (Koski *et al.*, 2009), which has been accepted by the IWC. The Committee **welcomes** these papers and looks forward to further analyses at next year's meeting.

9.1.2 Review recent catch information

SC/62/BRG27 reported that two female and one male bowhead whales were taken in April-May 2009 and three females in April-May 2010 for subsistence purposes in Disko Bay, West Greenland (no whales were struck in 2008 and no whales were struck and lost in 2009 and 2010). In light of the uncertainties surrounding eastern Arctic bowhead stock structure and abundance, the Committee **requests** the Secretariat to contact Canada to try to obtain data on Canadian catches.

9.1.3 Management advice

In 2007, the Commission agreed to a quota for 2008 to 2012 of two bowhead whales struck annually off West Greenland but the quota for each year shall only become operative when the Commission has received advice from the Committee that the strikes are unlikely to endanger the stock. In 2008, the Committee was pleased to have developed an agreed approach for determining interim management advice (IWC, 2009c), that is valid for two five-year blocks. The Committee again **agrees** that the current catch limit for Greenland will not harm the stock (noting that this applies whichever stock structure hypothesis prevails). It was also aware that catches from the same stock have been taken by a non-member nation, Canada. It **agrees,** as in previous years, that should Canadian catches continue at a similar level as in recent years, this would not change the Committee's advice with respect to the strike limits agreed for West Greenland.

The Committee reviewed the catch limits in Table 4 of the Report of 'Proposed consensus decision to improve the conservation of whales from the Chair and Vice-Chair of the Commission' (IWC/62/7rev). For Eastern Canada/West Greenland bowhead whales, the Greenland strike limit is 2 per year (plus a carryover provision of two unused strikes from the previous year). The Committee **agrees** that the strike limits for Eastern Canada/West Greenland bowhead whales that are listed in table 4 of IWC/62/7rev are in accord with its advice, recognising that the normal regular review is also intended as part of IWC/62/7rev. However, the Committee notes that Canada may allow for regular catches from this stock. If the size of Canadian catches increases then the Committee's advice may change in that the total number of removals may exceed the safe limit determined by the agreed approach. If the Canadian catch increases, then the Committee wishes to draw attention to the fact that the total number taken from the stock may be greater than what is safe. Given the importance of this issue, the Committee **recommends** that the Secretariat should contact Canada requesting information about catch limits for bowhead whales.

9.2 Eastern North Pacific gray whales

9.2.1 Summary of previous season's catch data

A total of 115 gray whales (58 males, 57 females) was harvested in Chukotkan waters in 2009 and 1 was lost. A total of 6 of the 115 individuals were considered as unfit for consumption in 2009 (samples were taken from all 6). Biological sampling was conducted on 61 gray whales.

9.2.2 Management advice

As noted under Item 8.2, the Committee **agrees** that it has completed the *Implementation Review* but that a new *Implementation Review* should take place next year. In this context, the Committee **agrees** that its position with respect to the provision of management advice was unchanged from last year, i.e. the *Gray Whale SLA* remains the appropriate tool to provide management advice for eastern North Pacific gray whales. This remains the case, at least until the 2011 *Implementation Review* is completed.

In line with the values in table 4 of the proposed consensus decision (IWC/62/7rev), the Secretariat ran the *SLA* using the updated information on catches and abundance agreed at this meeting. This confirmed that an annual strike limit of 145 animals will not harm the stock (note that 145 is the maximum catch that can be taken in any one year; the annual average catch is 129 whales). The additional five whales added to the annual maximum in any one year from that previously considered (140) was intended to account for 'stinky' whales (IWC/62/7rev). In providing its advice, the Committee **draws attention** to the need for a new *Implementation Review* next year with a focus on PCFG whales. It was noted that although the table included strike limits for 10 years, the proposed consensus decision envisages the usual periodic reviews of strike limits for indigenous whaling.

Borodin commented that the annual strike limit should include the actual number of struck-and-lost whales and 'stinky' whales (e.g. in 2009 the numbers were 1 and 6, respectively). If hunting is on large whales then the number of struck-and-lost whales will be higher. Within that context, he noted that the annual strike limit should not exceed 150 whales (the number included in the *Gray Whale SLA* trials for the early period of catches during the development process).

9.3 Bering-Chukchi-Beaufort (B-C-B) Seas stock of bowhead whales

9.3.1 Review catch information and new scientific information

The Committee was pleased to receive two papers dealing with broad-scale aerial surveys from the northeastern Chukchi (SC/62/BRG13) and Alaskan Beaufort (SC/62/BRG14) Seas respectively. Details can be found in Annex F, item 4.1.1.

SC/62/BRG13 presented preliminary analyses of broad-scale aerial surveys for large whales in the northeastern Chukchi Sea that were conducted in 2008 and 2009, and compared these with results from similar surveys conducted in that region from 1982-91. The distribution of bowhead whale sightings during the light ice years of the early period (1982, 1986, 1989 and 1990) was similar to the distribution of bowhead sightings during 2008-09. There did not appear to be any major shifts in cetacean distribution between the early and late surveys although there were unexpectedly no gray whale sightings in the offshore shoal areas during 2008-09. In general, it was noted that analysing cetacean distribution in relation to environmental factors like sea-ice was complicated with this data set because the timing of the surveys was not consistent between years.

SC/62/BRG14 presented a similar preliminary study for the Alaskan Beaufort Sea, using data from the Bowhead Whale Aerial Survey Project (BWASP) in 2000-09, with comparisons to historical data. Bowhead distribution was similar in 2000-09 compared with the observed distribution from earlier years with light ice cover.

The Committee **recommends** that these surveys continue on an annual basis in the future in light of their capacity to monitor the effects of climate change and other factors (including anthropogenic activities) on cetacean distributions in the Beaufort Sea.

SC/62/BRG17 provided information about acoustic monitoring during attempts to count migrating bowhead whales near Point Barrow, Alaska in 2009 and to test new acoustic equipment. Results demonstrated the efficacy of a new seafloor array procedure and indicate that it can be used in the future as the method for obtaining acoustic data for the bowhead census and population estimation process. The Committee **welcomes** this report and **encourages** the use of autonomous seafloor acoustic recorders when monitoring migrating bowhead whales.

The Committee also received information on summarised preliminary analyses on identifying yearling bowhead whales in aerial photographs (SC/62/BRG29) and recent efforts to estimate the population size of this stock of bowhead whales (Annex F, item 4.1.1). The Committee welcomed this new information and notes that a full survey effort is being planned again in 2011. In discussion, the importance of monitoring the tails of the distribution of migrating whales was noted in the light of information from this year's migration.

9.3.2 Management advice

SC/62/BRG18 provided information on the 2009 Alaskan hunt. A total of 38 bowhead whales were struck resulting in 31 animals landed). Challenging sea ice conditions and weather contributed to a poor spring hunt. Of the landed whales, 12 were males, 18 were females, while sex was not determined for one animal. Hunters mistakenly harvested two female calves (lengths of 6.2m and 6.6m) in the autumn thinking they were small independent whales. Autumn calves are close in body length to yearlings and it is difficult to determine their status when swimming alone. Other details are given in Annex F, item 4.1.2. It was reported that there were no catches of bowhead whales by Russia this year.

The Committee **reaffirms** its advice from last year that the *Bowhead SLA* remains the most appropriate tool for providing management advice for this harvest. The results from the *SLA* show that the present strike limits are acceptable.

The next *Implementation Review* for B-C-B bowhead whales is scheduled in 2012. The purpose of the *Implementation Review* is to evaluate new information which has become available since the last *Implementation Review* and assess whether the current state is outside the realm of plausibility covered by the *Implementation* trials. If so, it may be necessary to conduct further trials incorporating such information. Therefore, the Committee **encourages** researchers to present relevant papers and new information for consideration during next year's meeting, so that preparations for the next *Implementation Review* can proceed efficiently.

The Committee reviewed the catch limits in table 4 of 'Proposed consensus decision to improve the conservation of whales from the Chair and Vice-Chair of the Commission' (IWC/62/7rev). For B-C-B bowhead whales, the maximum strike limit is 67 per year (plus a carryover provision of 15 unused strikes from the previous year) for total landed of 560 (580 written in footnote 8 is a typo). The Committee **agrees** that the strike limits for B-C-B bowhead whales listed in table 4 are in accord with the management advice provided by the *Bowhead SLA*, noting that the normal regular review is also intended.

9.4 Common minke whale stocks off Greenland (AWMP)

9.4.1 West Greenland

9.4.1.1 SUMMARY OF PREVIOUS SEASON'S CATCH

In the 2009 season, 153 minke whales were landed in West Greenland and 11 were struck and lost. Of the landed whales, there were 105 females, 47 males, and one whale of unreported sex. Genetic samples were collected for 97 of the 153 minke whales landed in 2009.

9.4.1.2 MANAGEMENT ADVICE

In 2007, the Commission agreed that the number of common minke whales struck from this stock shall not exceed 200 in each of the years 2008-12, except that up to 15 strikes can be carried forward. Prior to last year, the Committee has never been able to provide satisfactory management advice for this stock. Last year, the Committee was for the first time able to provide management advice for this stock. It had adopted a new abundance estimate and agreed method for providing interim management advice. Such advice can be used for up to two five-year blocks whilst *SLAs* are being developed (IWC, 2009c). Based on the application of the agreed approach, and the lower 5^{th} percentile for the 2007 estimate of abundance (i.e. 8,918), the Committee **repeats its advice** of last year that an annual strike limit of 178 will not harm the stock.

9.4.2 East Greenland

9.4.2.1 SUMMARY OF PREVIOUS SEASON'S CATCH DATA

Three males and one female common minke whale were struck (and landed) off East Greenland in 2009 (no animals were struck and lost; see SC/62/ProgRepDenmark). Genetic samples were obtained from two of these whales. Catches of minke whales off East Greenland are believed to come from the much larger Central stock of minke whales.

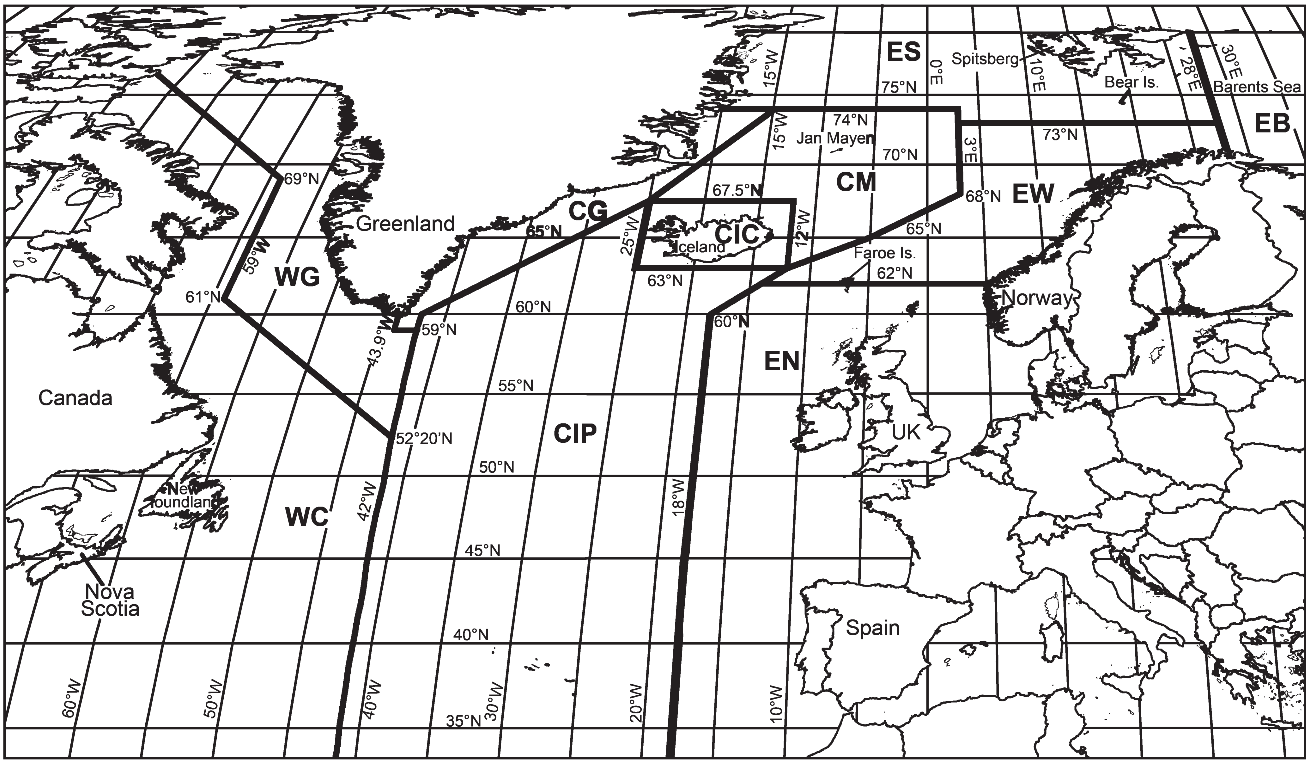


Fig. 2. The specifications for the Small Areas for the North Atlantic minke whales.

Table 3

Most recent abundance estimates for minke whales in the Central North Atlantic.

Small Area(s)	Year(s)	Abundance and CV
CM	2005	26,739 (CV=0.39)
CIC	2007	10,680 (CV=0.29)
CG	2007	1,048 (CV=0.60)
CIP	2007	1,350 (CV=0.38)

9.4.2.2 MANAGEMENT ADVICE

In 2007, the Commission agreed to an annual strike limit of 12 minke whales from the stock off East Greenland for 2008-12, which the Committee stated was acceptable in 2007. The present strike limit represents a very small proportion of the Central Stock (see Fig. 2 and Table 3). The Committee **agrees** that the present strike limit will not harm the stock.

9.5 Fin whales off West Greenland

9.5.1 Summary of previous season's catch data

A total of 8 (1 male; 7 females) fin whales were landed, and 2 struck and lost, in West Greenland during 2009 (SC/62/ProgRepDenmark). Genetic samples were collected for 5 of the 8 fin whales harvested during 2009.

9.5.2 Management advice

In 2007, the Commission agreed to a strike limit (for the years 2008-12) of 19 fin whales struck off West Greenland. The Committee agreed an approach for providing interim management advice in 2008 and this was confirmed by the Commission. It had agreed that such advice could be used for up to two five-year blocks whilst *SLA*s were being developed (IWC, 2009c). Based on the application of the agreed approach in 2008 (IWC, 2009c), the Committee **agrees** that an annual strike limit of 19 whales will not harm the stock.

9.6 Humpback whales off West Greenland

In 2007, the Committee agreed an approach for providing interim management advice and this was confirmed by the Commission. It had agreed that such advice could be used for up to two five year blocks whilst *SLA*s were being developed (IWC, 2009c). Using this approach, as last year, the Committee **agrees** that an annual strike limit of 10 whales will not harm the stock.

9.7 Humpback whales off St Vincent and The Grenadines

9.7.1 Summary of previous season's catch data

The Committee was advised that three females (lengths 34', 34'3" and 43'2") were taken during 2010. Neither genetic samples nor photographs were available for these animals. The Committee has encouraged St Vincent and The Grenadines to submit as much information as possible about any catches to the Committee via an Annual Progress Report.

The Committee **strongly recommends** collection of genetic samples for any harvested animals as well as fluke photographs, and submission of these to appropriate catalogues and collections. In respect of genetic samples, the Committee again **agrees** that the North Atlantic Whale Archive maintained by Per Palsbøll is an appropriate facility.

9.7.2 Management advice

In recent years, the Committee has agreed that the animals found off St Vincent and The Grenadines are part of the large West Indies breeding population. The Commission adopted a total block catch limit of 20 for the period 2008-12. The Committee **agrees** that this block catch limit will not harm the stock.

10. WHALE STOCKS

10.1 Antarctic minke whales (IA)

The Committee is currently continuing an in-depth assessment of the Antarctic minke whale. To complete this assessment, agreed abundance estimates from CPII and CPIII[3] are needed. Two different abundance estimation methods have been developed during the last few years, and although they give quite different point estimates, both are consistent in that they show an appreciable decline from CPII to CPIII. During the JARPA review in 2009, the quality of the Japanese ageing methods was questioned with implications for the catch-at-age analyses. During the present meeting, the priority topics discussed included: the two abundance estimation methods; the reasons for the differences between CPII and CPIII; age reading and the catch-at-age assessment models.

10.1.1 Produce agreed abundance estimates of Antarctic minke whales using IDCR/SOWER data

Skaug reported on work conducted by the Abundance Estimation Intersessional Working Group. Tasks to be considered by the group were directed towards elucidating possible causes for the difference in abundance estimates for Antarctic minke whales from the IDCR/SOWER data from the recent OK (Okamura and Kitakado, 2009) and SPLINTR (Bravington and Hedley, 2009) models. In completing most of these tasks, substantial progress had been made towards this in two regards: (i) development of a reference dataset for model comparisons; and (ii) Bravington had completed a non-spatial version of the SPLINTR model. For (i), a number of internal inconsistencies in the 'standardised' dataset were identified; as noted in IWC (2010f), it is essential that when comparing models, the data are identical. Since the purpose of this dataset is to allow appropriate comparisons between the models, the Committee **agrees** that this dataset is suitable for this purpose.

SC/62/IA14 provided results from applying the IWC 'standard' method (Branch, 2006), and the OK and SPLINTR models to simulated data, focussing on the latter two. In general, both models performed well, although when bias did occur, it tended to be positive for the OK model and negative for SPLINTR. The Committee thanked Palka for co-ordinating this extensive study. The simulated datasets have proved valuable in helping to develop and refine the models and for examining the differences between them. No simulated scenarios show the level of difference between the OK and SPLINTR estimates that the real data analyses reveal. This suggests either that the magnitudes of factors currently in the simulations do not cover the ranges found in the real data (either singly or in combination), or that there are additional factors not currently in the simulations that are important for modelling the real data.

During the pre-meeting and using the reference dataset, the OK and non-spatial SPLINTR outputs were compared. Estimated mean school sizes, effective strip half-widths, and encounter rates were combined using the simple line transect formula for estimating abundance. The resulting examination revealed that: (1) these estimated quantities from each model were being combined correctly to estimate abundance; (2) the effective strip half-widths for OK were about half of those of SPLINTR (i.e. the estimated abundances were approximately doubled, highlighting a need for further investigation); and (3) that the difference between the two models was not due to the data used and was probably not due to differences in mean school size. The Committee questioned whether sufficient progress had been made to determine whether further investigation was likely to determine the reason for the difference between the models. It **agrees** that if the Work Plan, including an intersessional workshop, is accomplished, there is a reasonable chance that this will be the case. It therefore **agrees** to proceed with these investigations until the 2011 Annual Meeting. The Committee also **agrees** a number of technical points related to this intersessional work (Annex G, item 5.1.8).

However, contingency plans (e.g. producing model-averaged estimates of abundance) will also need to be considered if it does not prove possible to resolve the difference in the estimates. Skaug compared estimates from OK, SPLINTR and a model-averaged estimate on the simulated data and found that the model-averaged estimator had smaller bias than either of the two individual models. There was some discussion on the appropriateness of using model-averaged estimates on the real data. However, as noted above, given the progress made this year, it is anticipated that the best outcome would be a resolution of the issue as a result of the intersessional work.

SC/62/IA3 and SC/62/IA12 presented the following 'survey-once' estimates (see Branch and Butterworth, 2001b) of abundance for the CPII and CPIII surveys from the OK and SPLINTR models respectively, as summarised in Table 4.

The Committee thanked both sets of authors for producing estimates and for the substantial amount of intersessional work, much of it collaborative. As last year, the issue is not that either set of diagnostics suggests not accepting the estimates, but rather that the estimates themselves are so different. This leads to the need to consider three – not necessarily unrelated – issues for next year: (1) pursuing the work to explain the differences; (2) the implications, if any, for future surveys; and (3) the procedural question of what the Committee should do if (1) does not succeed. As part of IWC/62/7rev, the Committee is expected to undertake an RMP *Implementation* for Antarctic minke whales in 2015 (and see Item 20). There is thus a pressing need for agreed absolute abundance estimates for the past surveys and an agreed method for analysing data from future surveys.

The Committee **strongly recommends** that the work plan and timeline set out in Annex G, Appendix 3 to finalise estimates be followed and completed. A workshop, to be held by February 2011 at the latest (see Item 21), is an essential component of this.

10.1.2 Conduct an analysis of aging errors that could be used in catch-at-age analyses

Lockyer presented the results of the Antarctic minke whale ageing exercise (SC/62/IA11) which she had carried out intersessionally following the 'blind' experimental design agreed by the Scientific Committee (IWC, 2009e, p.209). The study was assisted by staff from the laboratory at the Tokyo University of Marine Science and Technology, under the supervision of Kitakado. This had involved reading 250 earplugs from 1974/75-2005/06, i.e. including both Antarctic commercial and JARPA samples. The primary aim of the work was to determine whether evidence exists of a drift in reader performance, and, if so, to quantify it. A secondary aim was to quantify age-reading error variability.

The Committee thanks Lockyer and the Japanese graduate students who had assisted her, and for the professional manner in which they conducted the experiment. It also

[3]CPII and CPIII refer to the second and third set of IWC cruises, referring to 1985/86-1990/91 and 1991/92-2003/04, respectively.

Table 4

Comparison of 'survey-once' estimates of abundance, by Management Area, from the OK and SPLINTR models. Estimates shown have been extracted from the papers SC/62/IA3 and SC/62/IA12 and rounded, with CVs incorporating additional variance given in parentheses.

	Area I	Area II	Area III	Area IV	Area V	Area VI	Total
CPII							
OK	209,000	261,000	187,000	104,000	635,000	90,000	1,486,000
	(0.35)	(0.38)	(0.42)	(0.37)	(0.29)	(0.39)	(0.17)
SPLINTR	117,000	141,000	87,000	61,000	282,000	59,000	747,000
	(0.38)	(0.39)	(0.55)	(0.36)	(0.34)	(0.40)	(0.19)
CPIII							
OK	65,000	93,000	126,000	79,000	244,000	105,000	712,000
	(0.34)	(0.37)	(0.33)	(0.45)	(0.33)	(0.34)	(0.17)
SPLINTR	35,000	56,000	59,000	36,000	140,000	57,000	382,000
	(0.33)	(0.35)	(0.31)	(0.33)	(0.31)	(0.33)	(0.17)

endorses the recommendation by Lockyer that a standard reference set of minke earplugs be maintained for age-reading training purposes.

SC/62/IA2 explored the impact of period/reader on age-determination by comparing age-estimates for the above 250 earplugs for the control reader (Lockyer) and three Japanese readers (Masaki, Kato and Zenitani). Overall, the results demonstrated that the Japanese readers and the control reader differed in terms of both expected age given true age and variance in age-estimates. The results also suggested that the expected age and random uncertainty in age-estimates differed among the Japanese readers although the differences were not severe. This work will assist in determining how catch-at-age data are used in the statistical catch-at-age analyses and in future virtual population analyses.

The Committee **welcomes** this study as an important advance. It was noted that: (a) Lockyer tended to report greater ages than the Japanese readers; (b) differences amongst the Japanese readers were slight; and (c) that there was no indication of a trend in bias in Japanese readings over the period examined (i.e. from commercial whaling to special permit whaling). It was also noted that SC/62/IA11 does not provide any information about the accuracy of the age readings in absolute terms, given the absence of known-aged individuals. The absence of known-aged individuals is also the general norm for fish populations although for a number of these there are indications that layers were formed seasonally. Similarly, studies of fin whales, as well as corpora counts and information from animals with known histories, all indicate that the growth layers groups used to estimate whale ages are laid down annually.

In conclusion, the Committee **agrees** that no further experiments or analyses on age reading errors are needed to resolve ageing related problems raised in e.g. the JARPA review.

The Committee also **recommends** that, where they do not already, national or other guidelines for dealing with stranded animals include encouragement to obtain samples which could provide information on the animal's age.

10.1.3 Continue development of the catch-at-age models

SC/62/IA6 examined the impact of allowing for ageing error based on the analyses of the above (Item 10.1.2) age-reading experiment when conducting assessments for Antarctic minke whales in Areas III-E, IV, V and V-W using statistical catch-at-age analysis by means of sensitivity tests. These sensitivity tests explored three scenarios: (a) no ageing error; (b) ageing error is modelled as in previous base-models; and (c) ageing error is based on the results from SC/62/IA2. Time-trajectories of total (1+) population size and recruitment were qualitatively the same, irrespective of how age-reading error was modelled.

In discussion, it was noted that while estimates from recent years of recruitment and abundance for the three different assessments were close, absolute values showed relatively large differences until the 1960s, and estimation variance would be expected to be much higher over this period.

Though the Committee **agrees** that no further experiments or analyses on age reading errors are necessary. This decision did not, however, imply that other issues associated with the data and analyses, such as reasons for the different length distributions at age for younger-aged commercial and JARPA, had been resolved.

Completion of the work on investigation of catch-at-age based assessments requires undertaking the tasks as detailed in Annex G, item 5.2.4. These investigations will require an extension of permission from Japan for use of their Antarctic minke whale catch-at-age data, and would be improved if data from the most recent JARPA cruises could also be made available. The Committee **recommends** that such an approach be made to Japan under Procedure B of the DAA. Kato indicated that corpora count data were available, and that these data would be provided if necessary. An intersessional steering group under Punt was established to co-ordinate this work (see Annex Q).

10.1.4 Continue to examine the difference between abundance estimates from CPII and CPIII

Estimates from the OK, SPLINTR and standard methods (Branch, 2006) were consistent in that they showed a decline from CPII to CPIII. Conclusions reached about the reasons for these changes should integrate information from other sources such as changes in ice coverage during the survey periods concerned. Until recently, there was little quantitative information on the number of Antarctic minke whales that might be present within the pack ice. This year the Committee was pleased to receive several papers reporting on, and analysing data from, surveys of whales within the pack-ice.

SC/62/IA4 investigated trends of sea ice in the period of IWC IDCR/SOWER circumpolar surveys from CPI to CPIII (1978-2004). The sea ice trends are fundamental information to understand the year-to-year sea ice variability. The authors concluded that the difference in abundance estimates between the CPII and CPIII surveys can be partly explained by the change in the amount of open sea areas within the sea ice field. The Committee **agrees** that further region-specific investigation is necessary to examine the extent of the role changes in sea ice may play in examining the change in abundance estimates between CPII and CPIII. In this context the Committee received a progress report from the intersessional working group established to examine this issue (SC/62/IA5). The authors have made progress importing satellite sea ice data from Area II into a GIS database but the work is not expected to be completed until the next Annual Meeting. The Committee **recommends** that every effort be made to complete this important work on time. Although the exact nature of any models relating minke whales densities in open water to those in the ice was not discussed, it is important to continue investigation of the relationships between whale density and ice characteristics.

This requires investigation of at least: (1) the relationship between whale density and days after sea-ice melt; and (2) the relationship between estimates of abundance and sea ice characteristics. The Committee **agrees** the detailed plan for this work given in Annex G, item 5.1.8. Bravington, Murase, Kitakado and Kelly will co-operate in this work.

This year, the Committee was pleased to receive reports (SC/62/IA8 and SC/62/O15) from two aerial survey programmes: the Australian East Antarctic programme (which co-ordinated in 2009/10 with the SOWER survey) using a fixed wing plane; and the German programme surveying the area in the Weddell Sea from a helicopter launched from the ice breaker vessel, the *Polarstern* (which was also used as a Platform of Opportunity for cetacean sightings). These programmes represent some of the first attempts to gather quantitative data to estimate densities of minke whales in the pack ice. Preliminary analyses from each programme can be found in SC/62/IA9 and SC/62/IA13.

The Committee **welcomes** this work and a full discussion can be found in Annex G, item 5.1.6.2. It thanked the governments of Australia, Germany and the Netherlands for supporting this research. It also was **pleased** to see the successful collaboration (both in collection of data, and in regular communications and data exchanges) between the Australian programme and the SOWER survey.

10.2 Southern Hemisphere humpback whales

The report of the Committee on the assessment of Southern Hemisphere humpback whales is given in Annex H. This assessment has been on the agenda of the Scientific Committee since 1992. The Committee currently recognises seven breeding stocks (BS) in the Southern Hemisphere (labelled A to G - IWC, 1998b), which are connected to feeding grounds in the Antarctic (Fig. 3). Preliminary population modelling of these stocks was initiated in 2000 (IWC, 2001g) and in 2006 (IWC, 2007a), the Scientific Committee completed the assessment of BSA (eastern South America), BSD (western Australia) and BSG (western South America). The assessment of BSC was completed in 2009 (IWC, 2010g). Since then, the completion of the assessment of BSB (western Africa) has been considered a priority by the Committee (IWC, 2010g, p.234).

10.2.1 Breeding Stock B

10.2.1.1 DISTRIBUTION

The Committee received several papers addressing the distribution, new records or habitat use of humpback whales along the central and northern Atlantic coast of Africa (Bamy *et al.*, 2010; Carvalho *et al.*, In review; Picanço *et al.*, 2009; Weir, 2010).

10.2.1.2 POPULATION STRUCTURE

It has been hypothesised that there may be two humpback whale sub-stocks in the eastern South Atlantic (IWC, In press). Breeding sub-stock B1 winters along the central West African coast and around the northern islands of the Gulf of Guinea and sub-stock B2 has been observed off the west coast of South Africa (WSA), in an area which appears to serve as a feeding site or possibly a migratory corridor. The breeding site of sub-stock B2 is unknown. A boundary between these two sub-stocks has been tentatively placed in the vicinity of 18°S (IWC, In press), see Fig. 4. At this meeting, the Committee further evaluated the evidence for BSB substructure, in light of new information.

SC/62/SH30 presented three stock structure hypotheses that were used in the assessment models. These hypotheses included: (1) a single, fully-mixed stock; (2) two breeding stocks that mix only on the feeding grounds and (3) two breeding stocks with partial migratory overlap along the west coast of Africa. SC/62/SH8 described temporal population structure in humpback whales on the west coast of Africa using maternally (mitochondrial DNA control region) and bi-parentally (10 microsatellites) inherited markers. Results showed significant genetic differentiation, low gene flow and

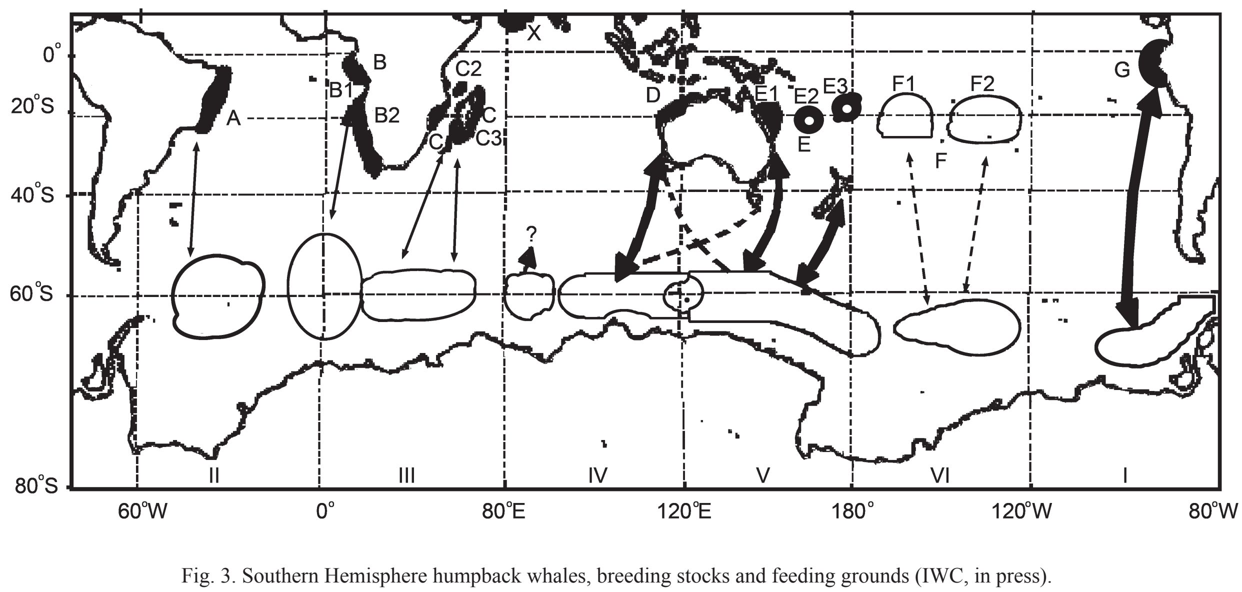


Fig. 3. Southern Hemisphere humpback whales, breeding stocks and feeding grounds (IWC, in press).

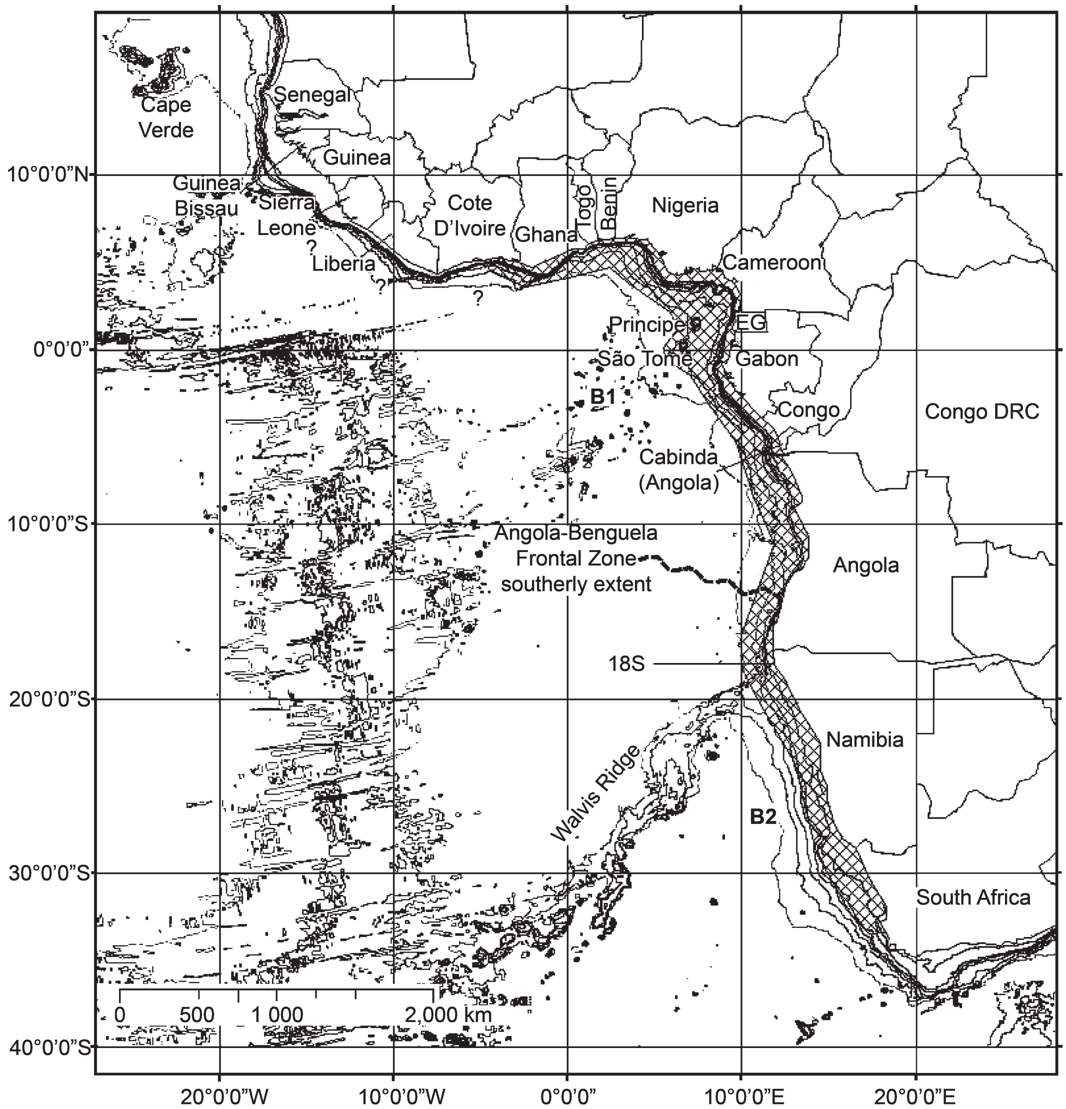


Fig. 4. Distribution of humpback whales in west Africa. The boundary between B1 and B2 has been proposed to be near 18°S (IWC, in press).

seasonal differences between WSA and Gabon. Movements of genetically identified individuals, both males and females, indicate that interchange occurs between these two region, with all movements to date being from north to south.

SC/62/SH15 examined humpback whale genetic structure in the Antarctic and evidence of connectivity to breeding grounds using biopsy samples collected during the 2006/2007 SOWER cruises. An updated analysis of the mitochondrial DNA (mtDNA) data presented in this paper was received during the meeting. Population structure was evaluated for the feeding grounds associated with BSB and BSC, under the catch allocation Hypotheses 1 and 2 developed by the Committee last year (Findlay *et al.*, 2010, fig.1). Under Allocation Hypothesis 1, Gabon was found to be significantly different from the Nucleus feeding areas of both BSB (10°W to 10°E) and BSC (30°E to 60°E). For Allocation Hypothesis 2, samples from Gabon were found to differ significantly from the BSB Nucleus (10°W to 10°E) and BSB/BSC Margin (10°E to 40°E). WSA was significantly different from BSB and BSC Nucleus, as well as the BSB/C margin area. Feeding grounds of BSB and Margin of B/C were found to be significantly different from the Nucleus area associated with BSC under Allocation Hypothesis 1. No significant differentiation was found across feeding areas under Allocation Hypothesis 2.

An analysis of mtDNA on feeding grounds (10°W-10°E) by latitudinal gradient revealed that no significant difference between Gabon and samples collected north of 60°S. WSA differed from samples obtained both north and south of 60°S on the basis of F_{ST} but significance was only found for samples obtained north of 60°S. These results were interpreted as indicative of some type of latitudinal variation in the distribution of whales from BSB in the Antarctic.

The Committee welcomed the genetic studies described above; this research is relevant to the assessments of Southern Hemisphere humpback whale stocks. The Committee **recommends** that a mixed stock analysis be performed to better inform stock structure assumptions and to increase the available data for population dynamics modelling.

The Committee also considered new photo-id matching results relevant to the stock structure of BSB. SC/62/SH10 presented preliminary results of photographic matching between Gabon, WSA and Antarctic Areas II and III. A total of three matches were found between Gabon and WSA. SC/62/

SH31 reported no matches resulted from the comparison of a photo-id catalogue from WSA and another from the south coast of east South Africa and southern Mozambique (BSC1). It was noted that a substantial number of images held by Oceans and Coast (the South African governmental agency from BSC1) have not been compared to WSA. In this regards, the Committee **recommends** comparisons of the WSA fluke photographs to the Oceans and Coast catalogue and **requests** that the relevant photographs and associated information be made available.

Barendse *et al.* (2010) described the results of shore-based observations on humpback whales off Saldanha Bay, WSA. This area was presumed to be a migration corridor for whales from the postulated BSB2 breeding sub-stock. The authors concluded that the area off WSA is not strictly a migration corridor, but also a primary or supplementary feeding ground. Discussion of this paper is given in Annex H, item 2.1.2.

SC/62/SH5 reviewed the catch history, seasonal and temporal trends in availability and the migrations of humpback whales along the west coast of southern Africa. After the initial decline in availability in all areas pre World War I, the catch history in Gabon differed markedly from those in the three southern grounds, especially off South Africa. This suggests some degree of stock sub-structure within BSB. A hypothesis of a single breeding ground (in the Gulf of Guinea) but separate, maternally-directed migratory routes to and from different feeding grounds was proposed.

The Committee concluded that the following points were relevant to the development of stock structure hypotheses based on its extensive review of information:

(1) there is probably more than one genetically distinct humpback whale population in the eastern South Atlantic;
(2) Gabon is a breeding ground and WSA exhibits characteristics of both a feeding ground and a migratory corridor;
(3) at least some of the animals sampled at Gabon migrate to the Antarctic to feed and that migration may follow an inshore route (via WSA), an offshore route or both (if the latter individual migrants maintain fidelity to a particular route or maintain alternate routes);
(4) some of the whales that breed at Gabon may maintain maternal feeding site fidelity to west South Africa, such that they do not migrate to the Antarctic; and
(5) individuals observed at WSA may migrate to an unidentified breeding site that is distinct from Gabon (if so, some fraction of those individuals may pass by Gabon, *en route* to that breeding site) or the breeding ground of these individuals may lie between Gabon and WSA.

In light of the new information presented above, the Committee indentified new stock structure hypotheses and progressed with exploratory population dynamics model runs. Results of these analyses are presented under Item 10.2.1.4 below. A minority statement in relation to item (5) above is found in Annex H, item 2.1.2.

10.2.1.3 ABUNDANCE ESTIMATES

The Committee received two papers with abundance estimates based on capture-recapture data. SC/62/SH2 reported on within-region photo identification and genotypic matching for WSA. Resightings between six different time-periods and five different datasets (three from photo-id data, one from microsatellite data and one combined) resulted in estimates of abundance ranging from 223 (CV=0.35) to 939 (CV=0.38) individuals. SC/62/SH11 presented estimates of abundance for humpback whales in Gabon for the period 2001-06 using photographic and genotypic data. While the estimates themselves provided in this paper were not discussed, the capture-recapture data were used in preliminary assessment models presented at the meeting (SC/62/SH30). Details of these papers and the data therein are presented under item 2.1.3 in Annex H.

10.2.1.4 POPULATION ASSESSMENT

After initial discussion of the assessment models in SC/62/SH30, the Committee developed additional stock structure hypotheses on the basis of the new information presented in Item 10.2.1.2. Additional model runs were then undertaken to inform the Committee about possible implications of various stock structure hypotheses and input data selection for population model outputs. Preliminary results suggested that the assessment model parameter estimates were relatively robust across the proposed stock structure hypotheses and input data for sub-stock B1 (Gabon). However, the population trajectories varied widely for sub-stock B2 (WSA). Based on these results, the Committee concludes that additional modelling was required and **agrees** upon a suite of stock structure hypothesis that would probably be used in the assessment of BSB (Annex H, item 2.1.4). The Committee selected three priority hypotheses that it **recommends** should be used in further population assessment (Fig. 5).

The Committee also discussed model input data and possible sensitivity analysis when evaluating the results of the stock assessment models (details in Annex H, item 2.1.4). Input data included allocation of breeding and feeding ground catches, values for minimum past population sizes (N_{min}), type of capture-recapture data (photo-id, genotype), proportions of whales migrating to breeding and feeding grounds, and rate of struck and lost whales. The Committee **agrees** to a selection of input data to be used as the reference cases and sensitivity scenarios in the population dynamic models, as presented in Table 5.

The Committee **agrees** that considerable progress was made during the meeting. However, there was insufficient time to complete the assessment of BSB. In this regard, the Committee notes that last year it had agreed to complete the assessment of BSB as a single stock if an assessment at the sub-stock level was not possible. However, in light of the new information brought forward this year, the Committee **agrees** that a considerably more robust assessment could be finalised if additional work was conducted intersessionally. The Committee **agrees** that the completion of the assessment of BSB by 2011 is a matter of the highest priority for the sub-committee on other Southern Hemisphere humpback whales. It **strongly recommends** that the strict work plan outlined in Table 6 be followed to facilitate completion at next year's meeting. Regular progress on these tasks will be monitored and reported by Zerbini to an intersessional group (Annex Q). The Committee **recommends** a pre-meeting to the Annual Meeting to ensure the timely completion of this work.

The modelling required to complete the assessment has financial implications for the Committee and this is discussed under Item 24.

The Committee **agrees** that it will conclude the assessment of BSB humpback whales at next year's meeting. Therefore, the Committee **recommends** that assessments of BSE and BSF humpback whales should be initiated and a progress report be presented at SC/63. An intersessional e-mail group was established under Jackson to assemble all the relevant

Table 5

Input data reference cases and sensitivities selected for use in population modelling for the assessment of BSB.

Data category	Population	Reference case	Sensitivity analysis
Capture-recapture	Gabon	Microsatellites, males-only* (see note below)	Flukes; microsatellites (both sexes)
Capture-recapture	WSA	Microsatellites* (see note below)	Right dorsal fin; flukes
Minimum past population	Gabon	$N_{min} = 68$	None
Minimum past population	WSA	$N_{min} = 24$	None
Catch allocation (north of 40°S)	Gabon	Congo and 50% Angola	Congo and Angola; Congo only
Catch allocation (north of 40°S)	WSA	50% Angola, Namibia and WSA	Namibia and WSA; Angola, Namibia and WSA
Catch allocation (south of 40°S)	Gabon	Allocation Hypothesis 1 developed last year	None
Catch allocation (south of 40°S)	WSA	Allocation Hypothesis 1 developed last year	None
Migration to unknown breeding ground	Gabon	25%	None
Migration to Antarctic	WSA	50%	100%; 0% (does not migrate)
Struck and loss rate	Both	0.15 (as presented in SC/62/O2)	0

*Microsatellite data will only be used as a reference case for capture-recapture data if genotyping errors can be incorporated into assessment models. Otherwise flukes will be used.

Table 6

Intersessional tasks to finalise the assessment of BSB humpback whales.

Task	Responsible persons	Final deadlines: Circulation to group for consideration	Final deadlines: Decision regarding use in model
Work on data inputs to model and possible refinements to stock hypotheses			
Inspection of mark-recapture data within and between Gabon and WSA for consideration in stock structure hypothesis refinement.	Barendse and Collins	15/12/10	31/01/11
Investigate and update estimates of potential and realized error in genetic and photo-identification data.	Carvalho, Collins, Rosenbaum, Cerchio	15/12/10	31/01/11
Re-analyse mark-recapture data from WSA using multi-year Program MARK (or equivalent) models to examine the effects of heterogeneity (for fluke data), tag loss (for dorsal fin data) and genotype error on abundance estimates, and assess the most appropriate data on interchange.	Barendse, Cerchio, Best	15/12/10	31/01/11
Conduct feeding-breeding ground mixed-stock analysis in order to estimate stock mixing proportions between Gabon and WSA and the Antarctic in order to further refine stock structure hypotheses for assessments.	Rosenbaum, Carvalho, Loo	15/12/10	31/01/11
Examine catch data for incorporation in population models, which should be sex-disaggregated, if possible.	Best and Butterworth	15/12/10	31/01/11
Comparison of WSA catalogue to South African government Oceans and Coast Catalogue (advantageous but not critical).	Barendse, Findlay and Meyeo	01/12/10	31/01/11
Modelling work			
Development of assessment models consistent with stock structure hypotheses selected by the Committee. Highest priority is for the models in Annex H, table 2. To the extent time permits variants of these models will be considered as sensitivities (Annex H, table 3).	Butterworth, Muller, Johnston	Some initial runs for highest priority stock hypotheses	Final runs for at least highest priority stock hypotheses
The assessment models should use the input data identified as the reference cases and sensitivities in table 2 above. Data output should include the posterior median and the 90% probability interval for the year for which the abundance prior corresponds. Present results for at least highest priority hypotheses.		15/01/10	One week before pre-meeting

data needed for these assessments. The assessment of BSD humpback whales (western Australia) had been completed at the SC meeting in 2005 (IWC, In press), but because of extensive mixing in the feeding grounds with other stocks (e.g. BSE) this stock might needed to be re-assessed along with BSE and BSF. The intersessional group will also consider the inclusion of BSD humpback whales in the assessments of the two other stocks.

The Committee **agrees** that a new item will be added to its agenda to consider new information on the Arabian Sea humpback whale population.

10.2.2 Review new information on other breeding stocks

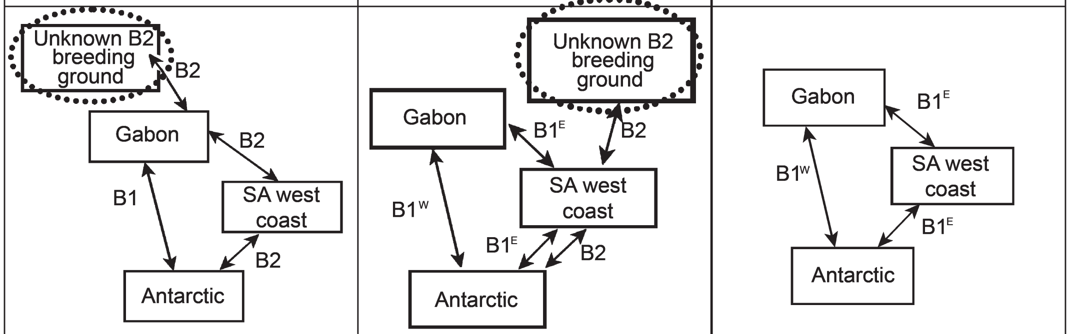
10.2.2.1 BREEDING STOCK A

The Committee welcomed two papers with new information relevant to BSA. SC/62/SH27 reported a photographic match of a female humpback whale between Abrolhos Bank, Brazil (BSA) and the east coast of Madagascar (BSC3), which represents a new mammalian distance record. SC/62/SH28 presented a new line-transect abundance estimate of 9,330 whales (95% CI=7,185-13,214; %CV=16.13) for the coast of Brazil in 2008. This stock appears to be undergoing a steady growth, but further studies are necessary to reduce uncertainties associated with $g(0)$ estimation and other potential sources of bias. Further details are described in Annex H, item 2.2.1.

10.2.2.2 BREEDING STOCK D

Two papers provided information relevant to Breeding Stock D. These are summarised below, with additional details provided in Annex H, item 2.2.2. SC/62/SH21 reported on the deployment of 23 satellite tags on southward migrating whales off Kimberley coast, northwestern Australia. In total, 263 days of location data tracked whales over a total distance of nearly 20,000km. This work has provided the most detailed movement data off northwestern Australia to date and revealed an unexpected 1,200km movement from the coast into the Indian Ocean.

SC/62/SH24 described an unusual peak in recorded mortalities (n=47) of humpback whales in Western Australia



Model Ia	Model IIa	Model III
Model description: model assumes two independent breeding sub-stocks which can mix on Antarctic feeding grounds. Whales from breeding sub-stock B1 feed in the Antarctic and migrate to Gabon for breeding. Whales from breeding sub-stock B2 feed off WSA and migrate along the West African coast through Gabon to a separate unidentified breeding ground. Additionally, some portion of B2 animals migrate to Antarctic feeding grounds. Variants on this model were not considered priority for the assessment of BSB.	*Model description:* model assumes two breeding sub-stocks, B1 and B2. B1 has two migratory components, B1E and B1W. Whales from B1W migrate from Antarctic feeding grounds directly to Gabon while whales from B1E migrate through waters off west South Africa before continuing on to the Gabon breeding grounds. Whales from sub-stock B2 feed primarily off WSA, do not migrate past Gabon and migrate to a separate unidentified breeding area. In addition, some portion of animals from sub-stock B2 migrates to Antarctic feeding grounds. Variants on this model were not considered priority for the assessment of BSB.	*Model description:* model assumes a single breeding stock, B1, with two migratory components B1W and B1E. B1W migrates directly to Gabon from Antarctic feeding grounds while B1E migrates through waters off west South Africa before continuing on to the Gabon breeding grounds. The proportion of animals using each migratory route may change over time.

Fig. 5. Stock structure hypotheses selected as priority for use in the BSB assessment.

in 2009. Only a few mortalities have been reported per year in previous decades. The authors hypothesised that this event could represent:

(1) an artefact of searching effort and coastal oceanography;
(2) a temporary increase in mortality rates; or
(3) the start of an increasing trend in mortality.

They considered the latter two hypotheses to be the most plausible, but noted that additional research would be required to discriminate between them. The Committee noted the importance of continued stranding monitoring to clarify the cause of such unusual events.

10.2.2.3 BREEDING STOCKS E AND F

The Committee welcomed papers on Breeding Stocks E and F and noted these will be relevant for the forthcoming assessment of these stocks. Two papers provided new information on the distribution and habitat use of humpback whales along the east coast of Australia (BSE1).

SC/62/SH21 described results from 13 satellite tags from northward migrating humpback whales off Evans Head, eastern Australia. In total, 371 days of location data tracked whales for nearly 21,000km. The results represent the first detailed movement data of this species in their proposed calving area around the southern Great Barrier Reef.

SC/62/SH25 described the first on-water photo-id study of humpback whales in the Great Barrier Reef Marine Park Cairns/Cooktown Management Area. Thirty percent of the 28 groups observed contained young calves, indicating that this may be an important nursery area for BSE1. Seven individuals were matched to sightings in other areas of east Australia in previous years. Group size, composition, distribution and behaviour were also discussed. Further work is planned and data are available for collaborative research.

Three papers provided new information on the population structure and dynamics of BSE and BSF. SC/61/SH14 presented annual realised growth rates and survival of post-yearling BSE1 humpback whales off New South Wales, Australia (1994-2009). Several caveats were noted and suggestions for further analysis of these data are described in Annex H, item 2.2.2.

SC/62/SH7 reported on a large collaborative comparison of microsatellite genotypes from the migratory corridor along eastern Australia (n=734), the South Pacific Islands (n=1,086) and Antarctic feeding Areas I-VI (n=175). Breeding ground interchange was detected between Eastern Australia-New Caledonia (n=11) and Eastern Australia-Tonga (n=1). The only matches made to feeding grounds were between Eastern Australia and Antarctic Area V (n=3), despite larger sample sizes from Areas IV and VI. The authors concluded that breeding sub-stocks may be mixing on both their breeding and feeding grounds.

They also highlighted the feasibility of this type of collaborative research for studying migratory interchange on a large-scale. SC/62/SH18 reported photographic and genotypic mark-recapture estimates of abundance for humpback whales breeding at the South Pacific Islands (BSE2, BSE3 and BSF) for the period 1999-2003 and concluded that total combined abundance for these breeding stocks likely lies between 2,361 and 3,520 whales. No significant trend in abundance for this population was detected.

Additional details on the discussion of papers on BSE and BSF can be found in Annex H, item 2.2.3.

10.2.2.4 BREEDING STOCK X (ARABIAN SEA POPULATION)

The Committee received two papers with new information on the status of breeding stock (BSX). It had been given this name at a 2006 workshop on Southern Hemisphere humpback whales (IWC, In press). The population is believed to be resident to the Arabian Sea, is currently estimated at 82 individuals (95% CI=60-111) (Minton *et al.*, In press) and recently listed by the IUCN as endangered (Minton *et al.*, 2008). The Committee **agrees** to henceforth call this the Arabian Sea population.

SC/62/SH6 reported on the genetic distinctiveness and current population status of the Arabian Sea population. Genetic analyses based on 11 microsatellite markers and mtDNA sequences revealed significant differentiation between whales sampled off the coast of Oman (n=67), relative to the North Pacific and four Southern Hemisphere regions. Estimated levels of differentiation are among the highest recorded for humpback whale populations worldwide.

It is very unlikely that there is currently any exchange between the Arabian Sea and the Southern Indian Ocean stocks. Tests of population expansion suggest that the population has not yet started recovering and may still be in decline. SC/62/SH20 discussed the anthropogenic threats facing this population and challenges faced in monitoring this endangered population. Baleen whales in this region are potentially vulnerable to impacts from fishing, coastal development, shipping and noise and impacts. At least one live humpback whale entanglement in a gillnet is known to have occurred during the period 2007 and 2009. Research effort has been severely limited in recent years.

The Committee thanked the authors for this new information, noting its **great concern** over the status of this population. The Committee **strongly recommends** the continuation of research on humpback whales in the Arabian Sea in light of the small population size and escalating threats (see also Annex J, item 9.3). It further recognised the difficulty of undertaking such studies for small populations in remote areas.

The Committee also makes the following **recommendations** (in order of priority) for this population:

(1) studies that enable identification and quantification of threats to the Arabian Sea population should be initiated, including an in-depth investigation into the impact of bycatch;
(2) studies and surveys in Oman should be continued and expanded in scope to include more detailed genetic, acoustic and behavioural studies, as well as satellite telemetry studies;
(3) surveys should be encouraged in additional locations in confirmed range countries (Kuwait, India, Iran, Iraq, Oman, Pakistan, Sri Lanka, United Arab Emirates, Yemen), with particular focus on those countries with large coastal regions, such as Pakistan and India - in this regard, abundance surveys should be repeated on a regular basis in order to enable determination of population abundance and trend;
(4) further investigation into humpback whale occurrence in suspected/potential range countries (Bahrain, Maldives, Qatar, Saudi Arabia) should also be conducted; and
(5) studies and surveys to determine the population identity of whales in the Seychelles Exclusive Economic Zone should be performed.

The Committee further noted that given that this is a small population with known anthropogenic threats, it may well benefit from the development of a conservation management plan, following the model for western gray whales described under Item 10.4 and based upon Donovan *et al.* (2008). The Committee **agrees** that this should be explored further, perhaps within the context of conservation management plans being discussed by the IWC Conservation Committee

Further discussion of the Arabian Sea population is found in Annex H, item 2.2.4

10.2.2.5 FEEDING GROUNDS

SC/62/SH3 described a pilot study of cetacean distribution off Adélie Land that was launched by the French Polar Institute (IPEV) as part of the Southern Ocean Research Partnership (SORP). One photo-id match supported a migratory link between BSE and Area V. The Committee **recommends** the continuation of this programme, noting its relevance and utility for the forthcoming assessments of BSE and BSF.

SC/62/O12 presented a preliminary report of a joint Australian-New Zealand Antarctic Whale Expedition. Thirty humpback whales were satellite tagged on the Southern Ocean feeding grounds, and over 60 biopsy skin samples and approximately 60 individual fluke photographs were also collected. The Committee welcomed this research, which will make an important contribution to forthcoming assessments, and **recommends** its continuation. It also **recommends** that photo-id, biopsy sampling and satellite tagging research be conducted in other poorly surveyed areas of the Southern Hemisphere. The Committee **appreciates** the data sharing that has occurred post-expedition; this has been very productive with respect to matches identified with the East Australian breeding region and it **recommends** the continuation of such open collaborations. Finally, the Committee further **recommends** that long-term studies of humpback whales be undertaken and continued in the Southern Hemisphere.

SC/62/SH19 reported molecular genetic species identification of 281 whale bones collected between 2006 and 2007 in South Georgia. The prominence of humpback, fin and blue whale bones correspond to the early catch record in this area. Historical and contemporary humpback whale mtDNA haplotype diversity will be compared to measure the extent of the 'exploitation bottleneck' of stocks around South Georgia. The Committee **welcomes** this work and strongly **encourages** the continuation of bone collection for 'historical' DNA analysis. It further noted that this research will be important for the comparison of historic and current population abundance and diversity.

10.2.2.6 PRELIMINARY MULTI-STOCK ASSESSMENT

SC/62/SH33 reported preliminary results from the development of a population model that aimed to include all seven Southern Hemisphere humpback whale breeding stocks in a single joint assessment, with the purpose of allowing high-latitude historic catches to be allocated to breeding stocks in proportion to abundance, rather than on set ratios. The Committee **encourages** the further development of this model and the presentation of results in future meetings.

10.2.3 Antarctic Humpback Whale Catalogue

SC/62/SH17 described the progress of the Antarctic Humpback Whale Catalogue (AHWC). A total of 899 photographs of 721 individuals were catalogued from Antarctic and Southern Hemisphere waters for the interim period. Images were submitted by 21 individuals and research organisations. These submissions bring the total number of catalogued whales identified by fluke, right dorsal fin/flank and left dorsal fin/flank photographs to 3,665, 413 and 407, respectively. New inter-area matches were as follows: BSG-Antarctic Peninsula (19), BSG-Chile (3), BSA and BSC3 (1; see SC/62/SH27) and BSE-Antarctic Peninsula (2; see Robbins *et al.*, 2008). Re-sightings were also made at the Antarctic Peninsula (3) and within BSG (11). Progress continues to encourage contributions from researchers and eco-tourism. A new on-line catalogue using Flickr is in development and can be viewed at *http://www.flickr.com/ahwc*. The Committee noted the importance of this IWC-supported work and **recommends** its continuation.

10.3 Southern Hemisphere blue whales

In 2002, the Committee recommended that the assessment of blue whales be started in 2005, after the completion of the IDCR/SOWER review (IWC, 2003a, p.41). In 2008, the Scientific Committee completed a circumpolar assessment of Antarctic blue whales (IWC, 2009f) and recommended that area-specific analysis be examined to evaluate whether separate assessments can be done for each IWC Management Area (IWC, 2009f). The Committee also recommended gathering data relevant for the assessment of non-Antarctic (pygmy-type) blue whales. Detailed discussions from this year can be found in Annex H, item 3.

10.3.1 New information

The Committee welcomed new abundance estimates of blue whales off Chile. A new analysis of line transect data collected as part of the 1997/98 SOWER cruise off Chile (Williams *et al.*, 2009b) resulted in an estimate of 303 individuals (95% CI=217-455). Aerial line transect surveys conducted off Isla Chiloé in 2007, 2009 and 2010 resulted in estimates of 97 (CV=0.51), 154 (CV=0.32) and 163 (CV=0.39) individuals, respectively. Further details of these surveys are presented in Annex H, item 3.1.

At last year's meeting, the Committee noted that available line transect estimates probably do not represent the total size of the population(s) present and recommended other approaches be used to estimate blue whale abundance. Progress was reported on the Alfaguara Project's field season off Isla de Chiloe (southern Chile), and particularly its continuing blue whale photo-id research. A preliminary mark-recapture abundance estimate was also presented for pygmy blue whales at the Perth Canyon, Western Australia. Further description of that on-going work is provided in Annex H.

The Committee **recommends** that new or revised estimates of abundance be provided to next year's meeting; specifically from Chile (Galletti and Hucke-Gaete). For Western Australia (Perth Canyon) the level of research necessary to improve the mark recapture data (which is currently very sparse in recaptures) for updated abundance estimates is unlikely to be affordable in the coming year. The Committee also **recommends** that the intersessional e-mail group under Bannister continues to work toward providing new estimates of mark-recapture abundance of blue whales and to report new information at next year's meeting.

The Committee was informed of progress on the development of a cooperative Southern Hemisphere blue whale photo-identification catalogue (SHBWC). Nine groups have joined the SHBWC, including researchers in Chile, the Eastern Tropical Pacific, Australia, Sri Lanka, and Antarctica. Photo-id data from the Japanese Institute for Cetacean Research (ICR) Whale Research Program under special permit in the Antarctic (JARPA 1987/88-2004/05 seasons) has also been submitted to the IWC Secretariat and will be added to the SHBWC through the appropriate data availability channels. The Committee **welcomes** the update on the work of the SHBWC and **recommends** its continuation. It **recommends** that the photographs from the ICR catalogue should be compared to those already held at the Southwest Fisheries Science Center.

SC/62/SH29 reported on archiving and matching of blue whale photographs collected by the IDCR/SOWER cruises between 1987/88 and 2008/09. Over 23,000 photographs were obtained from all six IWC Management Areas, with 219 individual whales identified. Results suggest some degree of residency within a summer feeding season.

The Committee **recommends** that work on the Southern Hemisphere Blue Whale Catalogue (SHBWC) be continued. Over the next two years this will require completion of the matching from the three regions. Budget implications are given under Item 24.

SC/62/SH21 reported on satellite tagging of pygmy blue whales off southwestern Australia. Three tags were deployed (two males, one female) and the whales were tracked for over 8,000km. The tag with greatest longevity (137 days) provided definitive evidence of a link between whales that feed offshore of the Perth Canyon and those that occur around eastern Indonesia, such as the Banda Sea where reports of blue whales appear to be increasing.

The Committee welcomed a number of studies on blue whale acoustics. SC/62/SH26 described the migratory patterns and estimated population sizes of pygmy blue whales traversing the Western Australian coast. An analysis of passive acoustic data estimated that 662-1,559 pygmy blue whales passed the sampling instrument during the 2004 southbound migration. The Committee noted that the acoustic approach to estimating population size reported here represents an important theoretical development, but noted that a number of assumptions of this method needed to be explored in more detail before it could be considered to produce robust estimates of abundance. The Committee also encouraged the continuation of this work.

Gedamke and Robinson (2010) reported the results of an acoustic survey for whales and seals in eastern Antarctic waters (30-80°E) between January and February 2006. Blue whales were the most commonly recorded species identified. They were detected in large concentrations where relatively extensive sea ice remained off the continental shelf and the more eastern waters off the Prydz Bay region. Two detections of pygmy blue whales represent the most southerly recordings of these species.

SC/62/SH13 described results from passive acoustic monitoring for the presence of baleen whales off the coast of Northern Angola, off the Congo River outflow. A series of pygmy blue whale calls were detected by two marine autonomous recording units deployed between March and December 2008, 15km and 24km offshore. This represents the first confirmed modern documentation of this sub-species in Southeast Atlantic waters north of 60°S since the cessation of commercial whaling for blue whales in the region. The calls were of the type attributed to the Sri Lanka population of pygmy blue whales, and not previously recorded outside of the Indian Ocean. Antarctic blue whale calls were not detected. The recording of Sri Lanka pygmy blue whale calls in the Atlantic Ocean was considered to be of great interest.

Progress was reported on a genetic study of Antarctic blue whales, which has been carried out with access to 218 IDCR/SOWER biopsy samples provided by the IWC. More than half of the haplotypes detected thus far have not previously been described. Analysis of the samples is ongoing and the results will be used to estimate the minimum historical population abundance of the Antarctic blue whale. The Committee welcomed this work and **recommends** its continuation. It was observed that this study expands on the haplotype data originally reported by LeDuc *et al.* (2007); the additional haplotypes reported here likely originated from IWC Management Areas II and III (Donovan, 1991), which were under-sampled in the previous study.

The Committee welcomed information on an upcoming study of the global taxonomy of blue whales using mitogenomic and nuclear sequence data. This work aims to conduct a comprehensive genetic assessment of blue whale taxonomy using next-generation sequencing methods to sequence whole mitogenomes and a large number of nuclear regions, for phylogenetic analysis. The project will particularly focus on determining the sub-specific status of blue whales in the North Pacific. The Committee **strongly encourages** continued collaborative efforts to acquire blue whale samples globally, and welcomed further updates on the results of the study

Four blue whale genetic projects are currently in progress: (1) genetics of blue whales in Geographe Bay, Western Australia, as part of a southern Australian study (11 samples collected, 11 analysed and archived, Möller, see SC/62/ProgRepAustralia); (2) a genetic population structure study of blue whales in the southeast and Eastern Tropical Pacific regions (Flores-Torres); (3) a global taxonomy study of blue whales (Lang); and (4) a genetic analysis of the diversity of IDCR/SOWER Antarctic blue whale biopsy samples and South Georgia whalebones (Sremba). The Committee **encourages** continuation of this research and **recommends** that results from these studies be reported when they become available.

10.4 Western North Pacific gray whales (BRG)

10.4.1 New scientific information

Considerable information was presented, and this is discussed in Annex F, item 6.1. Only a brief summary of that work is given here.

In SC/62/BRG11, data generated using a panel of 13 microsatellite loci were combined with updated information from mtDNA control region sequences to further assess the population structure of gray whales in the North Pacific. The results are consistent with the possibility that there may be some dispersal between two populations but that observed genetic differentiation is supportive of two populations.

SC/62/BRG10 presented the results of a paternity analysis conducted on the western gray whale population. The results suggest that some males that contribute to reproduction in this population may not regularly use the primary Sakhalin feeding ground. This highlights the need to collect genetic samples from animals recorded in other areas of the western gray whale's range. The results also provide evidence of interbreeding among animals that show fidelity to the Sakhalin feeding ground.

SC/62/BRG5 presents the first analysis of genetic (mtDNA) data obtained from the gray whales migrating along the Japanese coast (n=6) and incorporated comparison of these with a sample of animals from the Chukotkan hunt in 2008 (n=7). In summary, while recognising the small sample size: (a) all of the mtDNA haplotypes found had been previously reported; (b) the level of genetic diversity within samples was surprisingly high; (c) no genetic heterogeneity in haplotype frequencies was detected between the two samples; and (d) phylogenetic analysis of the haplotypes detected no distinct cluster for the Japanese whales.

The Committee **welcomes** these analyses. It **encourages** the collection of more samples from areas outside Sakhalin feeding ground when they are available and **recommends** a more detailed analysis of samples currently available and a number of suggestions are given in Annex F, item 6.1.

The Committee also received a number of papers on distribution and abundance. A number of points of interest were raised by these papers including:

(1) the potential for western gray whales to reoccupy parts of their former range if the currently small population expands (SC/62/BRG3);
(2) significant annual variation in whale densities among years within the Piltun and offshore feeding areas (SC/62/BRG4);
(3) updated information on an industry-sponsored monitoring programme using photo-id included the movement of animals between Sakhalin and Kamchatka and mother-calf pairs in Olga Bay, Kamchatka (SC/62/BRG9);
(4) updated information from the 2009 collaborative Russia-U.S. research programme (SC/62/BRG6);
(5) comparison of age at sexual maturity in western and eastern gray whales suggesting that the range 6-12 yrs is appropriate for both populations although further data would be welcome (SC/62/BRG2); and
(6) updated information on research and conservation in Japan including information on skeletal studies and an educational programme for fishermen (SC/62/O7).

The Committee **welcomes** all of the new information on this critically endangered population. It **encourages** further work and as in previous years, re-emphasises the importance of continued long-term monitoring. The Committee **recommends** that, if the observed density of gray whales in the Piltun feeding area continues to decline or remains lower than in previous years, future studies should investigate whether this reflects natural variation (e.g. in prey availability), industrial disturbance or some other factors.

Donovan reported on progress with the telemetry programme on western gray whales that has been recommended by the Committee (e.g. see IWC, 2010c). He reported that the programme is progressing and that all involved are grateful to Ilyashenko and his colleagues at IPEE for their work to try to ensure that this project goes ahead, particularly at this stage with respect to the permit issue. An overall administrative and scientific structure has been agreed between the participating institutions and companies, the IWC and IUCN. The scientific steering group is continuing to work on finalising the protocols that will ensure that the IWC Scientific Committee safeguards and guidelines are met as it has been tasked by the Committee; the final protocols will be drawn up in co-operation with IPEE and OSU. IWC, IUCN and the funding companies are also working hard on difficult budgetary issues. It is hoped that it will be possible for the programme to take place this summer.

10.4.2 Conservation advice

The Committee again **recognises** that the problem of net entrapment of western gray whales is a range-wide issue. It **welcomes** the efforts of Japan to reduce mortality, including the educational programme, and notes that net entrapments could occur in other range states. Brownell summarised plans for seismic surveys off Sakhalin Island in 2010. There is concern that anthropogenic sound, especially from seismic surveys, will negatively affect western gray whales in their primary feeding area. Previously, the Commission expressed concern and passed resolutions on this topic. Two seismic surveys in or near the feeding area are planned for 2010. It was noted at the recent meeting of the IUCN Western Gray Whale Advisory Panel that the company (Rosneft) planning the later survey has not followed the same procedures in regard to monitoring and mitigation as the company planning the first survey (by Sakhalin Energy). As currently planned, the Rosneft survey will occur while the highest number of feeding gray whales, including cow and calves, are present. The Committee is **extremely concerned** about the potential impact on western gray whales and **strongly recommends** that Rosneft postpone their survey until at least June 2011 The Committee also **recommends** that Rosneft use monitoring and mitigation measures similar to those used by Sakhalin Energy (see Annex F, Appendix 4), which have been independently reviewed by experts, and that all energy companies operating in the feeding areas of western gray whales should use comprehensive monitoring and mitigation measures to protect western gray whales.

As in previous years, the Committee **acknowledges** the important work of the IUCN Western Gray Whale Advisory Panel (WGWAP). This year's update on the panel's activities is given in Appendix 4 of Annex F. Noting that the WGWAP's present contractual five year life span ends after December 2011, the Committee **re-emphasises** its view that its work is important and should be **continued** if at all possible, and the Committee **requests** the Secretariat to send a letter to IUCN in this regard.

In 2009, the Committee welcomed the report of the IUCN range wide workshop (IUCN, 2009). An important conclusion of that workshop was the need for the development of a conservation plan for western gray whales and this recommendation was endorsed by the Scientific Committee.

This year, the Committee was extremely pleased to receive the first draft of this important Plan (SC/62/BRG24). It **commends** the authors, who include scientists from range states as well as elsewhere, for this important document. The Plan follows the guidelines developed for such plans by Donovan *et al.* (2008) that were endorsed by the Committee (IWC, 2009a). Much of it is based on the report and recommendations of the IUCN rangewide workshop that have also been endorsed by this Committee. The Committee emphasised that the Plan should be supported and endorsed by many stakeholders, including national and local governments, industry, and non-governmental organisations, as well as international organisations such as IWC and IUCN. The overarching goal of the Plan is to reduce mortality related to anthropogenic activities to zero as quickly as possible. The Plan includes 11 focussed actions (related to co-ordination, public awareness, conservation research, monitoring and mitigation) of high importance for the conservation of this critically endangered population. The most immediate, in terms of ensuring the success of the Plan is the appointment of a Steering Committee and of finding funds for and appointing a full-time Co-ordinator. This is also critical to the need, identified by the authors, to engage broad stakeholder participation in the Plan as soon as possible.

The Committee **strongly endorses** this Plan and **commends** it to the Commission and range states. It also **recommends** that it is broadly distributed, including being posted on the IWC and IUCN websites. Consideration is being given to it being published by the *JCRM*. The Committee **recommends** the Plan as a model for the development of other conservation plans for cetacean populations.

10.5 Southern Hemisphere right whales

10.5.1 Australian and New Zealand areas

The Committee received a number of papers on southern right whales from these areas. Details can be found in Annex F, item 5.3. A number of points of interest from these are given below:

(1) genetic comparison of animals around the subantarctic Auckland Islands and the main islands of New Zealand provided documented evidence for the first time of the movement between the two regions and, along with other available data, is most consistent with either the one stock or the extirpation/recolonisation hypotheses (SC/62/BRG16);
(2) results from satellite telemetry provided data on migratory movements of three whales tagged at the Auckland Islands revealed that animals from this nursery area/breeding ground can move north to their feeding ground - the reverse of the generally accepted migratory pattern for southern right whales (SC/62/BRG19);
(3) information on acoustic contact calls from southern right whales near the Auckland Islands (SC/62/E13); and
(4) updated information on long-term aerial survey monitoring programme along the southern Australian coast results in an annual increase rate for cow/calf pairs of around 7.5% (95%CI 3.2, 12.0) for the period 1993-2009 and a minimum population size of 2,530, with a total Australian population of about 3,000.

Difficulties or complications experienced in obtaining permits for biopsy sampling of right whale calves were discussed. Although there were legitimate concerns over possible disturbance to mother-calf pairs, no adverse effect had been shown on subsequent calving interval in a study of the effects of biopsying over 100 cow-calf pairs off South Africa, although the statistical power was low (Best *et al.*, 2005). Given the potential value of such sampling, particularly in establishing issues of paternity the Committee **recommends** that permitting authorities should view requests for biopsy sampling of cow-calf pairs on their scientific merit and apply appropriate safeguards to limit the degree of disturbance where necessary.

10.5.2 South America area

The primary item discussed under this item was the report of a workshop (convened by Brownell) held at the Centro Nacional Patagónico (CENPAT) in Puerto Madryn, Argentina from 15-18 March 2010. The goal of the workshop was to investigate the causes of the high mortality of southern right whales around Península Valdés, Argentina. Participants included experts on the ecology and marine environment of the Península Valdés region, scientists studying right whales in the South Atlantic and international experts on whale strandings and mortality.

Small numbers of strandings have been recorded in the region since 1971. However, since 2003, when the Southern Right Whale Health Monitoring Program (SRWHMP) was established, a total of 366 right whale deaths have been recorded, with peaks in 2003 (31), 2005 (47), 2007 (83), 2008 (95) and 2009 (79). Over 90% of the deaths have been of first-year calves. After investigating thoroughly a range of possible causes for these first year deaths, the workshop agreed three leading hypotheses (it was not possible to determine which was most likely and some combination of factors may have occurred, at least in some years): (1) reduced food availability for adult females; (2) biotoxins; and (3) infectious disease.

The workshop recommended a number of steps to build a better understanding of the cause or causes as listed in Annex F, item 5.3.2.

Of these, continuation of the long-term aerial photo-id programme, other complementary monitoring effort and the SRWHMP are highest priority. The workshop agreed that cooperation and collaboration among research groups is essential for addressing complex questions concerning the die-offs. A western South Atlantic right whale consortium (the North Atlantic right whale consortium) could be used to establish and maintain links among researchers and to share information (this should also include researchers in different parts of the range). Efforts to improve such cooperation and collaboration should be a high priority for local and national governments, NGOs and INGOs.

It was also agreed that the absence of conclusive information regarding the cause(s) of exceptional right whale mortality should not preclude authorities from proceeding with some management measures, particularly in relation to kelp gulls, where gull lesions are clearly harmful to the whales, especially the calves.

The workshop also recognised: (1) the considerable efforts of the researchers in Argentina (and abroad) to investigate the die-offs in the face of fiscal and logistical constraints; and (2) the importance of governmental commitment to the long-term conservation of right whales in Argentina.

The Committee thanked Brownell for his presentation and **endorses** the workshop report. The Committee **welcomes** the announced intention of the Argentine authorities to introduce this year a pilot plan for the control of nuisance gulls.

As in previous years, the Committee **recognises** the value of the long-term photo-id programme of right whales at Península Valdés that had now lasted 40 years, particularly in being able to describe the significance of the recent die-off events and test certain causation hypotheses. It **strongly recommends** its continuation. It also noted that this year emergency funding had been provided by the US Marine Mammal Commission to enable the necropsy programme to take place and strongly **recommends** the continuation of this programme to investigate the reason(s) for the die-off.

The Committee also considered SC/62/BRG15, a preliminary assessment of the genetic structure of the southern right whales from Península Valdés, Argentina. A number of comments to assist in future analyses were raised in discussion (Annex F, item 5.3.2) and the Committee looks forward to an updated analysis next year.

The Committee was pleased to receive information on the 2009 flights of an aerial survey programme off Brazil and it **recommends** the continuation of the surveys.

10.5.3 South Africa area

The Committee was pleased to receive updated information on demographic parameters obtained from the long-term monitoring programme of South Africa (SC/62/BRG30). The results are discussed in Annex F, item 5.3.3 but key features include an annual growth rate of about 7% (95% CI 6.5%, 7.5%); a mean calving interval of about 3.2 years; and a population size in 2006 as about 4,100 animals. SC/62/BRG31 examined the possibility of changes in some demographic parameters for right whales off South Africa through the analysis of re-sighting data for females with calves over the 1979-2006 period. No statistically significant change in adult survival rate or population growth rate was found but a reduction in mean calving interval from 3.2 to 3.1 years was detected.

SC/62/BRG33 reported on the recent announcement of the intention to drill exploratory boreholes for natural gas in eight districts of the coastal region of the southwest coast of South Africa, three of which included nearshore waters that were home to the largest concentration of cow-calf pairs on the African coastline. About 75% of cow-calf pairs on the southern African coast occur in this region in spring, some of which are resident for up to three months, while the westward coastal movement seasonally means that an even larger proportion of the population almost certainly uses the region.

The Committee viewed this potential development with concern, noting the current lack of information available on the proposed activities. It **recommends** to the South African government that all permits issued for exploratory activities should contain mandatory mitigation measures to avoid disturbance to right whales, including confining all marine drilling activity to the season when right whales are absent (January to May). It also **recommends** that if gas production is ultimately planned for the region, the use of closed areas or the development of further mitigation measures such as directional drilling should be considered.

The Committee **endorses** a proposal for the establishment of a Southern Ocean Right Whale Photo-identification Catalogue (the Antarctic Humpback Whale Fluke catalogue). The intention is to provide a resource that could be consulted when researchers holding images taken in coastal waters wished to establish linkages with feeding grounds in pelagic waters (see Appendix 2 of Annex F for detail). It was confirmed in discussion that this would be supplementary to such coastal catalogues. The Committee looks forward to receiving a progress report at its next meeting. Funding is dealt with under Item 24.

10.5.4 Plans to review southern right whales

Brownell reported on progress in preparing for the Southern Right Whale Assessment Meeting, planned to be held at Puerto Madryn, Argentina, in September 2011. Given that this meeting would be held very shortly after next year's IWC meeting a budget would have to be prepared at this meeting (and reserved until 2011). A small group was set up to draw up the budget and draft the Terms of Reference for the meeting (see Annex F, Appendix 3). The Committee **agrees** that this should be funded next year.

10.5.5 Other

The Committee recognises the importance of long-term studies, to provide biological information from photo-id and information on trend and population size from sighting and mark-recapture analyses. It **strongly recommends** the continuation of such long-term studies in relevant areas.

10.6 Other stocks of right whales and small stock of bowhead whales

10.6.1 North Atlantic right whales

An update was provided on North Atlantic right whales for the period May-October 2009, as an addendum to information presented in Pettis (2009). The summary reflects the work of the North Atlantic Right Whale Consortium (NARWC). A shared photographic catalogue was used to produce a 'best' estimate of population size of 438 for 2008. This total did not explicitly account for unphotographed whales in the population and may change slightly as additional data are incorporated into the catalogue. One right whale death was documented during the report period, but the cause was not determined. Additionally, there were three new entanglement cases and eight previous entanglement cases that had not yet been resolved.

The Committee **agrees** that the documented growth in the catalogue plus successive years of improved calf production gave grounds for cautious optimism over the future status of this population. However, while welcoming the management measures that have been taken to date, the Committee **repeats its previous recommendations** on this population that it is **a matter of absolute urgency** that every effort be made to reduce anthropogenic mortality to zero.

10.6.2 North Pacific right whales

SC/62/BRG3 reviewed past sightings of North Pacific right whales off western Kamchatka from spring to autumn. A number of sightings of these whales were made during Japanese-led surveys from 1989 to 2003; these were mostly restricted to the southern portion of study area. However, there were also a few sightings in earlier years by Soviet scientists, including in the northern part of the area. These sightings also highlight the need for directed research and monitoring of right off western Kamchatka in areas overlapping with fishery and oil and gas development activities.

SC/62/NMP22 provided results of observations of North Pacific right whales during the common minke whale sighting and biopsy survey conducted in the Okhotsk Sea in summer 2009. The research area was set north of 46°N, south of 57°N and west of 152°E in the Okhotsk Sea including the Russian EEZ. 17 schools (29 animals) of North Pacific right whales were found, mainly in the offshore waters deeper than 200m. Of these, 16 schools were targeted for photo-id research and 22 animals in 15 schools were individually identified (there are no re-sightings among them).

The Committee welcomes the sighting and photo-id information from these cruises and **encourages** continuing these studies in the area.

Wade *et al.* (2010) used photographic and genotype data to calculate the first mark-recapture estimates of abundance for right whales in the Bering Sea and Aleutian Islands. The estimated abundance data reveal this to be an extremely small population of perhaps around 30 animals. The results will be updated using more samples and images from another survey planned in the eastern North Pacific this year and the Committee looks forward to receiving this information.

Noting the extremely small size of this population, and also the potential for disturbance and ship-strike mortality from greatly increased ship traffic resulting from the likely opening of the northeast or northwest Passages due to sea ice retreat, the Committee considers it **a matter of absolute urgency** that further research be conducted on eastern North Pacific right whales, and **recommends** that this research focus on assessing status and identifying any current sources of anthropogenic mortality.

10.6.3 Small stocks of bowhead whales

SC/62/BRG3 summarised sightings of bowhead whales off western Kamchatka from existing published literature and other available sources. Okhotsk Sea bowhead whales were recorded only a few times in the study area during the spring-autumn period, with one sighting during winter; however it is known from historical whaling data that this species was abundant in the area, particularly in the northern regions during periods of open water.

SC/62/BRG20 reported the results of a survey for bowhead whales conducted in the Fram Strait during 29 March-14 April 2010. Two observations were made, but it was determined based on identifiable scars that both encounters were of the same individual.

Witting reported that 12 sighting of bowhead whales were made in the Northeast Water Polynia off Northeast Greenland during an aerial survey for walrus during August 2009. He also reported that a female with a calf was seen off Norske Island, Northeast Greenland in July 2009. In discussion, it was noted that two passive acoustic recorders were deployed in the Fram Straight during 2008-09 and that these instruments detected numerous bowhead sounds including songs.

The Committee welcomes the above information and **encourages** future updates and research.

10.7 Antarctic cruises

10.7.1 General review of 2009/10 cruise

The planning meeting for the 2009/10 IWC/SOWER cruise was held in Tokyo, Japan in September 2009 (SC/62/Rep6). The cruise took place in Area IV and had two main objectives: (1) to undertake a sightings survey in collaboration with an Australian Antarctic Division aerial survey; and (2) to continue research on the priority species (southern right, blue, fin, and humpback whales). The total number of minke whales sighted in the research area was 83 groups, comprising 152 animals; humpback whales were the most frequently sighted species (174 groups comprising 322 animals). Biopsy samples and individual identification photographs were taken from 21 and 45 humpback whales and 22 and 26 southern right whales, respectively. A total of 28 groups of southern right whales (38 animals) were sighted (SC/62/IA1).

The Committee thanks the Government of Japan for generously providing the vessel and crew for this survey, and also thanks the Cruise Leader for her efforts. Noting that this was the last IDCR/SOWER cruise, the Committee also extended its appreciation to all member nations and researchers who had contributed to this extensive programme, and particularly to the governments of Japan and the former Soviet Union, for providing the survey vessels. The data collected during the programme provide an unparalleled source of information on Antarctic cetaceans. The experience gained from these surveys will continue to be of use in planning future studies, in the Southern Ocean and elsewhere. The Committee **agrees** that a Special Issue of the *JCRM* on the IDCR/SOWER surveys is warranted and re-establishes the working group to progress this idea (see Annex Q).

10.7.2 Plans for cetacean sighting surveys in the Antarctic in the 2010/11 season

SC/62/O17 described a dedicated, systematic cetacean sighting survey which was being planned to take place from December 2010 to February 2011 in order to obtain estimates of abundance for use in the RMP. The research area will be south of 60ºS in Area V and the western part of Area VI (130ºE-145ºW), including the Ross Sea. This survey will be conducted in relation with the Japanese Whale Research Programme under special permit in the Antarctic (JARPA II). Two dedicated, sighting survey vessels, *Shonan-Maru No.2* and *Yushin-maru No.3*, will be used and the survey procedures will be based on the standard

SOWER search modes; closing (NSC) mode and passing with the independent observer (IO) mode.

In order to minimise difficulties associated with survey design, an intersessional Working Group was established under Matsuoka (Annex Q). The Committee **agrees** that Matsuoka is responsible for IWC oversight.

10.8 North Pacific cruises

10.8.1 Recommendations for 2010 cruise and short term objectives

During the last year's Scientific Committee meeting, Japan presented a proposal for a medium- to long-term research programme involving sighting surveys to provide information for cetacean stock management in the North Pacific. The Scientific Committee welcomed the initiative and agreed the value of a large-scale, medium-long term integrated research programme in the North Pacific and encouraged this in the context of international collaboration under IWC auspices.

A meeting to discuss the North Pacific survey programme was held in Japan in September, 2009 (SC/62/Rep3). The meeting agreed four terms of reference:

(1) review the Scientific Committee's issues in the North Pacific;
(2) review the past and ongoing survey activities and available data in range states;
(3) consider possible line transect survey plans and additional data collection (e.g. photo-id and biopsy) for the 2010 season; and
(4) prepare a proposal for an intersessional workshop (to be held between SC/62 and SC/63) on future surveys beyond 2011.

SC/62/IA15 was provided in response to the first term of reference from the meeting and provided a summary of the Scientific Committee issues relating to North Pacific sei, common minke, Bryde's, right and blue whales. The distributions of these whale species were described and requirements for further surveys, in order to estimate abundance and investigate stock structure, were considered.

SC/62/IA10 presented the research plan for an IWC/Japan whale sighting survey taking place in summer 2010. The plan had been drawn up following guidelines agreed at the North Pacific programme intersessional meeting. The research area (170°E-170°W) had been chosen because for some species it spans proposed stock boundaries and has been poorly covered by previous surveys, representing an important information gap for several large whale species. The cruise will collect line transect data to estimate abundance, and biopsy/photo-id data contributing to the work of the Scientific Committee on the management and conservation of populations of large whales in the North Pacific. It will provide:

(1) information for the proposed future in-depth assessment of sei whales in terms of both abundance and stock structure;
(2) information relevant to *Implementation Reviews* (e.g. common minke whales) in terms of both abundance and stock structure;
(3) baseline information on distribution and abundance for a poorly known area for several large whale species/populations, including those that were known to have been depleted in the past but whose status is unclear; and
(4) biopsy samples and photo-id photos to contribute to discussions of stock structure for several large whale species/populations, including those that were known to have been depleted in the past but whose status is unclear.

The cruise will last about 60 days (including transit time) between July and August. In order to adequately cover the longitudinal range, the latitudinal range is restricted between a southern boundary at 40°N and a northern boundary at the Aleutian Islands chain. Four researchers can be accommodated on this cruise; US and Korean scientists will participate. The cruise will follow the requirements for reports and documentation developed for cruises that could provide data for use under the RMP and will be the responsibility of the Japanese scientists.

The Committee thanked the Government of Japan for its generous offer of a vessel for this survey. Matsuoka was assigned responsibility for IWC oversight.

Brownell reported that a scientist from SWFSC had now been identified for the cruise, but major problems regarding CITES permits remain; these issues are similar to those described in SC/62/NPM22 that were encountered between Japan and Russia for the collection of minke whale biopsy samples in the Russian EEZ. There are CITES issues for both inside and outside the US EEZ, because samples collected outside the US EEZ have to enter US waters and then all samples must be exported to Japan. A possible solution (institutional permits) has been proposed to Japan and it is being considered. If these problems are not worked out, it will not be possible to collect any biopsy samples (inside or outside the US EEZ) during this cruise. This would be a major scientific loss to advancing our understanding of the stock structure of baleen whales in the North Pacific, specifically sei whales. The Committee **recognises** the importance of the CITES issue and agreed that it should be resolved among parties concerned expeditiously. The Committee **endorses** the working group's report, and **recommends** that the investigations regarding the use of Institutional permits to exchange biopsy samples proceed as soon as possible, with the results of the investigations being reported to the Planning Meeting scheduled for October 2010.

SC/62/O16 described two sighting surveys for cetaceans, taking place in the North Pacific in 2010, to examine the distribution of sei, Bryde's and minke whales and to estimate abundance for use in the RMP. Both surveys are in the middle part of the Western North Pacific. The main target species are sei and minke whales for the first survey and Bryde's whale for the second survey. The Committee assigned responsibility to Matsuoka for IWC oversight.

10.8.2 Mid- to long-term plans for the North Pacific Survey Programme

In addition to plans for a 2011 cruise, the Committee **recommends** that a coherent multi-year plan be developed for the survey programme in accordance with the discussion given in SC/62/Rep3. A Steering Group to oversee the IWC North Pacific surveys was established under Kato (Annex Q). It was proposed that a meeting of the Steering Group should be scheduled immediately prior to the Planning Meeting for the 2011 cruise, in order to develop the programme of research to be undertaken over the next few years.

10.9 Other

The precise taxonomic relationships and species delineations within the Bryde's/Eden's whale complex are currently uncertain. In South Africa, 'inshore' and 'offshore' forms of Bryde's whale have been described (Best, 1977), and there has been some uncertainty as to whether they should be referred to as *B. edeni* and *B. brydei* respectively. The Committee received a proposal for opportunistic collection of biopsy samples of Bryde's whales during a forthcoming research cruise between the Strait of Gibraltar and Cape Town, South Africa. These samples would be used to facilitate more in-depth genetic analysis of the relationship between the 'offshore' form and other more well sampled Bryde's whale species. The Committee **recommends** this proposal, assuming that relevant permits will be acquired. The Committee also **recommends** that biopsy samples from other whales be obtained, where legally permitted to do so.

11. STOCK DEFINITION (SD)

This Agenda Item was established in 2000, and has been handled since then by a Working Group; see IWC (1999d, p.83) for the original Terms of Reference. The term 'stock' has been used with different meanings in different contexts at different times, both within IWC and in other management and conservation contexts. These multiple meanings have sometimes hindered the Committee's ability to provide management advice. The Working Group was set up to clarify the issue of 'stocks' in a management context (see Item 11.3), to create a bridge between IWC and the expertise of the wider population genetics community (see Items 11.2 and 11.3), to develop software that evaluates the management utility of various population genetic analyses (see Item 11.2), and to develop guidelines for preparation and analysis of genetic data within an IWC context (see Item 11.1). These issues are of fundamental importance to the Committee's discussions on assessments and to the development of management advice. The Report of the Working Group is given as Annex I.

11.1 Statistical and genetic issues related to stock definition

11.1.1 Guidelines on DNA data quality

The Committee has previously endorsed a general set of guidelines for ensuring sufficient quality in genetic data used for management advice (IWC, 2009g; *http://www.iwcoffice.org/sci_com/handbook*). These guidelines constitute a 'living document' that will be updated as necessary. Since the issues involved are complex, the guidelines currently lack any numerical reference points, and the Committee again **encourages** suggestions accordingly. The intersessional e-mail group established in 2008 (Annex Q) was unable to report back this year, but will be continued in the coming year. The item remains on the agenda for the 2011 Annual Meeting.

11.1.2 Guidelines on genetic and statistical analysis

In parallel with the development of data quality guidelines, the Committee is developing guidelines for some of the more common types of statistical analyses of genetic data that are employed in IWC management contexts. These guidelines, which are being developed through another intersessional working group, are at an earlier stage of development than the DNA data quality guidelines. The proposed structure of the document, including a motivating example, was shown last year (IWC, 2009h).

This year, the Committee reviewed a preliminary version of the guidelines (SC/62/SD1), with drafts of several of the sections. Some further work is required, but after one further iteration, the guidelines should be able to appear on the IWC website. Following review of the text so far, a number of suggestions were made for the next iteration, including an 'FAQ' and the possible use of simulated datasets from TOSSM (see Item 11.2) as worked examples. The full list may be found in Annex I. This document will entail a great deal of effort, but should be of lasting importance. It deserves to be published, both online via IWC and in peer-reviewed literature.

11.1.3 Other approaches to stock identification

The Committee has previously considered the utility of acoustic data in questions of stock definition (IWC, 2005e, pp.248-49). Acoustics may be an efficient tool for proposing stock distinctions and boundaries, but interpretation can be difficult unless *inter alia* the stability of individual acoustic behaviour over time is known. This year, paper SC/62/SD2 presented results from acoustic monitoring of fin whales in different seasons and regions of the Mediterranean. The Strait of Gibraltar and Alborán Sea areas experience an influx, during the breeding season only, of fin whales that are acoustically consistent with Icelandic or Norwegian animals, but distinct from other Mediterranean fin whales. The results suggest a possible explanation for the low levels of gene flow that have been found between Mediterranean and North Atlantic fin whale populations. The Committee noted the value of these new data in suggesting rather precise areas where stock mixing and/or separation may occur, and consequently in assisting development of economical sampling design. It **encourages** plans to follow up this study with biopsy sampling.

11.2 TOSSM (Testing of Spatial Structure Models)

The aim of the TOSSM project is to facilitate comparative performance testing of population structure methods intended for use in conservation and management planning. From an IWC perspective, the TOSSM software package allows evaluation of methods for detection of genetic structure, in terms of how well the methods can be used to set spatial boundaries for management. As noted last year, the framework is now complete and the software is available for all to use; simulated datasets exist for three of the five stock-structure archetypes previously proposed by the Committee (IWC, 2009a, p.51). To date, ten methods have been tested on datasets from the two simplest Archetypes (single-stock panmixia, and two populations with limited migration sampled and harvested on the breeding grounds). No new results were received this year. Just as last year, though, the Committee noted the relevance of Archetype IV to North Pacific common minke whale discussions, where program STRUCTURE (Pritchard *et al.*, 2000) is receiving extensive use. It may well be possible to use TOSSM datasets to investigate the likely performance of STRUCTURE in a North Pacific minke whale-like setting, not merely in terms of overall 'boundary setting' but also in terms of specifics such as ability to assign individuals to specific stocks.

Mark-recapture data are another powerful tool for investigating stock issues. These have not yet been considered in TOSSM; next year, the Committee will consider the feasibility of incorporating mark-recapture data into TOSSM datasets. Another potentially powerful tool is the suite of coalescent-based methods but no coalescent-based approaches to boundary-setting have yet been considered in TOSSM. The Committee hopes to consider results of a TOSSM on the coalescent-based software MDIV next year.

There has been much discussion of how to interpret results from the program STRUCTURE, specifically in assigning individuals either to a smaller number of stocks which mix to a different extent in different places, or to a larger number of 'new' stocks that are less mixed. The Committee **encourages** the submission of papers investigating the performance of STRUCTURE for this question, and noted that datasets from TOSSM (existing ones, or new ones if necessary) might be a good starting point for such investigations.

11.3 Unit-to-conserve

'Unit-to-conserve' is a standing item on the SD Working Group agenda. It provides for discussion of potential 'definitions of stock' in a management context, including their operational implications for measurement and management. No new proposals were considered this year.

12. ENVIRONMENTAL CONCERNS (E)

The Commission and the Scientific Committee have increasingly taken an interest in the possible environmental threats to cetaceans. In 1993, the Commission adopted Resolutions on research on the environment and whale stocks and on the preservation of the marine environment (IWC, 1994a; 1994b). A number of resolutions on this topic have been passed subsequently (IWC, 1996a; 1997; 1998a; 1999b; 1999c; 2001c). As a result, the Scientific Committee formalised its work on environmental threats in 1997 by establishing a Standing Working Group that has met every year since then. Its report this year is given as Annex K.

12.1 State of the Cetacean Environment Report (SOCER)

The SOCER aims to provide Commissioners and Scientific Committee members with a non-technical summary of events, developments and conditions in the marine environment relevant to cetaceans. The report is compiled annually, in response to IWC (2001c), with a focus on one pre-selected region each year plus a global section.

The 2010 SOCER was focused on the Arctic and based on peer-reviewed papers published between 2008 and 2010. The overwhelming issue for the Arctic was climate change – e.g. rate of ice loss and ecosystem shifts – but many of the papers in the review period had already been summarized in previous Committee reports because of their global significance. There were few pollutant studies specifically on cetaceans in 2008-10, but the Arctic Monitoring and Assessment Programme (AMAP) 2009 Assessment of Arctic Pollution Status (*http://www.amap.no/*) provides a comprehensive review of pollutant levels in the Arctic. Globally, the environmental issue that received the most attention over the past year was underwater noise, especially disturbance from boat traffic, impacts of sonar on beaked whales and the acoustic impacts of wind farms. Of note, a bibliometric analysis showed that there has been a shift in focus in the cetacean research literature from basic biology topics, which were prevalent in the literature in the 1970s, to conservation topics in recent years. Next year the SOCER will focus on the Southern Ocean.

12.2 Review progress in planning for POLLUTION 2000+, Phase II

The IWC-Pollution 2000+ programme was initiated to investigate pollutant cause-effect relationships in cetaceans, and arose from a Workshop on chemical pollution and cetaceans held in Bergen, Norway in 1995 (Reijnders *et al.,* 1999). Following the Bergen workshop, a planning meeting was held in 1997 (Aguilar *et al.,* 1999a) and a workshop was held in 1999 (Aguilar *et al.*, 1999b), where Phase I of the POLLUTION 2000+ programme was launched. Phase I had two objectives: (1) to select and examine biomarkers for exposure to and/or effects of PCBs; and (2) to validate/calibrate sampling and analytical techniques. The results of Phase I were reviewed and a general framework for POLLUTION 2000+ Phase II was outlined (IWC, 2008a). Discussion for Phase II studies since that time has determined the need to: (1) produce a framework for modelling the effect of pollutants on cetacean populations; (2) identify cetacean populations to be studied under Phase II; and (3) develop a protocol for validating biopsy samples and applying this protocol to any large whale species selected.

Last year, the Committee had proposed the following modified goals for the Phase II programme:

(1) develop an integrated modelling and risk assessment framework to assess cause-effect relationships between pollutants and cetaceans at the population level, building on the progress made during Phase I and on recent research, using modification of a tiered risk assessment paradigm;
(2) extend the work to new species and contaminants as appropriate; and
(3) validate further biopsy sampling techniques for use in addressing issues related to pollution, including legacy contaminants and new contaminants of concern and associated indicators of exposure or effects.

In February 2010, an expert workshop (with expertise in chemical contaminants, toxicology, cetacean biology, veterinary medicine and biomarkers) was held to further develop proposals for Phase II of the programme (SC/62/Rep4). Presentations were made on risk assessment frameworks, chemicals of emerging concern, contaminant exposure, modelling approaches and case studies. Biomarkers of chemical exposure and effects were also discussed, with the workshop purposefully selecting those that have been validated in cetaceans. An international prioritisation survey for chemical contaminants was developed and will be distributed to subject matter experts, with a final report on survey results to be presented at the 2011 IWC Scientific Meeting.

The Committee **endorses** four **recommendations** made at the Workshop:

(1) to improve existing concentration-response (CR) function for PCB-related reproductive effects;
(2) to derive additional CR functions to address other endpoints (i.e., survival) in relation to PCB exposure;
(3) to integrate improved CR components into a population risk model (e.g., individual-based model) for one or more case study species (e.g. bottlenose dolphin and/or humpback whale); and
(4) to develop new biomarkers and improve the linkages between lower and higher levels of organisation (molecular - individual - population). The highest priority for biomarker development should include those with direct relevance to population-level endpoints such as reproduction and survival.

A plan to make progress on Phase II can be found in Annex K. The Committee noted data gaps and research needs identified at the Workshop, specifically noting that progress on this topic will require initiating new studies or additional support of existing efforts

The ICES Working Group on Marine Mammal Ecology (WGMME) met in April 2010 in part to 'Review the current contaminant loads reported in marine mammals in the ICES area, the cause-effect relationships between contaminants and health status, and the population-level effects of environmental impacts.' The SWG had reviewed recommendations made by the WGMME with regard to pollutants in marine mammals (*http://www.ices.dk/reports/ACOM/2010/WGMME/wgmme_final_2010.pdf*). and the Committee **endorses** these recommendations.

The Committee received new information (SC/62/E9) on the development of a suite of sensitive biomarkers from non-lethal sampling to evaluate the toxicological status of Bryde's whale in the Gulf of California. A 'multi-trial-biomarker-tool' was developed, combining protein biomarkers with concentrations of organochlorines and polycyclic aromatic hydrocarbons. A second biomarker study (SC/62/E10) examined a multi-response *in vitro* method to detect toxicological effects of contaminant mixtures on skin samples from cetaceans in the Mediterranean Sea. Preliminary findings indicate that the combination of protein biomarkers, gene expression levels and tissue contaminant levels may be a useful tool in determining 'multiple toxicological stress' in free-ranging cetaceans. The Committee **welcomes** these studies but **emphasises** the importance of standardisation of contaminant concentration reporting.

The Committee received an overview of the oil spill that followed the explosion on board and subsequent loss of the drilling structure 'Deepwater Horizon' on 20 April 2010, approximately 50 miles southeast of Louisiana in the Gulf of Mexico. The incident claimed the lives of 11 workers. Immediately after the spill, response networks for marine mammals, sea turtles, and birds were established, including four facilities for de-oiling of manatees, dolphins, and sea turtles.

As of 4 June, 31 dead dolphins and 277 dead sea turtles had been documented, with numerous accounts of large and small cetaceans seen swimming in oil-contaminated waters. The Committee **commends** all groups that are responding to impacted marine mammals and turtles in the region.

It also **agrees** that it is extremely important to learn as much information as possible from this tragedy in order to accurately assess impacts and be better prepared for potential future oil spills. In this regard, the Committee **strongly recommends** that the government of the USA, range states of the Gulf of Mexico and the responsible parties:

(1) search for and examine as many cetacean carcasses as possible that may have been impacted by the spill through detailed necropsies and thorough tissue sampling;
(2) analyse tissues for contaminants specifically related to spilled oil (i.e. polycyclic aromatic hydrocarbons, dispersants and mixtures of the two);
(3) provide detailed chemical composition of the dispersants that have been used in the Gulf of Mexico;
(4) develop and examine a suite of biomarkers that will be useful for understanding impacts from the spilled oil and use of dispersants in the Gulf of Mexico; and
(5) conduct biomarker studies of cetacean populations in the Gulf of Mexico, especially bottlenose dolphins, sperm whales and Brydes whales.

The situation in the Gulf of Mexico also emphasises the need for adequate environmental baseline data *before* oil and gas exploration, development, or production occurs in any region and for these data to inform mitigation and management decisions. Therefore, for member governments with on-going or planned offshore oil and gas activities within their territories the Committee **strongly recommends** the collection of baseline data to include:

- contaminant levels in cetaceans, their prey, and in sediments, especially polycyclic aromatic hydrocarbons (PAHs) and other contaminants that may interact with PAHs;
- biomarker levels in cetaceans and their prey;
- abundance and distribution of cetaceans and their prey; and
- condition of cetacean habitats (i.e. water quality, sediment quality, etc.).

Finally, the Committee **strongly recommends** contingency planning and training for oil spill responses in areas of oil and gas development. It looks forward to receiving an update on the studies into the effects of this spill at future meetings.

12.3 Review progress of CERD Working Group

The CERD working group was established in response to the report of a workshop on infectious and non-infectious diseases of marine mammals and impact on cetaceans that was held in 2007 (IWC, 2008d). The Committee received an update on its intersessional accomplishments and plans (Annex K, item 8), which are summarised in five categories: (1) skin disease; (2) diagnostic laboratories and veterinary experts; (3) prioritization of pathogens; (4) emergency response; and (5) enhancement of capacity and communications among stranding networks. With regard to the last category, capacity building workshops were held in four regions: West Africa, Caribbean, Brazil and India. Drawing information from the ICES working group and the IWC Ship Strike Working Group, a global inventory of stranding networks has been developed and the CERD working group is developing recommendations to maintain and provide access to the inventory.

The Committee also noted a prioritisation of cetacean pathogens developed on behalf of the US Working Group on Marine Mammal Unusual Mortality Events, from a survey that evaluated 76 pathogens based upon five factors. Of the pathogens included in the survey, most were potentially zoonotic, while others were associated with emerging/re-emerging human diseases in the United States. The ten highest priority pathogens among small cetaceans were morbillivirus, parapoxvirus, *Brucella* spp. anisakis, calicivirus, herpesvirus, nasitrema, *Clostridium* spp., and toxigenic *Escherichia coli*. Although the CERD WG is not tasked to compare cetacean-borne pathogens to those in terrestrial species, the Committee expressed interest in this broader approach, which is consistent with the global *One Health* approach to medicine (*http://onehealthinitiative.com/index.php*). Specifically, *One Health* highlights the importance of integration of surveillance systems in wildlife, domestic animals, public health and environmental health. The Committee **commends** projects that integrate a *One Health* approach to build capacity in countries that are responding to diseases that are shared by people and wildlife. Further, it **recommends** that marine species be considered by all organisation that are implementing the *One Health* approach. Finally, the Committee **commends** the many and varied accomplishments of the CERD WG and **endorses** the work plan for 2011 (Annex K, Appendix 3).

12.4 Review new information on anthropogenic sound: focus on 'masking sound'

The Committee's SWG on environmental concerns has included an item on underwater sound on its agenda each year since 2004 (IWC, 2005f, p.268). In 2009, a presentation on low-frequency 'masking sound' precipitated adopting it as a focal-topic. Low-frequency (LF) ocean noise has increased substantially in recent decades, concomitant with a three-fold increase in commercial shipping and other offshore industrial activities. The Committee reviewed a mechanistic model that dramatically demonstrates the reduction in the 'communication space' of baleen whales that now occurs, especially near shipping lanes and busy ports (Annex K, item 9). It then reviewed a variety of evidence with regard to the masking sound and its possible effects on whales, including: (1) altered calling patterns and frequency in the presence of LF sound from shipping and seismic airguns shown by fin whales in the western Mediterranean Sea and humpback whales off the coast of Northern Angola; (2) chronic exposure of the small population of humpback whales in the Arabian Sea to LF sound from construction, shipping and seismic surveys; and (3) the elevation of LF sound levels at distances from 450 to 2,800km from a seismic survey area south of Tasmania in the Southern Ocean. Based on the aggregate information presented to the SWG with regard to masking sound from anthropogenic sources, the Committee **recommends** that:

(1) seismic surveys be regulated in the same legal frame, whether for scientific or commercial purposes;
(2) baseline data be collected, satisfactorily analysed and modelled using appropriate techniques, regarding the seasonal and spatial distribution of whales in areas of interest to the geophysical community (scientific and commercial) before survey operations;
(3) the masking potential of anthropogenic sources be quantified and acoustic measurements be standardized to ensure that datasets among researchers are comparable; and
(4) in studies examining potential changes in whale acoustic behaviour, the ability to detect whale calls during periods of exposure and non-exposure to anthropogenic LF sound be quantified.

Further, the Committee **strongly recommends** that further research be conducted on the Arabian Sea humpback population (and see Item 10.2.2.4), including studies directed at quantifying the impacts of acoustic disturbance and masking to support conservation planning and protection for this small population.

The SWG had reviewed available information on plans for seismic surveys in support of oil and gas development planned for the Russian Far East, including the Sea of Okhotsk, Anadyr Gulf, the East Siberian and Chukchi Seas (Annex K, item 9.1). The scale of these activities is 'matched' by plans for broad-scale seismic surveys in the US Chukchi and across the US-Canadian Beaufort sea region. At least six endangered whale species (e.g. North Pacific right whales and Okhotsk Sea bowhead whales) occur in low numbers in waters offshore western Kamchatka, where seismic surveys are anticipated during summer 2010.

In light of this, the Committee **recommends** that additional surveys to provide baseline information on cetaceans be conducted in waters off western Kamchatka, and that seismic surveys and other potentially disturbing industrial activities should be conducted during times of lower cetacean abundance in all ocean regions whenever possible (e.g. see the mitigation and monitoring plan for a seismic survey in the Sakhalin region developed under the auspices of IUCN's Western Gray Whale Advisory Panel, and information regarding other seismic survey issues specific to western gray whales under Item 10.4 above). When informed that industry has initiated research into alternative (quieter) technology (vibroseis), the Committee **strongly encourages** this research and **recommends** continued development of such methods.

The conclusions from the workshop on 'Cumulative Impacts of Underwater Noise with Other Anthropogenic Stressors on Marine Mammals' were reviewed (Annex K, item 9.3). That workshop had agreed that cumulative impact assessments (CIAs) are needed to account for sub-lethal effects of human disturbance. The Committee **recommends** that member governments work to develop a quantitative approach for assessing cumulative impacts, including ways that anthropogenic sounds might impact cetaceans and their prey.

In regard to reducing LF sounds from shipping, the SWG (Annex K, item 9.4) had noted rapid progress, especially in the past three years, towards addressing this issue, including both the formation of a Correspondence Group within the Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO) and the granting of IMO 'observer status' to the IWC (IWC/62/4). With reference to the IWC's awareness of the critical nature of acoustic communication to whales and that interference, or masking, of this communication is to some extent preventable, the Committee **strongly recommends** that:

(1) the goal of noise reduction from shipping advanced in 2008 (i.e., 3dB in 10 years; 10dB in 30 years in the 10-300Hz band) be actively pursued;
(2) new and retro-fit designs to reduce noise from ship propulsion be advanced within the goals of the IMO, when and wherever practicable; and
(3) the IWC and IMO continue to work collaboratively to advance the goal of worldwide reduction of noise from commercial shipping when and wherever practicable including reporting progress on noise measurements and implementing noise reduction measures.

12.5 Review progress on work from the 2nd Climate Change Workshop

The 2nd Climate Change Workshop (IWC, 2010j) resulted in a series of recommendations summarised under three headings corresponding to working groups established at the workshop: Arctic; Southern Ocean; and Small Cetaceans (and see Annex K, item 10). With regard to the Arctic, three study themes were established: (a) Single Species-Regional Contrast; (b) Trophic Comparison; and (c) Distribution Shift. With reference to theme (a), planning discussions have been completed for a comparison of physical indicators of climate change and available data on population dynamics and behavioural ecology of the Bering-Chukchi-Beaufort Seas and Hudson Bay-Davis Strait populations of bowhead whales. In the Southern Ocean, the SWG was provided an update on the responses of the southern right whale population of Península Valdés, Argentina to climate driven changes on their feeding grounds off South Georgia. As was reported in the Southern Right Whale Die-Off Workshop (SC/62/Rep1 and see Item 10.5 above), one of three possible hypotheses to explain recent peaks in calf mortalities is a decline in food availability for adult females on their feeding ground during the year or two prior to calving. This hypothesis will be explored by updating an analysis on the relationship between changes in sea surface temperature and calving success. The Committee reviewed a draft agenda for a Small Cetaceans and Climate Change Workshop planned for November 2010, where the main focus will be: (1) restricted habitats – estuaries, reefs, environmental discontinuities, rivers and shallow waters; and (2) range changes – i.e. evidence of changes in distributions, reasons and consequences; and (3) with a review planned for small cetaceans in the Arctic Region and suggested that the definition of restricted habitat be broadened (Annex K, item 10). Noting that last year the Committee had recommended that countries should pay more attention to tertiary concerns arising from climate change, the Committee noted that Alter *et al.* (2010) provide arguments suggesting that tropical, coastal and riverine cetaceans are particularly vulnerable to those aspects of climate change that are mediated by changes in human behaviour.

12.6 Other habitat related issues

There has been a rapid expansion of marine renewable energy devices (MREDs) in European seas as governments strive to meet renewable energy commitments. Today there are some 89 such sites in various stages of development (most of these are wind farms), representing a five-fold increase in numbers since 2000, with a concomitant major increase in the size of planned developments. The SWG reviewed concerns associated with the construction, operation, maintenance and (ultimately) decommissioning of wind, tidal and wave renewable energy technologies (Annex K, item 11.1) and the Committee **strongly recommends** that countries co-operate to limit impacts on marine wildlife from these sources. The SWG subsequently discussed the ICES WGMME recommendations with regard to the effects of wind farm construction and operation on marine mammals (Annex K, item 11.1) and the Committee **endorses** those recommendations.

The French Agency for Marine Protected Areas (AAMP) has initiated the REMMOA project, a series of surveys across the French EEZ to identify hotspots of abundance and diversity. Extensive surveys have been conducted across the EEZ of Martinique and Guadeloupe, off Guiana and in the southwest Indian Ocean region. The South Pacific regions will be surveyed during 2010-11 (French Polynesia) and 2011-12 (southwest Pacific Ocean around New Caledonia and Wallis and Futuna) and the Atlantic survey is planned for 2012-13. The Committee also received information on systematic monitoring of density and abundance of the most common cetacean species of the Pelagos Sanctuary and in the seas surrounding Italy. The aim of this work, funded by the Italian Government, is to inform conservation measures throughout the Mediterranean Basin. It also responds to priority actions in a number of other international bodies (e.g. the Sanctuary Management Plan, ACCOBAMS, the Specially Protected Areas and Biodiversity Protocol under the Barcelona Convention, the EU Habitat Directive and the Convention on Biological Diversity). The Committee **commends** both of these studies and encourages their continuation. It noted the impressive advancements of current methods giving the authors the ability to correlate cetaceans with specific habitat features as well as other megafauna.

Finally, there has been limited progress since the update on the Madagascar Mass Stranding Event (MMSE) given in 2008 (IWC, 2009a, p.71). Two potential scenarios to move forward with an Independent Scientific Review Panel (ISRP) were identified: (1) a National Office of the Environment (ONE) to request and oversee an ISRP; or (2) the Environmental Governance Commission to serve as an intermediary body between the Government and/or ONE to promote the need for an ISRP to assess the results of the MMSE. The Committee welcomed this update and thanked The Wildlife Conservation Society and its partners' continuing efforts to bring the results of the MMSE to an appropriate conclusion through an ISRP process, as well as keeping the SWG updated on the current challenges and progress.

13. ECOSYSTEM MODELLING

The Ecosystem Modelling Working Group was first convened in 2007 (IWC, 2008c). It is tasked with informing the Committee on relevant aspects of the nature and extent of the ecological relationships between whales and the ecosystems in which they live. This advice is important to other responsibilities of the Committee: it can be used to simulate an ecosystem framework in which to evaluate management strategies; it can provide a bio-physical context within which to try to understand spatial or temporal (e.g. interannual, interdecadal, or long-term climate-driven) variability in cetacean population dynamics, distribution, behaviour, and health; it can provide insight into interactions between whales and fisheries; and it may inform the prioritisation and design of future IWC research projects by identifying critical information gaps and offering recommendations of when, where and how field efforts should be conducted to successfully collect new data that are necessary for providing insight into key questions. The Commission has stated their interest in such work in a number of resolutions (IWC, 1999a; 2001c; 2002a). Each year the Working Group reviews the progress in developing ecosystem models relevant to the work of the IWC, which is a broad task encompassing the evaluation of model inputs, assumptions, structure and outputs. In addition, the Working Group has placed a priority on discussions and collaborations with institutions outside of the IWC to facilitate the exchange of information on the state of the science of ecosystem modelling and, where applicable, to collaborate to achieve a common goal. No primary ecosystem modelling papers were received this year, so the Working Group dedicated its time to three general tasks: (1) reviewing ecosystem models and modelling approaches that were developed outside of the IWC; (2) learning about the Climate Impacts on Oceanic Top Predators (CLIOTOP) project; and (3) discussing and planning the future role of this Working Group within the Scientific Committee. The report of the Working Group is given as Annex K1.

13.1 Review ecosystem models relevant to the Committee's work

This year, Lehodey introduced the CLIOTOP project and in particular the ecosystem model that he and his colleagues developed to analyse and predict the spatio-temporal dynamics of tuna populations under the influence of environmental and fishing pressures (Lehodey *et al.*, 2008). The model has been applied to skipjack, bigeye, yellowfin and albacore tuna in the Pacific Ocean (Lehodey and Senina, 2009) and also been used to investigate potential influences of climate change on tuna population dynamics (Lehodey *et al.*, 2010).

CLIOTOP is a global project implemented under two International Geosphere-Biosphere Programme (IGBP) international research programmes: Global Ocean Ecosystem Dynamics (GLOBEC) and Integrated Marine Biogeochemistry and Ecosystem Research (IMBER). Its general objective is to enhance the understanding of oceanic top predators in their ecosystems in the context of both climate change and fishing, and to develop new tools leading to the evaluation of management strategies. CLIOTOP and the IWC share many common scientific interests, including: studying the behaviour, movement patterns and habitat of large predators; developing and applying technology for animal tracking; estimating food consumption rates; understanding and modeling predation by, and competition among, large predators; modelling and acoustic monitoring of prey fields; investigating various approaches to ecosystem modelling; and addressing issues of bycatch. The Committee **encourages** the establishment of collaborations between the IWC and CLIOTOP.

As part of its remit to preview general developments in ecosystem modelling to identify new modelling approaches and develop an evaluation framework that may be of benefit to the Committee's work, four recently published papers were reviewed (A'Mar *et al.*, 2009; Allen and Fulton, 2010; Buckley and Buckley, 2010; Hannah *et al.*, 2010). These covered issues of model structure, assumptions, complexity and validation. In discussion, it was noted that some existing research suggests that management strategies relying on empirical data through fisheries statistics performed better than those that incorporated ecological information; however, ecological data are valuable for constructing and constraining the range of ecosystem models that could be used to evaluate management strategies within the Scientific Committee.

13.2 Recommendations on the role of this Working Group within the Committee

SC/62/EM1 motivated discussions about the future of the Ecosystem Modelling Working Group. It provided background into the initial objectives and the history of the Working Group; reiterated the distinction between 'tactical' models (those used to set catch limits or to make other management advice) and 'strategic' models (those used to simulate an environment in which to test simpler models); listed some of the ecological and analytical issues that have been recurrent in Committee discussions to date; and introduced several recommendations to help the Committee evaluate ecosystem models, given the numerous uncertainties inherent in the modelling process. As did the Working Group, the Committee **agrees** to the following recommendations, based on those in SC/62/EM1:

(1) standardised templates should be developed for documenting metadata and analytical techniques;
(2) performance criteria should be established, including testing model fit to historic or present data and assessing its ability to generate ecologically reasonable predictions into the future;
(3) sensitivity analyses should be conducted to quantify and provide insight into the importance of model inputs (which can guide data collection priorities) and assumptions on model outputs;
(4) Scientific Committee members should be given access to relevant background information (such as the full mathematical specification) used in any presented ecosystem models that may inform management decisions (via the Secretariat);
(5) the Scientific Committee should explore various ecosystem modelling approaches for a system in order to compare performance across models;
(6) intersessional meetings should be used, when necessary, to allow in-depth examination of competing models; and
(7) the EM Working Group should continue to convene every year at the annual meetings to address issues relevant to the Scientific Committee and to remain informed about new developments in the ecosystem modelling field.

The Committee **emphasises** that the Working Group is an important forum for evaluating ecosystem model inputs, structure, assumptions and predictions related to its work. *Inter alia*, it is also the appropriate sub-group within the Committee for reviewing the ecosystem aspects of ongoing special permit whaling programmes.

The Committee **recognises** the need to involve outside experts in the Working Group. Work is underway to establish an avenue for exchanging information about new developments in ecosystem modelling and its feedback into management, and to solicit feedback on how ecosystem models could inform IWC management decisions.

The Committee **agrees** that the activities of the Working Group should be structured around the timetable of RMP assessments and *Implementations*, enabling ecosystem models relevant to a specific stock being assessed to be reviewed prior to the assessment; the North Pacific is the appropriate region for 2011. The Working Group will take efforts during the intersessional period to engage researchers involved in the North Pacific Marine Science Organization (PICES) and the North Pacific Research Board (NPRB) to collaborate on primary papers for next year's meeting on how North Pacific ecosystem models can be used to inform the RMP process. Two additional issues were highlighted for discussion next year, if primary papers can be prepared in advance. One is a review of functional responses, and the second is a review of methods for evaluating ecosystem models. It is expected that the latter will result in a framework that the Committee will use to guide future ecosystem model evaluations, providing model developers specific details regarding the information required to determine whether the input data and parameters, the model and the resulting predictions should be considered acceptable to inform the work of the Committee.

13.3 Work plan

The work plan is detailed under Item 24. The Working Group requests no funds for the upcoming year.

14. SMALL CETACEANS (SM)

The Committee has been discussing issues related to small cetaceans since the mid-1970s (IWC, 1976). Despite the differences of views over competency (IWC, 1993), the Commission has agreed that the Committee should continue to consider this item (IWC, 1995c). The report of the sub-committee on small cetaceans is given as Annex L.

14.1 Review taxonomy, population structure and status of small cetaceans of northwestern Africa and the Eastern Tropical Atlantic (ETA)

The priority topic this year was the review of the status of small cetaceans of northwestern African and eastern tropical Atlantic waters (Fig. 6), a region with a variety of ecosystems and coastal habitats. The review was greatly assisted by the availability of published review papers and documents prepared for this meeting by scientists working in Canary Islands (Spain), Mauritania, Cape Verde, Guinea, Ghana, Togo, Benin, Nigeria, São Tomé and Príncipe, Cameroon, Gabon, Congo and Angola.

The following sections represent a short summary of the extensive review. Details can be found in Annex L.

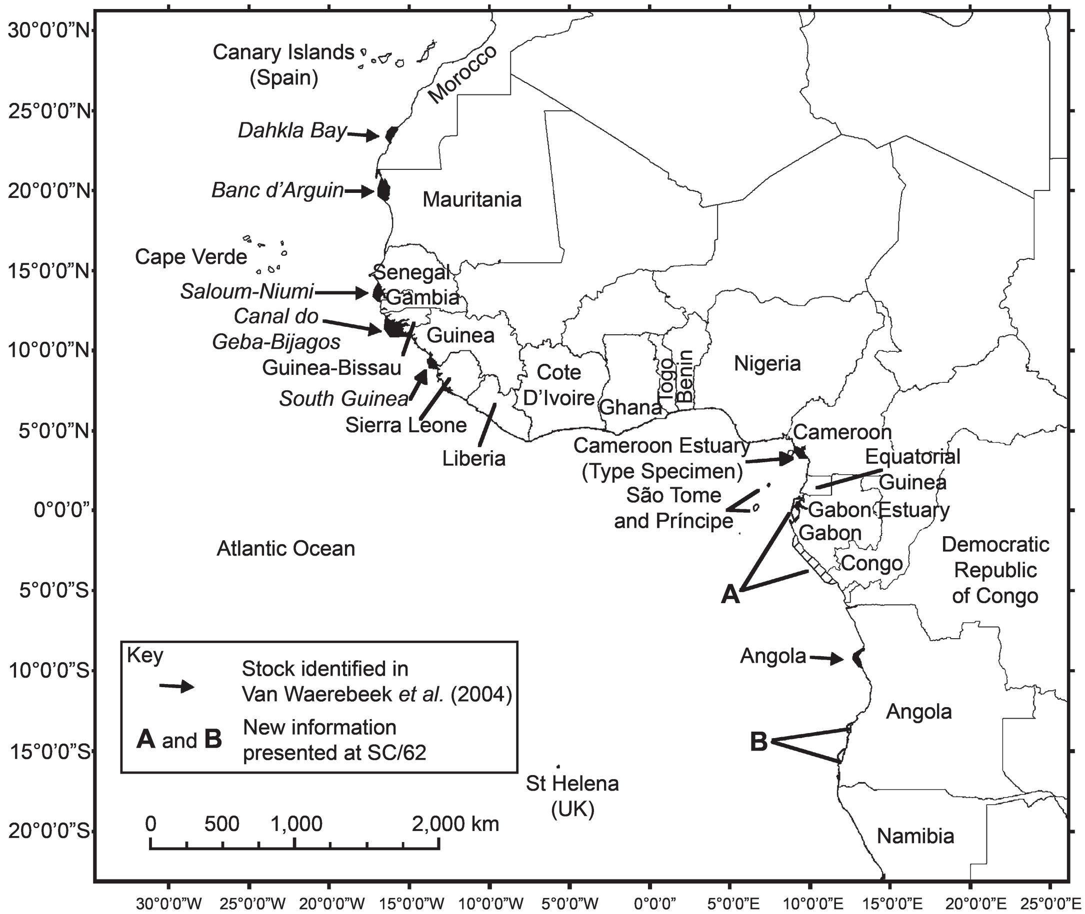


Fig. 6. Map of the northwestern and western African countries relevant to the cetacean distribution review. A=Information from SC/62/SM9. B=Information from SC/62/SM6.

Weir (2010) reviewed cetacean occurrence (sightings, strandings, direct captures, bycatch) in West African waters from the Gulf of Guinea to Angola, updating Jefferson *et al.* (1997). At least 21 odontocetes (including at least 17 delphinids) have been documented in the region. The author stressed that the region's cetaceans face several threats including bycatch, direct capture (e.g. in Ghana and Togo) and threats to them and their habitat, e.g. due to oil and gas development. Moore *et al.* (2010) reported information on cetacean bycatch from interview surveys in 2007 and 2008 in fishing communities of seven countries: Sierra Leone, Cameroon, Nigeria, Tanzania, Comoros, Malaysia and Jamaica They provided information on reported cetacean bycatches in Sierra Leone and Cameroon.

Further information on the region's cetaceans came from a number of papers focussing on country reports.

SC/62/SM9 reviewed recent information on Atlantic humpback dolphins in Gabon and Republic of Congo. Both countries have large and diverse national park systems that include protected coastal habitat. Given the low human population densities and the extent of relatively undisturbed habitat in Gabon and northern Congo, this region may represent a stronghold for the species. However, bycatch and evidence of dolphins in the bushmeat trade give cause for concern, particularly as the demand for fish in cities increases. The Committee commends the authors for their efforts in the region and **recommends** that research, monitoring and conservation efforts for humpback dolphins along the coast of Gabon and Congo continue.

The Committee received two papers covering Nigeria (SC/62/SM12 and SM1). Cetaceans occur throughout Nigerian coastal waters in the Gulf of Guinea, although there has been little directed cetacean research. Potential threats include: bycatches (a reported zero bycatch rate for Nigeria obtained in an interview survey by Moore *et al.* (2010) is not credible, probably due to low sample size); direct catches of delphinids (SC/62/SM1) for sale as 'marine bushmeat' (Clapham and van Waerebeek, 2007) which may be widespread; and habitat degradation (e.g. uncontrolled trawling operations, indiscriminate dumping of non-biodegradable nylon and plastic products and household items). The absence of monitoring may explain the lack of detailed information on direct catches. SC/62/SM1 reiterated the suggestion by Van Waerebeek *et al.* (2004) that Atlantic humpback dolphins inhabited the Niger Delta before large-scale oil exploration and extraction altered the coastal environment.

Information on Ghana was provided in SC/62/SM10 with an emphasis on the captures of small cetaceans in artisanal fisheries, mainly using drift gill nets. Cetaceans have been documented from three fish landing ports since 1995 but these landings do not represent the total for the country. It is often unclear if 'bycaught' cetaceans in Ghana are the result of unintentional or intentional taking. The species most frequently 'bycaught' are the clymene dolphin (24.5%), pantropical spotted dolphin (12.3%) and common bottlenose dolphin (12.3%). SC/62/SM10 suggested an increasing trend in the scale of landings between 1999 and 2010, and particularly since 2002-03. Once the practice of catching and marketing cetacean products becomes established, it can escalate rapidly as implied in the existing catch series. Although aquatic mammals are protected by law, there are no explicit regulations concerning the use of cetaceans killed in nets and the use of dolphin meat as bait in shark fisheries and for human consumption is not considered illegal. This means that catches are not concealed for fear of sanctions and therefore catch statistics can be obtained. This makes it feasible to study trends and carry out biological studies based on carcass sampling protocols.

As stated in SC/62/SM10, traditional taboos against catching dolphins are rapidly eroding in the Volta Delta region. This seems to happen in some areas of Nigeria as well. One important development is that the monetary value of a small cetacean is now roughly equivalent to that of a similar-sized large billfish. In fact, more money can be earned by selling the cetacean carcasses for shark bait as the export market in Asia for shark fins is lucrative and growing.

The Committee thanks the researchers working in Ghana for their efforts and notes that the evidently close cooperation with fisheries officials is encouraging.

Tchibozo summarised the current knowledge on small cetaceans along the 124km coastline of Benin (Tchibozo and van Waerebeek, 2007). The presence of four species has been confirmed: Atlantic spotted dolphins, common bottlenose dolphins, false killer whales and *Delphinus* sp. There have been no systematic studies on the distribution, abundance or ecology of small cetaceans in Benin. Although bycatch of cetaceans is known to occur in fisheries along the entire coast, no monitoring programme is in place.

SC/62/SM11 confirmed the presence of four small cetaceans in Togo's coastal waters: pantropical spotted dolphins, common dolphins, pilot whales and killer whales. However, there is no information concerning abundance, natural history or ecology. The main potential threats are:

(1) bycatch in fisheries, with the possibility that this has led or soon will lead to directed taking as has been observed elsewhere; and
(2) severe chemical pollution due to the mining of phosphorites and discharge of phosphate-rich mud into coastal waters.

Bamy *et al.* (2010) reported that four odontocetes occur along Guinea's 300km coastline: common bottlenose dolphins, Atlantic humpback dolphins, Atlantic spotted dolphins and pygmy sperm whales. It is probable that short-finned pilot whales, rough-toothed dolphins and common dolphins also occur there. This information comes mainly from observations during irregular, largely opportunistic surveys of fishing communities in 2001-03 by personnel from Guinea's Centre National des Sciences Halieutiques de Boussoura (CNSHB). There is no evidence of substantial directed or incidental takes (e.g. at the scale reported in Ghana) but monitoring and reporting have been limited. There is evidence that bycaught small cetaceans and a stranded whale were used for human consumption. The authors expressed concern about even occasional catches of Atlantic humpback dolphins.

During discussion, reference was made to the study by Brashares *et al.* (2004) on the relation between declining fish supplies in West African waters and the increase in hunting for 'bushmeat' and consequent declines in wildlife populations.

SC/62/SM8 updated Picanço *et al.* (2009) with information on small cetaceans off São Tomé and Príncipe. At least four species of small cetaceans are known to occur there with the common bottlenose dolphin and pantropical spotted dolphin being the most numerous.

Several species of small cetaceans were hunted historically in the Cape Verde Islands using hand harpoons. Despite protective legislation, cetaceans are still captured occasionally and their meat is sold and consumed (Hazevoet and Wenzel, 2000; Reiner *et al.*, 1996).

Vely summarised cetacean occurrence in Mauritania between 1987-95 based on dedicated surveys in two main areas: (a) between the southern border with Senegal and the village of Nouamghar at the northern entrance of the National Park of Banc d'Arguin (PNBA); and (b) within the PNBA. Species observed at sea were common bottlenose dolphins, Atlantic humpback dolphins and killer whales. Stranded specimens included harbour porpoises, clymene dolphins, common dolphins, Risso's dolphins, melon-headed whales, short-finned pilot whales, pygmy sperm whales, dwarf sperm whales and Cuvier's and Gervais' beaked whales.

Smit *et al.* (2010) summarised information on the presence and distribution of small cetaceans off the coast of La Gomera (Canary Islands), where a total of 21 species were observed at sea. The five most abundant species (87% of sightings) were common bottlenose dolphins, short-finned pilot whales, Atlantic spotted dolphins, short-beaked common dolphins and rough-toothed dolphins.

The Committee thanks all of the contributors but noted that its review was characterised by rather scarce information from the northwest African countries (see Annex L). However, enough new information was available from West Africa to update and make some corrections to the existing state of knowledge on cetaceans along the west African coast (see table 1 of Annex L).

IUCN Red List status for 21 out of 22 species is either Least Concern or Data Deficient (2008). The Atlantic humpback dolphin is listed as Vulnerable. There is a general lack of relevant information on many of the species, not only for western African waters but also globally, on taxonomy, population structure, abundance, life history and ecology.

The scarcity of information prevented the Committee from being able to make a reliable evaluation of the status of any of the species in the region. That being said, the information available in the review showed that nearly all species are taken either intentionally or unintentionally (SC/62/SM1, SM10 and SM11; see also Bamy *et al.*, 2010; Van Waerebeek *et al.*, 2008; and Weir, 2010). Especially for one species, the clymene dolphin, the Committee **expresses serious concern** about the ongoing observed landings in Ghana.

The Committee then reviewed two species on which there was a little more information.

Killer whales

Killer whales observed off Angola, Gabon and São Tomé were similar in external appearance to, and their appearance was consistent with, the Type A 'nominate' killer whale form described by Pitman and Ensor (2003). Weir *et al.* (2010) summarised published records from Liberia, Côte d'Ivoire, Ghana, Annobón Island (Equatorial Guinea) and Gabon as well as 31 sightings from Angola, Gabon and São Tomé, and a single record from Cameroon. De Boer (2010) provided an additional record of killer whales in the offshore waters of Gabon. Most sightings have been recorded since 2001, corresponding with the onset of dedicated survey work in the region. Bamy *et al.* (2010) found no confirmed records for the stretch of coast from southern Senegal (Casamance) to Liberia. They also questioned whether killer whales venture into the shallow waters of Guinea-Bissau, Guinea and Sierra Leone.

No information was received regarding recent intentional takes although one killer whale was recorded as landed in Ghana between 1998 and 2000 (SC/62/SM8).

The killer whale can be considered a regular component of the cetacean community off Angola and in the Gulf of Guinea. However, more survey work is required throughout the region to clarify its status and biology off tropical West Africa (Weir *et al.*, 2010). The IUCN Red List status of the species is Data Deficient.

Atlantic humpback dolphin

The Atlantic humpback dolphin - an endemic species for this region - was a priority species in 2002 (IWC, 2003b) but at that time the review focused on the Indo-Pacific humpback dolphin.

The taxonomy of the genus *Sousa* remains largely unresolved. Although three putative or nominal species have been widely discussed (*chinensis*, *plumbea* and *teuszii*), the IWC presently recognises only two, the Atlantic species *S. teuszii* and a geographically widespread Indo-Pacific species *S. chinensis*. Although the Committee was informed by Rosenbaum of a collaborative study to clarify the taxonomy of *Sousa*, the Committee **agrees** to retain its present nomenclature until formal publication of this information. It also **recommends** that samples from *S. teuszii* be provided to Rosenbaum as soon as possible so that they can be included in the ongoing efforts described above, which are essential for resolving questions questions concerning taxonomy and population structure.

Van Waerebeek *et al.* (2004) reviewed the state of knowledge on Atlantic humpback dolphins and proposed eight provisional management stocks based on the fragmentary information available to them. Six were confirmed as extant based on recent records: Dakhla Bay (Western Sahara), Banc d'Arguin (Mauritania), Saloum-Niumi (Senegal, Gambia), Canal do Gêba-Bijagos (Guinea-Bissau), South Guinea and Angola. The other two – Cameroon Estuary and Gabon – were considered historical. Those authors also noted the 'potential existence' of a western Togo stock. They concluded that there were nine confirmed range states: Morocco (including Western Sahara), Mauritania, Senegal, The Gambia, Guinea-Bissau, Guinea-Conakry, Cameroon, Gabon and Angola.

Van Waerebeek *et al.* (2004) stated that the species was limited to tropical and subtropical waters very near shore from Western Sahara in the north to Angola in the south; the distribution is patchy and limited to particular stretches of coastline separated by gaps of absence or very low density. In many cases, it was unclear whether the absence of records from an area means the species naturally does not occur there, or it has been extirpated in the area, or search effort and reporting have been insufficient.

Bamy *et al.* (2010) considered as uncertain the degree of distributional continuity and gene flow between the provisionally defined 'South Guinea stock' and other provisionally defined stocks (Van Waerebeek *et al.*, 2004). As in Guinea-Bissau, most of Guinea's coastline has features suitable as humpback dolphin habitat: warm and shallow waters on a shelf extending up to 200km from shore, with extensive mangrove creeks around four main river mouths. The lack of sighting records is probably partly due to the small amount of near-shore survey effort. Ghana represents a confirmed gap (SC/62/SM10).

Although much remains unknown about distribution and the extent to which it has changed over time as a result of human activities (e.g. bycatch, habitat degradation), current understanding is that there are regional pockets of relatively high density, such as in Senegal-The Gambia-Guinea-Bissau-Guinea-Sierra Leone, Gabon-Congo and Cameroon-Angola-Namibia.

Although its typical habitat was thought to be shallow coastal waters, especially estuaries, mangrove systems and sheltered bays (Van Waerebeek *et al.*, 2004), new information on the presence, distribution and behaviour of Atlantic humpback dolphins was received from Flamingos (southern Angola), Gabon and Congo (SC/62/SM9), also see Weir *et al.* (2009). In Gabon, Congo and elsewhere in the southern range of the species, humpback dolphins are regularly observed on open coastlines.

The loss and fragmentation of habitat due to expanding coastal communities, coastal development, dredging, trawling, deforestation, mangrove destruction, pollution, eutrophication and oil spills also threaten this species. Its preference in many areas for shallow, nearshore and estuarine habitat would render it particularly vulnerable to ubiquitous inshore set gillnets, beach seines and disturbance.

The Committee **agrees** that there is ample evidence for serious concern about the conservation status of this species (SC/62/SM1; SM6; SM9-SM11, and see also Bamy *et al.*, 2010). Although quantitative data or even good qualitative data (e.g. confirmation of species presence/absence) are lacking for much of the known or suspected range, the information available from areas where cetaceans have been consistently studied (e.g. Ghana, Guinea) indicates that the overall population is fragmented, bycatch (if not also directed catch) is occurring, and habitat conditions are deteriorating. Populations in Gabon and northern Congo appear healthy, but recently documented bycatches and utilisation in Congo may be indicative of a growing reliance on non-fish marine wildlife, including dolphins, as food.

In view of the growing concern (e.g. summarised in SC/62/SM6) that the Atlantic humpback dolphin faces some of the same threats that led to the extinction of the baiji and caused the vaquita to become critically endangered, the Committee **recommends** that IUCN reassess the Atlantic humpback dolphin's status in the light of new information.

It also **recommends** the following items for further conservation and research action for Atlantic humpback dolphins, taking into account *inter alia* the CMS regional action plan for the conservation of West African small cetaceans[4].

(1) Coordinated data collection should be facilitated in order to improve knowledge of the abundance, distribution and conservation status of *S. teuszii* throughout its known range. Specifically:
  - (a) estimates of abundance and distribution are urgently required (including where feasible photo-id);
  - (b) tissue samples should be obtained at every opportunity from stranded or bycaught Atlantic humpback dolphins. These need to be appropriately preserved and provided to scientists for genetic analyses investigating population structure;
  - (c) critical habitats should be identified, including areas of high density and regular occurrence ('hotspots') and migratory pathways (if such exist), as candidates for focused conservation effort; and
  - (d) overviews of existing knowledge, national species lists, specimen collections, research centres and protected areas should be compiled.

(2) Identify and mitigate known and potential threats to *S. teuszii*, particularly entanglement in fishing gear, and directed take and anthropogenic noise. Specifically this should include:

[4]Action Plan for the Conservation of Small Cetaceans of Western Africa and Macronesia, ratified in 2008 by West African member nations of CMS.

(a) improving the understanding of the causes, levels and impacts of bycatch on *S. teuszii*;
(b) assessment of the causes, level and intensity of directed small cetacean takes;
(c) efforts should be made to minimise the ecological impacts of fisheries on, and direct takes of, *S. teuszii* through the implementation of explicit fisheries management measures; and
(d) ensure that all littoral developments and activities take into account their potential for having negative effects on small cetaceans and the environment.

(3) The designation and management of national and transboundary marine protected areas that include *S. teuszii* habitat based on scientific data and broad stakeholder involvement should be encouraged.

The Committee also specifically **recommends** that regional or sub-regional research projects be conducted that would allow the preparation of management plans for the conservation of Atlantic humpback dolphins in particular areas. Candidate areas are: (a) off Flamingos, Angola; (b) along the coasts of Gabon-Congo; (c) Senegal-The Gambia-Guinea-Bissau-Guinea-Sierra Leone where the humpback dolphin population(s) may be transboundary and where bycatch is a serious concern; and (d) Mauritania where humpback dolphins were observed regularly in Banc d'Arguin National Park and environs over many years, but may have declined recently (Van Waerebeek and Perrin, 2007).

The Committee **strongly encourages** scientists in the range states to submit collaborative proposals for funding so that transboundary problems can be addressed in a comprehensive way, possibly cooperating with the staff of National Parks.

General recommendations relevant to all species

In general, the Committee **acknowledges** that the failure to manage industrial fisheries sustainably has often caused coastal artisanal and subsistence fisheries to suffer and, in turn, has led local people to seek alternative resources for consumption, including cetaceans.

Given the observed threats and the existing knowledge, the Committee makes the following general **recommendations** applicable to all small cetacean species in the west and northwestern Africa.

(1) The tallying of cetacean landings should be implemented as a standard procedure for fisheries observers at the national level, including the collection of photographic material, recognizing that small cetaceans are a *de facto* exploited marine living resource and therefore need to be monitored on a permanent basis.
(2) An intensive biological sampling programme based on fresh carcasses, collecting data on morphological variation, reproduction, growth, feeding, stock identification, genetics, migratory habits, etc. of cetacean species should be implemented.
(3) Use of platforms of opportunity should be intensified to collect data on distribution, relative abundance and behaviour of cetaceans.
(4) Further assessment of the links between declining fish catches and increasing takes of small cetaceans in West Africa should be made.

In at least three west African countries, Ghana, Togo and Guinea, the ongoing activities represented good examples of how the first two of these recommendations could be realised. The Committee **acknowledges** the contributions already being made by scientists in Nigeria and Benin and recognised that there is a great need for capacity building and financial support before such programmes can be implemented. The same is true for São Tomé and Príncipe where the status of small cetacean populations has not been fully assessed and for the Cape Verde Islands, where no study of small cetaceans has ever been conducted. With regard to the third recommendation, the Committee noted and commended the published work by Weir (2007; 2010) and de Boer (2010), much of which was based on data from platforms of opportunity (e.g. seismic survey vessels, oceanographic research vessels); these are seen as excellent examples of how this recommendation can be realised in more areas.

In conclusion, the Committee **recommends** international collaboration for funding and capacity building to support programmes for monitoring, management and conservation of coastal marine living resources in this region.

14.2 Review report from the working group on climate change and small cetaceans

The Committee received a summary on the ongoing plans for an IWC workshop on the effects of climate change on small cetaceans. The workshop plan (10-12 invited participants meeting for 3 days) was agreed last year but the workshop was not held in the last intersessional period as the final *tranche* of funding was only confirmed late in the year. The steering group and convener (Simmonds) are now finalising plans for the workshop, which will probably be held in Vienna in November 2010 (see Appendix 2 of Annex L). The focal topics are: (a) restricted habitats; (b) range changes; and (c) the Arctic region. During discussion it was suggested that pathogens should also be discussed.

The Committee **re-confirms** its support for the meeting and looks forward to receiving a full report of this workshop at the next annual meeting in 2011.

14.3 Review progress on previous recommendations

IWC Resolution 2001-13 (IWC, 2002b) directs the Scientific Committee to review progress on previous recommendations related to critically endangered species and stocks of cetaceans on a regular basis and the Committee noted that its previous recommendations stand until new information is received and considered.

14.3.1 Vaquita

The Committee reviewed new information on the critically endangered vaquita. SC/62/SM3 reported on a survey in the Upper Gulf of California that was conducted from mid-September, through October and November 2008 in a joint effort between the governments of Mexico and the US. The primary objective was to test alternative acoustic detection technology as a means of monitoring trends in vaquita abundance. Total abundance (based on both acoustic and visual data) was estimated as 250 animals (95% CI 110, 564). The estimate for waters inside the Vaquita Refuge was 123 (95% CI=64-239). The total estimate for 1997 had been 567 (95% CI=177-1,073). Analyses strongly support a population decline over the 11 years from 1997 to 2008. The overall distribution did not change between the two surveys, indicating that the apparent decline was not an artifact of a distributional shift. Approximately half of the population appears to be present inside the Vaquita Refuge area at any time, with individuals moving freely into and out of the refuge. Hence, they are at risk of interaction with fishing operations when outside of the refuge, and this means that protection from bycatch is only partial. Fishermen consider waters inside the Refuge to be a prime shrimping area and thus fishing activity is very intensive immediately outside its borders. The buyout programme begun by the Mexican government in 2007 has reduced the fishing effort by about 40%, but over 600 artisanal boats (*pangas*) are still fishing and those fishermen who remain active are strongly committed and unlikely to accept the buy-out offers from the government. This makes it crucial to develop alternative fishing methods that do not involve the risk of vaquita bycatch.

The Mexican government made a commitment to reduce the vaquita bycatch to zero within three years starting in 2008. There are no data to confirm that the bycatch rate has been reduced apart from an inference from the reduction in fishing effort; because of the regulatory situation, fishermen generally no longer report and deliver bycaught vaquitas to authorities. This makes the implementation of regulations particularly challenging.

SC/62/SM5 reported on the development of a monitoring plan to assess trends in vaquita abundance based on acoustics using C-POD. It is anticipated that the scheme will be in operation by the end of this year (2010). Jaramillo-Legorreta acknowledged the financial support provided to this work by a number of agencies and organisations in addition to the Mexican government: National Marine Fisheries Service, WWF, the Cousteau Society, Ocean Foundation, US Marine Mammal Commission and International Fund for Animal Welfare.

The Committee thanks Jaramillo-Legorreta for this update and commends those involved for their hard work and commitment to saving the vaquita. The Committee **agrees** that it would be useful to document (in working papers or publications) all of the costs of the vaquita conservation and monitoring efforts for future reference for other Countries with similar bycatch problems.

The Committee **remains gravely concerned** about the fate of the vaquita and it **reiterates its previous recommendation** (IWC, 2010h, p.324) that, if extinction is to be avoided, all gillnets should be removed from the upper part of the Gulf of California. The Committee further **recommends** intensified development and testing of alternative fishing gear (e.g. through a smart-gear competition) that fishermen can use in place of entangle gears. It **strongly encourages** Mexico to continue and intensify its efforts to conserve the vaquita.

14.3.2 Harbour porpoise

No primary papers on harbour porpoises were presented at this meeting.

A joint workshop of ASCOBANS/ECS recommended a revision of EU regulation 812/2004 on monitoring and mitigation of cetacean bycatch in gillnet and pelagic trawl fisheries, as at present it does not include small vessels of less than 15m length. The Committee **recommends** that the EU regulation should be reviewed if realistic total estimates of bycatch are to be provided.

Available information for the German North Sea and Baltic from 2003 to 2009 suggests an increasing trend in bycatch. As last year, the Committee **expresses concern** about the ongoing evidence of large-scale bycatch in this region, including the western Baltic (as discussed last year when the Committee called for more research). The Committee **notes**, in particular, that the harbour porpoise population in the Baltic proper is considered Critically Endangered. Better information on both the scale of incidental mortality and the stock affinities of the affected porpoises is essential.

Attention was drawn to the vulnerability of the recently identified a isolated Iberian population of harbour porpoises. The Committee **recommends** further study of this population.

14.3.3 Franciscana

The franciscana, endemic to the eastern coasts of Brazil, Uruguay and Argentina, is regarded as one of the most threatened small cetaceans in South America due to high bycatch levels as well as increasing habitat degradation throughout its range. It is classified as Vulnerable by IUCN. Secchi *et al.* (2003) proposed four management stocks (known as Franciscana Management Areas or FMAs): three in Brazil (FMA I-III), one in Uruguay (FMA III) and one in Argentina (FMA IV).

Mendez *et al.* (2010) stressed that considering all franciscana genetic analyses to date, there is strong evidence for the existence of at least three populations in Brazil (FMAs I, II and III), one in Uruguay (FMA III) and three in Argentina (FMA IV).

The Committee welcomes the new information concerning franciscana stocks in Argentina and encourages the continuation of research and conservation efforts on the species there, particularly in light of the high bycatch rates. It **recommends** that the possibility of further population structure within the range of the franciscana be investigated.

SC/62/SM7 presented information on distribution and provided the first estimate of abundance of franciscanas in FMA II (Brazil) from aerial surveys conducted in December 2008 and January 2009. Coverage included an area believed to correspond to a hiatus in the distribution between FMA I and FMA II. Sightings were confined to the coastal stratum, but offshore effort was low due to poor weather conditions. Corrected abundance was estimated to range between 8,000 and 9,000 individuals (CVs=0.32-0.35) although some additional sources of possible bias require investigation. Current estimates of incidental mortality in FMA II correspond to 3.3-6.2% of the estimated population size presented here, which is likely unsustainable.

The Committee **welcomes** this paper that addresses recommendations from previous years (IWC, 2005g, p.309). It notes that the estimates of abundance were probably negatively biased because of limited coverage of the offshore stratum and because estimates of group size from aircraft are consistently smaller than those from boats and land observation sites.

With regard to the aerial surveys in FMA II, the sub-committee commends Zerbini and his co-workers for their excellent work and **recommends** that further studies be carried out to:

(1) improve estimates of visibility bias;
(2) evaluate potential biases in the estimation of group sizes; and
(3) estimate franciscana diving parameters in areas where such information is not available.

The Committee also **recommends** that bycatch be estimated in additional areas and assessments be carried out of other possible threat factors such as underwater noise, chemical pollution from coastal development and industrial and human waste discharge, oil and gas exploration activities and vessel traffic.

14.3.4 Narwhal

Last year (IWC, 2010h, p.325), the Committee noted that new estimates of narwhal abundance had recently become available. Subsequently, the results of aerial surveys in Canada indicating total abundance greater than 60,000 narwhals were published (Richard *et al.*, 2010). The NAMMCO Scientific Committee considered new estimates from Greenland in its management advice given in April 2009 (IWC/62/4). At its 2009 meeting, the NAMMCO Council (NAMMCO Annual Report 2009, pp.96-97) considered the new information on narwhal abundance and revised its management advice accordingly. The 2005 NAMMCO assessment had concluded that narwhals in West Greenland were highly depleted and that annual sustainable harvest levels would be as low as 15-75 animals. However, population modelling with the new survey data from 2007 and 2008 indicated that overall abundance was at 51% (95% CI: 27-79%) of carrying capacity, with a 2009 modelled abundance of 12,000 (95% CI: 6,200-26,000), and NAMMCO concluded that its management objectives would be met at 70% probability with annual total removals of 310 (West Greenland) and 85 (East Greenland).

The Committee **thanks** the NAMMCO observer for providing information and **encourages** closer links between the NAMMCO and IWC Secretariats in sharing information, e.g. catch data. The possibility of a joint special meeting or workshop on monodontids (involving IWC, NAMMCO, Canada-Greenland Joint Commission on Narwhal and Beluga) should be considered in the near future, assuming that a data availability agreement can be established in advance. The next meeting of the Joint NAMMCO SC and JCNB scientific working group on narwhal and beluga will probably be in 2012, leaving adequate time to explore the potential of a joint meeting/workshop. The Committee **agrees** that an e-mail working group convened by Bjørge will follow up this possibility during the intersessional period and report back next year.

14.3.5 Irrawaddy dolphin

The freshwater population of Irrawaddy dolphins in the Mekong River is Critically Endangered (Smith and Beasley, 2004).

SC/62/WW4 reported on dolphin-watching tourism in the Mekong where photo-id studies indicate dolphins exhibit high site fidelity to particular deep-water pool areas that are very limited in size (1-2 km^2). The authors argued that an adaptive, precautionary approach is essential to managing tourism that targets small, closed, resident communities of cetaceans such as in this case. SC/62/WW4 recommended a range of management interventions, all aimed at decreasing the exposure of dolphins to dolphin-watching vessels.

The Committee received information from World Wide Fund for Nature (WWF)-Cambodia indicating that there are fewer than 100 dolphins based on a photographic mark-recapture analysis. At least 92 dolphins (>63% of them classified as calves) died in the period 2003-09, likely due primarily to entanglement in fishing gear and conservation efforts have focussed on the elimination of gill nets in the core habitat for dolphins in the 200km stretch of the Mekong between Kratie town and the Lao border. The conservation of dolphins in the Mekong is primarily the responsibility of the Commission on Dolphin Conservation and Ecotourism Development (Dolphin Commission). Despite its efforts, the mortality rate has remained high and the population apparently is continuing to decline. Dolphin conservation efforts in Cambodia reportedly have been hindered by inadequate funding for the Dolphin Commission and the lack of regulations that could help to reduce or eliminate the use of gill nets. There is also a need for much better cooperation among the Dolphin Commission, the Fisheries Administration and WWF. WWF and the Fisheries Administration are currently working to develop protected areas and other regulatory tools to protect dolphins. WWF and local NGOs are also working with local communities to reduce gill net use and to develop alternative livelihoods in order to reduce fishing pressure in core dolphin habitat.

The Committee **expresses grave concern** about the rapid and not fully explained decline of this riverine population. It commends the efforts by Cambodian government agencies and WWF-Cambodia to diagnose the cause(s) of the decline, and **strongly recommends** that every effort be made to stop and reverse it, e.g. by immediately eliminating entangling fishing gear in the pool areas used most intensively by the dolphins and by taking immediate steps to reduce the exposure of the dolphins to tour boat traffic.

14.3.6 Other

The Committee received an update (SC/62/SM2) of Amaral *et al.* (2009), the goal of which is to revise the model of worldwide population structure of common dolphins, genus *Delphinus,* using a multilocus approach. It has become clear that the long-beaked population in the northeastern Pacific is highly differentiated from all other populations based on both nuclear and mitochondrial markers. The differentiation between short-beaked populations occurring in different oceans is even higher than suggested in Amaral *et al.* (2009). Future analyses will estimate divergence times and migration rates between the different populations. This study also highlighted the difficulty of obtaining informative molecular markers other than mitochondrial DNA and microsatellites, due to the low overall level of polymorphism in the nuclear genome of common dolphins.

The Committee **encourages** the continuation of this global study of the genus. It also **recommends** that efforts should be made to obtain samples from regions where both short-beaked and long-beaked forms occur, as is the case in West Africa and the southeastern Pacific.

14.4 Other information presented

SC/62/BC6 presents a preliminary global review of operational interactions between odontocetes and the longline fishing industry and potential approaches to mitigation. This is a global problem for both cetaceans and fishermen. Mitigation strategies are needed to ensure the sustainability of both the odontocete populations and the longline fisheries. Bycatch occurs in many longline fisheries and involves at least 13 species but there are few quantitative data. The inadequacy of life history and population data adds to the difficulty of assessing the sustainability of the bycatch in most cases. Considerable effort has been devoted to solving the depredation problem and potential solutions have included acoustic and physical tools. Acoustic approaches to mitigation have proven problematic but recent trials using physical depredation mitigation devices have yielded promising results.

In discussion it was noted that longline fisheries for halibut and Greenland halibut in the northern North Atlantic have increasingly experienced problems with depredation of catches by northern bottlenose whales (*Hyperoodon ampullatus*).

New information was presented on the ongoing commitment of the Italian government (Ministry of the Environment) to conduct systematic abundance aerial surveys of small cetaceans in Italian waters (Ligurian, Tyrrhenian, Sardinian and Ionian seas) and in the Pelagos Sanctuary. Initial scientific and technical support was provided by the IWC Head of Science. The surverys are a priority action common to the Sanctuary Management Plan, ACCOBAMS and RAC/SPA UNEP. Among the preliminary conclusions from the completed surveys were: (1) the Sanctuary does not cover the full population range of striped dolphins; and (2) there is substantial seasonal variation in the density and abundance of striped dolphins (higher in summer). These density and distribution data from the surveys will be instrumental to the proposed ACCOBAMS basin-wide survey and will help guide the development of a long-term monitoring programme. The Committee also **welcomes** news of a complete survey of the Adriatic Sea funded by the Italian Government in July-August 2010.

The ACCOBAMS observer reported that a basin-wide survey of cetaceans in the Mediterranean and Black Seas remains one of ACCOBAMS' highest priorities. Activities are underway with the aim to start such a survey in the next triennium (2011-13).

The Committee **welcomes** the new information and **supports** continuation of such efforts in the Mediterranean Sea and adjacent areas. It specifically **endorses**, as it has in the past, implementation of the ACCOBAMS basin-wide survey, as soon as possible.

14.5 Review of takes of small cetaceans

At the last meeting, the sub-committee discussed various problems associated with the compilation of data on takes of small cetaceans including both direct catches and bycatch (IWC, 2010h, pp.326-28). It recommended a series of changes in how the data should be compiled, reported and interpreted. The process of setting up a system for direct electronic submission of these data by national representatives is still ongoing. The information retrieved by the Secretariat from national progress reports was reviewed. Data on bycatch of small cetaceans was presented in 12 National Progress Reports (Annex L, table 2).

The Committee **reiterates** the importance of having these data submitted and **encourages** all countries to do so.

The observer from NAMMCO advised that catch data from member countries are routinely published in the NAMMCO Annual Reports that are available on the website *http://www.nammco.no*.

Concern was expressed about the information from 12 West African countries indicating human consumption of cetaceans, exchange of cetacean meat in markets or direct capture of cetaceans (see Annex L, table 1); consumption and exchange can lead to targeted and unregulated direct hunting.

Information was received on small cetacean interactions with fishing gear in Machalilla National Park, Ecuador. Four species of cetaceans were caught incidentally: common bottlenose dolphins, dwarf sperm whales, Risso's dolphins and pantropical spotted dolphins. The Committee **expresses concern** about the implications of the bycatch documented in this preliminary study and looks forward to a more detailed report next year on the scale of the fisheries involved and therefore the implied magnitude of the cetacean bycatch.

14.6 Voluntary Fund for Small Cetaceans Conservation Research

The Committee discussed a proposed mechanism and procedure for allocating project support for high priority conservation projects (e.g. improving status of threatened species, capacity building) from the IWC Small Cetacean Research Fund. Australia's recent contribution to the fund is intended to support high priority research that demonstrably links to improving conservation outcomes for small cetaceans globally, particularly those that are threatened or especially vulnerable to human activities. Preference for funding will be based on a determination of need, the quality of the research application and the demonstration of links between research and conservation outcomes. Proposals that demonstrate a capacity building legacy will be viewed favourably.

In order to maximise the number of projects supported by the fund, and hence enhance conservation outcomes for small cetaceans, any single proposal will be limited to a maximum of £34,000. Other IWC member governments will also be encouraged to provide additional voluntary donations to the fund to further support small cetacean research.

A funding application form is being developed and made available via the IWC Secretariat. Applications should be received by the Secretariat at least 60 days prior to the start of the Committee's Annual Meeting. A Review Group will be appointed by the Convenor of the Small Cetacean sub-committee to review proposals in accord with agreed criteria. The group will make recommendations for funding to the Small Cetaceans sub-committee. It may suggest improvements to proposals where appropriate and can solicit the assistance of other researchers in the review process if necessary.

The recommended projects and budgets will be reviewed by the Small Cetacean sub-committee and the full Scientific Committee. Recommended proposals will be added to the Committee's budget as a specific request to the Voluntary Research Fund for Small Cetaceans. The Secretariat will organise contracts for the projects that are approved for funding by the Commission.

The Committee **emphasises** the importance of ensuring that proposal review and project selection meet the criteria and priorities of the sub-committee on small cetaceans. In addition to a call for proposals via a circular from the IWC Secretariat to all members of the Scientific Committee, a broader announcement mechanism will be developed.

The Committee **expressed** its gratitude to the Government of Australia for its generous contribution to the Voluntary Fund for Small Cetacean Conservation Research, which will make a significant difference to the Fund's ability to pursue its conservation priorities.

The Committee also **emphasises** the importance of building the Fund by obtaining donations from other sources. It was noted that good outcomes from the funded research should encourage more countries to contribute.

14.6.1 Project Proposal for the Voluntary Fund for Small Cetacean Conservation Research

A proposal for funding by the Small Cetacean Conservation Research Fund entitled '*Threatened Franciscanas: Improving Estimates of Abundance to Guide Conservation Actions*' was presented (Annex L, Appendix 3). The proposed work is directly linked to previous recommendations of the sub-committee, and responds directly to recommendations made at the present meeting based on consideration of SC/62/SM7 (see Annex L).

The sub-committee **strongly supports** the proposal, based on the following considerations:

(1) the franciscana is threatened by a variety of human activities in the region, particularly artisanal fishing;
(2) the proposal addresses a clear conservation need as expressed in present and previous recommendations; and

(3) more robust estimates of franciscana abundance (along with improved, more nearly complete estimates of bycatch as well as assessments of other threat factors) are needed to assess the status of populations and develop appropriate mitigation efforts.

The proponents have a strong track record (e.g. as reflected in the quality of the work described in SC/62/SM7).

The Committee therefore **recommends** that the proposal be funded by the Voluntary Fund for Small Cetacean Conservation Research and that a full report on the results be provided for consideration at a future meeting.

14.7 Work plan

The sub-committee on small cetaceans reviewed its schedule of priority topics which currently includes:

(1) systematics and population structure of *Tursiops*;
(2) status of ziphiids worldwide; and
(3) fishery depredation by small cetaceans.

The Committee **agrees** that the priority topic for the next annual meeting will be the status of ziphiids (beaked and bottlenose whales) worldwide.

Further discussion of potential future topics can be found in Annex L. As part of the discussion it was agreed to establish an intersessional correspondence group convened by Ritter to consider whether the issue of the consumption of cetaceans ('marine bushmeat') as some type of substitute for other resources that are becoming scarce should be added to the priority topic list. The group will collate information intersessionally and report back at the next annual meeting.

The Committee will also review the report from the Workshop on climate change and small cetaceans.

15. WHALEWATCHING (WW)

The report of the sub-committee on whalewatching is given as Annex M. Scientific aspects of whalewatching have been discussed formally within the Committee since a Commission Resolution in 1994 (IWC, 1995b).

15.1 Proposal for a large-scale whalewatching experiment (LaWE; including reports from the intersessional steering group and the advisory group)

The Committee received a proposal from the large-scale whalewatching experiment (LaWE) intersessional steering group. The report elaborated on the objectives, aims, methodology, design, management and funding considerations for this initiative (Annex M, Appendix 2).

Three options were presented for procedural mechanisms to manage the different components of the LaWE project, ranging from top-down (in which the IWC would play a steering group role) to decentralised (in which the IWC would play a coordinating role (Annex M, item 5.1, fig. 1). After discussion, the Committee **agrees** that a transitional process is preferable, with a top down approach (hierarchical structure) at the initial stage of the project progressing into a mechanism where the IWC would play more of a coordinating role (network structure). Discussions are detailed in Annex M, item 5.1.

IWC member nations will be able to use the results of the project as the basis for appropriate scientific management of whalewatching. The information collected during LaWE will also provide data on general biology and life history parameters of cetaceans that are relevant to other aspects of the Committee's work. There are a variety of potential funding sources for the LaWE effort including:

(1) IWC membership: funding derived from fees/contributions from member nations;
(2) national/regional initiatives: funding derived from national or regional governments involved in the support/promotion of whalewatching;
(3) NGOs: funding derived from national/international NGOs involved in the conservation of cetaceans;
(4) whalewatching operators: funding derived from whale/dolphin-watching operators; and
(5) hybrid model: targets key operators in high profile whalewatching areas with additional funding sought from host countries, IWC, NGOs, and other sources.

The Committee **recommends** that an e-mail correspondence group be formed to further develop the budget for the LaWE, although it noted that until power analyses are completed and species and sites are chosen, only approximate budgets can be created.

The Committee **agrees** to combine the two previous LaWE intersessional groups into one 'steering group' to maximise collaborative discussions (see Annex M, item 5.1).

The budget request to assist the LaWE intersessional work to develop procedural mechanisms to centralise data received from research groups relevant to LaWE with the Secretariat and commence power analysis for key parameters depending on data received is discussed under Item 24. In addition, funding is requested for a pre-meeting of the LaWE steering committee to review and advance intersessional progress on all aspects of the project, including reviewing data received, advancements in power analysis, and the selection of appropriate study species and sites.

There was no formal report from the advisory group, as the LaWE is not yet at the point of selecting research sites.

15.1.1 Other

SC/62/WW5 presented a summary of progress from a working group tasked with developing a formal mathematical structure from the US National Academy of Sciences Population Consequences of Acoustic Disturbance (PCAD) conceptual framework. The working group decided to develop three statistical models to provide the linkages from disturbance to population dynamics. Work has focused on the first models (disturbance to physiological conditions). First implementations with simple systems (southern elephant seals at-sea movement) proved extremely successful and body condition time series could be estimated and validated against body weight when the seals returned to the colony. A similar, albeit more complex, model was developed for coastal dolphin population case studies and will be implemented over the next year.

Discussions on the motivational state-space approach to the PCAD model and concern about the restrictions on the remit of the PCAD project are detailed in Annex M, item 5.1.

15.2 Review of whalewatching off North Africa

SC/62/SM8 reported on cetacean sightings, local human activities and conservation off São Tomé (São Tomé and Príncipe), Gulf of Guinea, West Africa. This region seems to be an important area for cetaceans; however, the status of species or populations has not been assessed due, in part, to lack of information and effort. A similar situation may exist in the Cape Verde Islands where there are resorts and a significant number of tourists. It was noted that several measures regarding the conservation of natural populations of cetaceans are needed for these areas (including international standards of operation, educational programmes and research) to reinforce a change to a more conservation-oriented perspective with direct involvement of local communities.

The Committee welcomed the report and noted the lack of information on whalewatching activities in western and northern Africa. Furthermore, it **expresses concern** at the potential for expansion of whalewatching activities in the region without sufficient scientific information on cetaceans and called for an assessment of the scope of activities to be made by relevant authorities as soon as possible.

An overview of whalewatching activities in the Mediterranean will be prepared under ACCOBAMS. More information is available on the Agreement's official website, *http://www.accobams.org*.

15.3 Assess the impact of whalewatching on cetaceans

SC/62/WW4 reported on the critically endangered Irrawaddy dolphin population inhabiting the Mekong River. Studies indicate dolphins exhibit high site fidelity during the dry season, have low genetic diversity and a high mortality rate. The locations of dolphin-watching areas are at two of the critical habitats for the remaining population in the river, numbering less than 100 individuals. Initially, at both locations, the dolphin-watching industry was land-based, with a few row-boats occasionally taking tourists into the pool to view dolphins. By the early 2000s this expanded to approximately 15 larger motorised boats that offered dolphin tours. Now it numbers more than 20. The authors believe that an adaptive, precautionary approach is essential to managing tourism that targets small, closed, resident communities of cetaceans and that for this Critically Endangered population, a 'no vessel-based dolphin tourism' policy is desirable. It was noted that the issues associated with Cambodian cetacean-watching tourism may be generic to developing countries.

The Committee reiterated **its concern** over the critically endangered Mekong River Irrawaddy dolphin population. In 2006, it had noted that there was compelling evidence that the fitness of individual odontocetes repeatedly exposed to tour vessel traffic can be compromised and that this can lead to population level effects (IWC, 2007b). It also stated that, in the absence of data, it should be assumed that such effects are possible until indicated otherwise – particularly for small, isolated and resident populations. Accordingly, the Committee **strongly recommends** that the Cambodian government and relevant agencies make every effort to reduce the exposure of dolphins to vessel-based tourism in deep-water pools in the Mekong River.

SC/62/WW1 reported on behavioural responses of southern right whales to human approaches in Bahia San Antonio, Rio Negro, Argentina. Results are listed in Annex M, item 6. The Committee noted the small sample size but commended the before-during-after experimental design.

SC/62/WW2 summarised recent advances in whale-watching research. Noren *et al.* (2009) investigated the prevalence of 'surface active behaviours' (e.g. spy hops, breaches) in the vicinity of boats in southern resident killer whales; Arcangeli and Crosti (2009) conducted a study on an Australian common bottlenose dolphin (*Tursiops truncatus*) population in the coastal waters of Bunbury; Christiansen *et al.* (2010) used a Markov chain analysis to investigate changes in Zanzibar Indo-Pacific bottlenose dolphin (*T. aduncus*) behavioural states in relation to boat traffic; Scarpaci *et al.* (In press) reported on the impact of swim-with-cetacean tourism on bottlenose dolphins within a 'sanctuary zone' in Port Phillip Bay, Australia; Sousa-Lima and Clark (2009) used automated acoustic recordings to monitor and track the singing behaviour of male humpback whales in Abrolhos Marine National Park, Brazil, a major humpback whale breeding ground; Stamation *et al.* (2010) monitored the behaviour of groups of humpback whales off Queensland Australia from both whalewatching vessels and land-based platforms; Filla and Monteiro (2009) investigated various types of whalewatching on estuarine or 'guianensis' dolphins (*Sotalia guianensis*) in Cananéia, southeast Brazil; and Jensen *et al.* (2009) found that common bottlenose dolphin and pilot whale (*Globicephala macrorhynchus*) communication calls could be masked substantially by small outboard engine noise. Summaries are presented in Annex M, item 7.

The Committee **welcomes** this review and encouraged the author to prepare a similar review for the next meeting. It was clarified that these reviews are not critiques of methods or results but rather a compilation of new research results of interest.

SC/62/WW3 reported on the US National Oceanic and Atmospheric Administration's efforts to develop management plans to reduce the exposure of resting spinner dolphins (*Stenella longirostris*) to human activity in Hawaiian waters. One management approach under consideration focuses on time-area closures to reduce the number and intensity of interactions between humans and dolphins during critical rest periods in particular bays. Research will combine boat-based and land-based visual observations with passive acoustic monitoring and is an international collaboration between researchers from American, Australian and Scottish universities. Time area closures will not be implemented until a full year of pre-closure data collection has been completed. The authors highlighted this study as a possible candidate project for inclusion in the Large-scale Whalewatching Experiment (LaWE) initiative, as it incorporates many facets that the LaWE initiative strives to achieve.

The Committee **commends** this study and deems it relevant to the LaWE initiative.

SC/62/WW8 presented a precaution on interpreting the results of impact study data analysis. The paper discussed the possibility of confounding variables when interpreting correlations between whalewatching exposure and reproductive parameters of female humpback whales (see Weinrich and Corbelli, 2009). Discussion is presented in Annex M, item 7.

The Committee **welcomes** this paper as an important consideration in impact analyses. It was noted that this contribution clarifies that whalewatching is essentially another habitat variable, and should be treated as such in multivariate models.

Parrot *et al.* (2010) report on an agent-based simulation platform to assess the characteristics of interactions between whales and vessels under different scenarios. The simulation is composed of a spatial environment in which a whale individual-based model and a boat agent-based model can evolve. It simulates the spatiotemporal movement of marine mammals and vessel traffic in the St Lawrence Estuary. It estimates movement parameters from long-term data collected using both onboard GPS and vessel monitoring systems for vessels and a variety of land-based and boat-based focal follows as well as sightings for marine mammals from whalewatching boats.

This platform can be used to inform decision-making by simulating different vessel and whalewatching traffic scenarios.

This project is highly relevant to the LaWE objectives and offers an avenue to simulate boat interaction consequences for cetaceans using behavioural statistical models of disturbance effects. The Committee **welcomes** this effort.

The Committee noted that its work on whalewatching has been influential with other research initiatives to understand effects of disturbances on cetacean populations.

At last year's meeting, there was discussion on the impacts of aerial whalewatching (IWC, 2010i). Groch noted that she was not able to analyse behavioural data collected in previous years during southern right whale photo-id surveys from a helicopter in Brazil. Sironi reported that a trial was conducted to record before-during-after behavioural observations during the 2009 southern right whale photo-id aerial survey in Argentina from a fixed-winged aircraft. Dedicated flights are required to obtain more accurate behavioural data.

15.4 Review reports of intersessional working groups

15.4.1 Online database for worldwide tracking of commercial whalewatching/associated data collection

Robbins summarised the status of an online database for tracking whalewatching operations and associated data collection programmes. This database was originally described in Robbins and Frost (2009) and is intended to facilitate studies of whalewatching impact as well as to allow better assessments of the scientific value of data collection programmes. Database development has made considerable progress intersessionally and should be available to go online prior to next year's meeting. The Committee **recommends** that the intersessional working group continue and report back next year (see Annex Q).

15.4.2 Swim-with-whale operations

Rose reported that due to time constraints, no progress was made intersessionally on field-testing a questionnaire to further assess the extent of swim-with-whale operations. However, a draft questionnaire is ready to be distributed and plans are in place to do so in the Dominican Republic and possibly Australia before next year's meeting. The Committee welcomes the commitment of funding for this effort by the Pacific Whale Foundation and **recommends** that the intersessional working group continue and report back next year (see Annex Q).

15.5 Other issues

15.5.1 Consider information from platforms of opportunity of potential value to the Scientific Committee

Progress continues in efforts to stimulate submission of opportunistic data from ecotourism cruise ships in the Southern Ocean to the Antarctic Humpback Whale Catalogue (AHWC). The availability of these data has broadened understanding of the exchange between areas and in some cases provided information that was previously not available. Ritter (2010) reported on a near-miss event involving a large vessel and humpback whales off Antarctica (see Annex M, item 9.1).

Smit *et al.* (2010) reported on opportunistic research off the coast of La Gomera, Canary Islands (Annex M, item 9.1). The study highlights the importance and the potential of mutual long-term co-operation between whalewatching operators and scientists. The Committee welcomes the reports and reiterated the value of collaboration between researchers and whalewatching operations and other platforms of opportunity.

15.5.2 Review of whalewatching guidelines and regulations

The compendium of whalewatching guidelines and regulations around the world is in the process of being updated and will be available on the IWC's website in August. SC/62/WW2 described several papers relating to guidelines and compliance including Noren *et al.* (2009), Williams *et al.* (2009a); Stamation *et al.* (2010); Sousa-Lima and Clark (2009); and Jensen *et al.* (2009).

Summaries of the reports are found in Annex M, item 9.2.

15.5.3 Review of risk to cetaceans from collisions with whalewatching vessels

No new information was brought to the meeting this year. Some members indicated that papers on this item would be submitted to next year's meeting. The Committee noted that this issue will be discussed at a joint workshop with ACCOBAMS in Monaco from 21-24 September 2010.

15.5.4 Future of the sub-committee on whalewatching

The Committee took note of IWC/62/CC8 and the possible interface between the Conservation Committee's work and its own work on whalewatching. The Conservation Committee has established a Standing Working Group on Whalewatching and intends to develop a draft strategic plan for five years (2010-15). IWC/62/CC8 made reference to the work of the Committee and various scientific issues and the section on Capacity Building and Development states that actions 'may include… provision of expert assistance through the Scientific Committee's sub-committee on whalewatching'.

The Committee requests clarification on the mechanism by which this expert assistance will inform the work of the Standing Working Group. It welcomes the opportunity to liaise with the Conservation Committee and Commission, but noted its own terms of reference, and believes that the advice it offers should be within that framework. One possible mechanism, for example, would be to designate a representative from the Committee to work directly with the CC on this issue, thereby providing a formal interface.

The Committee is also seeking clarification on the envisioned management objectives for whalewatching, as IWC/62/CC8 states both 'growth' and 'sustainability' objectives. Clarification will guide the scientific work of the Committee for Objective 7 of the LaWE project ('Develop an integrated and adaptive management framework for whalewatching that accounts for uncertainties, and includes monitoring and feedback mechanisms').

The Committee draws the attention of the Conservation Committee to the definitions of whale ecotourism developed at previous meetings (IWC, 2006c) and considered it important that the Conservation Committee takes a strategic view of what it might achieve in the five years. It also **stresses** the importance of a good scientific basis for the work that it is recommending to the Commission.

It was noted that it would be valuable to increase communication with and explore possibilities for collaborate with the UN World Tourism Organisation, as its remit complements the work of the sub-committee in a number of aspects. Lusseau agreed to liaise for this purpose.

15.5.5 Other

Eisfield *et al.* (2010) reported on the behaviour of a female solitary sociable dolphin studied on the southeast coast of England in 2007, previously addressed by the Committee. The report is summarised in Annex M, item 9.5.

The Committee **reiterates its recommendation** of 2008: habituation of solitary dolphins can make them vulnerable to harm, including being killed, and should be avoided.

16. DNA TESTING (DNA)

The report of the Working Group on DNA is given as Annex N. This particular Agenda Item has been considered since 2000 (IWC, 2001d; 2001e; 2001h) in response to a Commission Resolution (IWC, 2000).

16.1 Review genetic methods for species, stock and individual identification

No new documents were submitted under this Item this year. Last year, the Committee had reviewed Cipriano and Pastene (2009), which provided a comprehensive review of current knowledge of techniques to extract DNA from 'difficult' samples.

16.2 Review results of the amendments of sequences deposited in GenBank

During the first round of sequence assessment (IWC, 2009i, p.347), some inconsistencies were found for some sequences assigned to right and minke whales. These appeared to have been due to a lag in the taxonomy recognised by *GenBank* or uncertainty in taxonomic distinctions currently under investigation (e.g. the number of species and appropriate names for recently described species of 'Bryde's whales').

Last year, the Committee noted that the original submitter would be notified of the inconsistencies and a suggestion made that an amendment be made to the entry. Pastene reported that he had contacted *GenBank* officers to make the above indicated amendments. He was informed that only the original submitters of the sequences can make amendments to their submissions. In view of this he contacted the relevant scientists encouraging them to make the relevant amendments. As a result, the notification regarding Bryde's whale taxonomy (IWC, 2010c, p.73) was made. Amendment work by the original submitters of right and minke whale sequences is ongoing and this work will be completed during the next intersessional period.

The Committee thanked Pastene for his work in this regard.

16.3 Collection and archiving of tissue samples from catches and bycatches

The collection of tissue samples in Norway is from the commercial catches of North Atlantic common minke whales from 1997 to 2009. A total of 484 whales were landed in 2009 (see Annex N, Appendix 2).

The collection of samples in Japan is from special permit whaling in the Antarctic (JARPA II) and North Pacific (JARPN II), bycatches and strandings. The collection includes complete coverage for 2009 and the 2009/10 Antarctic season. A total of 506 genetic samples of the Antarctic minke whale and one of the fin whale were collected from the 2009/10 austral summer survey of JARPA II. From JARPN II in the western North Pacific (NP) samples stored in 2009 were: NP common minke whale, n=162; NP Bryde's whale, n=50; NP sei whale, n=100; and NP sperm whale, n=1. The samples from bycatch stored in 2009 were: NP common minke whale, n=119; NP humpback whale, n=3. Genetic samples were stored for the following stranded whales in 2009: NP common minke whale, n=3; NP humpback whale, n=1 and NP sperm whale, n=1 (see Annex N, Appendix 3).

The collection of samples from Iceland in 2009 was from commercial catches of North Atlantic common minke whales (n=81) and fin whales (n=125). Samples are currently in hand for all whales taken in 2003-09 (see Appendix 4 of Annex N).

The Committee welcomes this information from Norway, Japan and Iceland.

16.4 Reference databases and standards for diagnostic registries

Genetic analyses have been completed and data on mtDNA, microsatellites and sex entered in the Norwegian register for years up to 2007. The laboratory work on the 2008 samples is completed but has not yet been analysed. Laboratory work is ongoing for the 2009 samples (see Annex N, Appendix 2).

For the Japanese register, the genetic analyses based on mtDNA have been completed for North Pacific common minke, Bryde's, sei and sperm whales taken by special permit whaling up to 2009. Laboratory work on microsatellites for these samples is ongoing.

The genetic samples of Antarctic minke whales obtained by JARPA II have not yet been analysed, except for sex and for microsatellites of 190 samples taken in 2006-07 (six loci) and 551 taken in 2007-08 (six loci). For bycatch samples, genetic analyses based on mtDNA have been completed for all samples up to 2009. Laboratory work on macrosatellites for these samples is ongoing. Laboratory work is ongoing for stranded animals in 2009 for both mtDNA and STR (see Annex N, Appendix 3).

For the Icelandic register, genetic analyses (mtDNA and microsatellites) have been completed for common minke whales taken by special permit whaling in 2003-07. Laboratory work of samples taken under commercial whaling in 2006-09 is ongoing. Genetic analyses were completed for fin whale commercial samples collected in 2006 and 2009 (see Appendix 4 in Annex N). It was noted that only whales intended for export from Iceland were currently being genotyped for inclusion in that country's registry and that other whale samples will be genotyped as soon as possible.

The Committee **recommends** the adoption of a standard format for the updates of national DNA register to assist with the review of such updates in the future and agrees that the format used by the Norwegian registry update provides a suitable model. Pastene will work intersessionally with colleagues from Norway, Japan and Iceland to agree on the standard format. In addition, the Committee **agrees** that it would be useful to add a 'per cent completed' column for genetic analysis of tissue samples to assist in the annual review.

Whilst agreeing with these recommendations, Víkingsson reminded the Committee that Norway, Japan and Iceland are providing updates of their registries to the Committee on a voluntary basis.

The Committee noted that full technical specifications for the Japanese and Icelandic DNA registries have not been received or reviewed. Although such information is provided voluntarily, such a review would be helpful for the Committee's annual review of the status of DNA registries under its standing agenda items. The Committee recalled that updates of registers should include a list of references including the relevant documents on protocols used.

16.5 Other

SC/62/O19 describes a proposal to the IWC DAG under Procedure B, requesting access to the Japanese DNA register for the purposes of evaluating the technical aspects of traceability/trackability of sei, fin and Antarctic minke whale products purchased at commercial outlets in Santa Monica, USA and Seoul, South Korea. SC/62/O19 requested that the proposal be considered for endorsement by the Group.

The Committee could not reach an agreement on whether or not to endorse the proposal in SC/62/O19 of the current policy of Japan, Norway and Iceland regarding DNA registers access and market survey, although it recognised that the matching exercise proposed would, in principle, be valuable for testing functionality of DNA registers for identifying and tracking whale products.

16.6 Work plan

Members of the Committee were encouraged to submit papers in response to requirements placed on the Committee by the IWC Resolution 1999-8 (IWC, 2000). Results of the 'amendments' work on sequences deposited in *GenBank* will be reported next year.

17. SCIENTIFIC PERMITS (SP)

This Agenda Item was discussed by the Working Group on Special Permits in an evening session to enable all Committee members who wished to do so to attend. Bjørge was elected Chair of the Working Group. Reeves acted as Rapporteur, and the report has been directly incorporated here.

17.1 Review of activities under existing permits

All cruise reports from Japanese scientific permits from 1987 to the present are publicly available on the website of the Institute for Cetacean Research[5]. As in recent years, documents describing activities carried out in the preceding year were received by the Committee but not presented or discussed, except for points of clarification. Authors' summaries are included below. Full discussions will occur during the periodic reviews (see Item 17.3).

17.1.1 JARPN II

SC/62/O4 presented the results of the eighth full-scale survey of the Japanese Whale Research Program under Special Permit in the Western North Pacific-Phase II (JARPN II)-offshore component-, which was conducted from 10 May to 29 July 2009 in sub-areas 7, 8 and 9 of the western North Pacific. A total of five research vessels was used: one trawl survey vessel equipped with scientific echo sounder (TSV), one dedicated sighting vessel (SV), two sighting/sampling vessels (SSVs) and one research base vessel. A total of 6,374n.miles was surveyed. During that period 63 common minke, 482 sei, 93 Bryde's and 287 sperm whales were sighted. A total of 43 common minke, 100 sei, 50 Bryde's and one sperm whales was caught by the SSVs. All whales caught were examined on board the research base vessel. A total of 53 kinds of samples and data were obtained from each whale. A total of 16 skin biopsy samples were collected from blue (6), sei (9) and sperm (1) whales. As in previous surveys, common minke whales fed mainly on Pacific saury (*Cololabis saira*) and Japanese anchovy (*Engraulis japonicus*). Bryde's whales fed mainly on Japanese anchovy and oceanic lightfish. Sei whales fed mainly on copepods, Japanese anchovy and mackerels. Dominant preys in the stomach of one sperm whale were various kinds of squids, which inhabit the mid- and deep-waters. Qualitative and quantitative data on stomach contents will be used in the development of ecosystem modelling.

SC/62/O5 outlined the results of the sixth JARPN II survey (coastal component), conducted off Sanriku, northeastern Japan (i.e. the middle part of sub-area 7). The survey was carried out from 22 April to 21 May 2009 using four small sampling vessels and one echo sounder-trawl survey vessel. The research area was set within 50n.miles of Ayukawa port in the Sanriku district. The prey species survey was also conducted by the echo sounder-trawl survey vessel. A total of 4,756n.miles (464 hours) was surveyed and 111 schools (112 individuals) of common minke whales were sighted. No other large cetacean species was sighted. A total of 60 common minke whales were caught (27 males and 33 females) and landed at the JARPN II research station for biological examination. Only one individual in each sex was sexually mature. In addition the female was pregnant. The dominant prey species found in the forestomach was adult Japanese sand lances (*Ammodytes personatus*). The Japanese anchovy (*Engraulis japonicus*) and krill (*Euphausia pacifica*) were also observed but their frequency of occurrence was much lower. The prey species survey revealed high density of Japanese anchovy in the sampling area for common minke whale. These results suggest that during the 2009 survey common minke whales had prey preference for Japanese sand lance.

SC/62/O6 reported the results of the seventh JARPN II survey (coastal component), conducted off Kushiro, northeastern Japan (i.e. the northern part of sub-area 7). The survey was conducted from 5 September to 17 October 2009 using four small sampling vessels. The research area was set within 50n.miles of Kushiro port. The total searching effort by the sampling vessels was 5,136n.miles (494 hours) and 106 schools of common minke whales (107 individuals) were sighted; 59 animals were caught (36 males and 23 females) and landed at the research station. Of the males, 12 were sexually mature. None of the females sampled had attained sexual maturity. The walleye pollock (*Theragra chalcogramma*) was the most dominant prey species in the forestomach, followed by krill (*Euphausia pacifica*), Japanese anchovy (*Engraulis japonicus*), and Japanese common squid (*Todarodes pacificus*). Pacific saury (*Cololabis saira*) was not observed this year. All the animals feeding on walleye pollock were sexually immature. These results were almost the same as in the previous coastal surveys off Kushiro. The results suggest differences in feeding habits between immature and mature common minke whales off Kushiro in autumn. During the survey, other baleen whales were also sighted: 51 fin, 5 sei, and 22 humpback whales. They were observed in the vicinity of sampling positions of common minke whales that were feeding on krill.

17.1.1.1 POINTS OF CLARIFICATION

In response to a question regarding what new information of value in ecosystem modelling could be learned from the taking of one sperm whale last year (relative to the large number that had been caught and examined, with similar results regarding prey, in previous commercial whaling), the proponents stated that previous data on sperm whale diet from commercial catches were non-quantitative and did not consistently identify prey items to species level. They stated that this limited their utility in models such as ECOSIM and ECOPATH, and that data obtained from JARPN II were effectively used for ecosystem modelling. Others considered that this was not the case, and reiterated their view, and that of the JARPN II Review Panel (IWC, 2010a), that the catch of sperm whales in JARPN II is not scientifically justified.

[5] *http://www.icrwhale.org/CruiseReportJARPA.htm* and *http://www.icrwhale.org/CruiseReportJARPN.htm*.

17.1.2 JARPA II

SC/62/O3 presented the results of the third full-scale survey of the Japanese Whale Research Program under the Special Permit in the Antarctic-Second Phase (JARPA II), which was conducted during the 2009/10 austral summer season. Two dedicated sighting vessels (SVs), two sighting and sampling vessels (SSVs) and one research base ship were engaged in the research for 97 days from 14 December 2009 to 20 March 2010 in Areas III East (35°E-70°E), IV (70°E-130°E), V West (130°E-165°E) and part of Area V East (165°E-175°E). The total searching distance was 8,232n.miles. Eleven species including six baleen whales (Antarctic minke, blue, fin, sei, humpback and southern right whales) and two toothed whales (sperm and southern bottlenose whales) were identified during the research period. A total of 986 groups (2,242 animals) of Antarctic minke whales were sighted. It was the dominant species in the research area followed by the humpback whales (603 groups, 1,187 animals), and fin whales (56 groups, 186 animals). The number of sightings of the Antarctic minke whales was about 1.9 times higher than that of humpback whales in this survey. A total of 506 Antarctic minke whales and one fin whale were caught. All whales caught were examined on board the research base vessel. A total of 55 kinds of samples and data were obtained from each whale sampled. A total of 8 blue, 110 humpback and two southern right whales was photographed for natural marks. A total of 86 skin biopsy samples were collected from fin (1), humpbacks (84) and southern right (1) whales. To investigate vertical sea temperature profiles oceanographic surveys were conducted at 57 points using TDR. The main results of this survey were as follows: (1) whale composition in the research area was stable compared to previous JARPA II surveys in this area; (2) the ice-free extent of the research area was substantially larger than in past seasons and high density areas of Antarctic minke whales were observed near the continental shelf; (3) mature females of Antarctic minke whale were dominant in Prydz Bay; and (4) humpback whales were widely distributed in the research area and its density index was higher than that of the Antarctic minke whales in Areas IV West and V East. The 1994/95 IWC/SOWER cruise was conducted in similar areas and periods as in the present survey. In 1994/95 Antarctic minke whales were the most dominant species. The number of sightings of Antarctic minke whales in 1994/95 was about five times higher than that of humpback whales. According to the authors of SC/62/O3, comparison of whale abundance between these two surveys suggests that humpback whales were increasing and expanding into the research area.

17.1.2.1 POINTS OF CLARIFICATION

In response to a question on information on whether vomiting and faecal observations (SC/62/O3 table 7) referred to 'natural' events or were due to harpooning, the proponents explained that the recording of such observations was for the purpose of helping to evaluate the relative merits of lethal versus non-lethal sampling, and thus that there was no value in including observations of vomiting due to harpooning.

17.1.3 Planning for final review of results from Iceland's scientific take of North Atlantic common minke whales

Víkingsson summarised the status of Iceland's analytical work on the 200 common minke whales taken as part of its scientific research programme between 2003 and 2007; annual reports had been provided while the programme was still active. Last year it had been expected that most analyses would be completed and available in 2011; this would have allowed a formal review of the programme in 2012 following the Committee's guidelines (IWC, 2009j) provided the appropriate deadlines had been met. He reported that most of the laboratory analyses are either completed or in a final stage (see SC/62/ProgRepIceland). There had been changes and delays in some components, particularly those involving outsourced chemical analyses that required CITES permits. In addition, the serious economic difficulties experienced by Iceland in recent years have affected the programme and delayed completion of some analyses. Nonetheless, the necessary adjustments had been made to the workplan and he remained optimistic that the work would be completed on schedule.

In discussion, Víkingsson clarified that some of the analyses indicated in SC/62/ProgRep Iceland concerned species and specimens other than the 200 minke whales caught and sampled under Special Permit. Iceland's Special Permit programme had ended when the last of the 200 minke whales was taken in 2007.

In summary, an update on progress will be provided at the next Annual Meeting and approximately three months later a document will be submitted by Iceland that initiates the process leading to external review of the final results of this programme.

17.2 Review of new or continuing proposals

The Chair noted that both JARPA II and JARPN II are continuing on the basis of plans already submitted and reviewed in the Scientific Committee. There was no further discussion of this item. However, a statement in relation to this Agenda Item was received and can be found in Annex U. This statement reflects the view of many members. The response to this statement can be found in Annex U.

17.3 Procedures for reviewing Scientific Permit proposals

The Chair recalled that the Scientific Committee had spent considerable time in the past discussing this matter, and agreement on a process had been reached in 2009 (IWC, 2009j, colloquially known as 'Annex P') that had been used for the review of results of JARPN II. He noted that criticism by some members following the JARPN II review centred on how the procedures in 'Annex P' had been implemented rather than on the adequacy of the procedures themselves. Specifically, concerns had been expressed about the 'independence' of the specialists who served on the review panel, the Chair's decision not to request panel members to submit a conflict-of-interest declaration and the Chair's decision not to allow additional observers to attend the specialist workshop. The Chair noted in that regard that he also had not allowed scientists affiliated with the JARPN II programme to attend the deliberations of the expert panel.

Last year, it had been agreed to revisit at this meeting the question as to whether changes are needed to 'Annex P'. However, the Chair identified two factors weighing against the idea of having a full discussion at this time. First, given the ongoing discussions of the 'consensus package' prepared by the Commission Chair and Vice-Chair, it would be sensible to wait for outcome of those discussions before further discussion of 'Annex P'. Secondly, he believed that the dissatisfaction of some with the performance of the procedures for reviewing JARPN II was related to how these were implemented, rather than the wording of procedures themselves. In any event, Bjørge stressed that if the Committee decides to open 'Annex P' to revision, in his view such revision should be limited to only those aspects that have been controversial, i.e. the selection of experts to the review panel and the admission of observers. In discussion, it was further noted that given the schedule for reviewing the Iceland programme (as summarised under Item 17.1.3), there should be no need to implement 'Annex P' during the upcoming intersessional period. The Committee **agrees** that no further discussion of the procedures was needed at this time.

Childerhouse asked whether the adoption of a 'consensus package' would mean that Special Permit whaling would therefore end and preparations for reviews should begin. Bjørge replied that he was not in a position to advise on that, but he assumed that if the Commission reaches a decision that includes Special Permit whaling, it would then be incumbent on the Commission to provide guidance to the Scientific Committee on how permit reviews should be handled in the future.

18. WHALE SANCTUARIES

In the major discussion about sanctuaries in 2004, the Committee recommended procedures to facilitate the review of future proposals and future sanctuary reviews (IWC, 2005a, pp50-51). No new proposals for Sanctuaries were received this year. The item will remain on the Agenda for future meetings.

19. SOUTHERN OCEAN RESEARCH PARTNERSHIP

The Southern Ocean Research Partnership (SORP) was proposed by the Australian Government to the IWC in 2008 (IWC/60/16) with the aim of developing a multi-lateral, non-lethal scientific research programme that will improve the coordinated and cooperative delivery of relevant scientific information to the IWC. A framework and set of objectives for SORP were presented, discussed and endorsed last year (IWC, 2010c, pp.80-82).

At this year's meeting it was agreed to hold discussions at an evening session to allow all members who wished to attend to be able to do so without conflict with other sub-group meetings; that session was chaired by Gales and rapporteured by Childerhouse. It was agreed that the report of those discussions would be incorporated directly into the Plenary report.

19.1 Intersessional progress

SC/62/O9 reported on the intersessional progress on SORP. Progress was made on the following major items:

(1) establishment of a SORP Steering Group (SSG) with associated terms of reference;
(2) the holding of a Workshop further develop the SORP in Seattle in December 2009 (SC/62/O8);
(3) identification of seven proposed projects that will form the basis for SORP work into the future (SC/62/O10);
(4) the development of a funding mechanism for SORP projects (see below); and
(5) the holding of a first cruise of the joint Australia-New Zealand Antarctic Whale Expedition, AWE (SC/62/O12).

These items are covered in more detail below. It was noted that a full discussion of SC/62/O12 had taken place in the sub-committee on Southern Hemisphere whales (Annex H). The brief discussion under the present item focussed on suggested improvements in future cruises related to estimating abundance, the representativeness of the study area, the use of faecal sampling, the effect of satellite tagging on animals and some comments on the ability of the project to meet its objectives.

19.2 Report of the SORP Workshop, Seattle, December 2009

The SORP workshop (SC/62/O8) was hosted and supported by the Government of the USA and attended by 15 people from five nations. Its main aims were to continue developing the mechanism by which SORP would conduct its business and achieve its objectives. The workshop agreed that a focused approach to the research was required and this was best achieved through the development of research projects that were consistent with both the agreed SORP objectives and priority issues identified by the IWC Scientific Committee. To address this latter issue, a summary document of recommendations relevant to the Southern Ocean had been compiled. The proposed draft SORP projects that were developed at the workshop are described below.

19.3 Summary and consideration of proposed SORP projects

Several draft research projects were presented to the Committee in order to obtain comments and advice (SC/62/O10). The selection process had followed a lengthy consultation process starting at the Sydney SORP workshop (Southern Ocean Research Partnership, 2009) where broad themes were developed and these themes were endorsed by the Committee last year (IWC, 2011). *Inter alia* these draft projects developed at the Seattle SORP workshop are those that were considered to benefit from large scale, multi-regional participation and were consistent with both SORP objectives and IWC priority issues. The purpose of presenting these draft projects to the Committee this year was to seek initial comments and perhaps general endorsement of the overall approaches. The intention is that the project leaders will take any comments made into account when developing the projects intersessionally. It was clarified that there was no intention for the Committee to approve the draft budgets appended to the projects at this stage. These and other aspects of the proposals would require further development and should be re-submitted using the agreed funding mechanism (see Item 19.4) at the 2011 Annual Meeting.

19.3.1 Killer whales in the Southern Ocean

A short project description of 'Distribution, relative abundance, migration patterns and foraging ecology of three ecotypes of killer whales in the Southern Ocean' was presented. There are three ecotypes of killer whales described from Antarctic waters. Little is known about these ecotypes and it is important to understand these populations as killer whales play a key role in the Antarctic marine ecosystem. This is especially true with respect to the impacts that they have on prey populations including marine mammals, fish and penguins.

This project will investigate factors related to their ecosystem impact in Antarctica and adjacent waters, by focusing on their systematic relationships, abundance, distribution, movement patterns and prey preferences. It will include analyses of lipid, isotopes and contaminants from biopsy samples. Collaborators are from USA, Brazil, France and Brazil/Canada.

In discussion, it was agreed that this was an ambitious and valuable project outline. It was noted that the proposal required considerably more detail on the proposed analytical methods before it can be properly evaluated and that this was true for most of the draft projects presented. It is also important that any final proposal includes information on the conceptual and analytical and framework linking the sub-projects together. Suggested additional potential collaborators included Lauriano from the Italian Antarctic Programme and Bester from South Africa who is undertaking related work at Marion Islands.

19.3.2 Foraging ecology and predator prey interactions of whales and krill

A short project description of 'Foraging ecology and predator/prey interactions between baleen whales and krill: a multiscale comparative study across Antarctic regions' was presented. Little is known about the dynamics of predator-prey interactions and the response of baleen whales to the distribution of their prey in the Antarctic. As an important marine ecosystem (e.g. with respect to issues of climate change impacts as well as international management of marine living resources), research focused on cetacean foraging ecology in the Antarctic should help to fill a critical data gap. The project will use novel tagging technologies combined with traditional scientific hydroacoustic methods to quantify the types and frequency of prey consumed and daily consumption rates of poorly understood yet ecologically integral and recovering krill predators in the Antarctic: the humpback whale and the Antarctic minke whale. Collaborators are from USA and Australia for phase 1 and potentially Brazil, South Africa and Germany for phase 2.

In discussion, it was noted that this was an ambitious and valuable project. In addition, the proposal generally provides a good example of the level of detail required to allow for a full scientific evaluation. There were some methodological issues that required additional thought, including how the results from detailed studies collected at a fine spatial scale would be expanded to the medium and large scale, and also about the reliability of the method for estimating gulp volume. In response, it was noted that this project represents a step along the line in estimating consumption rates and that moving out from very fine to middle to large scale will be represent a challenge and needs further consideration. The similarity between aspects of this project and the Committee's SOWER 2000 project (IWC, 2000) developed but never implemented was noted and it was suggested that this may provide some useful additional ideas and information for the developers of the current project.

19.3.3 Oceania humpback mixing

A short project description of 'What is the distribution and extent of mixing of Southern Hemisphere humpback whale populations around Antarctica? Phase 1: East Australia and Oceania' was presented. An improved understanding of the movements and mixing of humpback whales around Antarctica has been identified as a priority for the Committee as part of its Comprehensive Assessment of Southern Hemisphere stocks. This information is integral to assessing the recovery of depleted populations. A key step in assessing recovery is estimating pre-exploitation size which requires knowledge of stock identity and appropriate allocation of historic catches to correct stocks. An improved understanding of the migratory and feeding behaviour of humpback whales should allow an appropriate allocation of catches made in this region to breeding stocks, which will improve the accuracy of recovery assessments and estimates of pre-whaling population sizes. Collaborators include New Zealand, Australia, USA, France, Samoa, Tonga and Chile.

In discussion, it was noted that when exploring allocation of past catches to breeding stocks, additional information would need to be considered given the potential temporal and spatial mixing of different breeding stocks and sexes on the feeding grounds and given the relatively small number of SOWER/IDCR samples available from this region. Similar work was being undertaken by other researchers (e.g. low to high latitude matches from Japanese and SOWER/IDCR data sets) which would help broaden the context for this work. It was noted that the outline study presented represents only Phase One; the focus is on Oceania and will include all the SOWER/IDCR data available. Future work is already being planned and there are plans to collaborate with researchers across the Southern Hemisphere (e.g. Africa, Chile, Brazil, Australia) using both mitochondrial and microsatellite data. It was suggested that the telemetry component of the study would be better structured if animals were tagged on the feeding rather than breeding grounds as this would provide more information on mixing. In response, it was noted that this had been the plan of the AWE but due to technical failure with the tags this had not been achieved. The issue of collaboration and inclusiveness was raised (as it had been at the IWC workshop on Southern Hemisphere humpback whales held in 2006) and it was noted that the proposal did not include all potentially valuable datasets. The Committee agreed that it was important that SORP projects are open to all researchers who hold appropriate datasets.

19.3.4 Fin and blue whale acoustics

A short project description of 'Acoustic trends in abundance, distribution, and seasonal presence of Antarctic blue whales and fin whales in the Southern Ocean' was presented. This initiative aims to implement a long term acoustic research programme that will examine trends in Southern Ocean blue and fin whale population growth, distribution, and seasonal presence through the use of passive acoustic monitoring techniques. Current understanding of blue and fin whale life history characteristics, population abundance, and any post-whaling recovery is extremely limited. While obtaining accurate absolute abundance estimates is currently beyond the reach of passive acoustic methods, measures of relative abundance and trends are more easily obtainable and can be conducted in a consistent manner. Comparison of relative abundance estimates from individual locations across many years collected by acoustic surveys can provide a precise measure of population growth. Comparison of relative abundance estimates within and between locations and years can further be used to assess trends in distribution and seasonal presence over time. Collaborators are from Australia, France, USA and Germany.

In discussion, it was noted that the primary focus was on the Indian Ocean. The Committee agreed that it would be useful to consider including similar acoustic data from other sources (e.g. the GLOBEC acoustic data that had been collected for six years at the Antarctic Peninsula) and was pleased to hear that the inclusion of such data is planned and that GLOBEC researchers will be approached soon. The plan to develop less expensive acoustic loggers was welcomed as an excellent step forward in the use of acoustics as a tool for monitoring. There was some thought that the timetable to complete the feasibility stage of the project (one year) may be too ambitious. As for other projects, more detail of the analytical methodology was requested. In terms of assessing the extent to which the project would meet its objectives (i.e. estimation of trends), it was noted that it would be helpful to see the detection range of the loggers as the small number of loggers planned to be deployed would cover a relatively small part of the Southern Ocean. It was recognised that complete coverage of the South Ocean was not possible given logistical constraints (i.e. the limited number of vessels in the area and where they go) but part of the future planning was to consider the best sites for deployment to maximise the usefulness and representativeness of those sites and to try and capture representative variability. It was suggested that it would be useful for the loggers to collect environmental as well as acoustic data which would help to provide context for any variability seen, provided this could also accommodate the objective of keeping the units small and affordable. The Committee noted that using such data to estimate absolute abundance is a long term and extremely ambitious objective of the project. The project leaders acknowledged that this would not be easy, noting that the project would start by estimating relative abundance to quantify trends and work towards absolute abundance. With respect to the long-term aim, it was suggested that the developers of the programme approach scientists such as Len Thomas (University of St Andrews) who had made some progress in the development of new analytical approaches to estimate density from acoustic data.

19.3.5 Year of the Blue Whale 2013/14

As one of the major initiatives within the SORP, the Committee discussed a proposal for a multi-vessel, circumpolar research project to focus on Antarctic blue whales in the austral summer of 2013/14. The proposed objectives for this 'Year of the Blue Whale' would be to:

(1) provide a circumpolar abundance estimate of Antarctic blue whales based on data collected during a single-season, multi-vessel survey design that incorporates acoustic localisation of blue whales and traditional sightings surveys;
(2) improve our understanding of Antarctic blue whale stock structure through the collection of genetic, photographic and acoustic data;
(3) improve understanding of linkages between blue whale feeding and breeding grounds using satellite telemetry; and
(4) characterise foraging habitat of blue whales on the basis of sightings surveys and satellite telemetry data.

It was recognised that any research effort to satisfy these ambitious objectives in a single year of field work will require substantial methodological development (e.g. to determine how to combine visual and acoustic survey techniques) as well as a need to build in provisions for substantial 'off-survey' activities (e.g. satellite tagging, biopsy sampling and individual photo-id). The project will also require substantial logistical planning to access and coordinate shipping and research activities around Antarctica within a single season. It had been proposed that a small scientific steering committee be established with the task of: (1) developing a full research proposal for the Year of the Whale; (2) determining the optimal scale of shipping and research effort required to fulfil the objectives; (3) initiate processes towards accessing these shipping resources; and (4) reporting back to the 2011 Annual Meeting.

In discussion, there was broad agreement about the general concept and draft proposal and several members expressed an interest in participating in planning for the SORP Year of the Whale. There was a short discussion of a suggestion that fin whales could be included in the proposal but it was noted that high density areas of blue and fin do not always overlap and that to include fin whales might dilute the effort with respect to blue whales. The Committee agreed that the inclusion of other species, while desirable, must be considered in light of the primary objective of assessing blue whales. Recent experience during the AWE had demonstrated that acoustics was a practical method of finding blue whales and that this would allow a blue whale cruise to minimise the amount of time searching and maximise the amount of time spent with blue whales. Recognising the ambitious nature of the project, it was suggested that the timeframe of 2013/14 was optimistic and that a delay in 1-2 years might be considered, given the enormous coordination and organisational effort required to ensure the success of such a large project. Consideration may also need to be given to spreading effort out over two years. The Committee **agrees** that until the proposal is more fully developed, it will not be possible to assess the logistical requirements necessary to complete the work. It was suggested that a small group of survey and other specialists, including those familiar with organising large multi-vessel multinational projects, should work together to further develop the proposal and report back to the SSG and the Committee next year (see Item 21); Gales agreed to co-ordinate this. Their task would *inter alia* be to determine the level of resources required, provide an outline of research methods (and analyses) and survey design, and assess the feasibility and timeframe of the project (if that group deemed it necessary, a short workshop might be considered).

19.3.6 Whales and climate change

This project has been identified as a potential project since the Sydney SORP workshop and it has been further discussed at the second IWC climate change workshop (IWC, 2010c), last year's Scientific Committee meeting and the recent Seattle SORP workshop. Long-term southern right whale datasets have been identified as the most likely existing data for correlation with long term climate changes. Leaper *et al.* (2006) demonstrated the utility of the long-term Argentinean study for assessing correlations with climate variables. It has been proposed that a project along these lines could be developed using a common method that can be applied to the Australian, South African and Brazilian long-term datasets, provided an initial examination revealed them suitable for this purpose. In this regard, consideration should be given to the development of recommendations about how existing programmes/datasets could be improved/modified to make them more suitable for future work along these lines.

As the Committee has previously recognised, an understanding of these issues requires long-term data on prey and/or climate as well as long-term whale data; this will require incorporation of relevant experts in these fields in the project. The Committee also agreed that it was worth examining the potential use of time series of whale oil production, provided that suitable climate data over the same period can be found. Investigation of long-term datasets from other species in the same ecosystem could also be valuable. The Committee **agrees** that formal proposals for work under a climate change project would be welcome for consideration at the 2011 Annual Meeting.

19.3.7 Non-lethal research techniques workshop

This proposal is for a technical conference/workshop to review the strengths and weaknesses of available non-lethal research methods for studies of living whale in the Southern Ocean and their ecological roles in the Southern Hemisphere. The objectives are to advance the synergies of non-lethal methods for investigations addressing a range of research themes. Presentations at the workshop will focus on methodological or technological advances to non-lethal methods, including those that are still under development, or with specific applications to populations in the Southern Hemisphere. Preliminary planning has been undertaken and it is likely to be held in Chile in late 2011.

It was suggested that the workshop could take place in association with the proposed Assessment workshop on southern right whales planned for Argentina in September 2011. A draft Agenda for this workshop can be found in Annex R.

19.4 Funding mechanism for SORP

The Committee **endorses** the process for evaluating requests for funding under the IWC/SORP research fund given in Annex R. It agrees that the IWC Head of Science and Chair of Scientific Committee should be included in the SORP Steering Committee.

20. ACTIONS ARISING FROM INTERSESSIONAL REQUESTS FROM THE COMMISSION

As part of the Commission's work on the Future of the IWC, the Chair and the Vice-Chair of the Commission, based on discussions within the Chair's Support group and the Small Working Group on the Future of the IWC, developed the 'Proposed Consensus Decision to Improve the Conservation of Whales'. The Committee received a short PowerPoint presentation explaining the background to the document, focussing on issue of relevance to the Scientific Committee. In particular, the Committee was asked, via the Small Working Group on the Future of the IWC, to provide scientific advice on a number of aspects of the proposed Consensus Decision; the Terms of Reference for our work are given in Annex G of IWC/62/6 rev. They are also given as Annex S to this report.

The parts of the report requiring review and advice, along with the sub-groups of the Committee that took the initial review can be summarised as follows:

(1) Review of Annex {DNA} on DNA registers and market sampling – jointly by the Working Group on DNA and the Working Group on the estimation of bycatch and other human induced mortality – see Annex N, item 9;
(2) Reviews of Annex {SI} on scientific information required from the catch and Annex {OI} review of operational information – the sub-committee on the RMP – see Annex D;
(3) Review of the potential workplan for the Scientific Committee – relevant sections were reviewed by the sub-committee on the RMP and the sub-committee on in-depth assessments (Annexes D, and G, respectively); and
(4) Review of the report of the Scientific Assessment Group (IWC/M10/SWG6) in the light of the numbers in table 4 of IWC/62/7rev (the table of catch limits) - relevant sections were reviewed by the sub-committee on the RMP, the working group on the *pre-Implementation assessment* of common minke whales in the western North Pacific, the sub-committee on in-depth assessments, the sub-committee on other Southern Hemisphere whale stocks (Annexes D, D1, G, and H, respectively).

The discussions within the sub-committees form the basis of the Committee's advice given below.

With respect to tasks (1)-(3) above, the complete Annexes incorporating our recommendations are included in Annex T, as is an updated timetable.

20.1 Review of Annex {DNA} on DNA registers and market sampling schemes

The Committee was requested to review Annex {DNA} of IWC/62/7rev for clarity and completeness. Annex {DNA} of IWC/62/7rev is based on the report of an earlier specialist workshop held from 7-9 March 2005 (IWC/M05/RMSWG 5). The objective of the review is to ensure that the Annex remains a cost-effective, robust, independent and transparent system in conjunction with the other monitoring and control measures.

To address the above objectives, the Committee **recommends** that the text given in Annex S replaces Annex {DNA} of IWC/62/7rev. Here follows a summary of the recommended changes.

1. SPECIFICATIONS FOR THE ESTABLISHMENT/MAINTENANCE OF A DIAGNOSTIC DNA REGISTER/TISSUE ARCHIVE

1.1 Laboratories

1.1.1 Minimal laboratory requirements

1.1.1 (6)	to clarify the length of time that archived samples were to be stored;
1.1.1 (7)	to clarify requirements that a variety of error-checking procedures should be followed and that sample quality should be checked routinely prior to genetic analysis.
1.1.1 (9)	to take into account several different factors in calibration exercises.
Footnote text	a more comprehensive definition of 'diagnostic DNA register'.

1.2 Sample collection

1.2.1 Size of the samples

1.2.2 Preservations

1.2	to specify training of and information to be collected by persons who may be involved in the collection of genetic samples for DNA registries other than commercial, scientific and indigenous catches (e.g. bycatches or stranded animals).
1.2.1 and 1.2.2	to clarify the sample preservation requirements.

1.4 Markers and methods of analysis

1.4.1 Mitochondrial DNA

1.4.2 Microsatellites

1.4.3 Sex identification

1.4.1, 1.4.2 and 1.4.3	to clarify that the analytical methods adhering to the quality standards as specified in the IWC genetic data quality guidelines must be approved by the international expert group.

1.7 External audit of DNA registers

1.7	to specify that the international expert group shall submit an annual report to the Secretariat of the IWC for distribution to contracting governments and the Commission (and, if necessary subsidiary bodies of the Commission) at least two months before it must be considered.

1.8 Submission procedure for samples for comparison with registers

The Committee considered all of section 1.8 in light of the stated objective of Annex {DNA}: 'to ensure a robust, independent and transparent system'. Item 1.8 makes a crucial contribution to these objectives, by providing a mechanism for sample verification that is not reliant on national market sampling schemes, and is also not reliant on the international expert panel, whose role is to audit the system rather to focus on individual samples. The Committee **agrees** that the current wording of item 1.8 does not fully make clear the intent of the mechanism and has thus provided new clarifying wording (including in the heading).

It also **agrees** to a new item 1.9, to specify the submission of DNA profiles to the IWC' central register from contracting governments under whose jurisdiction whales and whale products may be legally marketed.

2. SPECIFICATIONS FOR THE ESTABLISHMENT/ MAINTENANCE OF MARKET SAMPLING SCHEME
2.2 Development of appropriate market sampling schemes including audit

New 2.2 (4)	to take into account that some 'degraded' and/or 'processed' samples from market surveys could not be analyzed using exactly the same procedures as those currently used for 'fresh' and 'unprocessed' samples, but that methods could be developed to allow accurate comparison of such samples with profiles in DNA registries.

2.4 Reporting

2.4	a slight revision of the text concerning reporting to the IWC by the international expert group: the international expert group shall submit an annual report to the Secretariat of the IWC for distribution to contracting governments and the Commission (and, if necessary bodies of the Commission) at least two months before it must be considered.

20.2 Review of Annex {SI} to IWC/62/7rev – scientific information requirements

The draft Annex was based on previous recommendations of the Committee in the context of RMS discussions (IWC, 1995d). The Committee reviewed the Annex. In discussion it was recalled that the Committee has previously agreed that bulla do not provide a reliable means for estimating age (IWC, 2002c, p.12). It also noted that earplugs do not provide reliable age estimates for North Atlantic common minke whales. Walløe and Víkingsson reported that lengths could not always be recorded for minke whales in North Atlantic in the manner specified, although estimates of length are reported to the Secretariat.

Given the above the Committee **recommends:**

(1) reference to 'bulla' be removed from point 2(b); and
(2) the following footnote be added to point (a) 'Onboard small coastal whaling vessels such as those participating in Norwegian and Icelandic operations, it may be difficult to obtain accurate length measurements because whales are handled on a limited space. It is recognised that measurements in these cases may not be as accurate as those taken in ideal situations.'

The full revised Annex is given as Annex T.

20.3 Review of Annex {OI} to IWC/62/7rev – operational information requirements

The Committee **endorses** the operational information requirements as given in the proposed Annex.

20.4 Review of proposed timetable for future *Implementations* and *Implementation Reviews* (IWC/62/7rev Appendix B, p. 37)

The Committee **concurs** with the SAG that the schedule in Section 5 of IWC/62/7rev, updated following its deliberations as Table Y below, is ambitious. It noted that *Implementations* and *Implementation Reviews* can (and do) involve considerable time and resources from national scientists and, especially in cases when *Implementation Simulation Trials* are required, the Secretariat. Moreover, delays can occur when conducting *Implementations* given that the same members of the Committee are involved in many of the *Implementations* and *Implementation Reviews*.

The Committee has previously agreed that it can only conduct one *Implementation* at a time. The schedules for Western North Pacific Bryde's whales, and for North Atlantic common minke and fin whales given in IWC/62/7rev match the schedules expected from the *Implementations* for these species in terms of the Committee's agreed guidelines (IWC, 2005b). The Committee has previously been able to complete an *Implementation Review* during a single meeting, provided that no *Implementation Simulation Trials* are required.

The Committee therefore cannot conduct *Implementations* for Western North Pacific sei and Antarctic minke whales at the same time. The SAG had considered it more important to conduct an *Implementation* for Western North Pacific sei whales first given the size of current catches and the estimates of abundance for this stock. However, the Committee noted that there are also reasons to conduct an *Implementation* for Antarctic minke whales starting in 2012. After discussion of the relative amount of preparatory work required for *In-depth* and *pre-Implementation assessments* of North Pacific sei whales compared to Antarctic minke whales, the Committee **recommends** to deal with North Pacific sei whales before minke whales, as in IWC/62/7rev, and further **recommends** the schedule given in 20.5.3.4 below.

The Committee **recommends** that two years should be allowed for the *pre-Implementation assessment* for Antarctic minke whales irrespective of when the *Implementation* for these whales starts (under the current schedule, the first year of the *pre-Implementation assessment* would be 2014). It was also recognised that the current *Implementation* for these whales is sufficiently dated (1993) that it was unreasonable to expect that this 1993 *Implementation* can simply be reviewed after almost 20 years of developments in how to *Implement* the RMP.

The Committee therefore **recommends** that '/IR' (for *Implementation Review*) be deleted from the box for 2015 for Antarctic minke whales.

20.5 Review of the Scientific Assessment Group (SAG) Report

As part of the Commission's discussions on the Future of the IWC, the Commission's Chair and Vice-Chair developed the document 'Proposal Consensus Decision to Improve the Conservation of Whales' (IWC/62/7rev). During the development process but before finalisation of IWC/62/7rev, a small Scientific Assessment Group (SAG) was established to provide a report (IWC/M10/SWG6) of a concise scientific review on whether proposed catches were such that the long-term status of the populations concerned would be negatively affected. The numbers in table 4 of the proposed consensus decision (i.e. proposed whale catches for the period 2010/11-2019/20) are below those considered by the SAG. The terms of reference developed by the Small Working Group on the Future of the IWC (SWG) for the Committee's review of the SAG report in the light of the numbers in table 4 of IWC/62/7rev are given in Annex S and summarised below.

The Committee shall follow the terms of reference of the SAG (IWC/M10/SWG, Annex B), recognising:

(a) the need to be concise;
(b) the fact that there are a number of different approaches to evaluating short-term catches and no single method will be appropriate in all circumstances; and

(c) that the report should provide an integrated, pragmatic view on whether or not the proposed short-term catches (i.e. before the RMP can be used) are likely to negatively affect the long-term (i.e. RMP simulation framework timeline of 100 years) status of the stock *given* the timetable for RMP work.

It had also been requested that the Chair of the Scientific Committee should ensure that the time spent on this review should be such that it does not interfere with the Committee's focus on completing RMP-related work as soon as possible.

The SAG had noted that there were two categories of stocks for which advice was required: those for which the RMP could be applied immediately, and those for which it could not. The report below follows a similar pattern, focussing initially on the application of the RMP (western North Pacific Bryde's whales, North Atlantic common minke whales, North Atlantic fin whales) and then turning to those stocks for which it cannot immediately be applied (Antarctic minke whales, Southern Hemisphere fin whales, western North Pacific common minke whales, and western North Pacific sei whales).

20.5.1 General issues related to using the RMP

20.5.1.1 CATCH LIMIT CALCULATIONS (ACTIVATION, YEARS, INPUTS AND OUTPUTS)

As part of the SAG process, the RMP was applied to three species-Region combinations (western North Pacific Bryde's whales; North Atlantic minke whales; and North Atlantic fin whales) upon instruction from the Chair of the Commission. The calculations reported are therefore the results of applying the RMP itself, although results are also shown for tunings other than the Commission-agreed 0.72 tuning (the 0.6 tuning). The Committee repeated the RMP catch limit calculations for these stocks. Differences from the SAG's calculations are documented in the following sections. When applying the *CLA*, the phase-out rule was applied for each *Small Area* after the catch limit was cascaded to the *Small Areas* from the *Medium Area* rather than applying the phase-out rule before cascading the *Medium Area* catch limit to *Small Areas*, in accordance with RMP specifications (RMP specification 3).

20.5.1.2 TUNING LEVELS

The SAG report (and Annex D, Appendix 8) provides results for the 0.72 and 0.6 tunings of the RMP because the whaling countries in the Commission's support group had requested the latter tuning. This issue is discussed more fully in the SAG report.

The Committee noted that although the 0.6, 0.66 and 0.72 tunings of the *CLA* were recommended to the Commission by the Committee, having been subjected to testing during the development of the RMP, the *Implementation Simulation Trials* have only been conducted by the Committee for the 0.72 tuning of the RMP. Norwegian scientists have run the *Implementation Simulation Trials* for minke whales in the Northeast Atlantic for the 0.6 tuning of the RMP, but these calculations were not undertaken nor reviewed in detail by the Committee. In addition, which RMP variants are 'acceptable' may change if the tuning level is changed. The Committee **agrees** that the tuning level which was used when calculating catch limits using the *CLA* should be that which is tested in *Implementation Simulation Trials*; in this case only the 0.72 tuning. In principle, the *Implementation Simulation Trials* could be repeated for a new tuning if requested by the Commission. However, the criteria used to evaluate whether performance of an RMP variant is 'acceptable', 'borderline' or 'unacceptable' is linked to the 0.6 and 0.72 tunings of the RMP. The present criteria may need to be investigated if the Commission requested that a different tuning of the RMP should be considered.

20.5.1.3 OTHER ISSUES

The Committee notes that its advice is based on the schedule of RMP *Implementations* proposed in Appendix B of the Chair's and Vice-Chair's proposal (IWC/62/7rev). The Committee brings to the attention of the Commission its concern that delays in completion of these implementations may increase risks to whale populations. Attention is drawn to the two-year schedule for completion of an *Implementation* as set out in the Committee's agreed guidelines (IWC, 2005b) - proposals made in this report follow from the Committee's intent to progress work in terms of this schedule.

On a more general issue, the Committee draws the Commission's attention to the fact that the RMP and AWMPs are designed to provide advice on catch and strike limits for periods of up to 6 years. Further work may be needed to assess the risks associated with setting catch limits for longer periods than 6 years.

20.5.2 Application of Stocks/Regions for which the RMP can immediately be applied

The Committee reviewed the specifications (provided by the Secretariat) of how the RMP was applied during the SAG meeting to western North Pacific Bryde's whales, North Atlantic minke whales, and North Atlantic fin whales. The following items summarise the modifications to the initial applications by the Secretariat made by the Committee in reaching its agreed applications: these primarily involve clarifications with respect to time-stamps of abundance estimates and the addition of newly agreed abundance estimates. Table 7 lists the resulting catch limits from the 0.72 and 0.6 tunings of the *CLA*. The format used to document the input and present the results (see Annex D, Appendix 8 for the final format) illustrates the calculations made, and emphasises the results calculated using the Commission-agreed 0.72 tuning.

20.5.2.1 WESTERN NORTH PACIFIC BRYDE'S WHALES

The application of the RMP to western North Pacific Bryde's whales was based on a single abundance estimate for the *Region* (time-stamped at 2000). The Committee requested that the time-stamps for the *Small Areas* when applying catch cascading be set to the effort-weighted years.

It was noted that survey data were available for 1988-96 and some of these data were used when computing the additional variance for the 1998-2002 surveys (Shimada *et al.*, 2008). An abundance estimate can be computed for 1988-96, but the Committee has only accepted the estimate from the 1998-2002 surveys (IWC, 2009b). Although abundance estimates could be calculated using the 1988-96 data, account would need to be taken of the correlation of these estimates with those for 1998-2002 if they were included in RMP calculations of catch limits. However, the presently-coded version of the RMP does not allow input of a variance-covariance matrix for the abundance estimates. The Committee therefore **recommends** that:

(1) the program for the *CLA* be modified to allow variance-covariance matrices to be input (Annex D, item 2.4); and
(2) the data and resulting abundance estimates from the 1988-96 surveys should be reviewed for possible use in the RMP during the next *Implementation Review*.

Table 7

Summary of the application of the RMP (full details of the inputs to the RMP as well as relevant intermediate calculations are given in Annex D, Appendix 8). Phaseout has been applied where applicable.

Year	WNP Bryde's whales	North Atlantic fin whales		North Atlantic minke whales					
Sub-area	1W+1E	WI (variant 6)	WI (variant 2)	CIC	CM	ES	EB	EW	EN
Catch limits based on the 72% tuning (Commission's agreed value)									
2010	**5**	**46**	**87**	**224**	**135**	**58**	**92**	**152**	**70**
2011	**3**	**46**	**87**	**224**	**135**	**58**	**92**	**152**	**70**
2012	**1**	**46**	**87**	**224**	**135**	**46**	**92**	**152**	**70**
2013	**0**	**46**	**87**	**224**	**135**	**35**	**92**	**152**	**56**
2014	**0**	**46**	**87**	**224**	**108**	**14**	**92**	**152**	**42**
Catch limits based on the 60% tuning									
2010	33	90	155	345	208	122	195	322	148
2011	19	90	155	345	208	122	195	322	148
2012	4	90	155	345	208	97	195	322	148
2013	0	90	155	345	208	73	195	322	118
2014	0	90	155	345	166	29	195	322	89

The final specifications for how the RMP was applied to these whales are listed in Annex D, Appendix 8A.

20.5.2.2 NORTH ATLANTIC MINKE WHALES

The Committee **recommends** the following changes to the abundance estimates for minke whales in the Central North Atlantic:

(1) use the estimates in Annex D, Table 1 to construct an abundance estimate for *Small Areas* CG+CIP and include this abundance estimate in that for the C *Medium Area* for 2006;
(2) use the estimate for the CM *Small Area* in 2005 of 12,043 (CV 0.28) in place of the estimate of 6,174 (CV 0.36) because the former estimate is based on surveys which covered more of the CM *Small Area*; and
(3) use the revised version of the estimate of abundance for 2005 of 26,739 (CV 0.39) in place of the estimate of 24,890 (CV 0.45);

Allison recalculated the CVs for the abundance estimates for the C *Medium Area*.

The Committee **recommends** that the catch limits for the minke whales in the eastern North Atlantic be based on the latest sex ratio data (i.e. 2005-09) rather than 2004-08 as was used for the SAG report. The final specifications for how the RMP was applied to North Atlantic minke whales are listed in Annex D, Appendix 8B.

20.5.2.3 NORTH ATLANTIC FIN WHALES

The Committee had no changes to the application of the RMP used in the SAG report. The specifications for how the RMP was applied to North Atlantic fin whales are listed in Annex D, Appendix 8C. As noted under Item 6.2.1, the Scientific Committee has already confirmed that *Variant 2* would be acceptable for 10 years, followed by *Variant 1*, if accompanied by an acceptable research programme. No final research proposal to distinguish between stock structure hypotheses has yet been adopted. Therefore, *Variant 2* is not an available option at this time. However, a preliminary proposal was submitted and discussed at this meeting. The Scientific Committee made two specific recommendations for improvement. The proposal will be modified accordingly, in consultation with an advisory committee appointed by the Scientific Committee, and submitted to the next Annual Meeting for adoption.

20.5.3 Advice on Stocks/Regions for which the RMP cannot immediately be applied

20.5.3.1 ANTARCTIC MINKE WHALES

Information on the timetable for undertaking an *Implementation* of Antarctic minke whales is given under Item 20.4. If this timetable can be met, it is expected to be completed in 2016.

20.5.3.2 SOUTHERN HEMISPHERE FIN WHALES

Section 2.6 of IWC/M10/SWG6 considered Southern Hemisphere fin whales. It is proposed that catches would be taken alternately in the Indian Ocean (between 35°E-130°E) and Pacific Ocean (between 130°E and 145°W) sectors of the Antarctic. A total of 10 annual catches would be taken in the period 2010/11-2012/2013, starting in the Pacific Ocean sector. Catches would be reduced from 10 to 5 individuals from 2013/14 until 2019/2020.

The Committee noted that in the past there was extensive exploitation (nearly 750,000 fin whales were killed in the 20th Century), and that recent information on fin whales in the Southern Hemisphere is poor. The Committee also noted that there were additional abundance estimates for this population, derived from IDCR/SOWER surveys, which had not been considered by the SAG (e.g. Branch and Butterworth, 2001a; Butterworth and Geromont, 1995). Branch and Butterworth (2001) estimated that the circumpolar abundance of fin whales south of 60°S was 2,100 (CV=0.36), 2,100 (CV=0.45) and 5,500 (CV=0.53) for CPI, CPII and CPIII respectively. These estimates are negatively biased since the areas north of 60°S were not covered[6].

It is unlikely that sufficient information will become available in the interim period (up to 2020) for an RMP *Implementation* to occur. Nevertheless, some members noted that if the *CLA* of the RMP was used it would result in a catch limit of 0. The Committee **concurs** with the general conclusions of the SAG, i.e. that it is unlikely that the proposed catches will affect the long-term status of the stock[s]. Some members were concerned about providing *ad-hoc* advice on catch limits without any likelihood of a formalised procedure being available in the foreseeable future. They did not want this exercise to set a precedent for providing *ad-hoc* advice.

[6]IWC (1996b) reports IDCR estimates extended to south of 30°S by using Japanese Scouting Vessel survey results to provide an index of relative abundance.

20.5.3.3 WESTERN NORTH PACIFIC COMMON MINKE WHALES

Information on the timetable for undertaking an *Implementation Review* of western North Pacific common minke whales is given under Item 20.4. Given the progress made at this meeting (see Annex D1), it is expected that this will be completed in 2012.

The Committee noted that it was not possible to apply the RMP to the data for these minke whales owing to the considerable changes to the understanding of stock structure in recent years. It **agrees** that the present uncertainty precludes giving adequate advice regarding the catches in Table 4 of IWC/62/7rev The Committee generally **agrees** with the conclusions of the SAG; the Committee summarised its conclusions as follows.

(1) The *Implementation* process should be completed as quickly as possible. Completing the *Implementation Review* will allow advice on catches to be based on the RMP, which has been selected to ensure that catches are sustainable.
(2) A high priority should be accorded to research to determine the proportions of 'O' and 'J' stock in sub-area 12 because the implications of any proposed catches for both 'O' and 'J' stock clearly differ depending on this proportion. In this respect, the Committee welcomed the survey of sub-area 12 planned for summer 2010 and **emphasises** the importance of collecting as much data as possible to estimate stock proportions in sub-area 12.
(3) The proposed catches by coastal whalers in Table 4 of IWC/62/7rev may not help to improve the status of 'J' stock compared to current JARPN II catches. The incidence of 'J' stock in the catch decreases with distance offshore. The Committee received an analysis which estimated the number of 'J' stock animals under catch levels of 150 inshore and 70 offshore (Annex G1, Appendix 8). The Committee recognised the value of analysis such as those in Annex G1, Appendix 8 and **recommends** that further analyses be conducted using a finer spatial resolution and quantifying the uncertainty associated with the predictions, including the likely level of inter-annual variation in catches of 'J' stock animals.
(4) The Committee was unable to agree on the impact of the proposed catches on the 'O' stock. However it **agrees** that the risk to the 'O' stock will be minimised if the *Implementation Review* is completed as soon as possible so that advice can be based on the RMP and hence also **agrees** that catches of 'O' stock should not exceed present levels.

Table 8

Scientific Committee work plan for RMP *Implementations.*

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	202
Western North Pacific Bryde's whales				IR					IR		
NA common minke whales - eastern and central medium areas					IR						IR
NA fin whales - central medium area					IR					IR	
Western North Pacific common minke whales	PIA		RMP	[RMP]					IR		
Western North Pacific sei whales		IDA		PIA	RMP	[RMP]					IR
Antarctic minke whales					PIA	PIA		RMP			

IR= *Implementation Review* (often possible to complete in one year). PI = *pre-Implementation assessment* (may take more than one year). RMP completed *Implementation* (takes two years once the PIA is completed IDA= in-depth assessment, usually takes two years or more and feeds in a *pre-Implementation assessment.* As explained in the text, the plan ambitious and it may not be possible to achieve all of the work by th years indicated. Square brackets are used to express possible but perhap less likely dates.

20.5.3.4 WESTERN NORTH PACIFIC SEI WHALES

Information on the timetable for undertaking an *Implementation* of western North Pacific sei whales is given under Item 20.4. If the *Implementation* turns out to be as simple as suggested there, it is expected to be completed by 2014.

The SAG report was based on the assumption that the In-depth Assessment for North Pacific sei whales would be conducted in 2010 as planned last year. This year, the Committee has concluded that in view of the relatively simple information available on the population, the In-depth Assessment and *pre-Implementation assessment* could most efficiently be combined into a single exercise, and **agrees** a compromise date of 2013 for the combined assessment, with RMP catch limits to be set the following year if no complications arise. The Committee **concurs** with the SAG that priority for the Committee should be to complete the RMP *Implementation* as soon as possible rather than to develop formal interim management advice. The Committee was unable to agree on the impact of the proposed catches on sei whales. The Committee **recommends** that as a minimum there should be no increase in the present level of catches until the RMP *Implementation* has been completed. Catches for North Pacific sei whales resumed in 2002 and the annual catch since 2004 has been 100 animals.

Table 9

Workshops and intersessional meetings planned for 2010/11.

Subject	Agenda item	Venue	Dates	Steering Group
North Pacific sighting survey workshop	Item 10.8.1; Annex G	Tokyo	28-30 September 2010	Q15
North Pacific 2011 cruise: planning	Item 10.8.2; Annex G	Tokyo	24-26 September 2010	Q15
Small cetaceans and climate change workshop	Item 12.5; Annex K	Vienna	28 November- 1 December 2010	Q24
Abundance of Antarctic minke whales workshop	Item 10.1.1; Annex G	Bergen?	January 2011	Q13
North Pacific minke whale preparatory meeting	Item 6.3; Annex D1	Tokyo	25-27 September 2010	Q4
North Pacific minke First Intersessional Workshop	Item 6.3; Annex D1	Korea	14-17 December 2010	Q4
Workshop on AWMP	Items 8.2; 8.3; Annex E	TBA	March 2011	Q1

Possible pre-meetings immediately before SC/63 depending on intersessional progress: AWMP gray whale *Implementation Review*; western North Pacific common minke whale *Implementation Review;* assessment of humpback whale Breeding Stock B.

21. RESEARCH AND WORKSHOP PROPOSALS AND RESULTS

Table 9 lists the proposed intersessional meetings and workshops. Financial implications and further details are dealt with under Item 24.

Results from last year's intersessional IWC workshops are dealt with under the relevant Agenda Items.

21.1 Review results from previously funded research proposals

Results from IWC funded projects are dealt with under the relevant agenda items.

21.2 Review proposals for 2010/11

No unsolicited research proposals were received. The Committee has **agreed** mechanisms for reviewing proposals under the SORP programme (Item 19) and the Small Cetaceans Voluntary Fund (Item 15).

22. COMMITTEE PRIORITIES AND INITIAL AGENDA FOR THE 2011 MEETING

Revised Management Procedure (RMP)
The following issues are high priority topics:

GENERAL MATTERS

(1) complete review of the range of MSYR values for use in the RMP;
(2) finalise approach for evaluating proposed amendments to the *CLA*;
(3) evaluate the Norwegian proposal for amending the *CLA*;
(4) consider implications that the phase-out rule in the RMP is applied by *Small Area* when catch cascading is applied and the abundance estimates are based on multi-year surveys; and
(5) modify the Norwegian 'CatchLimit' program to allow variance-covariance matrices to be specified for the abundance estimates.

IMPLEMENTATION REVIEW **FOR NORTH PACIFIC COMMON MINKE WHALE**

(1) review results of intersessional workshops; and
(2) complete the work assigned to the 'First Annual Meeting' in accord with our guidelines.

IMPLEMENTATION **FOR THE WESTERN NORTH PACIFIC BRYDE'S WHALES**

(1) review the research proposal for the 'variant with research'.

IMPLEMENTATION **FOR THE NORTH ATLANTIC FIN WHALES**

(1) review revised research proposal for the 'variant with research'; and
(2) review abundance estimates for use in the *CLA*.

IMPLEMENTATION **FOR THE NORTH ATLANTIC MINKE WHALES**

(1) review any new abundance estimates.

Aboriginal Whaling Management Procedure (AWMP)
The following issues are high priority topics:

(1) work on developing appropriate long-term management advice for the Greenlandic fisheries with the primary focus on:
   (a) completing work on a sex-ratio based assessment of common minke whales off west Greenland; and
   (b) progress on developing *SLA*s for West Greenland fin and common minke whales;
(3) the *Implementation Review* for the eastern North Pacific gray whales; and
(4) consider any new scientific information related to conversion factors for edible products for Greenland fisheries.

Bowhead, right and gray whales (BRG)
The following issues are high priority topics:

(1) perform the annual review of catch information and new scientific information for B-C-B stock of bowhead whales and prepare for the 2012 *Implementation Review*;
(2) review stock structure and abundance for Eastern Canada and West Greenland bowhead whales;
(3) review scientific information on North Pacific and North Atlantic right whales;
(4) review progress towards southern right whale workshop;
(5) review new information on western gray whales;
(6) review information on other stocks of bowhead whales; and
(7) review new information on eastern gray whales (not relevant to *Implementation Review*).

In-depth assessment (IA)
The following issues are high priority topics:

(1) resolve the reasons for the differences between estimates of abundance of Antarctic minke whales between the OK and SPLINTR models;
(2) continue development of the catch-at-age models of Antarctic minke whales, including sensitivity tests to examine various assumptions regarding ageing errors and age-length keys; and
(3) continue examination of the differences between minke abundance estimated from CPII and CPIII, by further investigation of the relationship between sea ice and minke whale abundance.

Bycatch and other human-induced mortality (BC)
The following issues are high priority topics:

(1) collaboration with FAO on collation of relevant fisheries data and joining FIRMS;
(2) review progress in including information in National Progress Reports;
(3) continue development of the international database of ship strike incidents;
(4) consider methods for estimating risk and rates of bycatch and entanglement;
(5) consider methods and data sources for establishing time series of bycatch;
(6) review methods to estimate mortality from ship strikes; and
(7) review methods for assessing mortality from acoustic sources and marine debris.

Stock definition (SD)
The following issues are high priority topics:

(1) furtherance of guidelines for genetic analyses;
(2) updates on guidelines for DNA Data Quality;
(3) statistical and genetic issues concerning stock definition;
(4) TOSSM; and
(5) unit-to-conserve.

DNA (DNA)
The following issues are high priority topics:

(1) review genetic methods for species, stock and individual identification;

(2) review of results of the 'amendments' work on sequences deposited in GenBank;
(3) collection and archiving of tissue samples from catches and bycatches; and
(4) reference databases and standard for diagnostic DNA registries.

Environmental concerns (E)
The following issues are high priority topics:

(1) SOCER;
(2) review progress on POLLUTION 2000+;
(3) review new information impact of oil and dispersants on cetaceans;
(4) review progress of the CERD Working Group;
(5) review progress on recommendations from 2010 focus sessions on masking sound;
(6) review approaches as available from other international forums with regard to mitigation of effects of anthropogenic sound on cetaceans;
(7) review progress on work from the 2nd Climate Change Workshop; and
(8) review of marine renewable energy development.

Ecosystem modelling (EM)
The following issues are high priority topics:

(1) review ecosystem models from the North Pacific that may be relevant to assessments and RMP *Implementations*;
(2) review other issues relevant to ecosystem modelling within the Committee; and
(3) review ecosystem modelling efforts undertaken outside the IWC.

Southern Hemisphere whales other than Antarctic minke whales (SH)
The following issues are high priority topics:

(1) humpback whales-complete the assessment of breeding stock B;
(2) blue whales (Antarctic and pygmy): population estimates and continue work on the Southern Hemisphere blue whale catalogue;
(3) prepare for assessment of humpback whale breeding stocks D, E and F;
(4) review new information on the Arabian humpback populations.

Small cetaceans (SM)
The following issues are high priority topics:

(1) the status of status of Ziphiidae (beaked and bottlenose whales) worldwide;
(2) directed takes of small cetaceans;
(3) review report from climate change-small cetaceans workshop;
(4) other topics e.g. marine bushmeat; and
(5) review of progress on previous recommendations.

Whalewatching (WW)
The following issues are high priority topics:

(1) assess the impacts of whalewatching on cetaceans;
(2) review reports from intersessional working groups:
 (a) large-scale whalewatching experiment (LaWE) Steering Group;
 (b) LaWE Budget Development Group;
 (c) on-line database for world-wide tracking of commercial whalewatching and associated data collection; and
 (d) swim-with-whale operations;
(3) consider information from platforms of opportunity of potential value to the Committee;
(4) review of whalewatching guidelines and regulations; and
(5) review of collision risks to cetaceans from whalewatching vessels.

Scientific Permits
The following issues are high-priority topics:

(1) Review of activities under existing permits.
(2) Review of new or continuing proposals.
(3) Procedures for reviewing scientific permit proposals.
(4) Planning for final review of results from Iceland's scientific take of North Atlantic common minke whales.

23. DATA PROCESSING AND COMPUTING NEEDS FOR 2010/11

The Committee identified and agreed the requests for intersessional work by the Secretariat given in Table 10.

Table 10
Computing tasks/needs for 2010/11.

RMP – preparations for *Implementation*
Run a full set of trials using the Norwegian 'CatchLimit' program for North Atlantic fin whales, Western North Pacific Bryde's whales; and North Atlantic minke whales and place the results on the IWC website (Item 5.3).

AWMP
Work in preparation for/arising from the proposed workshop (Item 21).

NPM
Update the control program for North Pacific minke whales and undertake any work arising from the Preparatory Meeting and the First Intersessional Workshop including assembling the catch data at the appropriate spatial and temporal resolutions and coding and conditioning the operating models themselves (Item 6.3.2).

In-depth assessment
Validation of the 2009/10 SOWER cruise data for incorporation into the DESS database; complete validation of the 1995-97 blue whale cruise data and incorporate into the DESS database; prepare a catch series for North Pacific sei whales (Item 10.9.1).

Southern Hemisphere whale stocks
Documentation of the catch data available for Antarctic minke whales in preparation for the *pre-Implementation assessment* (Item 20.4).

Bycatch
Input bycatch data from the last season (2009) and for previous seasons (from 2003 back) into the bycatch database (Item 7.1).

24. FUNDING REQUIREMENTS FOR 2010/11

Table 11 summarises the complete list of recommendations for funding made by the Committee. The total required to meet its preferred budget is £316,700. The Committee **recommends** all of these proposed expenditures to the Commission. This is slightly above the projected amount available for funding (£315,750). The Committee **agrees** that the final column given in the table represents a budget that will allow progress to be made by its sub-committees and Working Groups in its priority topics.

A summary of each of the items is given below, by sub-committee or standing Working Group. Full details can be found in the relevant Annexes as given in Table 11.

The Committee was pleased to note that procedures have been agreed to review proposals for funds from the Small Cetaceans Voluntary Fund and the Southern Ocean Research Partnership (Items 14 and 19). One proposal under the former has been recommended (see Item 14.6.1). The Committee was also pleased to note that funding has been found for the Workshop on Small Cetaceans and Climate Change (see Item 12.5).

Table 11
Summary of budget requests.

	Annex	Short title	Requested (£)
RMP			
1	Annex D	Analysis and use of time-series of data on calving rates and intervals for use in the MSYR review.	7,000
NPM			
2	Annex D1	Pre-meeting and 1st Intersessional Workshop towards *Implementation Review* for WNP common minke whales.	25,000
AWMP			
3	Annex E	AWMP Workshop on Greenlandic fisheries and preparing for gray whale *Implementation Review.*	12,000
4	Annex E	AWMP developers fund.	8,000
BRG			
5	Annex F	Southern Ocean right whale photo-id catalogue.	3,800
IA			
6	Annex G	Investigate the relationship between sea-ice characteristics and Antarctic minke whale abundance estimates.	5,000
7	Annex G	Resolving differences in minke whale abundance estimates.	15,000
8	Annex G	Import of 2009/10 SOWER data and assist abundance working group.	3,000
9	Annex G	North Pacific sighting cruise.	58,000
10	Annex G	Workshop to plan medium-long term North Pacific sighting survey programme.	7,000
11	Annex G	Statistical catch-at-age estimators for Antarctic minke whales.	2,500
SH			
12	Annex H	Southern Hemisphere Blue Whale Catalogue Project.	18,900
13	Annex H	Modelling of Southern Hemisphere humpback whale populations.	3,000
14	Annex H	Antarctic humpback whale catalogue.	15,000
BC			
15	Annex J	Further development and maintenance of the IWC ship strike database.	5,000
16	Annex J	Development of an online submission database for Progress Reports.	5,000
E			
17	Annex K	Risk assessment modelling to determine the impact of pollutants on cetacean populations.	52,500
18	Annex K	State of the Cetacean Environment Report (SOCER).	3,000
WW			
19	Annex L	Data compilation and power analyses for the LaWE.	4,000
ALL			
20		Invited Participants to the 2011 Annual Meeting.	64,000
Total			**316,700**

Revised Management Procedure

(1) ANALYSIS AND USE OF TIME-SERIES OF DATA ON CALVING RATES AND INTERVALS FOR USE IN THE MSYR REVIEW

The Committee is conducting a review of the range of MSYR values to include in simulation trials when selecting among variants of the RMP. The third intersessional workshop on the review of MSYR assembled a number of datasets on calving rates and calving intervals for baleen whales. Efforts were made following the workshop to fit models which accounted for both process and observation error to the data on calving rates and calving intervals. However, numerical problems were encountered when implementing these models. Funding is required for researchers to overcome these problems to provide the inputs needed to apply the Bayesian hierarchical method adopted by the Committee for computing a posterior distribution for r_0.

North Pacific minke whales

(2) PREPARATORY MEETING AND FIRST INTERSESSIONAL WORKSHOP TOWARDS THE IMPLEMENTATION REVIEW FOR WESTERN NORTH PACIFIC COMMON MINKE WHALES

The schedule for an *Implementation Review* specifies that between the finalisation of the *pre-Implementation assessment* and the following annual meeting of the Scientific Committee, an intersessional workshop shall be held to address a number of issues. Given the complexity of this *Implementation Review*, it is important to hold a preparatory meeting before the First Intersessional Workshop.

Aboriginal Whaling Management Procedure

(3) WORKSHOP ON GREENLANDIC FISHERIES/PREPARATION FOR GRAY WHALE IMPLEMENTATION REVIEW

The Committee has a number of priority areas related to Greenlandic fisheries and an intersessional Workshop is required to address:

(1) progress on developing *SLAs* for West Greenland fin and common minke whales;
(2) progress on the development of the sex-ratio method; and
(3) preparation for the *Implementation Review* for eastern North Pacific gray whales.

(4) AWMP DEVELOPERS FUND

The developers fund has been invaluable in the work of *SLA* development and related essential tasks of the SWG. It has been agreed as a standing fund by the Commission. The primary development tasks facing the SWG are for the Greenlandic fisheries. These tasks are of high priority to the Committee and the Commission. The fund is essential to allow progress to be made.

Bowhead, right and gray whales

(5) SOUTHERN OCEAN RIGHT WHALE PHOTO-ID CATALOG

For several decades, extensive photo-id surveys have been carried out for southern right whales in the coastal waters of South America, southern Africa and Australia during winter and spring, and much valuable data on the demographics of these populations has been collected. Together with genetic information, these data also provide the opportunity to investigate interchange and mixing between the coastal populations. However, because of its geographic limitations it is uninformative about the links between these populations and those found (generally at higher latitudes) in summer where extensive catches were taken in pelagic whaling. Funding is requested to address this gap by compiling images of southern right whales taken away from coastal waters of the continents, in a catalogue and associated database.

In-depth assessments

(6) INVESTIGATE THE RELATIONSHIP BETWEEN SEA ICE CHARACTERISTICS AND ANTARCTIC MINKE WHALE ABUNDANCE ESTIMATES

No conclusions have yet been reached on the reasons for the appreciable decline in abundance estimates from CPII and CPIII. Changes in sea ice characteristics, such as its extent and configuration, have been considered as one of the most likely influential factors. In order to investigate this carefully, funding is required to enable the preparation of the following sea ice related data sets:

(1) timing of the ice melt index for the entire time series of CPII and CPIII; and
(2) sea ice characteristics (e.g. area of sea-ice-field) in the south of ice edge for the entire time series of CPII and CPIII.

(7) RESOLVING DIFFERENCES IN MINKE WHALE ABUNDANCE ESTIMATES

Over the past two years, two methods have been presented to estimate abundance from the CPII and CPIII IDCR/SOWER cruise data. However, there are large differences between the estimates. These differences are much greater than statistical uncertainty, and than generally seen in the simulated datasets. Following intersessional work by correspondence a workshop is required to attempt to finally resolve the difference between the two approaches.

(8) IMPORT 2009/10 SOWER DATA AND ASSIST ABUNDANCE WORKING GROUP

Funds are required to enable the 2009/10 IWC/SOWER data to be incorporated into DESS and to provide general support to the IWC Secretariat regarding DESS. Errors will be corrected in the 'standard' and IDCR/SOWER datasets before the 2010 Scientific Committee meeting.

(9) AND (10) 2011 NORTH PACIFIC SIGHTING CRUISE AND ASSOCIATED MEETINGS

A new medium- to long-term research programme involving sighting surveys to provide annual information for cetacean stock management in the North Pacific is scheduled to commence in 2011. The cruise will last a total of about 60 days between July and August and the vessel *Kaiko Maru* will generously be provided by the Japanese Government. A two-day planning meeting for the 2011 cruise will be held in Tokyo. It will be preceded by a three-day workshop to develop the medium to long term objectives of the research programme and associated fieldwork.

(11) STATISTICAL CATCH-AT-AGE ESTIMATORS FOR ANTARCTIC MINKE WHALES

The Committee is trying to understand the reasons for the apparent large declines in abundance indicated by estimates produced from these surveys. Several of these reasons can be explored by population dynamics modelling. In 2005, Punt and Polacheck developed the statistical catch-at-age (SCAA) model, which has been refined over the last few years and is considered the most appropriate modelling framework for addressing these issues. Funding is requested for Committee's researchers to implement the recommendations so that in 2011 it will be in a position to apply the SCAA model to the most recent datasets.

Other Southern Hemisphere whale stocks

(12) SOUTHERN HEMISPHERE BLUE WHALE CATALOGUE PROJECT

Little is known about the present-day migration of blue whales, population structure and abundance or the level of interchange among populations. In 2008, the IWC supported the creation of a Southern Hemisphere blue whale catalogue and Centro de Conservacion Cetacea in Chile was tasked with developing a central web-based system by which Southern Hemisphere blue whale photo-id matching could take place. Matching will be conducted during the next two years through this platform by researchers from three Southern Hemisphere regions. Comparisons of blue whale photo-id and the significant number of individuals catalogued will be time consuming and researchers will not have enough free time to dedicate to the matching process. Therefore funding is required to ensure the matching process is completed. This will be a two-year project and a further request for funding (£11,200) will be submitted next year.

(13) MODELLING OF SOUTHERN HEMISPHERE HUMPBACK WHALE POPULATIONS

(1) Deliberations at the 2010 Annual Meeting have led to a number of proposed variants of stock-structure models for breeding stock B. Computer software needs to be developed to implement these models to take account of tag-recapture data.
(2) Simultaneous analysis of all 7 breeding stocks using the current age-aggregated model is desirable so that:
    (a) the catch allocation uncertainty is taken into account in a consistent and even-handed manner;
    (b) uncertainties in the boundaries for such allocations can be properly included in the analysis; and
    (c) likely similarities in intrinsic growth rate parameters for the different stocks can be properly factored into the analyses.

Development of this model has commenced but still needs further development. A contribution towards the salaries of researchers is requested to enable progress to be made with (1) and (2).

(14) ANTARCTIC HUMPBACK WHALE CATALOGUE

The Committee is already committed to funding this project, which represents only a partial cost of running the catalogue and is of great benefit to its in-depth assessment of Southern Hemisphere humpback whales. The funds are required to continue the cataloguing of submitted photographs and further develop and enhance the system for on-line access. The work will be carried out by Carlson and Allen.

Bycatch and other human-induced mortality

(15) FURTHER DEVELOPMENT AND MAINTENANCE OF THE IWC SHIP STRIKE DATABASE

Development of the IWC ship strike database has continued intersessionally. Funding is required for: (1) completing work on public summaries; (2) the development of a handbook; (3) data entry and validation; and (4) annual ongoing work by the data review group. The need for a global database of incidents involving collisions between vessels and whales has previously been recognised by the Committee, as well as other bodies such as the International Maritime Organization (IMO) and ACCOBAMS.

(16) DEVELOPMENT OF AN ONLINE SUBMISSION DATABASE FOR PROGRESS REPORTS

In 2009 the possibility of developing an online form/ database for submission of national Progress Reports was discussed as part of work on bycatches and small cetaceans, in addition to the general work of the Committee. Due to time constraints it was not possible to progress this further. A small group met this year to design an initial template and the Committee is now in the position to start trialling such a database. Funding is required for an expert to work with the IWC Secretariat to create this database and an initial version will be available at the next Annual Meeting.

Environment

(17) RISK ASSESSMENT MODELING TO DETERMINE THE IMPACT OF POLLUTANTS ON CETACEAN POPULATIONS

The report of the Phase II Intersessional IWC Pollution 2000+ Workshop (SC/62/Rep4) recommends that a number of modelling exercises be undertaken. This will involve the development and implementation of two demonstration projects, using the risk assessment framework (based on an individual based model approach). Funding is required to employ a post-doctoral research assistant to conduct this work under the direct supervision of Schwacke and Hall, with input and guidance from the Pollution 2000+ Steering Committee. This will be a two-year project and a further request for funding (£70,750) will be submitted next year.

(18) STATE OF THE CETACEAN ENVIRONMENT REPORT (SOCER)

The Committee regards SOCER to be a useful document that provides a 'snapshot' of environmental developments relevant to cetaceans that was requested by the Commission. Money is requested to support the production of this report.

Whalewatching

(19) DATA COMPILATION AND POWER ANALYSES FOR THE LAWE

The LaWE initiative aims to understand the possible effects of whalewatching on the demographic parameters of cetacean populations. In order to develop procedural mechanisms to centralise relevant data and to commence power analysis for key parameters, funding is required to employ a research assistant for 6 weeks.

Other

(20) INVITED PARTICIPANTS (IPs) FUND

The Committee **draws attention** to the essential contribution made to its work by the funded IPs. The IWC-funded IPs play an essential role in the Committee's work, including the critically important roles of Chairs and rapporteurs. They represent excellent value as they receive only travel and subsistence costs and thus donate their time, which is considerable. As was the case for previous meetings, where possible, effort will be made to accommodate scientists from developing countries.

25. WORKING METHODS OF THE COMMITTEE

25.1 Citation of Scientific Committee documents

SC/62/SCP1 was produced in response to the discussion last year about the Committee's policy with respect to the citation of Scientific Committee documents (IWC, 2010c, p.92). At that time the Committee had noted that *inter alia* its policy must ensure transparency with respect to advice provided by the Committee and to respect the rights of scientists to first publication of data.

The authors of SC/62/SCP1 had examined both the policy of the *Journal* and that of the Committee with respect to the question of including 'Not to be cited (or used) without the permission of the author(s)' at the top of a paper. They noted that there was some ambiguity in the present rules that required clarification and suggested that the ability to include a 'not to be cited....' restriction to a paper should be removed and replaced by a 'please inform authors when citing outside an IWC meeting' header.

There was considerable discussion of this proposal. The Committee, as before was concerned to:

(1) ensure transparency;
(2) respect rights to first publication; and
(3) avoid the possibility that authors may refuse to submit papers of value to the Committee's work.

Recognising the sensitivities involved and the need to find an appropriate balance amongst items (1)-(3) above, the Committee **agrees** that in future, all papers presented to the Scientific Committee contain the following header (this information will also be included in the Scientific Committee Handbook and when providing information on document submission to meetings and workshops):

> 'Papers submitted to the IWC Scientific Committee are produced to advance discussions within that Committee: they may be preliminary or exploratory. It is important that if you wish to cite this paper outside the context of an IWC meeting, you notify the author at least six weeks before it is cited to ensure that it has not been superseded or found to contain errors.'

The Scientific Committee List of Documents attempts to keep track of papers that have been presented to Scientific Committee meetings and can be found on the IWC website[7]. Authors who are aware of particular problems with any of their past papers are invited to inform the Secretariat who will keep an updated compilation.

25.2 Working papers, late papers and related issues

As a result of discussions during the meeting, the Committee **agrees** on the need to clarify certain issues with respect to working papers and primary papers that arrive late. The definitions and rules regarding these (and other categories of paper including 'For Info' papers) can be found in the Scientific Committee Handbook[8].

Primary papers must be submitted by the end of the first day of the Annual Meeting. Considerable flexibility has been shown by the Chair and Head of Science in the way they have dealt with papers for which a title has been submitted but which for one reason or another, arrive late. Formally, they can be called working papers because they have missed the deadline and then immediately be 'upgraded' to primary papers to minimise copying. Unfortunately, this flexibility is tending to be abused as a larger number of papers are being submitted past the deadline. For this reason, the Committee **agrees** that in future only in exceptional circumstances will late papers be accepted. In addition, Chairs will be very strict on the criteria for accepting working papers i.e. they must arise from discussions and be requested and/or be likely to expedite resolution of disagreements or stimulate debate within the meeting.

Notwithstanding the question of late papers, the Committee **agrees** that there may be circumstances in the future where it is appropriate for certain working papers to be 'elevated' to the status of a primary paper during the meeting. The Chair and Head of Science will apply the following two criteria:

[7] *http://www.iwcoffice.org/publications/pubmain.htm.*
[8] *http://www.iwcoffice.org/sci_com/handbook.htm.*

(1) the working paper has been presented and discussed within a sub-group or the plenary, such that an opportunity to comment on it has been given; and
(2) the text of the sub-group or plenary report would be significantly improved, streamlined or clarified by the ability to reference the paper as a primary document.

26. ELECTION OF OFFICERS

The Committee **agrees** that there was no need for elections this year.

27. PUBLICATIONS

Donovan reported on issues relating to the production of the *Journal*. Unfortunately, the year has been plagued by a series of problems with respect to getting the *Journal* published, due to internal problems at the printers that the IWC has used for many years. Sadly, after attempts to secure further investment, they are no longer trading but the Secretariat had very little notice in terms of finding an alternative. We have managed to find another company that we are using on a trial basis, and thanks to the page-setting abilities of Andrea Cooke, we managed to at least get the large *Supplement* out on time. We are now dealing with a different company and the *Journal* and Supplements should once again appear promptly. That being said, the Secretariat is in the process of examining a number of companies for ability and price. It is expected that the resultant backlog of papers will be reduced or eliminated in the coming year. In addition, the possibility of including electronic subscriptions is being investigated. The most efficient and cost effective way to digitise earlier reports is also being investigated. The Committee, as in previous years, **reiterates** the importance of the *Journal* to its work and encourages members to urge their institutes to subscribe.

28. OTHER BUSINESS

This is the final meeting for Nicky Grandy, Secretary of the Commission. The Scientific Committee rose in appreciation of her dedicated work in organising its meetings over the last decade. It noted the calm, efficient, good humoured way that she (and the team she ran) had assisted the Scientific Committee, even in the face of its sometimes unreasonable demands. On behalf of the Committee, its elder statesman, John Bannister, presented her with a specially painted card and a beautiful Moroccan rug, wishing her the very best for the future – she will be greatly missed.

29. ADOPTION OF REPORT

In closing the meeting, Palka thanked the Secretariat for carrying out its work in the usual efficient manner. The report was adopted at 17:20 on 11 June 2010. As is usual, final editing was carried out by the Convenors after the meeting.

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Annex E

Report of the Standing Working Group on the Aboriginal Whaling Management Procedure (AWMP)

Members: Donovan (Convenor), Acquarone, Allison, Baker, Bickham, Borodin, Brandão, Brandon, Breiwick, Broker, Brownell, Butterworth, Childerhouse, Cipriano, Dupont, Fadeev, Givens, Gunnlaugsson, Heide-Jørgensen, Hiruma, Ilyashenko, Iñíguez, Jaramillo, Johnston, Kanda, Kitakado, Lang, Lockyer, Mate, Moore, J., Nukulina, Palka, Punt, Reeves, Roel, Rose, Schweder, Scordino, Suydam, Swindoll, Thomas, Tyurneva, Uoya, Walløe, Weller, Witting.

1. INTRODUCTORY ITEMS

1.1 Convenor's opening remarks
Donovan welcomed the participants to the meeting. He noted that given the logistics of the intersessional workshop, it had not been possible to dedicate sufficient time to consideration of Greenlandic issues related to future *SLA* development (SC/63/Rep2). Given that the focus of the pre-meeting was to provide time for that discussion to begin, he noted that that the relevant agenda Items 2 and 3 would be completed during the normal Standing Working Group (SWG) sessions.

1.2 Election of Chair
Donovan was elected Chair.

1.3 Appointment of rapporteurs
Givens and Punt acted as rapporteurs, with assistance from the Chair.

1.4 Adoption of Agenda
The adopted agenda is given in Appendix 1.

1.5 Documents available
The new primary documents available to the SWG were SC/63/AWMP1-5 and SC/63/Rep2.

2. CONCLUSIONS ON THE SEX RATIO METHOD

Witting (2005; 2006) proposed that the abundance of West Greenland minke whales could be estimated using time series data on the sex ratio of past catches. Since then, the proposed method and subsequent improvements to estimate only the lower confidence bound on the abundance (starting with Witting and Schweder, 2007) have been evaluated by the SWG to determine if they could provide reliable, accurate, and precise estimates at Annual Meetings and Workshops. Last year, the SWG agreed that despite considerable effort, it was still not possible to confirm whether a sex-ratio-based method was appropriate and effective. It agreed that it would no longer prioritise development of this technique unless a comprehensive final analysis could be endorsed at the 2011 Annual Meeting.

In response to the problems seen in the sex ratio method, SC/63/AWMP5 described a possible remedy involving transformation of a key parameter in the model. An illustrative example used a transformation which operates in a way that for population sizes much greater than are realistic, the impact of catches of females on abundance is damped. This leads to finite estimates of carrying capacity *K* even in circumstances where the trend over time in the proportion of whales in the catch that is male is decreasing (as is the case for West Greenland minke whales). The example was shown to produce positively biased estimates of the lower 5% confidence interval for current population size. However the degree to which this bias warrants concern is difficult to assess since the estimator is positively biased even in circumstances where the proportion of the catches that are male does not trend downwards over time.

The SWG thanked the authors of SC/63/AWMP5 for their efforts to resolve the problems. Although SWG members offered the authors a variety of technical suggestions and comments on the method, it was clear that exploratory work in SC/63/AWMP5 was not the comprehensive final analysis sought by the SWG. The most obvious limitation of the method was that estimation of abundances appeared to be strongly positively biased. This is problematic in relation to abundance estimation, but it was noted that the approach in SC/63/AWMP5 might still prove useful in a future *SLA* if, for example, the bias was corrected for, or the *SLA* was tuned to adapt suitably to the bias.

The SWG thanked Witting, Schweder, Brandão and Butterworth for their considerable effort over the last several years in developing a novel and scientifically interesting estimation approach for sex ratio data. Despite their outstanding contributions to the work of the SWG, no final solution had yet been developed to remedy the previously expressed concerns. The SWG also noted that the original motivation for the work, the need to obtain a satisfactory abundance estimate has been superseded by the aerial survey (Heide-Jørgensen *et al.*, 2010) that had resulted in an agreed abundance estimate (16,600; 95% CI:7,170-38,500) that was suitable for assessment. Discussion of how to proceed with the development of an operating model to evaluate candidate *SLA*s for this stock is provided under Item 3.2.

3. CONSIDERATION OF WORK REQUIRED TO DEVELOP *SLA*S FOR ALL GREENLANDIC HUNTS BEFORE THE END OF THE INTERIM PERIOD

In Greenland, a multispecies hunt occurs and the expressed 'need' is for 670 tonnes of edible products from large whales for West Greenland; this involves catches of common minke, fin, humpback and bowhead whales. The flexibility among species is important to the hunters and satisfying 'subsistence need' to the extent possible is a critical component of management. Last year, the SWG noted that the development of a combined approach to calculate strike limits for more than one species has not been previously attempted (IWC, 2011b).

The SWG **endorsed** the views of the intersessional Workshop that this matter should be deferred until single-species management approaches had been developed further. These would provide the necessary basis to extend to multi-species considerations, such as need being expressed on a species-combined rather than a species-specific basis.

For a number of reasons, primarily related to stock structure issues, the SWG noted that development of *SLA*s for Greenland aboriginal hunts (especially for common minke and fin whales) will be more complex that any *Implementation* the SWG had previously considered. The Committee endorsed an interim safe approach to setting catch limits for the Greenland hunts in 2008 (IWC, 2009b), noting that this should be considered valid for two five-year blocks i.e. the SWG target will be for agreed and validated *SLA*s, at least by species, for the 2017 Annual Meeting (assuming that the Commission sets 5-year block quotas in 2012 as scheduled). Given the complexity of the development process, this work is high priority and the SWG **emphasised** that it will be necessary to hold intersessional workshops (see Item 10) to expedite progress.

3.1 and 3.2 Fin whales and common minke whales

At its 2011 intersessional workshop, the SWG noted that the first step toward *SLA* development for West Greenland fin whales and common minke whales will be to define the operating model(s) that are to be used to test the performance of candidate *SLA*s.

The SWG noted that both of these species have been the focus of RMP *Implementations* and *Implementation Reviews*, even though the focus has not been on Greenland. It is clearly essential that the operating models used to develop *SLA*s for the Greenland hunts are based on those used in the RMP *Implementations.* These should be based on the existing *Implementation Simulation Trial* framework for the North Atlantic common minke (IWC, 1994; 2005, p.18; 2009a, p.11) and fin whales (IWC, 2010). Given the SWG's focus on Greenland, it is clear that the review of the RMP operating models and specifications will probably identify refinements and modifications to the existing trials structure to properly account for the West Greenland case, particularly with respect to stock structure; it is important that ultimately these discussions are held in collaboration with the sub-committee on the RMP to ensure consistency with operating models to the extent possible. In addition, the *SLA* development process will have to take into account catches made under the RMP.

As part of the conceptual discussions held within the SWG, Witting and Heide-Jørgensen produced some initial ideas on the better integration of the West Greenland situation with the existing RMP operating models. They agreed to develop these ideas further and present a paper to the proposed intersessional meeting.

3.3 Humpback whales

The Scientific Committee has previously agreed to provide management advice on the West Greenland feeding aggregation of humpback whales by treating this as an independent stock (IWC, 2008, p.21). The SWG welcomed new work presented this year on the development of a stock assessment model for these whales (SC/63/AWMP2).

SC/63/AWMP2 used recent abundance estimates, historical catches starting from 1664, and an age- and sex-structured population model to perform Bayesian assessments of West Greenland humpback whales. The historical catches included the West Greenland catches as a lower bound on the catch history, and the West Greenland plus 10% of the West Indies catches as an upper bound. Prior distributions for life history parameters had been constructed from studies on humpback whales in the North Atlantic to account for the uncertainty associated with the parameters. The abundance data included a fully-corrected West Greenland humpback abundance estimate of 3,270 (CV: 0.50) individuals in 2007 (Heide-Jørgensen *et al.*, 2008), a time-series of relative abundance estimates from aerial surveys (Heide-Jørgensen *et al.*, 2008), and a time-series of relative abundance estimates from mark-recapture analysis (Larsen and Hammond, 2004).

SC/63/AWMP2 examined whether the long-term dynamics (from 1664) is best described by density-regulated growth, with perturbed populations returning monotonically towards an equilibrium state, or by inertia dynamics, where populations typically return through damped cycles. There was substantial statistical support for inertia dynamics and rejection of density-regulated growth. It was estimated that the abundance declined from a population dynamic equilibrium of 2,900 (90% CI:1,800-5,900) individuals in 1664 to a minimum of 1,300 (90% CI:230-5,100) individuals in 1927. The depletion ratio for 2011 was estimated to be 1.4 (90% CI:0.68-3.1), and the model projected that the population will increase to 5,200 (90% CI:2,400-9,000) individuals in 2020 (assuming yearly post-2010 catches of 10).

The SWG noted that a key element of SC/63/AWMP2 was the comparison of three alternative dynamics models: exponential growth (E), density-regulated (D), and inertia dynamics (I). Model E fitted the available abundance data well, but was not appropriate to use without modification over time spans longer than a few decades because it included no regulation of abundance or density feedback mechanism. Model D explicitly included density regulation, but did not fit the data well over the long time period that started in 1664. However, it could be made to fit the abundance and catch data over a shorter period of time. In other applications (e.g., for eastern North Pacific gray whales), model misfit over similarly long time periods has been addressed by starting the model recently and estimating its status relative to carrying capacity at that time. Such an approach may be applicable to the West Greenland humpback case, too. Additional calculations during the meeting applied a density-regulated model over a short time-period starting in 1980, and this fitted the data as well as the exponential model. In this case, however, the data were not informative about an upper bound for the carrying capacity.

Model I led to a good fit to the abundance data when the model was started in 1664, but may be questionable for use as operating model because the inertia dynamics over long time periods will be quite sensitive to parameterisation. This sensitivity could also render the parameterisation of future projections (i.e., as an operating model to test *SLA*s) difficult.

SWG members offered several comments on these assessment methods. It was suggested that the prior distributions for the bias parameters should be changed to be uniform on a log scale because this would mean that the relative abundance indices would not provide information on absolute abundance. It was noted that only one of the abundance estimates used in the analysis was an estimate of absolute abundance, so the fitted abundance curve should pass right through that point. This result was not seen, but

Table 1

Most recent abundance estimates for minke whales in the Central North Atlantic.

Small Area(s)	Year(s)	Abundance and CV
CM	2005	26,739 (CV=0.39)
CIC	2007	10,680 (CV=0.29)
CG	2007	1,048 (CV=0.60)
CIP	2007	1,350 (CV=0.38)

calculations during the meeting using log uniform priors on the abundance parameters and the bias in the relative surveys did achieve this result.

It was noted that models E, D, and I used 7, 8, and 9 parameters, respectively, to fit 9 data points. One member expressed concern about the very low number of degrees of freedom in these models because: (i) posterior distributions for some of the parameters (survival and birth rates, and age of sexual maturity) could be misleading (see below); and (ii) in an over-parameterised model, nearly any predicted outcome can be achieved from a variety of parameter combinations. The SWG noted that when dynamics models are sex- and age-structured, it is common to find that the data provide information about only a few parameters (e.g. carrying capacity and MSYR or the inertia parameter) while the posterior distributions for the remaining parameters differ little from the priors because the abundance data do not provide much signal for these parameters. This was found in SC/63/AWMP2. In the present application, the data were also informative about the parameters specifying bias in the relative abundance estimates. For parameters about which the abundance data contain little information, incorporating prior distributions (as done in SC/63/AWMP2) can be interpreted as a strategy to incorporate additional uncertainty into the results. The priors on the life history parameters of SC/63/AWMP2 were based on studies of humpback whales in other areas of the North Atlantic than West Greenland.

Over-fitting can sometimes be identified using the correlation and strength of nonlinear relationships among posterior parameter estimates. A supplement to SC/63/AWMP2 listed the parameter correlation matrix for each model. Correlations ranged from zero to strong (~0.90), yet it is important to realise that correlations among parameter estimates can also reflect the underlying constraints established by the structure of the dynamics model. The SWG **agreed** to carefully monitor for signs of problems associated with over-fitting when it conditions operating models for *SLA* development and testing.

In conclusion, the SWG recognised that the development process of an *SLA* for Greenland humpback whales would focus on consideration of the West Greenland feeding aggregation as a management unit. This may allow less attention on the overall North Atlantic humpback whale stock structure and may also avoid attempting to incorporate the long time series of catch data and the attendant catch allocation problems noted during the comprehensive assessment (e.g. IWC, 2002b; 2003).

3.4 Bowhead whales

Discussion within the Committee in recent years has focussed on stock structure and associated abundance estimates. The present working hypothesis is that bowhead whales in eastern Canada-West Greenland comprise a single stock; the alternative hypothesis is one of two stocks: one in Hudson Bay-Foxe Basin and another in Baffin Bay - Davis Strait.

SC/63/AWMP3 used recent abundance estimates, historical catches starting from 1719, and an age- and sex-structured population model to conduct Bayesian assessments of bowhead whales in eastern Canada-West Greenland. It also included a model for a Baffin Bay-Davis Strait stock, given the alternative two stock hypothesis. The historical catches were based on Higdon (2010), with a lower bound on the catch histories being given by the high and medium quality catch data, and an upper bound being given by all available data. An agreed abundance estimate of 6,340 (CV: 0.38) for 2002 (IWC, 2009b) was available to represent either the abundance of the entire eastern Canada-West Greenland population, or the Baffin Bay-Davis Strait stock. A time series of five estimated sighting rates covering the range from 1981 to 1998 for the Disko Bay area (Heide-Jørgensen *et al.*, 2007) was also used when fitting the model.

SC/63/AWMP3 examined whether the long-term dynamics (from 1719) are best described by density-regulated growth or by inertia dynamics. For eastern Canada-West Greenland bowhead whales there was substantial statistical support for inertia dynamics and for rejection of density-regulated growth. It was estimated that abundance declined from a population dynamic equilibrium of 30,000 (90% CI:24,000-35,000) individuals in 1719 to a maximal depletion of 1,700 (90% CI:510-4,900) individuals in 1888. The depletion ratio in 2011 was estimated to 0.29 (90% CI:0.15-0.58), and the population was projected to increase to 10,000 (90% CI:5,200-20,000) individuals in 2020 (assuming yearly post-2010 catches of 5). For the Baffin Bay-Davis Strait stock under the two stock hypothesis, it was estimated that abundance declined from a population dynamic equilibrium with 34,000 (90% CI:23,000-40,000) individuals in 1719 to a maximal depletion of 3,400 (90% CI:590-8,500) individuals in 1888. The depletion ratio in 2011 was estimated to 0.25 (90% CI:0.13-0.52), and the population was projected to increase to 9,100 (90% CI:4,500-18,000) individuals in 2020 (assuming yearly post 2010 catches of 3).

In discussion, it was noted that this approach was very similar to the method used for humpback whales discussed under Item 3.3. However, in the bowhead case, limitations of the available data presented greater problems and raised concern for SWG members.

Most importantly, the SWG noted that 5 of the 6 abundance estimates used as data were rough indices of relative abundance (as opposed to absolute abundance) pertaining to a small area and hence may be questionable as indices of total abundance. These estimates were based on a total of only 11 sightings from aerial surveys of the spring aggregation of bowhead whales in the Disko Bay area. Data on body length suggest that it is primarily large and mature bowhead whales without calves that occur in the Disko Bay area (Heide-Jørgensen *et al.*, 2010), and it may be expected that the time series of sighting rates relate to a local age/sex aggregation. It was further noted that problems with over-parameterisation were more likely here than for West Greenland humpbacks. For these reasons, the SWG was sceptical that the available index data could be used to fit a dynamics model reliably.

It was noted that the posterior distribution for adult mortality appeared to be bounded above by approximately 1%, whereas analysis of the Bering-Chukchi-Beaufort Seas bowhead populations had supported values half as large and even smaller. The analysis did not include an explicit prior on adult mortality. Instead, values for adult mortality were calculated from sampled values from the priors on the other life history parameters and the prior on the population growth rate. Thus, it was not clear whether this result was an artefact of the prior distributions for the other parameters or driven by the data (through the likelihood function). If desired, the assessment could place a prior on the adult mortality rate rather than the growth rate, with the growth rate being calculated from the values of the other parameters. The SWG did not consider whether it was most desirable to control the growth rate or adult mortality using an explicit prior.

The analysis in SC/63/AWMP3 assumed a prior for the growth rate parameter that supported only positive values. However, Witting reported that negative values would have received some posterior probability had they been given some prior probability. During the meeting, a version of the analysis that fitted the mature component of the population to the sighting data from Disko Bay using a uniform prior from -0.07 to 0.07 on the growth rate of the exponential model was presented. The posterior estimate (3.8%, 90% CI: -2.7% - 6.1%) was less accurate, but with a point estimate rather similar to the estimate from the Bering-Chukchi-Beaufort Seas population of bowhead whales (3.4%, 95% CI: 1.7%-5%) (Zeh and Punt, 2005).

The SWG recalled that a primary purpose for this bowhead assessment is the development of an *SLA*. In this context, a high degree of precision appears unnecessary. The agreed abundance estimate for 2002 is 6,340 - CV: 0.38 (IWC, 2009b), yet the need envelope is probably likely to be around five strikes per year, to which probably less than five additional removals would be added to reflect takes by native communities in Canada, at least on present information (see Annex F). Compared to the abundance estimate, this level of removals would seem to have only limited impact. The SWG noted that it might be therefore possible to establish a simple *SLA* because these circumstances suggested that the need to develop a more sophisticated approach appeared to be a low priority. Furthermore, a simple method would still be subject to an *Implementation Review* if the approach appeared inadequate or if the need envelope or level of Canadian takes increased. Development of a simple method would require the determination of a need envelope, and the Chair of the SWG was asked to discuss need envelopes with the hunters.

4. IMPLEMENTATION REVIEW OF GRAY WHALES WITH EMPHASIS ON THE PCFG

At the 2010 Annual Meeting (IWC, 2011a), it had been agreed that the information on stock structure and hunting presented, although some of it had not met the Data Availability Guideline requirements (IWC, 2004) for the 2010 review, warranted the development of trials as part of a new *Implementation Review* in 2011 to evaluate the performance of *SLA*s for hunting in the Pacific Northwest, with a primary focus on the PCFG (Pacific Coast Feeding Group). It also agreed that the 2010 *Implementation Review* had shown that the population as a whole was in a healthy state, but that over the next few years, further work should be undertaken to investigate the possibility of structure on the northern feeding grounds, especially in the region of the Chukotkan hunts.

4.1 Summary of intersessional Workshop

Donovan summarised the report of the intersessional Workshop held in La Jolla, California from 28 March-1 April 2011. With respect to gray whales, the focus of the workshop was preparing to complete an *Implementation Review* of eastern gray whales at the 2011 Annual Meeting, with the focus on the proposed Makah hunt and the PCFG. Most of the effort centred on reviewing the available information in the context of developing an operating model and trial structure such that conditioning and trial runs could be completed before and at the Annual Meeting.

The SWG received new and updated information on stock structure and movements (including information, some preliminary, on movements of gray whales between the western and eastern North Pacific), abundance and trends (including estimates for the PCFG and for the 'total'), catch data (including bycatches) and feeding ecology.

The Workshop agreed that the trials would consider three geographic regions. The north area is north of 52°N (roughly northern Vancouver Island), the PCFG area is between 41°N and 52°N, and the 'south' area is south of 41°N. The trials will consider two stocks ('PCFG' and 'north'). Some PCFG whales will be found outside of the PCFG area at various times during the year. However, this is not problematic since the historical catches north of 52°N occurred well north of 52°N and future catches will either occur in the Bering Sea or in the Makah U&A[1].

The discussions of trial structure were greatly aided by the presentation of Punt (2011) in which an age- and sex- structured operating model was presented that could form the basis of operating models for the *Implementation Review.* The *SLA* to be considered was provided by the Makah Tribal Council (details are presented in SC/63/Rep2, Annex D). Its implementation in the operating model is included in Appendix 3 to this report as part of the overall trial specifications, as are details of catches, bycatches, abundance, biological parameters including MSYR and performance statistics, including updates from the present meeting.

Unlike previous *Implementations*, the PCFG was for a 'small' population (previously referred to as a 'Type 3 Fishery'). Based on the work of Punt and Breiwick (2002), it was agreed that demographic uncertainty would be largely inconsequential even for a population of 200. However, it also agreed: (1) that the lowest number of mature females during the 100-year projection period should be included in the standard set of summary statistics so that an evaluation of the potential for depensation could be made; and (2) the set of trials will include cases in which there is environmental variability in the form of mortality events.

The Workshop agreed to the following specifications for the base-case trials:

(1) Two stocks (PCFG, non-PCFG).
(2) Four spatio-temporal strata (south, north, PCFG [Dec.-May], CPFG [Jun.-Nov.]).
(3) Split of catch to stock:
  (a) south: 1% PCFG; 99% non-PCFG;
  (b) PCFG [Dec.-May]: 20.3% PCFG; 79.7% non-PCFG;
  (c) PCFG [Jun.-Nov.]; 100% PCFG; and
  (d) north: 0% PCFG.
(4) The split of the catch to stock is deterministic in the past, but stochastic in the future.
(5) The probability of a PCFG whale being classified as non-PCFG is 0.
(6) The probability of a north whale being classified as PCFG is 0.01.
(7) 50% of struck animals are lost.
(8) Selectivity is to be 1+.
(9) All catches occur prior to May[2].
(10) $MSYL_{1+} = 0.6$; $MSYR_{1+}=4.5\%$.

[1]'Usual and accustomed fishing grounds' – Although these include the Strait of Juan de Fuca the hunt will be prohibited there due to the large portion of PCFG whales photographed in that area. The hunt will be limited to 1 December - 30 May to minimise the likelihood of PCFG whales.
[2]This assumption is conservative because it will lead to the highest assessed risk to the PCFG stock. In principle, it would be desirable to model to relative probability of strikes by month but no data are available to make any estimates. Sensitivity is explored to the assumption that all of the catches occur in April.

From this, the Workshop developed an initial set of *Evaluation* and *Robustness Trials* (SC/63/Rep2, tables 4 and 5) and reviewed and modified the performance statistics from the 2004 *Implementation.* The revised set of statistics can be found in Appendix 3 to this report.

A number of intersessional tasks were set and progress with these is discussed under Item 4.3.

4.2 Review of information on the PCFG

SC/63/AWMP1 presented a review of published and gray literature on PCFG gray whales. The objective of the paper was to familiarise the AWMP SWG with the biology of the PCFG whales and to draw attention to important components of the PCFG as it relates to management.

The first issue for management consideration is the range of the PCFG. The IWC currently defines PCFG whales as gray whales observed in multiple years between 1 June and 30 November between 41°N and 52°N (IWC, 2011b). This definition is based on research that does not uniformly survey the potential range of PCFG gray whales; the northern and southern extents of the range are poorly sampled. Gosho *et al.* (2011) found that 17.5% of gray whales photographed during surveys at Kodiak Island, Alaska matched to whales in the Cascadia Research Collective catalogue of whales in the PCFG area. If Kodiak Island were included in the PCFG range then the population estimate for the PCFG would be biased low by 100-200 whales.

The second issue for management consideration is immigration. Recently Frasier *et al.* (2011) and Lang *et al*. (2011) have found small but significant differences in mitochondrial DNA haplotype frequencies between PCFG whales and samples thought to be representative of the overall Eastern North Pacific (ENP) population and high genetic diversity in both PCFG and ENP whales. Lang *et al*. (2011) suggested that the high observed genetic diversity and low level mtDNA differentiation is consistent with the PCFG either being a recently founded group or a group exhibiting filopatry recruitment with low level recruitment. Photo-id surveys show recruitment into the PCFG at rates thought to be greater than the potential calf production of the PCFG (Calambokidis *et al.*, 2010; IWC, 2011b).

The newest time series of abundance estimates for PCFG whales indicates that there was an average recruitment of 25.8 whales into the PCFG between 1999 and 2002, coinciding with the observed mortality event of ENP whales (IWC, 2011b). Ethnographic records presented by Scordino suggest that gray whales have been hunted off the coast of Washington during the 1 June-30 November timeframe since at least the 1850s. Stable isotope findings are less conclusive, but may show that the PCFG has existed for the past 1,500 years in which Makah whaling has been documented. Together, these results strongly suggest that some level of immigration is occurring to the PCFG. As a result, when setting up *Implementation Trials*, some degree of immigration from the ENP must be considered and there should be recognition of potential negative bias to population estimates of the PCFG.

Scordino also provided an overview of the Makah Tribe's proposed hunt (SC/63/Rep2, Annex D). The SWG noted that unlike the *SLA*s for the BCB bowhead and the ENP gray whales, the *SLA*s to be evaluated for the hunt in the Makah U&A were not developed by the SWG, but are rather based on the proposed hunt and variants thereof developed by the Makah Tribe.

4.3 Progress with intersessional tasks

4.3.1 Finalise the specifications for the trials

4.3.1.1 PROVIDE UPDATED ABUNDANCE ESTIMATES AND THE ASSOCIATED VARIANCE-COVARIANCE MATRIX

Jeff Laake provided the updated abundance estimates for inclusion in the trials (see SC/63/Rep2, Annex H). The SWG thanked Laake for providing this information before the agreed deadline.

4.3.1.2 SPECIFY HOW TEMPORAL AUTOCORRELATION IN THE ABUNDANCE ESTIMATES WILL BE MODELLED

The inter-annual correlation between the PCFG abundance estimates is generally small (maximum 0.215 between the abundance estimates for 2007 and 2008). The SWG **agreed** that this level of correlation is sufficiently low that it is not necessary to take it into account in trials.

4.3.2 Refine the estimates of PCFG/north mixing based on the 2009 photo-ID data

Weller notified the SWG that the 2009 and 2010 photo-id data were not available for use during the current meeting.

4.3.3 Coding and validation

4.3.3.1 TRIALS

The trials specified during the March 2011 AWMP Workshop focused on the performance of *SLA*s for the proposed hunt in the Makah Tribe's U&A, because, except for the proposed Makah hunt and the associated possibility of a stock in the PCFG area, the *Implementation Review* for the ENP gray whales had been completed during the 2010 Annual Meeting. The trials developed during the Workshop considered a number of major hypotheses, including those related to:

(a) MSYR;
(b) levels of immigration;
(c) the level of mixing between PCFG and northern whales when the Makah hunt is likely to take place; and
(d) aspects of the hunt including struck and lost rates.

SC/63/AWMP4 showed how the trials specified during the March 2011 AWMP Workshop led to poor residual patterns for the fits to the revised abundance estimates for the PCFG. It provided a set of revised trials which include a pulse of immigration from the northern into the PCFG stock, in 1999 and 2000. In general, the operating models on which the revised trials are based are able to mimic the abundance data adequately. However, a subset of the trials (e.g. with high annual rates of immigration) are unable to mimic the abundance data well.

The SWG thanked Punt for conducting this intersessional work. The SWG noted that the abundance estimates exhibit a high rate of increase during the early years which is biologically implausible. Pulse immigration was one way to allow the operating model to mimic the abundance data. However, pulse immigration is not the only way to achieve consistency between the operating model and the data. Specifically, an alternative explanation is that the trend in abundance from 1998 to 2002 is not due to immigration, but is instead due to a change in survey bias. It was recognised that neither model adjustment was developed independently of the abundance data. Thus, it was not surprising that models including a change in survey bias or pulse immigration fit the abundance data better than models which have neither effect, and which exhibit a residual pattern as noted in SC/63/AWMP4. Regardless, the SWG recognised the need to explore a plausible range of hypotheses with respect to the rates of increase in the abundance estimates.

The predicted abundance trajectories (historical and future) for the three types of model differ, reinforcing the need to include alternative scenarios for changes in underlying abundance. Witting noted that models based on inertial dynamics were unlikely to be able to mimic the change in abundance estimates better than the other models considered by the SWG due to the short time period of the phenomenon discussed above.

The SWG emphasised that the set of operating models used to test *SLA*s need to cover the plausible range. The SWG discussed the relative plausibility of a change in survey bias. It was noted that there is no direct evidence for such a change, such as marked changes in survey effort and its spatial distribution (although changes in survey effort have occurred - see Appendix 2). Moreover, the trend in abundance for the more intensively surveyed area from Oregon to Northern British Columbia shows the same trend as the entire PCFG area. However, there may be reasons other than a simply change in effort for a change in survey bias. For example, consider the case when individual PCFG whales have very heterogeneous detection probabilities. This would cause a downward bias in estimated abundance. Over several years, the accumulated data might begin to dominate and average away any such bias, leading to the pattern used in the SWG's survey bias model (Fig. 1). Another possible contributor to the (artificial) appearance of survey bias is the approach used for the capture-recapture abundance estimation that an animal is defined as being part of the PCFG only if it is seen in at least two years in the PCFG area.

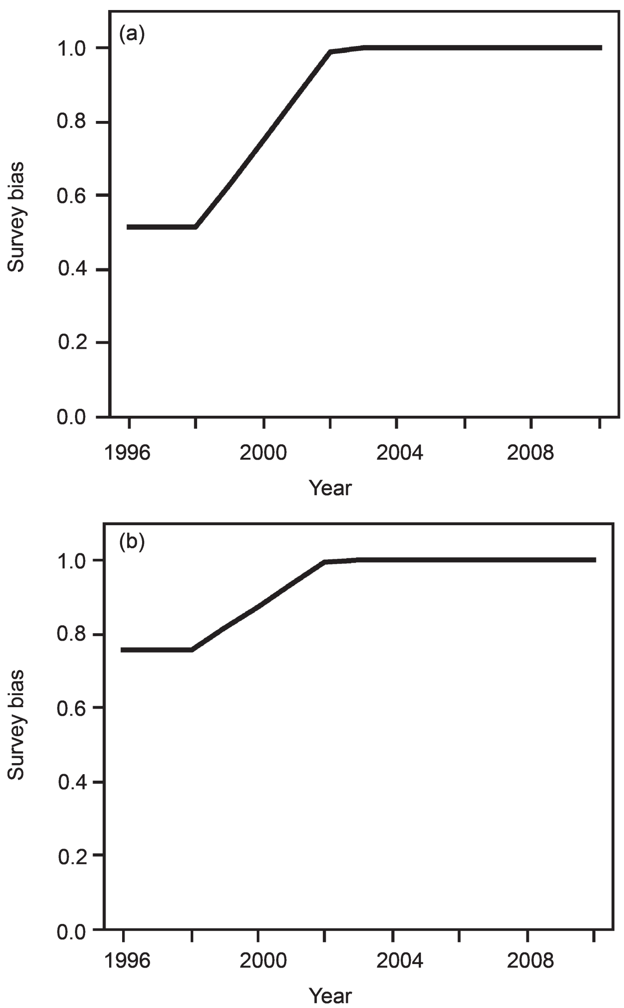

Fig. 1. Bias as a function of time for the 'A' trials (top panel) and the 'Y' trials (bottom panel).

The SWG considered how to best move forward given the concerns with the trials structure established during the March 2011 Workshop and with that in SC/63/AWMP4. Furthermore, although software which could be used to condition and run trials during the meeting was available, the programs have yet to be validated by the Secretariat.

In order to establish a work plan, the SWG identified four 'broad' base-case models which captured hypotheses for the trend in the abundance data for PCFG area.

(1) The 1998 abundance estimate is biased due to 'discovery' and 20 whales immigrated into the PCFG stock from the northern stock in each of 1999 and 2000 (hypothesis E).
(2) There has been no pulse immigration into the PCFG stock; rather the abundance estimates are subject to time-varying bias (Fig. 1a) (hypothesis A).
(3) There has been no pulse immigration into the PCFG stock and the abundance estimates are unbiased (hypothesis X).
(4) 10 whales immigrated into the PCFG stock from the northern stock in each of 1999 and 2000 and the abundance estimates are subject to time-varying bias (but not the extent as for hypothesis A; Fig. 1b) (hypothesis Y).

The SWG then identified a subset of the evaluation trials in SC/63/AWMP4 which cover a range of the factors which might impact eventual performance and could help the SWG select which trials to focus on (Table 2). The factors considered were:

(a) $MSYR_{1+}$;
(b) need in the Russian hunt;
(c) the probability of harvesting a PCFG whale during an April hunt in the PCFG area;
(d) the struck and lost rate in the PCFG hunt;
(e) low-level (non-pulse) immigration into the PCFG stock from the northern stock;
(f) episodic events; and
(g) the sex-ratio of future catches in the PCFG area.

The SWG also selected a number of diagnostic plots and tables to help it understand the behaviour of the models and trials, in order to narrow down the *SLA* testing framework. Among the items considered were:

(1) Time-trajectories of 1+ population size (northern and PCFG stock) in absolute terms and relative to carrying capacity, along with the fits to the abundance estimates. This plot allows an evaluation of whether conditioning has been achieved satisfactorily.
(2) Histograms of the 100 parameter vectors for each trial. This plot allows an evaluation of whether and how conditioning has impacted the priors for these parameters.
(3) Individual time-trajectories of 1+ population size for the northern and PCFG stocks, individual time-trajectories of strikes for the northern and PCFG area, a summary (median and 95% intervals) for the depletion of the PCFG stock, and a summary (median and 95% intervals) for the time-trajectories of 1+ population size when (a) there are no future catches, (b) there are only incidental catches, and (c) there are incidental catches and catches due to hunts in the PCFG and northern area.
(4) Tables showing the statistics selected during the March 2011 Workshop.

Table 2a

The *Evaluation Trials*. Values given in bold type show differences from the base case trial. The values under 'Immigration' only pertain to the 'E' trials. The trials indicated by a 'Y' in the 'Tested' column were considered in detail by the SWG during the meeting.

Trial	Tested	Description	*MSYR*$_{1+}$ north	*MSYR*$_{1+}$ PCFG	Final need	Immigration (%)	Survey freq.	Survey bias (north)	Future survey CV
GE01	Y	Base case	4.5%	4.5%	340/7	20+0	10 / 1	1	Base
GE02	Y	MSYR$_{1+}$=1%	4.5%	1%	340/7	20+0	10 / 1	1	Base
GE03	Y	MSYR$_{1+}$=2%	**2%**	**2%**	340/7	20+0	10 / 1	**0.5→1**	Base
GE04		MSYR$_{1+}$=6%	**6%**	**6%**	340/7	20+0	10 / 1	1	Base
GE05		MSYR$_{1+}$=1%; Immigration=2	4.5%	1%	340/7	**20+2**	10 / 1	1	Base
GE06	Y	MSYR$_{1+}$=2%; Immigration=2	**2%**	**2%**	340/7	**20+2**	10 / 1	**0.5→1**	Base
GE07		MSYR$_{1+}$=1%; Immigration=4	4.5%	1%	340/7	**20+4**	10 / 1	1	Base
GE08		MSYR$_{1+}$=2%; Immigration=4	**2%**	**2%**	340/7	**20+4**	10 / 1	**0.5→1**	Base
GE09		MSYR$_{1+}$=1%; Immigration=6	4.5%	1%	340/7	**20+6**	10 / 1	1	Base
GE10		MSYR$_{1+}$=2%; Immigration=6	**2%**	**2%**	340/7	**20+6**	10 / 1	**0.5→1**	Base
GE11		MSYR$_{1+}$=2%; Difficult	**2%**	**2%**	340/7	20+0	10 / 1	**0.5→1**	**½ CV_{est}**+
GE12		MSYR$_{1+}$=2%; Immigration=2; Difficult	**2%**	**2%**	340/7	**20+2**	10 / 1	**0.5→1**	**½ CV_{est}**+
GE13		High need	4.5%	4.5%	**530/7**	20+0	10 / 1	1	Base
GE14	Y	MSYR$_{1+}$=2%; High need	**2%**	**2%**	**530/7**	20+0	10 / 1	**0.5→1**	Base
GE15		MSYR$_{1+}$=2%; Immigration=2; High need	**2%**	**2%**	**530/7**	**20+2**	10 / 1	**0.5→1**	Base
GE16	Y	GE01 + 3 episodic events&	4.5%	4.5%	340/7	20+0	10 / 1	1	Base
GE17		All PCFG whales; ϕ_{fut}=1.000	4.5%	4.5%	340/7	20+0	10 / 1	1	Base
GE18		ϕ_{fut}=0.600	4.5%	4.5%	340/7	20+0	10 / 1	1	Base
GE19	Y	Struck and lost (0%)	4.5%	4.5%	340/7	20+0	10 / 1	1	Base
GE20		Struck and lost (75%)	4.5%	4.5%	340/7	20+0	10 / 1	1	Base
GE21		All PCFG catches in May	4.5%	4.5%	340/7	20+0	10 / 1	1	Base
GE22		MSYR$_{1+}$=2%; Struck and lost (0%)	**2%**	**2%**	340/7	20+0	10 / 1	**0.5→1***	Base
GE23		MSYR$_{1+}$=2%; Struck and lost (75%)	**2%**	**2%**	340/7	20+0	10 / 1	**0.5→1***	Base
GE24		MSYR$_{1+}$=2%; All PCFG catches in May	**2%**	**2%**	340/7	20+0	10 / 1	**0.5→1***	Base
GE25		MSYR$_{1+}$=2%; Immigration=2; Struck and lost (0%)	**2%**	**2%**	340/7	**20+2**	10 / 1	**0.5→1***	Base
GE26		MSYR$_{1+}$=2%; Immigration=2; Struck and lost (75%)	**2%**	**2%**	340/7	**20+2**	10 / 1	**0.5→1***	Base
GE27		MSYR$_{1+}$=2%; Immigration=2; All PCFG catches in May	**2%**	**2%**	340/7	**20+2**	10 / 1	**0.5→1***	Base
GE28		Higher 1999-2000 Immigration	4.5%	4.5%	340/7	**30+0**	10 / 1	1	Base
GE29		MSYR$_{1+}$=2%; Higher 1999-2000 Immigration	**2%**	**2%**	340/7	**30+0**	10 / 1	**0.5→1**	Base
GE30		Lower 1999-2000 Immigration	4.5%	4.5%	340/7	**10+0**	10 / 1	1	Base
GE31		MSYR$_{1+}$=2%; Lower 1999-2000 Immigration	**2%**	**2%**	340/7	**10+0**	10 / 1	**0.5→1**	Base
GE32		Stochastic events 10% every 5 years&	4.5%	4.5%	340/7	20+0	10 / 1	1	Base
GE33		MSYR$_{1+}$=2%; Stochastic events 10% every 5 years&	**2%**	**2%**	340/7	20+0	10 / 1	**0.5→1***	Base
GE34		MSYR$_{1+}$=1%; Immigration=2; Stochastic events 10% every 5 years&	4.5%	**1%**	340/7	**20+2**	10 / 1	1	Base
GE35	Y	MSYR$_{1+}$=2%; Immigration=2; Stochastic events 10% every 5 years&	**2%**	**2%**	340/7	**20+2**	10 / 1	**0.5→1***	Base
GE36		Base case + PCFG sex-ratio=0.59	4.5%	4.5%	340/7	20+0	10 / 1	1	Base
GE37		MSYR$_{1+}$=1%; Immigration=2; PCFG sex-ratio=0.59	4.5%	**1%**	340/7	**20+2**	10 / 1	**1**	Base
GE38	Y	MSYR$_{1+}$=2%; Immigration=2; PCFG sex-ratio=0.59	**2%**	**2%**	340/7	**20+2**	10 / 1	**0.5→1***	Base
GE39		All PCFG whales; ϕ_{PCFG}=1.000; MSYR=2%	2%	2%	340/7	20+0	10 / 1	**0.5→1**	Base

*To be adjusted based on initial analyses. &The average value for adult survival needs to be adjusted to ensure the population is table for these trials. +The provided CV is half of the true value. %First value is the 1999/2000 immigration and the other number is the non-1999/2000 immigration.

The SWG noted that the time-trajectories of strikes for the PCFG area are uninformative, but that the 'ray plot' developed during the March 2011 Workshop was not more informative. The SWG requested that in the future, the number of strikes of PCFG-stock animals be added to the tabular summary. It was also not possible to condition all of the 'X' and 'Y' trials during the meeting owing to very strong posterior correlations. Specifically, it was not possible during the meeting to obtain 100 unique parameter vectors for the trials in which MSYR$_{1+}$ is 4.5% for the northern stock and 1% for the PCFG stock without adjusting the priors.

The SWG noted that carrying capacity varied among the hypotheses (a wide range for the 'E', 'X' and 'Y' trials and a relatively narrow range for the 'A' trials). The SWG also noted that the results for both the northern and PCFG stocks differed between the various hypotheses even when the remaining specifications were the same (e.g. the final depletion for the northern stock for trials GA03 and GE03). The SWG emphasised the need to fully understand the results before drawing any final conclusions about the relative merits of the four operating models or any changes to the list of evaluation and robustness trials, with the exception that the SWG agreed to move the trial with MSYR$_{1+}$=2% and all future Makah hunting takes PCFG animals to the evaluation set (this is reflected in Table 2).

The SWG established a Steering group (Donovan [Convenor], Allison, Brandon, Butterworth, Givens, Punt, Scordino) to further review the trials structure before the proposed intersessional workshop. The SWG **strongly recommended** that the abundance estimates for the PCFG be updated to include data for 2009 and 2010. A paper presenting all of the abundance estimates should be provided to the SWG.

4.3.3.2 PARAMETER VECTOR GENERATION

This issue will be considered during the next *Implementation Review*.

4.4 Review of results, conditioning and work plan

The SWG was unable to fully review the conditioning because the full set of trials have yet to be completed. Similarly, the SWG did not review the results of the trials.

Table 2b

The Robustness Trials.

Trial	Description	$MSYR_{1+}$ north	$MSYR_{1+}$ PCFG	Final need	Survey freq.	Survey bias (north)	Future survey CV
GR01	5 year surveys	4.5%	4.5%	340 / 7	10/1	1	Base
GR02	Difficult 2%+5yr surveys	2%	2%	340 / 7	10/1	0.5→1	½ CV_{est}
GR03	Linear decrease in *K*	4.5%	4.5%	340 / 7	10/1	1	Base
GR04	Linear increase in PCFG *K*; decrease for North *K*	4.5%	4.5%	340 / 7	10/1	1	Base
GR05	Linear decrease in PCFG *K*; increase for North *K*	4.5%	4.5%	340 / 7	10/1	1	Base
GR07	Linear increase in *M*	4.5%	4.5%	340 / 7	10/1	1	Base
GR08	Linear increase in PCFG *M*	4.5%	4.5%	340 / 7	10/1	1	Base
GR09	Linear increase in north *M*	4.5%	4.5%	340 / 7	10/1	1	Base
GR10	No PCFG whales; ϕ_{PCFG}=0.000	2%	2%	340 / 7	10/1	0.5→1	Base
GR11	Perfect detection; $p_1 = 0$; $p_2 = 0$;	4.5%	4.5%	340 / 7	10/1	1	Base
GR12	Perfect detection; p_1 =0; p2=0.01-0.05	4.5%	4.5%	340 / 7	10/1	1	Base
GR13	Survey bias PCFG + $p_1 = 0.5$	4.5%	4.5%	340 / 7	10/1	1	Base
GR14	Survey bias PCFG + $p_1 = 0.5$	2%	2%	340 / 7	10/1	1	Base
GR15	Correlation (draw for N; same quantile in the range for PCFG)	4.5%	4.5%	340 / 7	10/1	1	Base
GR16	Correlation (draw for N; same quantile in the range for PCFG)	2%	2%	340 / 7	10/1	1	Base
GR17	3 PCFG unepisodic event of 75 years; MSYR=2%	2%	2%	340 / 7	10/1	0.5→1	Base

Details of factors

Factors	Other levels (reference levels shown bold and underlined)
$MSYR_{1+}$	2%, **<u>4.5%</u>**, 6%
Immigration rate (annual)	**<u>0, 2</u>**, 4, 6
Immigration rate (1999/2000)	10, **<u>20</u>**, 30
Proportion of PCFG whales in PCFG area, ϕ_{fut}	0, **<u>0.203</u>**, 1
Struck and lost are	0, **<u>50%,</u>** 100%
Northern need in final year (linear change from 150 in 2009)	**<u>340</u>**, 530
Historic survey bias	**<u>None,</u>** increasing between 1967 to 2002 from 0.5→1 50% (PCFG only)
Survey CV	**<u>BaseCase,</u>** ½ CV_{est}
Future episodic events	**<u>None</u>**, 3 events occur between yrs 1-75 (with at least 2 in yrs 1-50) in which 20% of the animals die, events occur every 5 years in 10% of the animals die
Time dependence in *K*	**<u>Constant</u>**, halve linearly over 100yr
Time dependence in natural mortality, *M* *	**<u>Constant,</u>** double linearly over 100yr
Timing of harvest	**<u>April</u>, May**
Parameter correlations	Yes, **<u>No</u>**
Probability of mismatching north whales, p_2	0, **<u>0.01</u>**, 0.01-0.05
Probability of mismatching PCFG whales, p_1	**<u>0</u>**, 0.5
Frequency of PCFG surveys	**<u>Annual</u>**, 5-year

The SWG **agreed** that its work plan for the 2012 Annual Meeting and associated interessional period would be as follows:

(1) update the output from the control program to include the number of struck PCFG whales [Punt, June 30, 2011] (Item 4.3.3);
(2) validate the control program and the code for implementing the PCFG hunt (Item 4.3.3);
(3) refine the set of trials (Steering Group, Item 4.3.3);
(4) condition all of the trials and conduct all of the projections before the Workshop (Item 4.3.3); and
(5) conduct a Workshop, probably in March 2012 with a focus on the completion of the *Implementation Review* (Item 4), and an initial consideration of operating models for West Greenland fin whales (although progress on all species will be considered).

5. IMPLICATIONS OF NEW INFORMATION ON GRAY WHALE STOCK STRUCTURE

5.1 Summary of relevant BRG discussions (see Annex F)

Kitakado summarised the discussions in the BRG sub-committee related to the implications of western gray whales being seen off the US west coast: (1) there is now more uncertainty regarding Pacific gray whale stock structure; (2) there is no need to revise stock structure assumptions for Pacific gray whales at present; and (3) range-wide studies need to be undertaken to better understand the situation.

5.2 Conclusions with respect to *Implementation Review*

Given the information under Item 5.1, the SWG **agreed** that formally there was no need to modify the existing trials structure which had been designed to evaluate the *SLA*s for the northern and PCFG areas in the context of eastern gray whales. However, this structure does not incorporate conservation implications for western gray whales. Therefore, the SWG **stresses** that the new information on movements of gray whales described under Item 5.1 highlights the importance of further clarification of the stock structure of North Pacific gray whales. In particular, the matches of western gray whales with animals seen in the PCFG area and other areas along the west coast **emphasises** the need for efforts to estimate the probability of a western gray whale being taken in aboriginal hunts for Pacific gray whales. It **strongly endorses** the research programme developed by the BRG sub-committee that focuses on photo-id, genetics and telemetry (see Annex F), incorporating both further analysis of existing data and collection of new data. The results of the research may require further trials for future *SLA* testing; this will certainly be a matter for the next *Implementation Review* if not before. The SWG will continue to monitor discussions within BRG and is willing to respond to any guidance or requests for further information from the Commission.

Final dates for the 2012 meeting are not yet known but likely deadlines for the DAA process are as follows.

- Final datasets available (6 months): 30 November 2011.
- Papers using novel methods (3 months): 28 February 2012.
- Papers using standard methods (2 months): 31 March 2012.
- Papers responding to those above (1 month): 30 April 2012.

6. ANNUAL REVIEW OF MANAGEMENT ADVICE

The SWG recognises the logistical difficulties in collecting samples in remote areas but in order to assist in its work, it **recommends** that biological information and material be collected from as many whales as possible.

6.1 Common minke whales off West Greenland

6.1.1 New information

In the 2010 season, 179 minke whales were landed in West Greenland and 7 were struck and lost (SC/63/ProgRepDenmark). Of the landed whales, there were 122 females, 53 males, and four whales of unreported sex. Witting noted that there are plans to tag minke whales in the coming years to establish correction factors to be applied to future surveys.

6.1.2 Management advice

In 2007, the Commission agreed that the number of common minke whales struck from this stock shall not exceed 200 in each of the years 2008-12, except that up to 15 strikes can be carried forward. In 2009, the Committee was for the first time ever able provide management advice for this stock based on a negatively biased estimate of abundance of 17,307 (95% CI 7,628-39,270) and the method for providing interim management advice which was confirmed by the Commission. Such advice can be used for up to two five-year blocks whilst *SLA*s are being developed (IWC, 2009a, p.16). Based on the application of the agreed approach, and the lower 5th percentile for the 2007 estimate of abundance (i.e. 8,918), the Committee repeats its advice of last year that an annual strike limit of 178 will not harm the stock.

6.2 Common minke whales off East Greenland

6.2.1 New information

Nine common minke whales were struck (and landed) off East Greenland in 2010 (no animals were struck and lost) (SC/63/ProgRepDenmark). Of the landed whales, there were two females, four males, and three whales of unreported sex. The SWG noted that catches of minke whales off East Greenland are believed to come from the large Central stock of minke whales.

6.2.2 Management advice

In 2007, the Commission agreed to an annual quota of 12 minke whales from the stock off East Greenland for 2008-12, which the Committee stated was acceptable in 2007. The present strike limit represents a very small proportion of the Central Stock (see Table 1). The SWG agreed that the present strike limit would not harm the stock.

6.3 Fin whales off West Greenland

6.3.1 New information

A total of four fin whales (all females) were landed, and one struck and lost, in West Greenland during 2010 (SC/63/ProgRepDenmark). An acoustic study on fin whales in Davis Strait between Greenland and Canada found that call frequencies peaked in November-December, and continued until the area was covered by ice in January (Simon *et al.*, 2010).

6.3.2 Management advice

In 2007, the Commission agreed to a quota (for the years 2008-12) of 19 fin whales struck off West Greenland. The Committee agreed an approach for providing interim management advice in 2008 and this was confirmed by the Commission. It had agreed that such advice could be used for up to two five-year blocks whilst *SLA*s were being developed (IWC, 2009a). Based on the application of the agreed approach in 2008 (IWC, 2009a), the SWG agreed that an annual strike limit of 9 whales will not harm the stock.

6.4 Humpback whales off West Greenland

6.4.1 New information

A total of nine (three males; five females; one unreported sex) humpback whales were landed (none were struck and lost) in West Greenland during 2010 (SC/63/ProgRepDenmark). Genetic samples were obtained from five of these whales.

6.4.2 Management advice

In 2007, the Committee agreed an approach for providing interim management advice and this was confirmed by the Commission. It had agreed that such advice could be used for up to two five year blocks whilst *SLA*s were being developed (IWC, 2009a, p.16). Using this approach, as last year, the SWG agreed that an annual strike limit of 10 whales will not harm the stock.

6.5 Humpback whales off St Vincent and The Grenadines

6.5.1 New information

The SWG received no information on 2010-11 catches by St Vincent and The Grenadines. The SWG **strongly recommended** that catch data, including the length of harvested animals, be provided to the Scientific Committee. It also **strongly recommended** that genetic samples by obtained for any harvested animals as well as fluke photographs, and that this information be submitted to appropriate catalogues and collections.

6.5.2 Management advice

In recent years, the Committee has agreed that the animals found off St Vincent and The Grenadines are part of the large West Indies breeding population. The Commission adopted a total block catch limit of 20 for the period 2008-12. The SWG **agreed** that this block catch limit will not harm the stock.

7. ABORGINAL WHALING MANAGEMENT SCHEME

7.1 Draft guidelines for *Implementations* and *Implementation Reviews*

The SWG did not have time to discuss this Item at the meeting. Given this, the SWG **agreed** that the item would be referred to the intersessional workshop and the Chair agreed to circulate a draft proposal at least one month before the Workshop.

7.2 Scientific aspects of an aboriginal whaling scheme

The SWG refers to the previous discussions of this matter and notes that the Commission is still considering the Committee's recommended text on this matter (IWC, 2002a, pp.157-8).

8. PLANNING FOR A BOWHEAD WHALE *IMPLEMENTATION REVIEW*

8.1 Summary of relevant BRG discussions (see Annex F)

Kitakado reported that the BRG sub-committee had received some updates on genetic analyses and age determination of bowhead whales. It also welcomed information on dedicated ice-based abundance surveys (with visual and acoustic components) with independent observers in 2010 and 2011, and a concurrent 2011 aerial photo-id survey. It noted that SC/63/BRG1 had presented a sophisticated method to estimate detection probabilities using the 2010 ice-based data. Work is continuing to develop a new abundance estimate but this is not expected to be completed before 2013.

8.2 Work plan

The purpose of an *Implementation Review* is to examine new information to see if the current situation is outside the parameter space tested in the existing trials. The SWG noted that no information had been presented at the present meeting to suggest that this was the case. It **agreed** that an *Implementation Review* should be scheduled for the 2012 Annual Meeting. In accordance with the Committee's DAA, the following deadlines apply:

Final dates for the 2012 meeting are not yet known but likely deadlines for the DAA process are:

- final datasets available (6 months): 30 November 2011;
- papers using novel methods (3 months): 28 February 2012;
- papers using standard methods (2 months): 31 March 2012; and
- papers responding to those above (1 month): 30 April 2012.

The SWG recognised that it was unlikely that a new abundance estimate would be available for the *Review.* It noted that this is not a required component of an *Implementation Review.* Once an agreed abundance estimate is received it will be incorporated routinely into the *SLA* for the provision of management advice.

9. PROGRESS OF FOLLOW-UP WORK ON CONVERSION FACTORS FOR THE GREENLANDIC HUNT

For indigenous hunting of whales in West Greenland, need is expressed in terms of kilogrammes of edible product (across species), whereas for the development of *SLA*s the SWG approach is to express need in terms of numbers of strikes (per species). Based on the recommendations in the report of the Commission's Small Working Group on Conversion Factors for use in Greenland Hunts (Donovan *et al.*, 2010), the Committee had requested Greenland to provide information on its sampling scheme and data validation protocols to the present meeting. The focus of the recommendations concerned the fin, humpback and bowhead whales for which provisional conversion factors had been proposed; sufficient data had been available to develop a conversion factor for the common minke whale (Donovan *et al.*, 2010).

The SWG received a response to this request (Appendix 4). It was informed that data had been obtained for a small number of humpback whales, fin whales and bowhead whales using a new protocol and with the assistance of wildlife officers. The Greenland Institute of Natural Resources is planning to continue its efforts this year, targeting humpback and bowhead whales, with the effort extending to fin and minke whales in later years. The Greenland Ministry of Fisheries indicated that data collection will have to run for 'quite some years before an appropriate sampling size is reached'.

The SWG welcomed the provision of a report and appreciated and encouraged this work, recognising the logistical difficulty of collecting this kind of data. However, it noted that considerably more detail is needed for it to evaluate the proposed programme; it noted that the authors of the original report had offered to assist in the development of a programme and the SWG **urges** Greenland to take advantage of this offer and it **requests** that a detailed report be presented for consideration at the next meeting.

In particular, the report should provide:

(1) a description of the field protocols and sampling strategy, including effort and likely sample sizes;
(2) a description of analysis methods and models; and
(3) presentation from results thus far, including from preliminary analyses with the available data.

Such information will assist the SWG in addressing issues such as appropriate sample size.

10. WORK PLAN

Details of the work plan can be found under the relevant agenda items. The priority topics for next year will be:

(1) continue work on the development of *SLA*s for the Greenlandic hunts with a focus on common minke whales and fin whales (Item 3);
(2) complete the *Implementation Review* for eastern gray whales with a focus on the PCFG (Item 4);
(3) complete an *Implementation Review* for BCB bowhead whales (Item 8);
(4) develop guidelines for *Implementations* and *Implementation Reviews* (Item 7);
(5) provide management advice for the appropriate subsistence hunts (Item 6); and
(6) review the Greenlandic programme to provide information on conversion factors (Item 9).

Essential components of achieving this work are:

(1) the holding of an intersessional Workshop, probably in March 2012 with a focus on:
    (a) operating models for Greenland fin and minke *SLA* development based on RMP *Implementations* (if time is available, progress on humpback and bowhead whales will also be reviewed);
    (b) gray whale *Implementation Review*;
    (c) draft of guidelines for *Implementation*; and
(2) continuation of the AWMP Developer's Fund.

11. ADOPTION OF REPORT

The report was adopted at 16:22 on 7 June 2011. The SWG thanked Donovan for his predictably excellent chairmanship. Donovan thanked the rapporteurs and particularly Punt for his unstinting dedication to undertaking the computing work and his almost superhuman ability to work without sleep.

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Appendix 1

AGENDA

1. Introductory items
    1.1 Convenor's opening remarks
    1.2 Arrangements for the meeting
    1.3 Election of Chair
    1.4 Appointment of rapporteurs
    1.5 Adoption of Agenda
    1.6 Documents available
2. Conclusion on the sex ratio method
3. Consideration of work required to develop *SLA*s for all Greenland hunts before the end of the interim period
    3.1 Common minke whales
    3.2 Fin whales
    3.3 Humpback whales
    3.4 Bowhead whales
4. *Implementation Review* of gray whales with emphasis on the PCFG
    4.1 Summary of intersessional workshop
    4.2 Review of information on the PCFG
    4.2 Progress with intersessional tasks
        4.2.1 Finalise the specifications for the trials
        4.2.2 Refine the estimates of PCFG/north mixing based on the 2009 photo-id data
        4.2.3 Coding and validation
        4.2.4 Conditioning
    4.3 Review of results, conclusions and work plan
5. Implications of new information on gray whale stock STRUCTURE (with BRG)
    5.1 Summary of relevant BRG discussions
    5.2 Conclusions with respect to *Implementation Review*
6. Annual review of management advice
    6.1 Common minke whales off West Greenland
    6.2 Common minke whales off East Greenland
    6.3 Fin whales off West Greenland
    6.4 Humpback whales off West Greenland
    6.5 Humpback whales off St Vincent and The Grenadines
7. Aboriginal Whaling Management Scheme
    7.1 Draft guidelines for *Implementations* and *Implementation Reviews*
    7.2 Scientific aspects of an aboriginal whaling scheme
8. Planning for a bowhead whale *Implementation Review* (with BRG)
    8.1 Summary of relevant BRG discussions
    8.2 Work plan
9. Progress on follow-up work on conversion factors for the Greenlandic hunt
10. Work plan
11. Adoption of Report

Appendix 2

ASSESSING POTENTIAL FOR SURVEY BIAS IN THE PCFG TIME SERIES OF ABUNDANCE

J. Brandon, A. Lang, J. Scordino and D. Weller

In discussion of SC/63/AWMP4, the question was posed as to whether the apparent pulse of external recruitment during 1999-2002 might have been due to survey bias. Survey bias could be generated by differences in effort over time or due to differences in the availability of whales over time.

Effort

Based on examination of Calambokidis (2010) and our understanding of survey effort included in that study, there seems to be no dramatic trends in effort over time, although some inter-annual variation has occurred. However, we did find a shift in effort through time in the sub-area of Northern California (NCA)[1]. This shift can be seen in table 7 of Calambokidis (2010) that shows whales seen annually by sub-area. The apparent pulse of early effort in NCA coincided with the Humboldt State (HSU) research group's survey effort during 1998-2002 (with a gap in HSU effort until 2008).

[1]The geographic area (41-52°N) for the proposed abundance estimates is slightly different than those for abundance estimates calculated in Calambokidis (2010), but does include NCA at its southern extent (see fig. 1 of Calambokidis, 2010).

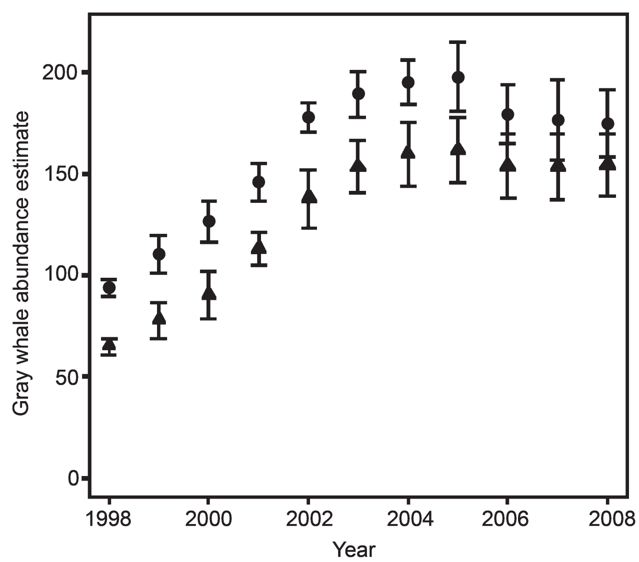

Fig. 1. From Laake (pers. comm.). Plot of PCFG (41-52°) (circle) and OR-NBC (triangle) abundance estimates from 1998-2008 with +/- 1 standard error bars. The OR-NBC abundance estimate excludes data from NCA. NBC=Northern British Colombia, which is at the northern extent of the proposed abundance estimates (see Calambokidis, 2010, fig. 1).

To better understand this issue, Jeff Laake was contacted via e-mail and asked the following question: 'What percentage of the 'Recruited' animals during 1998-2002 (and 2008) entered your updated abundance estimates via photos from NCA?' His response is as follows:

> '… there was effort in NCA and S. Oregon even though we hadn't contracted HSU because CRC[2] sampled in that area (John C[3] can verify that). Also, there is likely quite a bit of shifting in gray whale distribution between NCA and SOR[4]. Secondly, the pattern in the population estimates is the same even if you restrict the estimates to OR-SVI[5] region as shown in the plot I put together for the meeting (see Annex F, SC/63/Rep2). I also went ahead and ran the abundance estimates excluding NCA and you can see that the pattern is the same for it.'

> 'There was certainly a reduction in effort in some years (I believe it was in 2006 where NMML had no funding to provide) and there have also been shifts in whale distribution like in 2007 where whales went off in Oregon and were largely absent from SVI that typically produces the most sightings. However, I don't think this will affect the overall pattern greatly. The 'increase' is certainly influenced by discovery of whales that have been around and not seen, but using the sample of those seen prior to 1998 and not in 1998, this tapered off quickly with most added in 1999 and very few added past 2000'.

Availability

If the availability of whales has shifted through time (for example, if many PCFG whales consistently fed offshore until 1999, then began to use inshore waters more consistently), this could lead to bias in the time series of abundance estimates. Given the data available, however, it is difficult to quantify this hypothesis, and thus to judge its plausibility.

Genetics

If survey bias is not present, the high number of new whales observed in some years of the study suggests external recruitment into the PCFG. Given the high haplotype diversity in the ENP gray whale population, it is likely that recruits would carry haplotypes not previously found in the PCFG. The addition of haplotypes found in single animals into the PCFG sample set would not have a large effect on frequency-based analyses, suggesting that some immigration into the PCFG could occur while maintaining genetic differentiation from the northern feeding group. As well, while photo-identification data may pick up a pulse of new recruits within a season, there would be some time lag before the signature of that pulse is picked up in the genetics. This suggests that a recent and discrete pulse of new animals into the PCFG may not yet have had a large impact on estimates of genetic differentiation. However, it does not seem plausible that we would observe genetic differentiation between the PCFG and northern feeding whales if ~20 animals per year were recruited into the PCFG on a consistent basis.

To better assess the plausibility of these and other scenarios, we suggest that simulations (built on the TOSSM model) could be used in the future to assess the extent of external recruitment into the PCFG that could occur while maintaining genetic differentiation between the PCFG and northern feeding strata.

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[2]Cascadia Research Collective.
[3]John Calambokidis, Cascadia Research Collective.
[4]Southern Oregon.
[5]Oregon - Southern Vancouver Island.

Appendix 3

GRAY WHALE TRIALS SPECIFICATIONS

This document outlines a set of trials to evaluate the performance of *SLA*s for hunting in the Pacific Northwest, with a primary focus on the PCFG (Pacific Coast Feeding Group). The operating model assumes the two groups (the 'north' group and the PCFG) are separate stocks.

A. The population dynamics model

The underlying population dynamics model is deterministic, age- and sex-structured, and based on a two-stock version of the Baleen II model (Punt, 1999).

A.1 Basic dynamics

Equation A1.1 provides the underlying 1+ dynamics.

$$\begin{aligned} R^{s,m/f}_{t+1,a+1} &= (R^{s,m/f}_{t,a} + I^{s,m/f}_{t,a} - C^{s,m/f}_{t,a})\,\tilde{S}^s_t\,S_a + U^{s,m/f}_{t,a}\,\tilde{S}^s_t\,S_a\,\delta_{a+1} && 0 \le a \le x-2 \\ R^{s,m/f}_{t+1,x} &= (R^{s,m/f}_{t,x} + I^{s,m/f}_{t,x} - C^{s,m/f}_{t,x})\,\tilde{S}^s_t\,S_x + (R^{s,m/f}_{t,x-1} + I^{s,m/f}_{t,x-1} - C^{s,m/f}_{t,x-1})\,\tilde{S}^s_t\,S_{x-1} && \\ U^{s,m/f}_{t+1,a+1} &= U^{s,m/f}_{t,a}\,\tilde{S}^s_t\,S_a\,(1-\delta_{a+1}) && 0 \le a \le x-2 \end{aligned} \tag{A1.1}$$

$R^{s,m/f}_{t,a}$ is the number of recruited males/females of age *a* in stock *s* at the start of year *t*;

$U^{s,m/f}_{t,a}$ is the number of unrecruited males/females of age *a* in stock *s* at the start of year *t*;

$C^{s,m/f}_{t,a}$ is the catch of males/females of age *a* from stock *s* during year *t* (whaling is assumed to take place in a pulse at the start of each year);

δ_a is the fraction of unrecruited animals of age *a*-1 which recruit at age *a* (assumed to be independent of sex and stock);

S_a is the annual survival rate of animals of age *a* in the absence of catastrophic mortality events (assumed to be the same for males and females):

$$S_a = \begin{cases} S_0 & \text{if } a = 0 \\ S_{1+} & \text{if } 1 < a \end{cases} \tag{A1.2}$$

S_0 is the calf survival rate;

S_{1+} is the survival rate for animals aged 1 and older;

$\tilde{S}^s_t$ is the amount of catastrophic mortality (represented in the form of a survival rate) for stock *s* during year *t* (catastrophic events are assumed to occur at the start of the year before mortality due to whaling and natural causes; in general $\tilde{S}^s_t$ =1, i.e. there is no catastrophic mortality);

$I^{s,m/f}_{t,a}$ is the net migration of female/male animals of age *a* into stock *s* during year *t*; and

x is the maximum (lumped) age-class (all animals in this and the *x*-1 class are assumed to be recruited and to have reached the age of first parturition). *x* is taken to be 15 for these trials.

Catastrophic mortality is assumed to be zero (i.e., $\tilde{S}^s_t$ = 1) except for the north stock for 1999 and 2000 when it is assumed to be equal to the parameter $\tilde{S}$. This assumption reflects the large number of dead ENP gray whales observed stranded along the coasts of Oregon and Washington during 1999 and 2000 relative to annual numbers stranding there historically (Brownell *et al.*, 2007; Gulland *et al.*, 2005). The mortality event is assumed to have only impacted the north stock because the abundance estimates for the PCFG stock increased when the mortality event occurred in contrast to those for the north stock which declined substantially.

Immigration only occurs from the north stock to the PCFG stock and only animals aged 1+ immigrate. The annual number of animals immigrating is given by $I_t = \bar{I}\, N_t^{\text{north, 1+}}/20{,}000$ where $\bar{I}$ is the hypothesised recent average number of individuals recruiting into the PCFG from the north stock (i.e., 2, 4 or 6). The annual number of immigrants by age and sex is given by:

$$I^{s,m/f}_{t,a} = I_t \frac{N^{\text{north},m/\text{f}}_{t,a}}{\sum_{a=1}^{x}(N^{\text{north,m}}_{t,a} + N^{\text{north,f}}_{t,a})} \tag{A1.3}$$

A.2 Births

The number of births to stock *s* at the start of year *t*+1, B^s_{t+1}, is given by:

$$B^s_{t+1} = b^s_{t+1} N^{s,f}_{t+1} \tag{A2.1}$$

$N^{s,f}_t$ is the number of mature females in stock *s* at the start of year *t*:

$$N^{s,f}_t = \sum_{a=a_m}^{x} (R^{s,f}_{t,a} + U^{s,f}_{t,a}) \tag{A2.2}$$

a_m is the age-at-maturity (the convention of referring to the mature population is used here, although this actually refers to animals that have reached the age of first parturition);

b^s_{t+1} is the probability of birth/calf survival for mature females:

$$b^s_{t+1} = b_{-\infty}\{1 + A^s(1-(D^s_{t+1}/D^s_{-\infty})^{z^s})\} \tag{A2.3}$$

$b_{-\infty}$ is the average number of live births per year per mature female in the pristine (pre-exploitation) population;

A^s is the resilience parameter for stock *s*;

z^s is the degree of compensation for stock *s*;

D^s_t is the size of the component of stock *s* in year *t* upon which the density-dependence is assumed to act; and

$D^s_{-\infty}$ is the pristine size of the component of stock *s* upon which the density-dependence is assumed to act.

The number of female births, $B_t^{s,f}$, is computed from the total number of the births during year *t* according to the equation:

$$B^{s,f}_t = 0.5\, B^s_t \tag{A2.4}$$

The numbers of recruited/unrecruited calves is given by:

$$\begin{aligned} R^{s,f}_t &= \pi_0\, B^{s,f}_t & R^{s,m}_t &= \pi_0\,(B^s_t - B^{s,f}_t) \\ U^{s,f}_t &= (1-\pi_0)\, B^{s,f}_t & U^{s,m}_t &= (1-\pi_0)(B^s_t - B^{s,f}_t) \end{aligned} \tag{A2.5}$$

π_0 is the proportion of animals of age 0 which are recruited (0 for these trials).

For the trials $D_t^s = N_t^{s,1+}$ and $D^s_{-\infty} = K^{s,1+}$ because density-dependence is assumed to act on the 1+ component of the population and affects fecundity and infant survival. $N_t^{s,1+}$ and $K^{s,1+}$ are defined according to the equations:

$$N^{s,1+}_t = \sum_{a=1}^{x}(R^{s,\mathrm{f}}_{t,a} + U^{s,\mathrm{f}}_{t,a} + R^{s,\mathrm{m}}_{t,a} + U^{s,\mathrm{m}}_{t,a}) \qquad K^{s,1+} = \sum_{a=1}^{x}(R^{s,\mathrm{f}}_{-\infty,a} + U^{s,\mathrm{f}}_{-\infty,a} + R^{s,\mathrm{m}}_{-\infty,a} + U^{s,\mathrm{m}}_{-\infty,a}) \tag{A2.6}$$

A.3 Catches

The historical (*t*<2010) catches by stratum (north, south, PCFG December-May, and PCFG June-November) are taken to be equal to the reported catches (see Table 1). The historical catches are allocated to stocks in fixed proportions as follows.

(1) North area catches: all north animals.
(2) PCFG area catches in December-May: PCFG animals with probability ϕ_{PCFG} (base-case value 0.203, as determined by the photo-ID data).
(3) PCFG area catches in June-November: all PCFG animals.
(4) South area catches: PCFG animals with probability ϕ_{south} (base-case value 0.01, as determined by relative abundance).

Table 1

Historical catches of eastern north Pacific gray whales.

	South			PCFG Jun.-Nov.			PCFG Dec.-May			North			Total		
Year	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total
1930	0	0	0	0	0	0	0	0	0	23	24	47	23	24	47
1931	0	0	0	0	0	0	0	0	0	5	5	10	5	5	10
1932	5	5	10	0	0	0	0	0	0	5	5	10	10	10	20
1933	30	30	60	0	0	0	0	0	0	8	7	15	38	37	75
1934	30	30	60	0	0	0	0	0	0	36	30	66	66	60	126
1935	55	55	110	0	0	0	0	0	0	16	28	44	71	83	154
1936	43	43	86	0	0	0	0	0	0	50	62	112	93	105	198
1937	0	0	0	0	0	0	0	0	0	12	12	24	12	12	24
1938	0	0	0	0	0	0	0	0	0	32	32	64	32	32	64
1939	0	0	0	0	0	0	0	0	0	19	20	39	19	20	39
1940	0	0	0	0	0	0	0	0	0	56	69	125	56	69	125
1941	0	0	0	0	0	0	0	0	0	38	39	77	38	39	77
1942	0	0	0	0	0	0	0	0	0	60	61	121	60	61	121
1943	0	0	0	0	0	0	0	0	0	59	60	119	59	60	119
1944	0	0	0	0	0	0	0	0	0	3	3	6	3	3	6
1945	0	0	0	0	0	0	0	0	0	25	33	58	25	33	58
1946	0	0	0	0	0	0	0	0	0	14	16	30	14	16	30
1947	0	0	0	0	0	0	0	0	0	11	20	31	11	20	31
1948	0	0	0	0	0	0	0	0	0	7	12	19	7	12	19
1949	0	0	0	0	0	0	0	0	0	10	16	26	10	16	26
1950	0	0	0	0	0	0	0	0	0	4	7	11	4	7	11
1951	0	0	0	0	0	0	1	0	1	5	8	13	6	8	14
1952	0	0	0	0	0	0	0	0	0	17	27	44	17	27	44
1953	0	0	0	0	0	0	6	4	10	15	23	38	21	27	48
1954	0	0	0	0	0	0	0	0	0	14	25	39	14	25	39
1955	0	0	0	0	0	0	0	0	0	22	37	59	22	37	59
1956	0	0	0	0	0	0	0	0	0	45	77	122	45	77	122
1957	0	0	0	0	0	0	0	0	0	36	60	96	36	60	96
1958	0	0	0	0	0	0	0	0	0	55	93	148	55	93	148
1959	1	1	2	0	0	0	0	0	0	73	121	194	74	122	196
1960	0	0	0	0	0	0	0	0	0	58	98	156	58	98	156
1961	0	0	0	0	0	0	0	0	0	77	131	208	77	131	208
1962	4	0	4	0	0	0	0	0	0	55	92	147	59	92	151
1963	0	0	0	0	0	0	0	0	0	68	112	180	68	112	180
1964	15	5	20	0	0	0	0	0	0	75	124	199	90	129	219
1965	0	0	0	0	0	0	0	0	0	71	110	181	71	110	181
1966	15	11	26	0	0	0	0	0	0	80	114	194	95	125	220
1967	52	73	125	0	0	0	0	0	0	109	140	249	161	213	374
1968	41	25	66	0	0	0	0	0	0	48	87	135	89	112	201
1969	39	35	74	0	0	0	0	0	0	50	90	140	89	125	214
1970	0	0	0	0	0	0	0	0	0	71	80	151	71	80	151
1971	0	0	0	0	0	0	0	0	0	57	96	153	57	96	153
1972	0	0	0	0	0	0	0	0	0	61	121	182	61	121	182
1973	0	0	0	0	0	0	0	0	0	97	81	178	97	81	178
1974	0	0	0	0	0	0	0	0	0	94	90	184	94	90	184
1975	0	0	0	0	0	0	0	0	0	58	113	171	58	113	171
1976	0	0	0	0	0	0	0	0	0	69	96	165	69	96	165
1977	0	0	0	0	0	0	0	0	0	87	100	187	87	100	187
1978	0	0	0	0	0	0	0	0	0	94	90	184	94	90	184
1979	0	0	0	0	0	0	0	0	0	58	125	183	58	125	183
1980	0	0	0	0	0	0	0	0	0	53	129	182	53	129	182
1981	0	0	0	0	0	0	0	0	0	36	100	136	36	100	136
1982	0	0	0	0	0	0	0	0	0	57	111	168	57	111	168
1983	0	0	0	0	0	0	0	0	0	46	125	171	46	125	171
1984	0	0	0	0	0	0	0	0	0	59	110	169	59	110	169
1985	0	0	0	0	0	0	0	0	0	54	116	170	54	116	170
1986	0	0	0	0	0	0	0	0	0	46	125	171	46	125	171
1987	0	0	0	0	0	0	0	0	0	48	111	159	48	111	159
1988	0	0	0	0	0	0	0	0	0	43	108	151	43	108	151
1989	0	0	0	0	0	0	0	0	0	61	119	180	61	119	180
1990	0	0	0	0	0	0	0	0	0	67	95	162	67	95	162
1991	0	0	0	0	0	0	0	0	0	67	102	169	67	102	169
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	21	23	44	21	23	44
1995	0	0	0	0	0	0	0	0	0	48	44	92	48	44	92
1996	0	0	0	0	0	0	0	0	0	18	25	43	18	25	43
1997	0	0	0	0	0	0	0	0	0	48	31	79	48	31	79
1998	0	0	0	0	0	0	0	0	0	64	61	125	64	61	125
1999	0	0	0	0	0	0	0	1	1	69	54	123	69	55	124
2000	0	0	0	0	0	0	0	0	0	63	52	115	63	52	115

Cont.

Table 1. (cont.)

	South			PCFG Jun.-Nov.			PCFG Dec.-May			North			Total		
Year	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total
2001	0	0	0	0	0	0	0	0	0	62	50	112	62	50	112
2002	0	0	0	0	0	0	0	0	0	80	51	131	80	51	131
2003	0	0	0	0	0	0	0	0	0	71	57	128	71	57	128
2004	0	0	0	0	0	0	0	0	0	43	68	111	43	68	111
2005	0	0	0	0	0	0	0	0	0	49	75	124	49	75	124
2006	0	0	0	0	0	0	0	0	0	57	77	134	57	77	134
2007	0	0	0	0	1	1	0	0	0	50	81	131	50	82	132
2008	0	0	0	0	0	0	0	0	0	64	66	130	64	66	130
2009	0	0	0	0	0	0	0	0	0	59	57	116	59	57	116
Total	**330**	**313**	**643**	**0**	**1**	**1**	**7**	**5**	**12**	**3,715**	**5,345**	**9,060**	**4,052**	**5,664**	**9,716**

The future catches by stratum are incidental catches and the catches arising from application of the *SLA*s. Subsistence catches are only assumed to occur in the north and the PCFG area from December-May. The sex-ratio of future catches is assumed to be 50:50. The catches are allocated to stock as outlined above, except that the subsistence catches from the PCFG area in June-November are modelled individually. Thus, the catch from the PCFG area is allocated to the PCFG stock based on Bernoulli trials with probability:

$$\frac{\sum_{m/f}\sum_{a'} R^{\text{PCFG,m/f}}_{y,a'}}{\delta\sum_{m/f}\sum_{a''} R^{\text{north,m/f}}_{y,a''}+\sum_{a''} R^{\text{PCFG,m/f}}_{y,a''}} \tag{A3.1}$$

where δ is the relative probability of harvesting a PCFG versus a north animal had the sizes of the two populations been the same. δ is calculated from ϕ under the assumption that the number of PCFG animals is 200 and north animals is 20000, i.e:

$$\delta = (200/\phi - 200)/20000 \tag{A3.2}$$

The incidental catches by stratum for the historical period are computed using the equation:

$$C^{\text{I}/s}_y = \begin{cases} 0.5\left\{p^I - \frac{p^I-1}{69}[y-1999]\right\}\bar{C}^I & \text{if } y \le 1999 \\ \bar{C}^I & \text{otherwise} \end{cases} \tag{A3.3}$$

$C^{\text{I}/s}_y$ is the incidental catch of animals of sex *s* during year *y*;

$\bar{C}^I$ is the mean catch in the stratum (see Table 2).

The catches from the PCFG and north stocks are then allocated to age and size using the formula:

$$C^{s,\text{m}}_{t,a} = C^{s,\text{m}}_t R^{s,\text{m}}_{y,a} / \sum_{a''} R^{s,\text{m}}_{y,a''}; \qquad C^{s,\text{f}}_{t,a} = C^{s,\text{f}}_t R^{s,\text{f}}_{y,a} / \sum_{a''} R^{s,\text{f}}_{y,a''}; \tag{A3.4}$$

The probability of not identifying a PCFG whale as such, is p_2, (base-case value 0) while the probability of incorrectly identifying a north whale as a PCFG whale is p_1 (base-case 0.01). If the survey frequency is not annual, p_2 is defined as:

$$p_{2,t} = 1 - \frac{\sum_{a\ge SF}(R^{\text{north,m}}_{t,a} + R^{\text{north,f}}_{t,a} + U^{\text{north,m}}_{t,a} + U^{\text{north,f}}_{t,a})}{\sum_{a\ge 1}(R^{\text{north,m}}_{t,a} + R^{\text{north,f}}_{t,a} + U^{\text{north,m}}_{t,a} + U^{\text{north,f}}_{t,a})} \tag{A3.5}$$

where SF is the survey frequency for the PCFG area.

Table 2

Average historical incidental catches.

Stratum	Average incidental catch
North	0[1]
PCFG [Dec.-May]	2
PCFG [Jun.-Nov.]	1.4[2]
South	3.4

[1]Obviously not actually zero, but will be small relative to population size.
[2]Includes southern whales during June-November as these whales are almost certainly PCFG animals.

A.4 Recruitment

The proportion of animals of age *a* that would be recruited if the population was pristine is a knife-edged function of age at age 0, i.e.:

$$\pi_a = \begin{cases} 0 & \text{if} \quad a = 0 \\ 1 & \text{otherwise} \end{cases} \tag{A4.1}$$

The (expected) number of unrecruited animals of age *a* that survive to age *a*+1 is $U_{t,a}^{s,m/f}\, S_a$. The fraction of these that then recruit is:

$$\delta_{a+1} = \begin{cases} [\pi_{a+1} - \pi_a]/[1-\pi_a] & \text{if } 0 \le \alpha_a < 1 \\ 1 & \text{otherwise} \end{cases} \tag{A4.2}$$

A.5 Maturity

Maturity is assumed to be a knife-edged function of age at age a_m.

A.6 Initialising the population vector

The numbers at age in the pristine population are given by:

$$\begin{aligned} R_{-\infty,a}^{s,\text{m/f}} &= 0.5 \;\; N_{-\infty,0}^{s} \;\; \pi_a \prod_{a'=0}^{a-1} S_{a'} && \text{if} \quad 0 \le a < x \\ U_{-\infty,a}^{s,\text{m/f}} &= 0.5 \;\; N_{-\infty,0}^{s} \;\; (1-\pi_a) \prod_{a'=0}^{a-1} S_{a'} && \text{if} \quad 0 \le a < x \\ R_{-\infty,x}^{s,\text{m/f}} &= 0.5 \;\; N_{-\infty,0}^{s} \prod_{a'=0}^{x-1} \frac{S_{a'}}{(1-S_x)} && \text{if} \quad a = x \end{aligned} \tag{A6.1}$$

$R_{-\infty,a}^{s,\text{m/f}}$ is the number of animals of age *a* that would be recruited in the pristine population;

$U_{-\infty,a}^{s,\text{m/f}}$ is the number of animals of age *a* that would be unrecruited in the pristine population; and

$N_{-\infty,0}^{s}$ is the total number of animals of age 0 in the pristine population.

The value for $N^s_{-\infty,0}$ is determined from the value for the pre-exploitation size of the 1+ component of the population using the equation:

$$N_{-\infty,0}^{s} = K^{s,1+} \Bigg/ \left(\sum_{a=1}^{x-1} \left(\prod_{a'=0}^{a-1} S_{a'} \right) + \frac{1}{1-S_x} \prod_{a'=0}^{x-1} S_{a'} \right) \tag{A6.2}$$

It is well-known that it is not possible to make a simple density-dependent population dynamics model consistent with the abundance estimates for the eastern north Pacific stock of gray whales (Butterworth *et al.*, 2002; Cooke, 1986; Lankester and Beddington, 1986; Reilly, 1981; 1984). This is why recent assessments of this stock (Punt and Wade, 2010) have been based on starting population projections from a more recent year (denoted as τ) than that in which the first recorded catch occurred. The trials are therefore based on the assumption that the age-structure at the start of τ=1930 is stable rather than that the population was at its pre-exploitation equilibrium size at the start of 1600, the first year for which catch estimates are available. The choice of 1930 for the first year of the simulation is motivated by the fact that the key assessment results are not sensitive to a choice for this year from 1930-1968 (Punt and Butterworth, 2002; Punt and Wade, 2010). Note that even though the operating model ignores the catch data for 1600-1929, these catches are nevertheless provided to the *SLA* for the north area.

The determination of the age-structure at the start of 1930 involves specifying the effective 'rate of increase', γ, that applies to each age-class. There are two components contributing to γ, one relating to the overall population rate of increase (γ^+) and the other to the exploitation rate. Under the assumption of knife-edge recruitment to the fishery at age 1, only the γ^+ component (assumed to be zero following Punt and Butterworth, 2002) applies to ages *a* of age 0. The number of animals of age *a* at the start of τ=1930 relative to the number of calves at that time, $N_{\tau,a}^{s,*}$, is therefore given by the equation:

$$N_{\tau,a}^{s,*} = \begin{cases} 1 & \text{if } a = 0 \\ N_{\tau,0}^{s,*}\, S_0^s & \text{if } a \le 1 \\ N_{\tau,a-1}^{s,*}\, S_{a-1}^s\,(1-\gamma^+) & \text{if } 1 < a < x \\ N_{\tau,x-1}^{s,*}\, S_{x-1}^s (1-\gamma^+)/(1-S_x^s\,(1-\gamma^+)) & \text{if } a = x \end{cases} \tag{A6.3}$$

B_τ^s is the number of calves in year τ (=1930) and is derived directly from equations A2.1 and A2.3 (for further details see Punt, 1999):

$$B_\tau^s = \left(1 - \left[1/(N_\tau^{s,f} b_{-\infty^s}) - 1\right]/A^s\right)^{1/z^s} \frac{D_{-\infty}^s}{D_\tau^{s,*}} \quad \text{(A6.4)}$$

$D_\tau^{s,*}$ is the number of animals in the density dependent component of the population relative to the number of births at that time (see equation A2.6).

The effective rate of increase, γ, is selected so that if the population dynamics model is projected from 1930 to 1968, the size of the 1+ component of the population (both stocks) in 1968 equals a pre-specified value, P_{1968}.

A.7 z and A
A^s, z^s and S_0, are obtained by solving the system of equations that relate *MSYL*, *MSYR*, S_0, S_{1+}, $f_{\max}$ a_m, A^s and z^s, where $f_{\max}$ is the maximum theoretical pregnancy rate (Punt, 1999).

A.8 Conditioning
The method for conditioning the trials (i.e. selecting the 100 sets of values for the parameters a_m, S_0, S_{1+}, $\tilde{S}$, K_{1+}^{NORTH}, K_{1+}^{PCFG}, A^{NORTH}, A^{PCFG}, Z^{NORTH} and z^{PCFG}) is based on a Bayesian assessment of the eastern North Pacific stock of gray whales (Punt and Butterworth, 2002; Wade, 2002). The algorithm for conducting the Bayesian assessment is as follows.

Table 3
The prior distributions for the eastern north Pacific stock of gray whales.

Parameter	Prior distribution
Non-calf survival rate, S_{1+}	U[0.95, 0.999]
Age-at-maturity, a_m	U[6, 12]
K_{1+}^{NORTH}	U[16,000, 70,000]
K_{1+}^{PCFG}	U[100, 500]
Maximum pregnancy rate, $f_{\max}$	U[0.3, 0.6]
Additional variation (population estimates), CV_{add}, in 1968	U[0, 0.35]
1968 abundance, P_{1968}^{NORTH}	U[8,000, 16,000]
1968 abundance, P_{1968}^{PCFG}	U[50, 300]
Catastrophic mortality, $\tilde{S}$	U[0.2,1.0]

(a) Draw values for the parameters S_{1+}, $f_{\max}$, a_m, K_{1+}^{NORTH}, K_{1+}^{PCFG}, P_{1968}^{NORTH}, $\tilde{S}$, CV_{add}^{NORTH} (the additional variance for the estimate of 1+ abundance Carmel, California in 1968), CV_{add}^{PCFG} (the additional variance for the estimate of 1+ abundance from North California to Southeast Alaska in 1968 – had such a survey taken place) from the priors in Table 3. It is not necessary to draw values for $MSYR_{1+}$ and $MSYL_{1+}$ because the values for these quantities are pre-specified rather than being determined during the conditioning process.

(b) Solve the system of equations that relate $MSYL_{1+}{}^s$, $MSYR_{1+}{}^s$, S_0, S_{1+}, $f_{\max}$, a_m, A^s and z^s to find values for S_0, A^s and z^s.

(c) Calculate the likelihood of the projection for each area, given by

$$-\ell nL = 0.5\ell n\,|\mathbf{V}+\Omega| + 0.5\sum_i\sum_j(\ell nN_i^{\text{obs}} - \ell n\hat{P}_i^{1+})[(\mathbf{V}+\Omega)^{-1}]_{i,j}(\ell nN_j^{\text{obs}} - \ell n\hat{P}_j^{1+}) \quad \text{(A8.1)}$$

N_i^{obs} is the i^{th} estimate of abundance[1] (Tables 4a, 4b),

$\hat{P}_i$ is the model-estimate corresponding to N_i^{obs},

V is the variance-covariance matrix for the abundance estimates, and

Ω is a diagonal matrix with elements given by $E(CV_{add,t}^2)$:

[1]The shore-based abundance estimate for year *y*/*y*+1 is assumed to pertain to abundance at the start of year *y*+1.

$$E(CV^2_{add,t}) = \eta(0.1 + 0.013P^* / \hat{P}_t) = CV^2_{add} \frac{0.1 + 0.013P^* / \hat{P}_t}{0.1 + 0.013P^* / \hat{P}_{1968}} \quad \text{(A8.2)}$$

(a) Steps (a)-(c) are repeated a large number (typically 1,000,000) of times.

(b) 100 sets of parameters vectors are selected randomly from those generated using steps (a)-(c), assigning a probability of selecting a particular vector proportional to its likelihood. The number of times steps (a)-(c) are repeated is chosen to ensure that each of the 100 parameter vectors are unique.

The expected value for the estimate of abundance of the north area is taken to the total abundance (PCFG and north stocks combined) while the abundance estimates for the PCFG area are assumed to pertain to the PCFG stock.

B. Data generation

B.1 Absolute abundance estimates

The historic (t<2010) abundance estimates (and their CVs) are provided to the *SLA* and are taken to be those in Tables 4a and 4c. Future estimates of absolute abundance (and their estimated CVs) are generated and provided to the *SLA* once every F years during the management period (starting in year 2011 where F=10 for the northern area and F=1 for the PCFG area). The CV of the abundance estimate (CV_{true}) may be different from the CV provided to the *SLA* (further details are provided below).

The survey estimate, $\hat{S}$, may be written as:

$$\hat{S} = B_A PY w / \mu = B_A P^* \beta^2 Y w \quad \text{(B1.1)}$$

B_A is the bias (the bias for the bulk of the simulations for the north area is 1 while the bias for PCFG area is generated from $\ell n B_A \sim N(-0.335, 0.112)$ – this bias reflects the difference between the abundance estimates on which the ABL is based [which pertain to Oregon to Southern Vancouver Island] and the abundance of the entire stock];

P is the current total 1+ population size ($= N_t^{1+}$); (B1.2)

Y is a lognormal random variable: $Y = e^{\phi}$ where: $\phi \sim N[0; \sigma_\phi^2]$ and $\sigma_\phi^2 = \ell n(1+\alpha^2)$ (B1.3)

w is a Poisson random variable, independent of Y, with $E(w) = \text{var}(w) = \mu = (P / P^*) / \beta^2$; and (B1.4)

P^* is the reference population level (the pristine 1+ population, $= K^{1+}$).

Note that under the approximation $CV^2(ab) = CV^2(a) + CV^2(b)$,

$$E(\hat{S}) = B_A P_t \text{ and } CV^2_{true}(\hat{S}) = \alpha^2 + \beta^2 P^* / P \quad \text{(B1.5)}$$

The steps used in the program to generate the abundance estimates and their CVs are given below[2].

The *SLA* is provided with estimates of CV_{est} (the estimation error associated with factors considered historically) for each future sightings estimate.

The estimate of $CV_{est,t}$ is given by:

$$\hat{C}V_{est,t} = \sqrt{\sigma_t^2 (\chi_n^2 / n)} \qquad \sigma_t^2 = \ell n(1 + E(CV^2_{est,t})) \quad \text{(B1.6)}$$

$E(CV^2_{est,t})$ is the sum of the squares of the actual CVs due to estimation error:

$$E(CV^2_{est,t}) = \theta^2 (a^2 + b^2 / w\beta^2) \quad \text{(B1.7)}$$

χ_n^2 is a random number from a χ^2 distribution with n (=19; the value assumed for the single stock trials for the RMP) degrees of freedom;

[2]The steps used to generate estimates of abundance and their CVs are as follows (steps (i)-(iii) are part of the conditioning process).

(i) Read in CV_{est} (basecase value= 0.075 = value used to generate the 1968 abundance). Generate values of CV^2_{add} for 1968.

(ii) Set η using equation B1.8b and the value of CV_{add} generated in step (i).

(iii) Set θ_2 using equation B1.7a and the values for CV_{est} from step (i) and $w\beta^2 = P / P^* = P_{1968} / P^*$. Set α_2 and β_2 using equation B1.9.

(iv) Generate w (Poisson random variable – see equation B1.4) and ϕ (lognormal random variable – see equation B1.3).

(v) Set abundance estimate $\hat{S}$ using equation B1.1.

(vi) Set $E(CV^2_{est,t})$ using equation B1.7a.

(vii) Generate $\hat{C}V_{est,t}$ from a χ^2_n distribution using equation B1.6a.

a^2, b^2 are constants and equal to 0.02 and 0.012 respectively.

The relationship between CV_{est} and CV_{true} is given by:

$$\eta = [E(CV_{true}^2) - E(CV_{est}^2)] / (0.1 + 0.013P^* / P) \quad \text{(B1.8a)}$$

where η is a constant known as the additional variance factor. The value of η is based on the population size and CVs for 1968 (for consistency with the way the CV for P_{1968} is generated in Table 3):

$$\eta = CV_{add}^2 / (0.1 + 0.013P^* / P_{1968}) \quad \text{(B1.8b)}$$

The values of α and β are then computed as:

$$\alpha^2 = \theta^2 a^2 + \eta\, 0.1\,, \qquad \beta^2 = \theta^2 b^2 + \eta\, 0.013 \quad \text{(B1.9)}$$

Table 4a

Estimates of absolute abundance (with associated standard errors) for the eastern north Pacific stock of gray whales based on shore counts (source: Laake *et al*, 2010).

Year	Estimate	CV	Year	Estimate	CV
1967/68	13,426	0.094	1979/80	19,763	0.083
1968/69	14,548	0.080	1984/85	23,499	0.089
1969/70	14,553	0.083	1985/86	22,921	0.081
1970/71	12,771	0.081	1987/88	26,916	0.058
1971/72	11,079	0.092	1992/93	15,762	0.067
1972/73	17,365	0.079	1993/94	20,103	0.055
1973/74	17,375	0.082	1995/96	20,944	0.061
1974/75	15,290	0.084	1997/98	21,135	0.068
1975/76	17,564	0.086	2000/01	16,369	0.061
1976/77	18,377	0.080	2001/02	16,033	0.069
1977/78	19,538	0.088	2006/07	19,126	0.071
1978/79	15,384	0.080			

Table 4b

Estimates of absolute abundance (with associated standard errors) for 41°-52°N (source: J. Laake, pers. commn).

Year	Estimate	CV	Year	Estimate	CV
1998	104	0.044	2004	206	0.058
1999	122	0.082	2005	205	0.087
2000	146	0.072	2006	188	0.083
2001	170	0.061	2007	186	0.106
2002	198	0.039	2008	194	0.087
2003	204	0.063			

Table 4c

Estimates of absolute abundance (with associated standard errors) for the Oregon to southern Vancouver Island (source: J. Laake, pers. commn).

Year	Estimate	CV	Year	Estimate	CV
1998	65	0.061	2004	160	0.097
1999	78	0.113	2005	162	0.098
2000	90	0.130	2006	154	0.104
2001	113	0.071	2007	153	0.105
2002	137	0.104	2008	154	0.099
2003	153	0.085			

C. Need

The level of need in each year, Q_t, will be supplied to the *SLA*. The need is given by $Q_t = Q_{2010} + \frac{t-2010}{100}(Q_{2110} - Q_{2010})$ where Q_{2010} (=150/7 for the north and PCFG areas respectively) is the need at the start of the first year in which the AWMP is applied and Q_{2110} is the value 100 years later. The level of need supplied.

D. Implementing the Makah harvest regime
The overall application of the Makah management regime is as follows.

(1) Compute the ABL (Allowable Bycatch Limit of PCFG whales).

(2) Strike an animal.

(3) If the animal is struck-and lost in December-April[3]:

(a) if the total number of struck and lost animals is 3, stop the hunt;

(b) if the total number of struck animals equals the need of 7 stop the hunt;

(b) go to step (2).

(4) If the animal is struck-and lost in May:

(a) add one to the number of whales counted towards the ABL;

(b) if the ABL is reached, stop the hunt;

(c) if the total number of struck and lost animals is 3, stop the hunt;

(d) if the total number of struck animals equals the need of 7, stop the hunt;

(e) go to step (2).

(5) If the animal is landed and is matched against the catalogue[4]:

(a) add one to the number of whales counted towards the ABL;

(b) if the ABL is reached, stop the hunt;

(c) if the total number of landed whales equals 5, stop the hunt;

(d) if the total number of struck animals equals the need of 7, stop the hunt;

(e) if the number of landed whales for the current five-year block equals 20, stop the hunt;

(f) go to step (2).

(6) If the animal is landed and does not match any whale in the catalogue:

(a) if the total number of landed whales equals 5, stop the hunt;

(b) if the total number of struck animals equals the need of 7, stop the hunt;

(c) if the number of landed whales for the current five-year block equals 20, stop the hunt;

(d) go to step (2).

E. Statistics
The risk- and recovery-related performance statistics are computed for the mature female and for the total (1+) population sizes (i.e. P_t is either the size of the mature female component of the population, N^f_t, or the size of the total (1+) population, N_t^{1+}). P_t^* is the population size in year t under a scenario of zero strikes in the northern and PCFG area (but allowing for incidental catches) over the years $t \geq 2010$ (defined as $t=0$ below), P_t^{**} is the population size in year t under a scenario of zero strikes in the PCFG area (but allowing for incidental catches and strikes in the north area) over the years $t \geq 2010$ (defined as $t=0$ below), and K_t^* is the population size in year t if there had never been any harvest.

The trials are based on a 100-year time horizon, but a final decision regarding the time horizon will depend *inter alia* on interactions between the Committee and the Commission regarding need envelopes and on the period over which recovery might occur. To allow for this, results are calculated for T=20 and 100.

Statistics marked in bold face have previously been considered the more important. Note that the statistic identification numbers have not been altered for reasons of consistency. Hence, there are gaps in the numbers where some statistics have been deleted.

E.1 Risk
D1. Final depletion: P_T/K. In trials with varying K this statistic is defined as P_T/K_t^*.

[3]Whether a whale is struck and lost is determined from a Bernoulli trial with probability 0.5 (base-case).
[4]PCFG whales are mismatched as north stock whales with probability p_2 while north stock whales are matched to the catalogue with probability p_1.

D2. Lowest depletion: $\min(P_t / K)$: $t = 0,1,\ldots,T$. In trials with varying K this statistic is defined as $\min(P_t / K_t^*)$: $t = 0,1,\ldots,T$.

D6. Plots for simulations 1-100 of $\{P_t : t = 0,1,..,T\}$, $\{P_t^*: t = 0,1,..,T\}$, $\{P_t^{**}: t = 0,1,..,T\}$.

D7. Plots of $\{P_{t[x]}: t = 0,1,..,T\}$ $\{P_t^*{}_{[x]}: t = 0,1,..,T\}$ and $\{P_t^{**}{}_{[x]}: t = 0,1,..,T\}$ where $P_{t[x]}$ is the xth percentile of the distribution of P_t. Results are presented for $x = 5$ and $x = 50$.

D8. Rescaled final population: P_T/P_T^* and P_T/P_T^{**}.

D9. Minimum population level in terms of mature females, $\min(P_t)$: $t = 0,1,\ldots,T$.

D10. Relative increase P_T/P_0.

E.2 Need (for PCFG, statistics N1-N12 will be computed for the total number of strikes as well as the number of landed animals).

N1. Total need satisfaction: $\sum_{t=0}^{T-1} C_t / \sum_{t=0}^{T-1} Q_t$

N2. Length of shortfall = (negative of the greatest number of consecutive years in which $C_t < Q_t$) / T.

N4. Fraction of years in which $C_t = Q_t$.

N5. Proportion of block need satisfaction: $\Gamma/(T-h+1)$ where Γ is the number of blocks of h years in which the total catch equals the total need; h is 5 for these trials.

N7. Plot of $\{V_{t[x]}$: t=0,1, T - 1$\}$ where $V_{t[x]}$ is the xth percentile of the distribution of $V_t = C_t / Q_t$ [catch for the PCFG area].

N8. Plots of V_t for simulations 1-100.

N9. Average need satisfaction: $\frac{1}{T}\sum_{t=0}^{T-1}\frac{C_t}{Q_t}$

N10. AAV (Average Annual Variation): $\sum_{t=-1}^{T-2}\left|C_{t+1} - C_t\right| / \sum_{t=-1}^{T-2} C_t$

N11. Anti-curvature: $\frac{1}{T-1}\sum_{t=0}^{T-2}\left|\frac{C_t - M_t}{\max(10, M_t)}\right|$ where $M_t = (C_{t+1} + C_{t-1}) / 2$

N12. Mean downstep (or modified AAV): $\sum_{t=-1}^{T-2}\left|\min(C_{t+1} - C_t, 0)\right| / \sum_{t=-1}^{T-2} C_t$

N13. Average annual number of animals landed.

N14. Average annual number of animals struck and lost.

N15. Ray plot. For each simulation, make a line plot of cumulative absolute year-to-year quota changes versus time (x-axis). Superimpose all these rays.

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Appendix 4

GREENLANDIC RESPONSE TO 'ITEM 9.1 CONVERSION FACTORS FOR EDIBLE PRODUCTS FOR GREENLAND FISHERIES' FROM THE IWC SCIENTIFIC COMMITTEE MEETING, 2010

Ministry of Fisheries, Hunting and Agriculture, Government of Greenland

The SWG requested Greenland to provide information on its sampling scheme and data validation protocols at this year's SC meeting.

Shortly after the 62nd Annual IWC meeting, a meeting between hunters, scientists, wildlife officers and managers concerning a revised sampling scheme resulted in a suggestion of using bins for the collection of the three types of edible products, weighing one and counting how many times it was filled with each product as a way of validating the total weight measurements.

This suggestion was implemented by including it in the Executive Order (nr. 11, 16 July 2010) regulating the hunt on large whales. Normally, it takes at least three months to prepare a new executive order due to the hearing process. Because of its importance, the Greenland Cabinet made a decision to implement the executive order with a shorter hearing process.

Furthermore an instruction on how to collect relevant data has been made to the wildlife officers following a hunt and a flensing situation on bowhead and humpback whales.

Focusing on the largest species, since the implementation of the extended sampling scheme 10 humpback whales (9 in 2010 and 1 in 2011), 2 fin whales (2010) and 1 bowhead whale (2011) have been caught in Greenland. Of these 13 catches, wildlife officers were able to follow the hunt of the bowhead whale and 2 humpback whale catches. During the last three hunting seasons all 7 bowhead whale caught in Greenland have been followed by wildlife officers and/or scientists/managers resulting in a working paper presented at IWC and a scientific paper under review. This covering has required a high level of effort and resources from the wildlife officers and the scientist/managers involved.

The Greenland Institute of Natural Resources are planning to have 2-3 persons collecting samples from this years hunt on humpback whales in Mid-Greenland (3 animals). During this field work an effort for estimating bin weight of the three types of edible products will also be prioritised. The plan is to extend this work to fin whales and minke whales.

Experience, especially on challenges of organising the practicalities so far, shows that this revised data collection will have to run for quite some years before an appropriate sample size is reached.

Report of the Scientific Committee

The meeting was held at El Panama Hotel and Conference Centre, Panama from 11-23 June 2012 and was chaired by Debra Palka. A list of participants is given as Annex A.

1. INTRODUCTORY ITEMS

1.1 Chair's welcome and opening remarks
The Chair welcomed the participants to the 2012 IWC Scientific Committee meeting noting that the Committee faced a long and complex Agenda this year. In particular, she thanked the Government of Panama for providing the facilities for this year's meeting and the IWC Commissioner for Panama, Tomas Guardia for his assistance. The Committee paused in silence for Alexandre de Lichtervelde, the previous Commissioner from Belgium who had been deeply involved in the issue of ship strikes, and Frank Hester, a long time Scientific Committee member, who had both sadly passed away since the last meeting. They both will be greatly missed.

Simon Brockington, the Executive Secretary to the IWC, addressed the meeting on behalf of the Commission to convey a message of gratitude. He noted that the Scientific Committee is rightly regarded as one of the foremost international fora dedicated to cetaceans, and that this reputation stemmed from the quality of research conducted by the participants. He hoped that the meeting would be productive both in terms of providing advice to the Commission, but also in allowing knowledge to be gained and shared between participants so as to allow improved research in the future. He wished all participants a successful meeting.

On behalf of the Government of Panama, Giovanni Lauri, the Administrator General of the Aquatic Resources Authority of Panama (ARAP) addressed the Committee and welcomed the participants to Panama. He hoped that everyone would enjoy their time in Panama City and wished the meeting every success.

1.2 Appointment of rapporteurs
Donovan was appointed rapporteur with assistance from various members of the Committee as appropriate. Chairs of sub-committees and Working Groups appointed rapporteurs for their individual meetings.

1.3 Meeting procedures and time schedule
Brockington summarised the meeting arrangements and information for participants. The Committee agreed to follow the work schedule prepared by the Chair.

1.4 Establishment of sub-committees and working groups
As intimated last year, (IWC, 2012f, p.59) and included in the draft agenda, a pre-meeting of the Standing Working Group on Environmental Concerns met from 9-10 June 2012 in Panama City to consider interactions between marine renewable energy developments and cetaceans. Its report is given as SC/64/Rep6.

A number of sub-committees and Working Groups were established. Their reports were either made annexes (see below) or subsumed into this report (see Items 17 and 19).

Annex D – Sub-Committee on the Revised Management Procedure (RMP);
Annex D1 – Working Group on the *Implementation Review* of Western North Pacific common minke whales (NPM);
Annex E – Standing Working Group on an Aboriginal Whaling Management Procedure (AWMP);
Annex F – Sub-Committee on Bowhead, Right and Gray Whales (BRG);
Annex G – Sub-Committee on In-Depth Assessments (IA);
Annex H – Sub-Committee on Other Southern Hemisphere Whale Stocks (SH);
Annex I – Working Group on Stock Definition (SD);
Annex J – Working Group on Estimation of Bycatch and other Human-Induced Mortality (BC);
Annex K – Standing Working Group on Environmental Concerns (E);
Annex K1– Working Group to Address Multi-species and Ecosystem Modelling Approaches (EM);
Annex L – Standing Sub-Committee on Small Cetaceans (SM);
Annex M – Sub-Committee on Whalewatching (WW); and
Annex N – Working Group on DNA (DNA).

1.5 Computing arrangements
Allison outlined the computing and printing facilities available for delegate use.

2. ADOPTION OF AGENDA

The Adopted Agenda is given as Annex B1. Statements on the Agenda are given as Annex R. The Agenda took into account the priority items agreed last year and approved by the Commission (IWC, 2012a, pp.27-29). Annex B2 links the Committee's Agenda with that of the Commission.

3. REVIEW DATA, DOCUMENTS AND REPORTS

3.1 Documents submitted
Donovan noted that the pre-registration procedure, coupled with the availability of electronic papers, had again been successful. With such a large number of documents, pre-specifying papers had reduced the amount of photocopying and unnecessary paper dramatically. He was pleased to note that this year the percentage of people opting to receive their papers entirely electronically had continued to grow. As last year, the Secretariat provided participants with a memory stick with all of the papers that had been received by the official deadline. Revised or new papers and reports were uploaded onto the IWC website. The list of documents is given as Annex C. The issue of electronic papers is discussed further under Item 24.

3.2 National Progress Reports on research
The Committee is in the transition phase from receiving paper Progress Reports to online submission into a database. A Working Group was established to facilitate this process and its report is given as Annex O. The Committee **reaffirms** its view of the importance of national Progress Reports and **recommends** that the Commission continues to urge member nations to submit them following the new online system. It thanks the Secretariat and especially Tandy and Miller for their development work on the portal.

Table 1
List of data and programs received by the IWC Secretariat since the 2011 meeting.

Date	From	IWC ref.	Details
Catch data from the previous season			
08/07/11	St Vincent: R. Ryan	E103 Cat2011	Information on the St. Vincent and The Grenadines humpback harvest 2011 season.
01/03/12	Canada: A. McMaster	E103 Cat2011	Information on the Canadian bowhead harvest 2011 season.
30/03/12	Iceland: E. Thordarson	E103 Cat2011	Individual catch records from the Icelandic commercial catch 2011.
22/05/12	Russia: R.G. Borodin	E103 Cat2011	Individual catch records from the aboriginal harvest in the Russian Federation in 2011.
24/05/12	Norway: N. Øien	E103 Cat2011	Individual minke records from the Norwegian 2011 commercial catch. Access restricted (specified 14/11/00).
11/06/12	Japan: S. Hiruma	E103 Cat2011	Individual data for Japan special permit catch, 2011, N Pacific (JARPN II) and 2011/12, Antarctic (JARPA II).
Other catch data			
10/04/12	Canada: J. Ford	E105	Comparison of N Pacific catch data held by Canada with the IWC database, including 1,471 new individual records.
Sightings data			
01/12/11	K. Matsuoka	E102	2011 POWER cruise sightings data.
22/12/11	K. Matsuoka	E102	Data from the JARPN II sighting survey in the North Pacific 2011 (Matsuoka *et al.*, 2011); inc. sightings, weather, effort and distance and angle experiment data.
Other			
30/11/11	USA: D. Palka	E101	List of data for the NP gray whale *Implementation Review* in June 2012.
23/03/12	A. Punt	E104	Programs and data used in AWMP gray whale trials up to March 2012 Workshop.
23/06/12	A. Punt	E104	Programs and data used in AWMP gray whale trials at the 2012 Scientific Committee.

3.3 Data collection, storage and manipulation

3.1.1 Catch data and other statistical material

Table 1 lists data received by the Secretariat since the 2011 meeting. As requested last year, the Secretariat had contacted both Canada and Indonesia to request information on recent catches. The information received from Canada is included in Table 1, but no response has been received to date from Indonesia. The Committee **requests** that the Secretariat try again to obtain data on catches off Indonesia.

3.1.2 Progress of data coding projects and computing tasks

Allison reported that Version 5.2 of the catch database was released in November 2011 and a new release was due shortly. Work has continued on the entry of catch data into both the IWC individual and summary catch databases, including data received from the 2010 season. Sightings data from the 2010 POWER cruise (see Item 10.8) has been validated.

Programming work during the past year has focused on amending the control program and datasets for use in the North Pacific common minke whale *Implementation* trials and is discussed further under Item 6.3.

4. COOPERATION WITH OTHER ORGANISATIONS

The Committee noted the value of co-operation with other international organisations to its work. The observers' reports below briefly summarise relevant meetings of other organisations but the contributions of several collaborative efforts are dealt with in the relevant sub-committees.

4.1 Convention on the Conservation of Migratory Species (CMS)

4.1.1 Scientific Council

The report of the IWC observer at the CMS Scientific Council meeting held in Bergen, Norway from 17-18 September 2011 is given as IWC/64/4E. With relation to cetaceans, their agenda included items on critical sites and ecological networks for migratory species, impacts of marine debris on migratory species and presentation of the report of the Working Group on Aquatic Mammals. It was agreed that the narwhal and the North Pacific killer whale populations be considered for cooperative action. A draft resolution on a programme of work for cetaceans (to implement the previous CoP resolution 'Adverse human-induced impacts on cetaceans') was endorsed. Note was taken of the recent split of the finless porpoise into two species, *Neophocaena brevirostris* and *N. asiaeorientalis* and both were recommended for inclusion in Appendix II of the Convention.

The Committee thanked Perrin for his report and **agrees** that he should represent the Committee as an observer at the next CMS Scientific Council meeting. Further information can be found at *http://www.cms.int*.

4.1.2 Conference of Parties

The report of the IWC observer at the 10th Conference of Parties for CMS held in Bergen 20-25 September 2011 is given as IWC/64/4E. The Convention now has 117 Parties. Three Resolutions related primarily to cetaceans:

Resolution 10.14 *Bycatch of CMS-listed species in gillnet fisheries* called on Parties to *inter alia* assess the risk of bycatch arising from their gillnet fisheries and conduct research to identify and improve mitigation measures (including use of alternative fishing gear and methods) and instructed the Scientific Council to develop terms of reference for studies identifying the degree of interaction between gillnet fisheries and CMS-listed species;

Resolution 10.15 *Global programme of work for cetaceans* laid out tasks for the Scientific Council, Secretariat and Parties to advance the conservation of CMS-listed cetaceans, organised primarily on a regional basis; and

Resolution 10.24 *Further steps to abate underwater noise pollution for the protection of cetaceans and other migratory species* among other recommendations strongly urged the Parties to prevent adverse effects on cetaceans and other marine species by restricting the emission of underwater noise, understood as keeping it to the lowest necessary level with particular priority given to situations where the impacts on cetaceans are known to be heavy.

The resolutions can be seen in full on the CMS website (*http://www.cms.int.*).

The Committee thanked Perrin for his report and **agrees** that he should represent the Committee as an observer at the next CMS Scientific Council meeting.

4.1.3 Agreement on Small Cetaceans of the Baltic and North Seas (ASCOBANS)

There was not a meeting of parties in the intersessional period. The next meeting of parties will take place on 22-24 October 2012 in Brighton, UK. The report of the observer at the 19th meeting of the Advisory Committee to ASCOBANS held in Galway, Ireland 20-22 March 2012 is given as IWC/64/4F. Topics covered included:

(1) *Baltic Sea harbour porpoises*. Those in the Western Baltic, Belt Seas and the Kategat form a different population to those of the Baltic proper and the North Sea and since 2005 there has been a 60% decline in the population size of the former. A separate conservation plan for this area should be established.
(2) *Working Group on a Conservation Plan for Harbour Porpoises in the North Sea*. A follow-up SCANS II survey was recommended, as was bringing smaller and recreational fisheries under the reformed Common Fisheries Policy.
(3) *Working Group on Bycatch*. A review of the 1.7% removal rate was recommended.
(4) *Dogger Bank surveys*. Independent surveys, both aerial and vessel-based, indicate that the harbour porpoise is the most common cetacean in the area, with most records on the slopes of the bank.
(5) *Small cetacean hunt outside agreement area*. Tagging data indicates the pilot whale population subject to the Faroese hunt also occurs in the ASCOBANS agreement area. Because of considerable uncertainties regarding the population ASCOBANS welcomes future studies (e.g. SCANS, CODA, T-NASS).

A working group on marine debris was established and in collaboration with ACCOBAMS, the ASCOBANS Secretariat is working to acquire satellite-based data on shipping density to identify high risk areas and trends. A joint ECS/ASCOBANS/ACCOBAMS workshop on management of Marine Protected Areas (MPAs) for cetaceans will be held at the 2013 ECS conference.

The Committee thanked Scheidat for her report and **agrees** that she should represent the Committee as an observer at the next ASCOBANS Advisory Committee meeting and Meeting of Parties. Further information can be found at *http://www.ascobans.org*.

4.1.4 Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS)

No meetings of ACCOBAMS occurred intersessionally, but a Scientific Committee meeting is scheduled for November 2012. The Committee **agrees** that Donovan should represent the IWC at this meeting.

4.1.5 Memorandum of Understanding (MoU) on the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia

There was no report related to the MoU on the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia. Perrin will represent the Committee at future activities.

4.1.6 Memorandum of Understanding (MoU) for the Conservation of Cetaceans and Their Habitats in the Pacific Islands Region (MoU for Pacific Islands Cetaceans)

There was no report related to the MoU for Pacific Islands Cetaceans. Donohue will represent the Committee at future activities. Further information can be found at *http://www.pacificcetaceans.org*.

4.2 International Council for the Exploration of the Sea (ICES)

The report of the IWC observer documenting the 2012 activities of ICES is given as IWC/64/4A. The ICES Working Group on Marine Mammal Ecology (WGMME) met in February 2011. It conducted a review of the effects of tidal turbines on marine mammals and provided recommendations on research, monitoring and mitigation schemes. The working group recommended identification of sites of low risk for turbine deployments before consenting to further devices or upscaling in more sensitive sites. It also recommended extreme care when extrapolating environmental impacts between species and device types and caution when scaling up environmental lessons learned from studies of single turbines.

Marine spatial planning practices were considered by the working group. It recommended that data on cetacean presence and occurrence be incorporated at a very early stage of planning and it emphasised the importance of including information on seasonal changes in distribution. Due to the wide-ranging nature of cetaceans the relevance of 'important areas' outside MPAs should be assessed within marine spatial plans.

The working group discussed designation of MPAs. It recommended that the boundaries should be decided based on long-term data series (of at least five years). Creation of MPAs in response to public opinion without scientific evidence to support their selection risks providing false assurances and could reduce the pressure for targeted action on the most significant threats.

The Working Group on Bycatch of protected species (WGBYC) met in February 2011. It reviewed the status of information on recent bycatch estimates and assessed the extent of the implementation of bycatch mitigation measures. Reports from 15 member states indicated extrapolated estimates of bycatch for 2009 of 879 striped dolphins, 1,500 common dolphins, 11,000 harbour porpoises and at least 10 bottlenose dolphins in a variety of fisheries. Estimates are patchy and monitoring obligations not being met by several member states. Implementation of bycatch mitigation measures was also found to be poor, with few countries able to confirm that obligations for pinger deployment were being met.

The 2011 ICES Annual Science Conference (ASC) was held in Gdansk, Poland, 19-23 September 2011. Some sessions were designed with marine mammals included as an integral part. A number of sessions were of relevance to the Committee, including those describing:

(1) integration of top predators into ecosystem management;
(2) integration of multi-disciplinary knowledge in the Baltic Sea to support science-based management; and
(3) the extraction of energy from waves and tides – consequences for ecosystems.

Butterworth advised that a World Conference on Stock Assessment Methods for Sustainable Fisheries will be held from 16-18 July 2013, in Boston, USA with Steve Cadrin, Mark Dickey-Collas and Rick Methot as Conveners, as part of the ICES SISAM initiative. A Scientific Steering Group (including Butterworth of the IWC Scientific Committee), linked to SISAM, has been set up to assist the Conveners in planning the Symposium.

The symposium will be structured with presentation sessions, participatory workshops and open floor discussion groups. Further information can be found at *http://ices.dk/iceswork/symposia/wcsam.asp*.

The Committee thanked Haug for the report and **agrees** that he should represent the Committee as an observer at the next ICES meeting.

4.3 Inter-American Tropical Tuna Commission (IATTC)
The report of the observer at the 82nd meeting of the IATTC held La Jolla, USA 4-8 July 2011 is given as IWC/64/4C. The Antigua Convention came into force on 27 August 2010 and under this the IATTC is expected to give greater consideration to non-target and associated species, including cetaceans, in taking management decisions. A summary of ongoing work describing what is known about the direct impact of the fisheries on other species in the ecosystem and the environment. This ongoing work will shape future directions of AIDCP (see Item 4.4) and IATTC measures aimed at managing fisheries and conserving dolphins.

The Committee thanked Rusin for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next AIDCP meeting.

4.4 Agreement on the International Dolphin Conservation Program (AIDCP)
The report of the observer at the 24th Meeting of Parties to the AIDCP held in La Jolla, USA on 21 October 2011 is given as IWC/64/4C. The AIDCP mandates 100% coverage by observers of fishing trips by purse seiners of carrying capacity greater than 363t in the agreement area and in 2011 all trips by such vessels were sampled by independent observers.

The overall dolphin mortality limit (DML) for the international fleet in 2011 was 5,000 animals and the unreserved portion of 4,900 was allocated to 86 qualified vessels that requested DMLs. In 2010 no vessel exceeded its DML. The number of sets on dolphin associated schools of tuna made by vessels over 363t has been increasing in recent years, from 9,246 in 2008 to 10,910 in 2009 to 11,645 in 2010, however fewer were made in 2011 – 9,604. This type of set accounted for 44% of the total number of purse-seine sets made in the ETP in 2011. While fewer dolphin sets were made in 2011, this remains a frequent practice and the predominant method for catching yellowfin tuna by purse-seine in the ETP. Assessment surveys scheduled for 2009 and 2010 have been delayed so it is unclear when abundance estimates for cetaceans in the ETP will be available to update the 2006 survey data.

The Committee thanked Rusin for attending on its behalf and **agrees** that he should represent the Scientific Committee as an observer at the next AIDCP meeting.

4.5 International Commission for the Conservation of Atlantic Tunas (ICCAT)
No observer for the IWC attended the 2011 meeting of ICCAT.

4.6 Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR)
The report of the IWC observer at the 30th Meeting of the CCAMLR Scientific Committee (CCAMLR-SC), held in Hobart, Australia from 23-27 October 2011 is given as IWC/64/4J. The main items considered at the CCAMLR meeting of relevance to the IWC included: (1) fishery status and trends of Antarctic fish stocks, krill, squid and stone crabs; (2) incidental mortality of seabirds and marine mammals in fisheries in the CCAMLR Convention Area; (3) harvested species; (4) ecosystem monitoring and management; (5) management under conditions of uncertainty about stock size and sustainable yield; (6) scientific research exemption; (7) CCAMLR Scheme of International Scientific Observation; (8) new and exploratory fisheries; (9) joint CCAMLR-IWC Workshop with respect to ecosystem modelling in the Southern Ocean; and (10) the CCAMLR performance review.

The publication status of documents from the 2008 joint CCAMLR-IWC Workshop on ecosystem modelling was discussed. Almost all expert groups have completed their review papers. The review process for the papers, which will be published in either *CCAMLR Science* or the *Journal of Cetacean Research and Management*, will begin soon.

MPAs were discussed in detail. The area of the southern South Orkney shelf and the Seasonal Pack-ice Zone and part of the Fast Ice Zone south of the shelf was the first MPA designated by CCAMLR. The following milestones were previously agreed:

(1) by 2010, collate relevant data for as many of the 11 priority regions as possible;
(2) by early 2011, convene a workshop to review progress, share experience and determine a work programme for the identification of MPAs;
(3) by 2011 identify candidate areas for protection in as many priority regions as possible;
(4) by 2011, submit proposals for areas for protection to the CCAMLR-SC; and
(5) by 2012 submit proposals on a representative system of MPAs to the CCAMLR Commission.

The Committee thanked Kock for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next CCAMLR-SC meeting. In addition, Butterworth will act as an observer at meetings of the WG-EMM.

4.7 Southern Ocean GLOBEC (SO-GLOBEC)
The synthesis and analysis process under SO-GLOBEC has continued and has produced a number of papers relating cetacean distribution to prey and other environmental variables. There is no active work with respect to SO-GLOBEC at this time.

4.8 North Atlantic Marine Mammal Commission (NAMMCO)
4.8.1 Scientific Committee
The report of the IWC observer at the 18th meeting of the NAMMCO Scientific Committee (NAMMCO SC) held in Gjógv, Faroe Islands from 2-5 May 2011 is given as IWC/64/4I. The ICES-NAMMCO workshop on bycatch monitoring reviewed indirect and direct bycatch monitoring, data collection and fleet data needed for raising estimates to fleet level. It was noted that bycatch numbers could be high both in Norway and Iceland. The NAMMCO SC strongly encouraged Norway, Iceland and the Faroes to proceed with the implementation of their bycatch monitoring systems. The NAMMCO SC reiterated its recommendation to Greenland to investigate the degree to which bycatch is reported as catch.

Extensive biological sampling was conducted by Iceland from all fin whales landed in 2010. Analysis of all samples is complete and a DNA registry has been initiated.

The 2007 abundance estimates for humpback whales for all areas have now been provided to, reviewed and endorsed by the NAMMCO SC. For the first time since 1986 there was a quota for humpback whales in West Greenland and all nine whales were caught. The NAMMCO SC recommended eye sampling of the whales for age determinations, as well as tail photographs.

Corrected estimates for minke whales for the 2007 and 2009 Icelandic aerial surveys were endorsed. The best available estimate of abundance for 2007 was 48% of that for 2001. Abundance in 2009 remains the lowest yet seen in all areas. The NAMMCO SC agreed that the new evidence presented strengthened the conclusion that the observed decline in abundance was not a result of error in measuring or analyses.

A conventional distance sampling abundance estimate of pilot whales for the Iceland-Faroes shipboard area was endorsed by the NAMMCO SC. They noted the difficulties in providing abundance estimates appropriate for management of this species given the absence of adequate data.

Observations of bowhead whales around Svalbard, Norway from 1940-2009 show an increase in abundance in the last decade. This could be due to an increase in the numbers of whales or increased tourism and a dedicated reporting system. An acoustic study that will continue through 2012 has shown that bowhead whales are present in the Fram Strait throughout the winter and generally during most of the year. A satellite tracked whale from the Spitsbergen stock moved from the so-called northern whaling ground to the southern whaling ground during summer and then back north again during winter. This is opposite of the general seasonal movement patterns for other bowhead whale stocks, but in accordance with reports from whalers in previous centuries.

An aerial survey in West Greenland was scheduled for spring 2012. The primary targets were planned to be narwhals and white whales, with bowhead whales and walruses secondary targets.

The Committee thanked Walløe for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next NAMMCO SC meeting.

4.8.2 Council

The report of the IWC observer at the 20th Annual Meeting of NAMMCO held in Oslo, Norway in September 2011 is given as IWC/64/4B. All requested stock assessments for large whale species in the North Atlantic have now been finalised based on sightings data from the Trans North Atlantic Cetacean Sightings Surveys (T-NASS) in 2007 and additionally in 2009. Management procedures applied have been derived from those already developed by the Scientific Committee of the IWC using the Revised Management Procedure (RMP) approach. An RMP-like approach has been recommended by the Scientific Committee of NAMMCO for some large whale stocks in their discussions on general models to be adopted by NAMMCO. These stock assessments by the constitute the main basis for catch limits set for some baleen whale stocks (fin and minke whales) in the North Atlantic.

Based on T-NASS data, an updated abundance estimate for pilot whales has been made in the areas surveyed in 2007. Although the combined area represented is small and not directly comparable with previous surveys, the available information gives no reason to amend previous conclusions on the sustainability of the Faroese catch. The next regular NASS is scheduled to take place between 2013 and 2015 and planning is already under way.

The working group on marine mammal/fisheries interactions continued its work on development of a large international ecosystem modelling project. A network has been established between several leading scientists in this field aimed at securing funding for the project which includes applying four different modelling approaches to two data rich areas, the Barents Sea and Icelandic coastal waters.

A training course for observers appointed under the NAMMCO joint control scheme for the hunting of marine mammals is to be organised this year.

The Committee thanked Katsuyama for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next NAMMCO Council meeting. Further information on NAMMCO can be found on their website[1].

4.9 International Union for the Conservation of Nature (IUCN)

Cooke and Reeves, the IWC observers, reported on the considerable cooperation with IUCN that had occurred during the past year and this is given as IWC/64/4K.

Western gray whales

The mandate of the IUCN Western Gray Whale Advisory Panel (WGWAP) has been renewed for a further five years, under the aegis of the IUCN Global Marine and Polar Programme. The Panel has expressed concerns about plans to install a third offshore platform for oil and gas extraction just offshore of the gray whale feeding ground, but this project has now been postponed. Analyses of the data collected during a 2010 seismic survey with respect of the effects on gray whales and the effectiveness of mitigation measures are still in progress. Similar mitigation and data collection arrangements are in place for a smaller seismic survey that is currently underway and further information is given in Annex F, Appendix 9. The work of WGWAP is discussed further under Item 10.4.2.

Red List updates

A current list of all cetacean species and populations that have been assessed for the Red List, and their current Red List classification, is maintained on the Cetacean Specialist Group website[2] with links to the assessments which are held on the Red List website (*http://www.redlist.org*). Updates since the last Annual Meeting include separate assessments for the two recently recognied species of finless porpoises (*Neophocaena asiaeorientalis* and *N. phocaenoides*), both listed as Vulnerable. New assessments are underway for the dolphins in the genus *Inia*, which were recently split into two species, *Inia geoffrensis*, the Amazon River dolphin, and *I. boliviensis*, the Bolivian bufeo.

Cetacean Specialist Group

The website of the IUCN Cetacean Specialist Group (*http://www.iucn-csg.org*), contains regular updates of IUCN's cetacean-related activities and other work in which group members are involved. New items since last year relate to vaquita conservation efforts, Mekong River dolphins in Cambodia, Indus dolphins in Pakistan, new cetacean protected areas in Bangladesh.

World Conservation Congress

The IUCN 4-yearly World Conservation Congress will be held 6-15 September 2012 in Jeju, Korea with the theme 'Nature+'. The programme includes three cetacean-related events: a workshop on lessons learned from the IUCN western gray whale conservation initiative; a presentation on a local population of Indo-Pacific bottlenose dolphins found around Jeju Island; and a workshop on cetacean conservation and whale-watching in Africa[3].

The Committee thanked Cooke and Reeves for their report. It also thanked Larsen who has now left the IUCN,

[1]*http://www.nammco.no.*
[2]*http://www.iucn-csg.org/index.php/status-of-the-worlds-cetaceans.*
[3]*http://www.worldconservationcongress.org.*

for his contributions in the past and **agrees** that Cooke should continue to act as observer to IUCN for the IWC.

4.10 Food and Agriculture Organisation (FAO) related meetings – Committee on Fisheries (COFI)
No observer for the IWC attended the 2011 meeting of COFI.

4.11 Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)
No observer for the IWC attended the 2011 meeting of CITES.

4.12 North Pacific Marine Science Organisation (PICES)[4]
The report of the IWC observer at the 20th annual meeting of PICES held 14-23 October 2011 in Khabarovsk, Russia is given as IWC/64/4H. The Marine Birds and Mammals Advisory Group (AP-MBM) recommended that PICES request the IWC Scientific Committee includes a seabird observer on the IWC-POWER cruise survey vessel in the future.

Spatial ecology and conservation was selected as the basis of the new activity plan for the AP-MBM. The objectives are:
(1) synthesise distribution data on marine birds and mammals and its temporal change in the North Pacific;
(2) examine the physical and biological factors that correspond to the distribution and abundance of marine birds and mammals and their economic/ecological hot spots; and
(3) provide information on ecological areas in the PICES regions to aid understanding and sustainable use of marine resources.

Two sessions at the 2012 AP-MBM workshop were of relevance to the IWC, these were: (1) environmental contaminants in marine ecosystems: seabirds and marine mammals as sentinels of ecosystem health; and (2) the feasibility of updating prey consumption by marine birds, marine mammals and large predatory fish in PICES regions.

The Committee thanked Kato for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next PICES meeting.

4.13 Eastern Caribbean Cetacean Commission (ECCO)
No information on the activities of ECCO was provided.

4.14 Protocol on Specially Protected Areas and Wildlife (SPAW) of the Cartagena Convention for the Wider Caribbean[5]
The report of the IWC observer to SPAW is given as IWC/64/4D. The MSP LifeWeb Project was launched in October 2010, which aims to assist with the implementation of decisions from the Convention on Biological Diversity, as well as those of the Cartagena Convention and its SPAW protocol. Recent activities under this project include:
(1) a workshop on integration, mapping and GIS analysis of marine mammal migration routes, critical habitats and human threats in the wider Caribbean region (May 2011);
(2) assisting in the coordination of a conference on Marine Mammal Protected Areas (November 2011);
(3) identifying marine mammal data sources within the wider Caribbean region and collating information in an online database;
(4) a workshop on broad-scale marine spatial planning (March 2012);
(5) analysis of identified marine mammal data in order to develop data layers and maps on the critical habitats for marine mammals in the wider Caribbean; and
(6) a workshop on broad-scale marine spatial planning and transboundary marine mammal management (May 2012).

In 2011 a project focusing on marine mammal watching was implemented. It aims to improve and centralise the level of information and knowledge on the status, distribution and threats of marine mammals in the region. A related workshop was held in October 2011. The Committee thanked Carlson for attending on its behalf and **agrees** that she should represent the Committee as an observer at the next SPAW meeting.

4.15 Indian Ocean Commission (IOC)[6]
No information on the activities of IOC was provided.

4.16 Permanent Commission for the South Pacific (CPPS)[7]
No information on the activities of CPPS was provided.

4.17 International Maritime Organisation (IMO)[8]
The report of the IWC observer to the IMO is given as IWC/64/4G. The IWC has contributed to IMO discussions on addressing ship strikes and the impacts of underwater noise from shipping. The IMO has established a correspondence group to develop non-mandatory draft guidelines for reducing underwater noise from commercial ships (Donovan is a member of this group). This group will report to the IMO's 57th session of the sub-committee on ship design and equipment in early 2013.

The IMO is also working to develop a mandatory Polar Code to control the expected increase in ship traffic in polar waters (the Arctic and the Antarctic) that results from climate and other changes. The Polar Code is intended to function alongside existing IMO conventions and to augment existing measures to reduce the environmental impacts of shipping taking into account the greater environmental sensitivity of polar waters. An IMO Workshop on Environmental Aspects of the Polar Code was held in Cambridge in September 2011 where there was considerable discussion of ship strikes and underwater noise impacts on whales. The Polar Code work is also co-ordinated by the IMO sub-committee on ship design and equipment.

The Committee thanked Leaper for his report and **agrees** that the IWC Secretariat should represent the Committee at the next IMO meeting.

4.18 Conservation in the southeastern Pacific under the framework for the Lima Convention
No information on conservation in the southeastern Pacific under the framework for the Lima Convention was provided.

4.19 International Committee on Marine Protected Areas (ICMMPA)[9]
At its 60th Annual Meeting in Santiago, Chile, the Committee endorsed support for the first International Conference on Marine Mammal Protected Areas (MPAs), which was

[4] *http://www.pices.int*.
[5] *http://www.cep.unep.org/cartagena-convention*.
[6] *http://www.coi-ioc.org*.
[7] *http://www.cpps-int.org*.
[8] *http://www.imo.org*.
[9] *http://www.icmmpa.org*.

subsequently held in Hawaii in 2009. The committee that organised the conference is now a task force of the IUCN. It hopes to continue its constructive relationship with the IWC and SC/64/O1 is the summary report of the second (ICMMPA) meeting. The meeting was held in Martinique in the French Caribbean from 7-11 November 2011. The aim was to seek solutions to shared problems related to marine mammal conservation and to MMPA network and site design, creation and management. A secondary aim was to orient those working in MMPAs to set those protected areas in the broader context of marine management.

The conference theme was 'Endangered Spaces, Endangered Species' and workshops focused on monk seals, sirenians, river dolphins and other small and large cetaceans; special attention was given to the vaquita, the most endangered, space-restricted marine mammal in the world. Plenary sessions focused on:

(1) special considerations for particularly endangered marine mammals and whether MPAs are the right tool;
(2) refining understanding of marine mammal critical habitat and hotspots to inform MMPA designation;
(3) using marine spatial planning and ecosystem-based management to address broad threats to marine mammals;
(4) managing MMPAs for localised threats and mitigation by spatial protection and other means;
(5) development of MMPAs in the wider Caribbean region; and
(6) regional cooperation for MMPA scientific and technical networking.

The workshops focused on marine mammals and oil spills, decision-making with limited data, best practices for whale watching in MMPAs, integrating marine mammal data in marine spatial planning, forging agreements to establish effective MMPA networks, and the widespread mortality attributed to fisheries bycatch.

Proceedings of this second ICMMPA meeting will be available and released shortly and a third ICMMPA meeting is planned to be held in about two years' time. A proposal was received from Australian scientists and decisions on exact location and date are yet to be taken.

5. REVISED MANAGEMENT PROCEDURE (RMP) – GENERAL ISSUES

5.1 Complete the MSY rates review

Since 2007, the Committee has been discussing maximum sustainable yield rate (MSYR) in the context of a general reconsideration of the plausible range to be used in population models used for testing the *Catch Limit Algorithm* (*CLA*) of the RMP (IWC, 2008g; 2009b; 2010c; 2010i; 2011m). The current range is 1% to 7%, in terms of the mature component of the population. As part of its review, the Committee has been considering observed population growth rates at low population sizes. An important issue raised (Cooke, 2007) was that should variability and/or temporal autocorrelation in the effects of environmental variability on population growth rates be high, simple use of such observed population growth rates could lead to incorrect inferences being drawn over the lower end of the range of plausible values. In 2010, the Committee agreed a Bayesian approach (Punt, 2010) for calculating a probability distribution for the rate of increase for an 'unknown' stock in the limit of zero population size, once the inputs needed to apply it become available (IWC, 2011g).

Last year, the Committee had agreed that the review would be completed at this meeting (IWC, 2012f). However, given effectively no intersessional progress, the issue was furthered but not completed during the present meeting (Annex D, Appendix 2) as follows:

(1) values of demographic parameters to be used for the calculation of the CV and autocorrelation of the rate of increase were agreed for the 15 populations for which estimates of growth rate at low population size were available if it is assumed that only fecundity is stochastic;
(2) calculations were undertaken for the case where there is no variability in survival rate; and
(3) progress was made on the implementation of two approaches for specifying variability in survival rate; one which results in the same CV for the rate of increase for variability in survival rate as the CV implied by the variability in fecundity, and another which is based on an approach involving optimal allocation of energy between reproduction and survival.

The Committee expressed serious concern that once again the process has not been completed and it carefully examined whether it was worth continuing the process. However, given the good progress during the meeting, and the work plan developed (Annex D, item 2.1), the Committee **agrees** that no more than one further year would be allowed for this process. If the MSYR review cannot be completed at next year's meeting, the current range of MSYR rates (1% - 7% in terms of the mature component of the population) will be retained.

To ensure completion of these tasks, a three-day intersessional meeting is required, with at least five participants, ideally back-to-back with another intersessional meeting. An intersessional Steering Group, under Butterworth (Annex Q1), was appointed to co-ordinate the meeting and associated preparation. Any models related to variability in survival rate to be considered must be fully specified to the Steering Group at least one month before the intersessional meeting. The financial considerations are given under Item 23.

5.2 Finalise the approach for evaluating proposed amendments to the *CLA*

The Committee last discussed this issue in 2006 (IWC, 2007c) noting that it was originally intended that this work would occur in conjunction with the completion of the MSYR review (see Item 5.1 above). The Committee re-established a Working Group under Allison (Annex Q2) to develop trials to examine the effects of possible environmental degradation in terms of trials in which *K*, and perhaps MSYR, varies over time.

The Committee **stresses** that this work must be completed by the next Annual Meeting irrespective of the progress made under Item 5.1.

5.3 Evaluate the Norwegian proposal for amending the *CLA*

The Committee was unable to complete its evaluation of the Norwegian proposal given the discussions under Items 5.1 and 5.2 above. The Committee **agrees** that this task will be completed at the next Annual Meeting either using the revised values from the MSYR review or the existing values if the review is not completed.

5.4 Modify the 'CatchLimit' program to allow variance-covariance matrices

The 'CatchLimit' program implements the *CLA* and now allows variance-covariance matrices for the abundance estimates to be specified (IWC, 2012f). Allison noted that it includes some non-standard coding statements and she will be working with the Norwegian Computing Center during the intersessional period to develop a final version of the program.

5.5 Update the Requirements and Guidelines for Conducting Surveys and *Implementations*

The Committee's Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme (IWC, 2012x) were written when only design-based surveys were realistic. Subsequently, spatial modelling approaches have been developed as an additional realistic approach. In addition, many [quasi] design-based surveys do not formally meet design-based criteria, and there may be a question regarding on the adequacy of resultant estimates. The Committee has frequently considered model-based and quasi-design-based estimates (e.g. IDCR/SOWER and SCANS), but without explicit criteria and not necessarily in the context of the RMP. Two linked issues therefore arise: under what circumstances might approval from the Scientific Committee reasonably be given to surveys that are not design-based; and should the Guidelines should be amended to give more specific advice on the considerations for evaluating model-based estimates (including extrapolations) and/or quasi-design-based estimates.

The statistical issues involved are complex, both theoretically and in practice. A number of detailed starting points for discussion are noted in Annex D, item 2.5, and sufficient experience with model-based methods has now accumulated to warrant a review. The Committee, also recognising the importance of this work for all sub-committees that consider abundance estimates in a conservation and management context, therefore **recommends** that such a review (covering model-based abundance estimation in theory and practice, and its relation to the design-based approach), be conducted. The review (Annex D, Appendix 4) will also provide draft text for inclusion in the Committee's Requirements and Guidelines for Conducting Surveys document. The financial considerations are given under Item 23.

5.6 Evaluate the optimisation method used when conditioning trials

Punt and Elvarsson (2011) developed and compared a number of ways to improve the performance of the optimisation algorithm underlying the conditioning process, as discussed in Annex D, item 2.6. The Committee noted that the optimisation scheme used for conditioning the trials for the western North Pacific minke whales had been modified accordingly.

5.7 List of abundance estimates and their recommended uses

The list of accepted abundance estimates for those stocks that have been subject to RMP *Implementations* (and *Reviews*) are provided in Annex D, Appendix 2 along with references to discussions as to whether they are acceptable for use in conditioning, acceptable for use in trials and/or acceptable for use in applications of the *CLA*. The only exception was for western North Pacific common minke whales where evaluation is ongoing (see Item 6.3).

5.8 Work plan

The Committee's views on the work plan developed by the sub-committee on the RMP are given under Item 21 and financial matters are considered under Item 23.

6. RMP – PREPARATIONS FOR *IMPLEMENTATION*

6.1 Western North Pacific Bryde's whales

6.1.1 Prepare for 2013 Implementation Review

The Committee was informed that Japan wished to postpone the 2013 *Implementation Review* for North Pacific Bryde's whales until 2016 because:

(1) dedicated sighting surveys have been conducted in the western North Pacific since 2010 and additional surveys targeted towards Bryde's whales were planned for 2012 and beyond;
(2) lower latitudinal waters in the eastern North Pacific will be covered during the IWC-POWER research programme during 2013-15;
(3) there are currently no genetic samples for sub-area 2 (east of 180°). It is expected that biopsy samples will be collected from Bryde's whales during the IWC-POWER research programme; and
(4) new genetic samples have been obtained for sub-area 1 (west of 180°) during JARPN II as well as other sources, but the data have yet to be analysed.

6.1.2 Recommendations

Implementation Reviews should normally be scheduled not later than six years after the completion of the previous *Implementation* (or *Review*) (IWC, 2012y). The western North Pacific Bryde's whale *Implementation* was completed in 2007 (IWC, 2008f). However, the Committee **recommends** that the *Implementation Review* for western North Pacific Bryde's whales be delayed until 2016 given:

(1) the *Implementation* completed in 2007 considered a range of hypotheses related to stock structure and productivity;
(2) three more years of catches are unlikely to lead to conservation concerns given the results of the *Implementation*;
(3) that it cannot conduct more than one *Implementation Review* at a time (see Items 6.2 and 6.3 below); and
(4) a delay would allow additional sightings and genetics data to become available.

6.2 North Atlantic fin whales

In 2009, the Committee agreed (IWC, 2010e) that if the RMP is implemented for North Atlantic fin whales, certain variants (see table 4 of IWC, 2010e, p.122) could be implemented without a research programme. It also agreed that another variant would be acceptable only with an agreed research programme for the reasons given in IWC (2010e). A primary aspect of this related to whether or not a particular stock hypothesis, 'hypothesis IV', was appropriate.

SC/64/RMP3 responded to a recommendation from the Committee last year that further analysis of the Discovery marking data should be carried out within the framework of the *Implementation Simulation Trials* as detailed in Annex D, item 3.2. The Committee noted that SC/64/RMP3 provided evidence suggesting that stock structure hypothesis IV is inconsistent with existing data but recognised that making a final decision on its acceptability could also involve additional trials. This can best be achieved within the context of an *Implementation Review*.

Annex D, table 1 summarises new information available for an *Implementation Review*. The Committee **agrees** that the available information is sufficient to warrant an *Implementation Review* in 2013. It noted that while the *Implementation Review* would be focused on providing advice for the Icelandic hunt, the discussions of stock structure would also be valuable in the context of the SWG's work to develop an *SLA* for the aboriginal hunt off West Greenland (Annex E).

6.2.1 Recommendations

The Committee **recommends** that the *Implementation Review* for the North Atlantic fin whales be brought forward to 2013. The *Review* should start during a pre-meeting immediately before the 2013 Annual Meeting to ensure that it is completed in one year. An intersessional email Steering Group (Annex Q3) was established to coordinate the work prior to the 2013 meeting.

6.3 North Pacific common minke whales (continue *Implementation*)

The Committee is conducting an *Implementation Review* for western North Pacific common minke whales and is following the schedule set out in its Requirements and Guidelines (IWC, 2012i). At last year's meeting, the Committee had been unable to complete the tasks required for the First Annual Meeting, primarily because it had not been possible to complete conditioning of the *Implementation Simulation Trials*, a major task given their complexity. This meant that the two year schedule for the *Implementation Review* had been disrupted.

This year's meeting was effectively a repeat of the First Annual Meeting with the same list of tasks that had been initiated last year. There had been another intersessional Workshop in December 2011 to facilitate the work necessary to ensure that all relevant tasks could be completed at this year's meeting as described under Item 6.3.1.

6.3.1 Report of the December 2012 Intersessional Workshop

Donovan presented a summary of the report of the Intersessional Workshop held 12-16 December 2012, kindly hosted by the Government of Japan (SC/64/Rep2). The primary objective of the Workshop was to ensure completion of the conditioning of trials in time for the 2012 Annual Meeting, although a number of other topics were addressed to assist the Committee in its work to complete the *Implementation Review*. Conditioning is the process of selecting the values for the parameters of the operating models that implement the trials such that the predictions from these models are consistent with the available data.

The Intersessional Workshop covered issues relating to: stock structure and mixing matrices; conditioning; abundance estimates for use in trials; specification of these trials; plausibility of stock structure hypotheses; and data/analyses to reduce the number of stock structure hypotheses in future *Implementations*. Considerable progress was made and details are given in Annex D1, item 3 and SC/64/Rep2.

6.3.2 Conditioning

Following the Intersessional Workshop, a number of problems with the fits of the operating model to the data had been identified. Suggested changes to the trial specifications were developed, details of which are given in Annex D1, item 4.1, which the Committee **endorses**.

The Committee reviewed the results for the six baseline trials (stock structure hypotheses A, B and C with MSY rates of 1% and 4%) given in Annex D1, Appendix 2 and **agrees** that the conditioning for these trials had been acceptably achieved. There was insufficient time to evaluate the results of the conditioning of all the sensitivity tests. However the Committee **agrees** that the results for trials for which 100 simulations were available suggested that it is possible to determine whether conditioning has been achieved successfully based on the fit of the operating model to the actual data.

The Committee received a summary report from a small group appointed to review the results of trials run to date. Allison reported that all trials for stock structure hypotheses A and C with MSYR=1% had now been run with the actual data. Conditioning had been achieved for all these trials except two, for which the mixing matrices needed adjustment. Based on these results and on extensive past experience with reviewing the results of such trials, the Committee **agrees** that conditioning of the *Implementation Simulation Trials* of western North Pacific common minke whales had been acceptably achieved.

6.3.3 Update to standard datasets - abundance estimates

Abundance estimates play three roles in the *Implementation* process: (1) for use in conditioning trials; (2) for use when applying the *CLA* during *Implementation Simulation Trials*; and (3) for actual application of the *CLA*. The abundance estimates for use during conditioning were selected during the First Intersessional Workshop in December 2010 (IWC, 2012d). At this meeting, the Committee needed to select which abundance estimates to use when applying the *CLA* during *Implementation Simulation Trials*. The abundance estimates for use in actual application of the *CLA* will be finalised next year.

The Committee received a cruise report of a sightings survey in the Yellow Sea in May 2011 (SC/64/NPM6) and an estimate of abundance for minke whales from this survey (SC/64/NPM7); details are given in Annex D1, item 5.1.1. The Committee expressed its appreciation to the Government of Korea for its continued commitment to surveys for minke whales in Korean waters and to An for his role of oversight on behalf of the Committee. In discussion, the Committee raised a number of issues with the analysis that requires further work. Therefore this estimate was not accepted for use in *Implementation* of the RMP at this meeting but the Committee looks forward to the presentation of a revised estimate in the future.

The Committee received SC/64/NPM2, an updated summary of the information on survey procedures for the Japanese dedicated sighting surveys conducted by the Institute of Cetacean Research (ICR) and the National Research Institute of Far Seas Fisheries (NRIFSF), in response to a recommendation from the December 2011 Intersessional Workshop (SC/64/Rep2). The authors concluded that sighting procedures for the ICR surveys follow the RMP Requirements and Guidelines for Surveys, except that the surveys were not subject to Committee oversight, and that the survey procedures for the NRIFSF surveys met all the Requirements and Guidelines. The Committee also received SC/64/NPM3, which presented abundance estimates from JARPN II (see Item 17) sightings data for minke whales in sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 collected during 2008 and 2009. Details are given in Annex D1, item 5.1.2.

A number of issues were raised and discussed relating to survey design, survey direction relative to migration, survey protocol for responding to bad weather and achieved coverage; details are given in Annex D1, item 5.1.2. One specific point was that the estimates of abundance for 2008 and 2009 use information from other years. The Committee therefore **recommends** that variance-covariance matrices be computed for the entire time-series of abundance estimates for sub-areas 7CS, 7CN, 8, and 9.

Whether and how to use estimates with low coverage or design concerns and the treatment of JARPN and JARPN II surveys (i.e. surveys that had not originally been intended to produce estimates for use in the RMP) that did not have Committee oversight raised issues beyond the specifics of the *Implementation Review* of western North Pacific minke whales. Accordingly, the Committee had a general discussion of these issues, the report of which is given under Item 5.8.

In light of that discussion, a small group reviewed all of the available abundance estimates to determine whether or not they were acceptable for use when applying the *CLA* during *Implementation Simulation Trials*. Each available estimate was categorised as 'Yes', 'No', 'No agreement', and 'Yes*' (see Annex D1, Appendix 3). The category Yes* indicates that they can be used in the trials but that further analysis needs to be considered for the estimate to become acceptable for application of the RMP. Surveys which had been accepted for use in the trials during the 2003 *Implementation* were automatically deemed acceptable. The Committee **endorses** the categorisations given in Annex D1, Appendix 3.

Regarding those estimates for which no agreement had been reached on whether or not they were acceptable for use in trials, the Committee **agrees** that the baseline trials should be conducted for the least and most aggressive RMP variants both using and not using the 'No agreement' estimates when applying the *CLA*. If the results of the trials are sensitive to the inclusion of the 'No agreement' estimates, the proponents would be requested to justify how the 'No agreement' estimates could become acceptable with further analysis. The final decision on whether further analysis is likely to allow 'No agreement' estimates to be acceptable will be made by the Intersessional Steering Group established under Butterworth (Annex Q10).

Annotation 21A to the RMP specifications (IWC, 2012y) states that 'A part of an *Area* which is unsurveyed in a single year may count as surveyed when the data from several years are combined, provided that an appropriate multi-year regression analysis is used, and additional variance is taken into account'. In response to a recommendation in SC/64/Rep2, the Committee received SC/64/NPM5, which extrapolated abundance estimates to parts of sub-areas 8, 11, and 12NE which were not covered during some past surveys, to eliminate the bias in estimated abundance trend which arises due to variable coverage. Details are given in Annex D1, item 5.1.2.

The Committee noted that blocks B11-2 and B12NE-2 had only been surveyed once which meant that there are insufficient data to inform additional variance. The Committee **agrees** that the information for sub-area 8 satisfied the requirements for applying annotation 21A.

6.3.4 Update to standard datasets – best catch series

The Committee **agrees** with the recommendation in Annex D of SC/64/Rep2 that the 'Best' catch series was appropriate for the direct catches.

The Committee noted that a single series of bycatches would be used for all of the trials when applying the RMP, irrespective of the true values for the bycatches, which differ among trials, and simulations within trials. The Committee **agrees** that the bycatches would be set to the averages of the predicted bycatches based on the fit to the actual data of the operating model for the six baseline trials (see Annex D1, Appendix 4).

Regarding the specification of future bycatches in the trials, the Committee **agrees** that this should be achieved by assuming that the bycatch rate in the future equals the bycatch rate estimated for the trial in question averaged over the previous five years (Annex D1, Appendix 9).

6.3.5 Final consideration of plausibility

A key step in the Committee's Requirements and Guidelines for *Implementations* (IWC, 2012y) is assigning plausibility to hypotheses and, by extension, to all of the *Implementation Simulation Trials*. Trials are assigned 'low', 'medium' or 'high' weights, or are categorised as 'no agreement', which are treated as 'medium' weighted trials. Trials with 'low' weights are not considered further in the *Implementation*.

When the results of the trials are examined, for each management variant (see Item 6.3.5.1), 'acceptable' conservation performance is required for all 'high' weight trials but 'borderline' or 'unacceptable' conservation performance for a number of 'medium' weight trials, leads to further consideration of a possible 'with research' option, as detailed in IWC (2012y). Unacceptable performance of a management variant in any 'high' weight trial leads to that variant being eliminated from further consideration, including with respect to the 'with research' option.

The schedule for *Implementations* in the Committee's Requirements and Guidelines for *Implementations* (IWC, 2012y) required final decisions on the plausibility of hypotheses to be made at this year's meeting.

SC/64/Rep2 noted that the present meeting would decide whether analyses of CPUE data (or sighting per unit effort data, SPUE) could be used qualitatively to inform assignment of plausibility weights to the hypotheses (stock structure and MSYR) on which the trials are based (see Annex D1, item 3.6). The Workshop had noted that a document outlining relevant operational factors needed to be developed for the Committee to make a decision in this regard, and it had made a number of recommendations regarding such a document.

SC/64/NPM4 summarised information pertaining to catch, sightings and effort data from Japanese small-type whaling during 1977-87 in relation to minke whales. The authors concluded that CPUE or SPUE data can be useful as an index of population trend if standardised.

The Committee thanked the authors of SC/64/NPM4, which covered most of the factors identified. It noted that there was considerable variation in where individual vessels operated during the year, and that if vessel movement reflects availability of whales, CPUE or SPUE may be biased as an index of relative abundance. It was suggested that focusing on April-May only may provide more consistency.

Following the presentation of the results of additional analyses, the Committee considered that further analysis and model diagnostics would need to be provided before the resultant SPUE trends could be used to assist the assignment of plausibility to hypotheses related to stock structure and MSYR. Given the time available, this was not feasible this year. It was noted that these data could be re-analysed and presented to the next *Implementation Review*, although some members considered that use of whaling SPUE data was inherently problematic and that no analyses of these data would lead to information which could inform plausibility.

6.3.5.1 STOCK STRUCTURE

In response to a request made intersessionally, the Committee received papers from the proponents of Hypotheses A/B

(SC/64/NPM1) and of Hypothesis C (SC/64/NPM11) summarising their main features and supporting evidence. Details of these papers are given in Annex D1, item 6.2. A graphical representation of these stock structure hypotheses is given in fig.1 of IWC (2012h, p.103).

Two papers containing new genetic analyses were presented. SC/64/NPM9 used computer simulations to examine the effect of different sample sizes on the distributions of the correlations between θ and F_{IS}, following an analysis presented last year (Waples, 2011) in which it was proposed that, in a sample that contains individuals only from two distinct stocks, the largest departures from equilibrium (quantified as F_{IS}) should be seen at the loci that show the largest allele frequency differences between the two stocks (quantified as θ). Details are given in Annex D1, item 6.2. given the considerable variability seen in the simulated data, the authors of SC/64/NPM9 suggested that further evaluation is required before the results of (Waples, 2011) could be used as evidence against Hypotheses A and B.

In discussion, it was suggested that it would be useful to extend these analyses to the two-locus (linkage disequilibrium - LD) correlations that were also reported in (Waples, 2011). Additional discussion is given in Annex D1, item 6.2.

SC/64/NPM10 responded to a request from last year's meeting for follow-up analyses comparing the performance of two Bayesian clustering programs (STRUCTURE and HWLER) for detecting the number of gene pools represented in a sample. Details are given in Annex D1, item 6.2. Both programs only detected one population when true panmixia was modelled, but both also failed to detect a second population at the weakest level of differentiation (F_{ST} = 0.007). STRUCTURE reliably detected two populations at F_{ST} = 0.02 but HWLER did not, but HWLER was more consistent in resolving mixtures for F_{ST} > 0.03.

In discussion, the Committee noted that the results provide additional confirmation that these Bayesian clustering methods cannot detect the weakest levels of population structure, at least using currently available numbers of genetic markers. Details of additional discussion are given in Annex D1, item 6.2. Several more technical aspects of the performance of STRUCTURE at moderate levels of population differentiation (F_{ST} = 0.045-0.06) were also discussed; details are given in Annex I.

In response to a request in SC/64/Rep2, the summary information relating to key stock structure questions developed last year (Appendix 9 of Annex D1 of last year's report - IWC, 2012h) was reformatted and presented to the Committee. It was revised following discussion and a final version is given in Annex D1, Appendix 6. This table provided a useful starting point for final considerations of plausibility of stock structure hypotheses.

The Committee also received Annex D1, Appendix 7, which synthesised information relating to the relevance of departures from Hardy-Weinberg equilibrium at one and two gene loci, to distinguish between stock-structure hypotheses. The author's overall conclusion was that evidence from Hardy-Weinberg departures for more than two O+J stocks is only weak to moderate. Details of discussion are given in Annex D1, item 6.2.

Following these presentations and discussions, the Committee considered a concise overall summary by the 'G5 group' of geneticists of their interpretation of the relative support for and against the five hypothesised stocks (JE, JW, OE, OW, Y), based on the cumulative genetic information presented and discussed during the last several years. This summary table is given in Annex D1, Appendix 8.

During the discussion, there was some attempt to reduce the number of stock structure hypotheses for consideration in the *Implementation Simulation Trials*. It was noted that the conclusion in Annex D1, Appendix 8 regarding Y stock did not depend on data on conception date, which some consider the strongest evidence for Y stock. Some members suggested that as a consequence, Hypothesis A be assigned 'Low' plausibility. This was not agreed to by the proponents of that hypothesis, who pointed out that reliability of the conception date data has been questioned (e.g. IWC, 2012h) and who argued that the genetic data are too limited to be considered strong support for existence of Y stock. Similarly, assigning 'High' plausibility to a 4-stock version of Hypothesis C that includes two O stocks but only one J stock, and 'Medium' plausibility to Hypothesis C did not receive agreement.

It was not possible to reach agreement on any of these alternatives and, as a consequence, all three main stock structure hypotheses (A, B and C) were 'no agreement'. The Committee **agrees** that they should therefore be treated as if they had been assigned 'Medium' plausibility and that the *Implementation Review* should proceed on this basis.

Pastene commented that although several types of data had been considered during the *Implementation* process thus far, he felt that the conclusions on plausibility were too heavily weighted to the genetic data. The Committee reaffirms the importance of using data from a suite of techniques.

Some members expressed their concern that, despite an enormous investment in research, no consensus had been reached on according low plausibility to the hypothesis of two J stocks. They noted the conclusion of five geneticists who were not proponents of any of the hypotheses (Gaggiotti, Hoelzel, Palsbøll, Tiedemann and Waples) that, based on existing genetic data and analyses, the evidence for the two J stock hypothesis is low and the evidence against it is medium or high (Annex D1, Appendix 8). They questioned whether it would ever be possible to agree, on the basis of genetic analyses, that a hypothesis be given low plausibility if such a statement was not considered by the Committee to be sufficient.

Other members considered that the genetic data were insufficient to evaluate any of the three stock structure hypotheses. They noted that genetic data do not provide information on annual mixing rates between *Small Areas*, which has been shown to be an important consideration in the application of the RMP (Martien *et al.*, 2008). They also noted the discussion on the lack of samples from the breeding grounds and recommendations for further research to determine the levels of demographic mixing between breeding populations in relation to management outcomes.

6.3.5.2 MSYR AND OTHER FACTORS

The previous *Implementation* assigned 'high' plausibility to $MSYR_{mat}$=4% and 'medium' plausibility to $MSYR_{mat}$=1% (IWC, 2005a). It was noted that these whales are found in a region in which there are very large fisheries which might impact the prey base. However, the size of any such an effect on MSYR cannot be quantified at this time. In addition, the review of MSY rates will not be completed during the current meeting so there is effectively no new information related to MSYR for western North Pacific minke whales. The Committee therefore **agrees** to assign 'high' plausibility to $MSYR_{mat}$=4% and 'medium' plausibility to $MSYR_{mat}$=1%, as in the previous *Implementation*.

The baseline trials are based on the hypothesis *g*(0)=0.8, based on the estimate of *g*(0) by Okamura *et al.* (2010) for the combination of top barrel and upper bridge. The December 2010 First Intersessional Workshop (IWC, 2012d) had noted that this estimate is conservative because the *g*(0) value is to be applied identically to all surveys, including those by Korean vessels which have lower top barrels, and hence seem likely to miss a greater proportion of minke whales on the trackline. The Committee therefore **agrees** to assign 'high' plausibility to *g*(0)=0.8 and 'medium' plausibility to *g*(0)=1.

Regarding the full set of sensitivity trials, the Committee **agrees** to assign 'medium' plausibility to all except for the following three trials.

(1) Trial 24, which is based on stock structure hypothesis C, but there is a single O-stock and two J-stocks. This trial was assigned 'low' plausibility given the results of the genetics analyses (see Annex D1, Appendix 8).
(2) Trials 21 and 29, which are based on the abundance in sub-areas 5 and 6W, respectively, being set to the 'minimum' values. These trials were assigned 'low' plausibility because the Korean surveys in sub-areas 5 and 6W only cover a small fraction of the overall area of these sub-areas.

The Working Group noted that results of trials 21 and 29 might provide useful information regarding the behaviour of the trials, and **recommends** that these trials be conducted if time is available.

Annex D1, Appendix 5 lists the factors considered in the trials and the final plausibilities assigned by the Committee to each factor.

6.3.6 Specifications of operational features and management variants

In order to implement the *CLA* in trials, specifications of proposed whaling operations are required. Japan intends to conduct coastal whaling in sub-areas 7CS, 7CN and 11, and pelagic whaling in sub-areas 8 and 9. Coastal whaling will be restricted to 10 n.miles. from the coast and during August-October in sub-area 11 to minimise catches of J-stock animals. Whaling in sub-areas 8 and 9 will take place during April-October. Korea intends to conduct whaling using small-type catcher boats in sub-areas 5 and 6W from March to November. Operations will be conducted up to 60 n.miles. from the coast in sub-area 5 and up to 30 n.miles. from the coast in sub-area 6W.

It is also necessary to specify the management variants that will be implemented in the trials. A management variant defines the way the *CLA* is applied to *Management Areas*. This includes specifying *Medium Areas*, *Small Areas* and combinations of *Small Areas* (*Combination Areas*), specifying from which *Management Areas* catches are to be taken, and selecting *Catch-cascading* and/or *Catch-capping* options.

The **agreed** RMP variants and the associated *Small* and *Medium Area* definitions are given in Annex D1, Appendix 9.

The Committee noted that the trials will take longer to run than in previous *Implementations* because the *CLA* will be implemented using the Norwegian 'CatchLimit' program rather than the Cooke version of the *CLA*. The Committee **agrees** that priority should be given to running all RMP variants for the baseline trials as quickly as possible so that any of the RMP variants that are clearly likely to perform 'unacceptably' can be excluded from further consideration. The process of distributing and evaluating trials will be co-ordinated by the Intersessional Steering Group (see Annex Q2).

6.3.7 Specifications and classification of final trials

The final trial specifications are given in Annex D1, Appendix 9.

The Committee **agrees** that for running the trials it will be assumed that the proportional coverage of sub-areas will remain unchanged.

The planned future surveys and a proposal for how past surveys can be combined to calculate survey estimates for *Small Areas* are given in Annex D1, Appendix 9.

SC/64/NPM8 reported that a survey in the Yellow Sea will be conducted during spring 2013. Details are given in Annex D1, item 8.2. The Committee was pleased to hear that additional surveys would continue to be conducted in the waters off Korea and appointed An to provide oversight on its behalf. In relation to survey design, the Committee had recommended some changes to the survey design, which was subsequently modified during the meeting (see Annex D1, item 8.2).

SC/64/O9 reported on a sightings and satellite tagging survey for common minke whales in sub-area 7 in April-June 2011. Only two animals were encountered and efforts to deploy a tag were unsuccessful. SC/64/O10 reported on a sighting and biopsy sampling survey for common minke whales in the Okhotsk Sea, including the Russian EEZ, in May-June 2011. Three schools of minke whales were targeted for biopsy sampling, but no samples were obtained because of difficulties closing on the animals. The Committee expresses its support for continued efforts to collect telemetry and biopsy data to help elucidate stock structure for minke whales in this region. More details are given in Annex D1, item 9.

6.3.8 Consideration of data/analyses to reduce hypotheses in future

The Committee had a general discussion of the fact that, in spite of many years of concerted efforts and a great deal of genetic and non-genetic data, considerable uncertainties remain regarding stock structure of western North Pacific minke whales. This issue is particularly difficult because of the lack of any samples from breeding grounds. The Committee considered a number of types of genetic analyses that might help to reduce these uncertainties in the future. These included sensitivity analyses of recently-used methods and development and application of new analyses, details of which are given in Annex D1, item 9. The importance of considering further work on non-genetic data was also noted. The Committee notes that plans for international collaborative work, including a Workshop, to assist the Committee prepare for an *Implementation Review* under the RMP and the development of an AWMP *SLA* for the Greenland hunt for North Atlantic minke whales (Annex D, Appendix 6) could serve as a useful model for this.

In addition to proposed analyses specifically related to North Pacific common minke whales, the Committee considered an approach that would more broadly address core stock-structure problems that recur for many species in many areas. This general approach has two parts: (1) determining what levels of demographic mixing between breeding populations do and do not make a difference in terms of conservation goals or management outcomes; and (2) using genetic and other methods to determine whether actual levels of connectivity are above or below this threshold.

The Committee **agrees** that work towards this general approach should receive high priority. Suggestions to facilitate implementation of this approach are given in Annex D1, item 9; further discussion is given in Annex I.

It was noted that the *Implementation Review* for North Atlantic common minke whales will undertake some of this work (see Annex D, item 3.3) and that it would be desirable to coordinate efforts in that regard. It was also noted that similar work was being undertaken by scientists at the US Southwest Fisheries Science Center. Cumulative results of these analyses should make it apparent whether general rules of thumb about 'tipping point' levels of migration can be identified, or whether the outcomes are so diverse that each situation must be evaluated on its own merits.

As noted in SC/64/Rep2, in addition to issues of stock structure, other difficulties in conducting the present *Implementation Review* centred on abundance estimates, including their unavailability in some areas and the large CVs for some of the estimates that were available. The difficulties faced by the Committee in determining the acceptability of abundance estimates for use in trials (see Annex D1, item 5.1.2) amplify this concern.

The Committee **agrees** that, to avoid such difficulties in future *Implementation Reviews*, it should consider taking a more active and collaborative approach to this issue. Examination of trial results will assist in identifying the key temporal and geographical areas where new/improved abundance estimates would be most valuable. The Committee should consider developing, in conjunction with the appropriate range states, a short-medium term survey strategy (including design and required effort) and analytical approach that would improve the availability of satisfactory abundance estimates with reasonable CVs at the appropriate geographical and temporal scale to facilitate future *Implementation Reviews*. This could follow a similar process to that used to develop the IWC-POWER programme (Annex G, item 6.2).

6.3.9 Inputs for actual application of the CLA

The Committee **agrees** that the best estimates of the direct catches and the average predicted bycatch from the six baseline trial would be used for applications of the *CLA*.

The Committee did not have sufficient time to select abundance estimates for use in application of the *CLA*. This issue will need to be addressed at the Second Intersessional Workshop (see Item 20).

6.4 North Atlantic common minke whales

6.4.1 Review new information

SC/64/RMP4 summarised the results of aerial surveys covering most of the continental shelf waters of the Icelandic economic zone; the off season component was part of the Icelandic research programme on common minke whales conducted during 2003-07. The Committee noted that SC/64/RMP4 will be considered during the review of this programme in 2013 (see Item 17.1.3).

SC/64/RMP5 summarised a sighting survey conducted in the eastern Norwegian Sea in the *Small Management Area EW* during the summer 2011. Details are given in Annex D, item 3.3.1 This was the fourth year in the ongoing six-year survey programme which runs from 2008-13. The Committee **welcomes** the information provided. The data will be included in developing a future abundance estimate for North Atlantic minke whales.

6.4.2 Prepare for 2014 Implementation Review

The Committee agreed last year (IWC, 2012i) to undertake an *Implementation Review* of common minke whales in the North Atlantic in 2014. It has agreed that this will include a full review of stock structure and other issues, recognising that there has been substantial new information collected over the period since the original hypotheses were developed during the *Implementation* itself (IWC, 1993b).

The Committee recognised that it was important to begin preparations for the review in sufficient time to allow for this thorough analysis. It therefore **recommends** the work plan (including a joint intersessional Workshop with AWMP in 2014) as outlined in Annex D, Appendix 6, to consider stock structure hypotheses for North Atlantic common minke whales. It appointed a Steering Group under Palsbøll (Annex Q4).

6.5 North Atlantic sei whales

Víkingsson *et al.* (2010) represented a proposal to initiate a *pre-Implementation assessment* of sei whales in the Central North Atlantic. As required (IWC, 2005b), the paper provides a broad outline of the available data relevant to a *pre-Implementation assessment*, including historical catches, distribution and abundance from dedicated and non-dedicated sightings surveys, stock structure (Discovery marking, genetics and satellite telemetry), biological parameters, feeding ecology and pathology. The authors concluded that the data are sufficient to warrant a *pre-Implementation assessment* of sei whales in the North Atlantic.

The decision whether to initiate an *Implementation* is made by the Commission. The Committee **recommends** that an intersessional group convened by Víkingsson (Annex Q5) should be established with Terms of Reference to review the available data for North Atlantic sei whales in the context of a *pre-Implementation assessment* and provide a report to the 2013 Annual Meeting. The Committee will review the report and any new information so that the Commission can be advised whether sufficient information is available to proceed with the *pre-Implementation assessment*.

6.6 Work plan

The Committee's views on the work plan developed by the sub-committee on the RMP are given under Item 21.

7. ESTIMATION OF BYCATCH AND OTHER HUMAN-INDUCED MORTALITY (BC)

The report of the Working Group on Estimation of Bycatch and Other Human-induced Mortality is given as Annex J. This subject was introduced onto the Agenda in 2002 (IWC, 2003e) because under the RMP, recommended catch limits must take into account estimates of mortality due to *inter alia* bycatch, ship strikes and other human factors in accordance with Commission discussions at the 2000 Annual Meeting (IWC, 2001a), although of course such mortality can be of conservation and management importance to populations of large whales other than those to which the RMP might be applied. Subsequently, the issue of ship strikes has become of interest to the Commission's Conservation Committee (e.g. IWC, 2011b) while entanglement response is being considered by the Commission's Working Group on Whale Killing Methods and Associated Welfare Issues (e.g. see IWC/64/WKM&AWI Rep1).

7.1 Collaboration with FAO on collation of relevant fisheries data

There has been an ongoing effort by the Secretariat and Sea Mammal Research Unit to consolidate data on entanglements submitted in the National Progress Reports into a single database to be shared with FAO. All bycatch records reported to the IWC for the period 1967-2010 have now been entered. The IWC is currently an observer to the Fisheries Resources Management System partnership (FIRMS), a collaborative partnership organised by the FAO, which enables fishery management bodies to share information. It was hoped that FIRMS may hold data on fishing effort that could be useful in estimating bycatch but FIRMS appears to have changed its focus somewhat since initial discussions. The Committee **recommends** that the Secretariat contact FIRMS to establish whether the partnership is still attempting to collate data on fishing effort in such a way that could be of use to the Committee in estimating bycatch.

7.2 Estimation of bycatch mortality of large whales

A long-term data set on entanglements and disentanglements off South Africa showed two centres of entanglement involving humpback or southern right whales, one off the coast of KwaZulu-Natal (KZN) involving nets set to protect bathers from sharks and the second off the coast of the Western Cape involving traps and attached lines set for rock lobster. Interventions were successful in removing gear from 81% of whales entangled in shark nets off KZN (38 humpback, 17 right whales), while 11 humpback and 2 right whales were found dead. Off the Western Cape, whales were successfully disentangled in 23% of cases (*n*=90) and partially dis-entangled in another 12%. The trend in humpback whale entanglement since 1990 was compatible with the recorded rate of population increase. Entanglement rates of southern right whales apparently increased from 1990 and this could also be attributed to an increase in the population (Meyer *et al.*, 2011).

Entanglement data from the coasts of Newfoundland and Labrador, Canada from 1979 to 2008 included 1,209 large whale entanglements, consisting primarily of humpback whales (80%) and minke whales (15%). Reported entanglements dropped from an average of 64 prior to the moratorium on cod fisheries in 1992 to 19 afterwards (Benjamins *et al.*, 2011).

The Committee noted the value of the extensive data sets described in these studies and that they contributed to an understanding of the impacts, rates and trends over time in entanglement mortality. Both studies had been able to identify trends over time and relate these to either population size or fishing effort. The Committee **recommends** the continuation (or initiation) of these and similar studies and encourages the presentation of results at future Committee meetings.

7.3 Estimation of risk and rates of entanglement

Recent capacity building on entanglement response, conducted by the IWC working in conjunction with both national and regional authorities in Argentina, stimulated an analysis of entangled southern right whales in the province of Chubut. Of nine confirmed cases of entanglement, five involved moorings and four involved marine debris or fishing gear. Six of these whales were successfully released. Many of the mooring systems contained heavy chain and relatively thick diameter rope, but were still found to entangle whales. Whales were often seen ‘playing’ with mooring and anchor lines and this behaviour is believed to be a primary mechanism for entanglement in this region.

The primary focus of the second IWC Workshop on Welfare Issues Associated with the Entanglement of Large Whales held in 2011 (IWC/64/WKM&AWI Rep1) was on entanglement response and capacity building but several topics from the Workshop were also relevant to estimating risk, including the mechanisms by which large whales become entangled. The Committee noted the value of data collected during entanglement responses and welcomed the efforts at the Workshop to develop a data form to standardise the data now being collected around the world. The Workshop participants had also proposed to form a ‘global network of entanglement response teams’ and seek the endorsement of the IWC as an expert panel to advise member nations on issues related to large whale entanglement including setting up response networks, methodologies for understanding scope and impact on local populations, and response capacity building. The Committee **supports** the call for the proposed group and a potential database noting that this will assist the work of the Committee. In many cases there are additional data available from entanglement incidents that could supplement the summary data currently requested in National Progress Reports. The IWC could become a repository for such data through a similar effort to the ship strike database.

7.4 Review progress on including information in National Progress Reports

Due to some delays with changing to electronic submission of Progress Reports, not all of these were reviewed at the meeting. It was noted that, when complete, electronic submission will facilitate linking relevant data to the ship strike database. Suitable links within the submission system could also encourage the entry of data to the ship strike database where more detailed information is available.

7.5 Ship strikes

New information on ship strikes was received for the Arabian Sea region, South Africa and Sri Lanka. A preliminary summary of strandings, lethal entanglements and ship strikes of large whales in the Arabian Sea region, revealed seven documented ship strikes and four lethal entanglements between 2000 and 2012 and included three Arabian Sea humpback whales. The Committee has noted its concern over the status of this population and the increasing shipping traffic in this region (see Item 10.7 for further discussion).

Of 71 recorded mortalities of southern right whales off the South African coast between 1999 and 2010 five bore injuries consistent with a ship strike.

The southern coast of Sri Lanka has one of the busiest shipping routes in the world and overlaps with an area of high whale sightings. Two pygmy blue whales were struck and killed in Sri Lankan waters in early 2012. In the absence of any abundance estimates for the local population, the population impacts of ship strikes are unknown. The Committee **draws attention** to the urgent need for long-term monitoring of the blue whale population in Sri Lankan waters and elsewhere in the northern Indian Ocean. The Committee **recommends** that the Secretariat send a letter to the Sri Lankan Government, drawing their attention to its discussion of this topic and ways in which the Committee may assist.

There is a need to better understand the variables that will affect whether a ship struck whale will strand and predict where death may have occurred. A deterministic model that uses wind archives and outputs of tidal models to predict the drift of floating objects has been developed by MétéoFrance. The model can make forward calculations to predict a stranding location or backward calculations to estimate the likely origin of an object. This model had been used to predict whether small cetacean carcasses in the Bay of Biscay would reach the coast (Peltier *et al.*, 2012). It was noted that some carcasses may 'sail' across the wind to variable degrees and a large whale carcass may also 'swim' after death, because of the action of swell on its tail flukes. The Committee **recommends** further study of carcass drift, detection and deterioration for large whales that could be used to establish the location of death from a ship strike or other sources.

A better understanding of the relationship between vessel speed and collision risk is needed to assess risk. A recent study (Wiley *et al.*, 2011) evaluated the relative risk reduction that might be achieved by speed restrictions. Two studies based on the locations relative to the ship at which humpback whales were observed from cruise ships inferred greater collision risks with increases in speed (Gende *et al.*, 2011; Harris *et al.*, 2012).

A Workshop focusing on ship strikes in the Bay of Biscay was held in London in April 2012 (Bull and Smith, 2012). It made a series of recommendations, mainly dealing with mitigation measures but also related to assessing risk. In particular, the workshop considered ways in which a large data set of observations from vessels may be used. The Committee **welcomes** the approach taken by the Workshop to engage a wide variety of stakeholders, and noted that the report could also be relevant to work in other regions. The Workshop had considered what could be inferred from observations of 'near miss' incidents. The difficulties in defining a 'near miss' have been discussed before and further analyses leading to papers for next year's meeting were encouraged.

A proposal for a Workshop of cetacean and shipping experts to agree on appropriate analytical and modelling techniques to assess ship strike risks arose out of the IWC-ACCOBAMS ship strike Workshop in 2010 (IWC, 2011d). At the time there was some uncertainty about the availability and content of data on shipping density. Analysis approaches are likely to be most effective on a case by case basis and there are now commercial sources of raw data from Automatic Identification Systems (AIS). The Committee **agrees** that a dedicated Workshop is not needed at this stage but **encourages** presentation of papers examining ship strike risks based on overlap of shipping and whale density.

7.6 Continue to develop a global database of ship strike incidents

The IWC has been developing a global database of incidents involving collisions between vessels and whales since 2007.* A web based data entry system has now been in place for two years but there have been few new reports submitted. Most of the interessional database related efforts were to promote awareness, including work by Mattila who has been seconded to the Secretariat to assist with work on mitigating conflicts between whales and marine resource users. As last year, the Committee **agrees** that a more pro-active approach is needed to encourage data to be entered and it **repeats its recommendation** for the appointment of a dedicated IWC ship strike data coordinator with the tasks described in Annex J, Appendix 2 (see also Item 23). The Committee also **recommends** that the Guide for Authors for the *Journal of Cetacean Research and Management* should encourage authors of papers containing data on ship strike incidents to report these to the database.

Some members noted concern that ship strikes may increase in the Arctic as shipping begins to utilise increases in navigable waters resulting from reduced sea ice coverage. The Committee **welcomes** the offer to present new information on this issue at its next meeting.

http://www.iwcoffice.org/sci_com/shipstrikes.htm.

7.7 Other issues

A number of papers concerning the impacts of marine debris were considered under Item 12 (see Annex K). The Committee **encourages** further activities that could help to quantify mortality related to marine debris, noting the difficulty in determining if debris is from actively fished gear.

7.8 Work plan

The Committees discussions on the sub-committee's work plan are incorporated under Item 21.

8. ABORIGINAL SUBSISTENCE WHALING MANAGEMENT PROCEDURE (AWMP)

This item continues to be discussed as a result of Resolution 1994-4 of the Commission (IWC, 1995b). The report of the SWG on the development of an aboriginal whaling management procedure (AWMP) is given as Annex E. The Committee's deliberations, as reported below, are largely a summary of that Annex, and the interested reader is referred to it for a more detailed discussion. The primary issues at this year's meeting comprised: (1) *Implementation Review* of eastern gray whales with special emphasis on the PCFG (the Pacific Coast Feeding Group); (2) undertaking an *Implementation Review* for B-C-B (Bering-Chukchi-Beaufort Seas) bowhead whales; (3) developing *SLA*s and providing management advice for Greenlandic hunts; and (4) review of management advice for the humpback whale fishery of St. Vincent and The Grenadines. This represented a significant workload.

8.1 Complete *Implementation Review* of eastern North Pacific gray whales with an emphasis on the PCFG

At the 2010 Annual Meeting (IWC, 2011h), the Committee agreed that the information on stock structure and hunting presented, although some of it had not met the Data Availability Guideline requirements (IWC, 2004b) for the 2010 review, warranted the development of trials as part of an immediate new *Implementation Review* to evaluate the performance of *SLA*s for hunting in the Pacific Northwest, with a primary focus on the PCFG. It had also agreed that the 2010 *Implementation Review* had shown that the population as a whole was in a healthy state, but that over the next few years, further work should be undertaken to investigate the possibility of structure on the northern feeding grounds, especially in the region of the Chukotkan hunts.

The Committee started the process of the new *Implementation Review* at an intersessional Workshop in 2011 (IWC, 2012c) and followed that with work at the 2011 Annual Meeting (IWC, 2012g). A second Workshop was held in March 2012 kindly hosted by the SWFSC in La Jolla, California (SC/64/Rep3). At that Workshop, most of the effort centred on finalising the operating model and trial structure and completing conditioning. The present meeting reviewed progress made at and since the Workshop and focused on finalising the *Implementation Review*. This summary here incorporates work from the intersessional Workshops and the present meeting.

8.1.1 Stock structure

The *Implementation Review* considers three geographic regions:

(1) the 'north' area (north of 52°N i.e. roughly northern Vancouver Island);
(2) the PCFG area (between 41°N and 52°N); and
(3) the 'south' area (south of 41°N).

The trials consider two stocks ('PCFG' and 'north'). PCFG whales, which are treated as a separate management unit, are defined as gray whales observed (i.e. photographed) in multiple years between 1 June and 30 November in the PCFG area (IWC, 2011f). Not all whales seen within the PCFG area at this time will be PCFG whales and some PCFG whales will be found outside the PCFG area at various times during the year. However, this is not problematic since the historical catches north of 52°N occurred well north of 52°N and future catches will either occur in the Bering Sea or in the Makah U&A (Makah Usual and Accustomed Fishing Grounds). The remaining animals ('north') represent the large eastern North Pacific stock (the stock to which the whales taken during the Chukotkan hunt belong).

Several papers addressed stock structure and related issues (e.g. levels of immigration) at both the intersessional Workshop (see SC/64/Rep3, item 2.4.2.2) and the present meeting (see Annex E, item 2.2.2). Notwithstanding the difficulties arising out of the complexities of the issue, the Committee was particularly pleased to see efforts to use the IWC's TOSSM framework (IWC, 2007e; Lang and Martien, 2012; SC/64/AWMP4; and see Item 11.3). In that context, it was recommended that future TOSSM analyses consider a broader range of parameter choices to explore the robustness of the conclusions to uncertainty. In concluding discussions on this issue, it was agreed that the trials (see Table 3) covered a suitably broad range of immigration rates.

8.1.2 Abundance

The Committee reviewed the mark-recapture abundance estimates provided in SC/64/Rep3 and a new paper (SC/64/AWMP10). The agreed abundance estimates from a modified Jolly-Seber approach (Laake, 2012) are provided in Table 2 for the OR-SVI region (Oregon to southern Vancouver Island ~42-49ºN) and the NCA-NBC region (northern California to northern British Columbia ~41-52ºN). Given the large bias in the first (1998) estimate, the estimates for this year are out of conditioning.

Abundance estimates for the total eastern North Pacific are those provided by Laake (2012); they are given in Annex E, Appendix 2, table 4a.

8.1.3 Catch data (direct and incidental)

The agreed catch series for the period of the trials (i.e. 1930 onwards) are given in Annex E, Appendix 2, table 1. Following work at the intersessional Workshop and further review by an intersessional group established in SC/64/Rep3, it was agreed that the average annual kills during 2000-09 were 2 for the PCFG (December-May), 1.4 for the PCFG (June-November) and 3.4 for the 'south' (December-May) and this information was used to forecast future incidental catches.

8.1.4 Mixing

Mixing relates to: (1) mixing of stocks in the three areas; and (2) the relative probability of whaling in the Makah U&A taking a PCFG whale given the number of PCFG and 'north' whales. The latter can be estimated as the proportion of PCFG whales to total whales in photographs during December-May from the outer coast of northern Washington (0.3; SC/64/Rep3). However, there are a number of uncertainties and assumptions surrounding such an analysis resulting in the need for sensitivity tests (i.e. alternative trials spanning a range of values).

Table 2

Abundance estimates (*N*) and standard errors in OR-SVI and NCA-NBC after exclusion of known calves from the year in which they were identified as calves.

Year	*N*	SE(*N*)
Region: OR-SVI		
1998	63	4.1
1999	78	8.4
2000	89	11.9
2001	117	8.9
2002	133	15
2003	151	13.7
2004	157	15.5
2005	162	15.7
2006	154	15.3
2007	152	14.5
2008	150	12.5
2009	146	14.9
2010	143	16.8
Region: NCA-NBC		
1998	101	6.2
1999	135	12
2000	141	13.2
2001	172	12.6
2002	189	9.2
2003	200	16.4
2004	206	14.9
2005	206	22.6
2006	190	18.8
2007	183	23.1
2008	191	16.1
2009	185	23.2
2010	186	18.7

Table 3

SLA variants suggested by the Makah tribe used in the *Trials*.

Variant number	PCFG limit	Struck and lost count toward APL
1	APL Formula	No
2	APL Formula	Yes
3	APL Formula	Yes
4	1	No
5	1	Yes
6	1	Yes
7	2	No
8	2	Yes
9	2	Yes
10	No limit	N/A
11	No limit	N/A

8.1.5 Biological parameters and MSYR

Biological parameter values were agreed last year (IWC, 2012j). The priors, based on the 2004 *Implementation,* are given in the trial specifications (Annex E, Appendix 2). The most likely value for $MSYR_{1+}$ for the north stock was agreed to be 4.5% i.e. the posterior median from the most recent assessment of this stock (Punt and Wade, 2012). The *Evaluation Trials* also consider a value for $MSYR_{1+}$ for the north stock of 2% (rounded lower 90% posterior bound from the Punt-Wade assessment). There are insufficient data to estimate MSYR for the PCFG and so two scenarios are considered for the Trials as discussed last year (IWC, 2012j): (1) $MSYR_{1+}$ for the PCFG stock is the same as that for the north stock and there is no immigration (this is unlikely given the data but provides a conservative lower bound); and (2) three values of $MSYR_{1+}$ but with some immigration and emigration.

Table 4
Details of factors considered in trials.

Factors	Other levels (reference levels shown bold)
$MSYR_{1+}$ (north)	**2%**, **4.5%**
$MSYR_{1+}$ (PCFG)	**1%**, **2%**, **4.5%**
Immigration rate (annual)	**0, 1, 2**, 4, 6
Pulse immigration (1999/2000)	**0**, 10, **20**, 30
Proportion of PCFG whales in PCFG area, ϕ_{fut}	0, **0.3**, 0.6, 1
Struck and lost rate (PCFG area)	0, **50%,** 75%
Northern need in final year (linear change from 150 in 2010)	**340**, 530
Historic survey bias	**None,** Increasing between 1967 to 2002 from 0.5→1 (north only), 50% (PCFG only)
Future episodic events	**None,** 3 events occur between yrs 1-75 (at least 2 in yrs 1-50) in which 20% of the animals die. Events occur every 5 years in which 10% of the animals die.
Time dependence in *K*	**Constant**, Halve linearly over 100yr, Double linear over 100yr
Time dependence in natural mortality, *M* *	**Constant,** Double linearly over 100yr
Parameter correlations	Yes, **No**
Probability of mismatching north whales, p_2	0, **0.01**, 0.01-0.05
Probability of mismatching PCFG whales, p_1	**0**, 0.5
Frequency of PCFG surveys	**Annual**, 6-year
Incidental catch	**Reference**, double reference, half reference
Future sex ratio	**0.5:0.5**, 0.2:0.8 (M:F)
Episodic events with future pulse events	**None,** 3 events occur between yrs 1-75 (with at least 2 in yrs 1-50) in which 20% of the north stock die and a pulse of 20 animals is added to the PCFG stock.

8.1.6 Variants
The management plan proposed by the Makah Tribe is given in Annex D of SC/64/Rep3 and a number of alternative *SLA*s were proposed for analysis in SC/64/Rep3 as given in Table 3. These variants explore:

(1) how the allowable bycatch of PCFG whales level[10] (APL) of PCFG whales is calculated (three options);
(2) the time of year in which the hunt is modelled to occur and hence whether struck and lost animals are counted against the APL (two options); and
(3) the effectiveness of the *SLA* if only PCFG whales are available for harvest (i.e. in effect a summer hunt).

Variants 1-3 use the APL[11] formula presented in the proposed plan, variants 4-9 have fixed bycatch limits, and variants 10 and 11 explore the impact of not having a limit on bycatch of PCFG whales (i.e. the hunt is only stopped if the total strike limit is reached, or the number of struck-and-lost animals reaches its limit, or the landing limit is reached).

8.1.7 Final trials and conditioning
The final trial structure was agreed in SC/64/Rep3. A summary of the factors considered in the trials is given as Table 4. The *Evaluation Trials* agreed are shown in Table 5 and the *Robustness Trials* are shown in Table 6. These trials were finalised at the March 2012 Workshop (SC/64/Rep3). Conditioning the trials[12] began at the Workshop and was evaluated after the meeting by an intersessional Steering Group (SC/64/AWMP11). Only three trials, B02C, I02C and P05A were eliminated after considering the conditioning results, leaving 72 *Evaluation Trials* in all.

8.1.8 Review results of trials
Evaluation of *SLA*s is based on the objectives accepted by the Commission (IWC, 1983; 1995b) which are to:

(1) ensure that the risks of extinction to individual stocks are not seriously increased by subsistence whaling;
(2) enable aboriginal people to harvest whales in perpetuity at levels appropriate to their cultural and nutritional requirements, subject to the other objectives; and
(3) maintain the status of stocks at or above the level giving the highest net recruitment and to ensure that stocks below that level are moved towards it, so far as the environment permits.

Highest priority is accorded to the objective of ensuring that the risk of extinction to individual stocks is not seriously increased by subsistence whaling.

As their name implies, *Evaluation Trials* are used to examine the performance of the variant *SLA*s against the Commission's objectives. *Robustness Trials* are more extreme trials that are primarily to ensure whether an *SLA* performs as expected in such cases.

The results of all of the trials, expressed in tabular and graphical form (see examples in Annex D, Appendices 3-5) for all agreed performance statistics (conservation and need related) are available from the Secretariat.

The SWG (Annex E, item 2.5.1) screened the trials for conservation performance to focus on those that required more detailed examination. The criteria used were:

(1) the lower 5%ile of the final depletion distribution < than 0.6 (the MSYL level) and the lower 5%ile of the rescaled final depletion is lower than 0.6 for any of variants 1-10;
(2) the trial involved episodic events; and
(3) the lower 5%ile of the trend in 1+ population size indicated a decline in population size of 5% or larger over the final 20 years of the 100-year projection period for any of variants 1-10.

After this initial evaluation a number of features became apparent (see Annex E, items 2.5.1 and 2.5.2), primarily related to conservation performance (apart from variant 5, which had poor need satisfaction) that led the Committee to eliminate further consideration of all but variants 1 and 2.

[10]The Makah Tribe has proposed a hunt management plan with time and area restrictions to target migrating ENP whales, yet there is still a chance that PCFG whales are incidentally harpooned as bycatch to the targeted ENP gray whale hunt.
[11]The APL formula is provided in Annex E, Appendix 2.
[12]Conditioning is the process of selecting the values for the parameters of the operating model such that the predictions from this model are consistent with the available data.

Table 5

The *Evaluation Trials*. Values given in bold type show differences from the base case trial. The final three columns indicate which trials apply to which 'broad' hypotheses (P=pulse, B=bias, I=intermediate – see IWC, 2012i). For 'broad' hypotheses B and I, the number given is the pulse in 1999/2000. Unless specified otherwise ϕ_{PCFG} = 0.3, the struck and lost rate is 0.5, and there are no stochastic dynamics or episodic events. *Trials B02C, I02C and P05A removed after reviewing condition results – see text.

									Hypothesis		
Trial	Need to condition	Description	$MSYR_{1+}$ North	$MSYR_{1+}$ PCFG	Final need	Annual immigration	Survey frequency	Survey bias (north)	P	B	I
1A	Y	$MSYR_{1+}$=4.5%/4.5%	4.5%	4.5%	340 / 7	2	10 / 1	1	20	Y	10
1B	Y	$MSYR_{1+}$=4.5%/2%	4.5%	2%	340 / 7	2	10 / 1	1	20	Y	10
1C	Y	$MSYR_{1+}$=4.5%/1%	**4.5%**	**1%**	340 / 7	2	10 / 1	1	20	Y	10
1D	Y	$MSYR_{1+}$=2%/2%	**2%**	**2%**	340 / 7	2	10 / 1	**0.5→1**	20	Y	10
2A	Y	Immigration=0	4.5%	4.5%	340 / 7	**0**	10 / 1	1	20	Y	10
2B	Y	Immigration=0	4.5%	2%	340 / 7	**0**	10 / 1	1	20	Y	10
2C	Y*	Immigration=0	**4.5%**	**1%**	340 / 7	**0**	10 / 1	1	20	Y	10
2D	Y	Immigration=0	**2%**	**2%**	340 / 7	**0**	10 / 1	**0.5→1**	20	Y	10
3A	Y	Immigration=1	4.5%	4.5%	340 / 7	**1**	10 / 1	1	20	Y	10
3B	Y	Immigration=1	4.5%	2%	340 / 7	**1**	10 / 1	1	20	Y	10
4A	Y	Immigration=4	4.5%	4.5%	340 / 7	**4**	10 / 1	1	20	Y	10
4B	Y	Immigration=4	4.5%	2%	340 / 7	**4**	10 / 1	1	20	Y	10
5A	Y*	Immigration=6	4.5%	4.5%	340 / 7	**6**	10 / 1	1	20	Y	10
5B	Y	Immigration=6	4.5%	2%	340 / 7	**6**	10 / 1	1	20	Y	10
6A		High Northern Need	4.5%	4.5%	**530 / 7**	2	10 / 1	1	20	Y	
6B		High Northern Need	4.5%	2%	**530 / 7**	2	10 / 1	1	20	Y	
7A		3 episodic events	4.5%	4.5%	340 / 7	2	10 / 1	1	20	Y	
7B		3 episodic events	4.5%	2%	340 / 7	2	10 / 1	1	20	Y	
8A		Stochastic events 10% every 5 years	4.5%	4.5%	340 / 7	2	10 / 1	1	20	Y	
8B		Stochastic events 10% every 5 years	4.5%	2%	340 / 7	2	10 / 1	1	20	Y	
9A		Episodic events with future pulse events	4.5%	4.5%	340 / 7	2	10 / 1	1	20	Y	
9B		Episodic events with future pulse events	4.5%	2%	340 / 7	2	10 / 1	1	20	Y	
10A		Relative probability of harvesting a PCFG whale, ϕ_{PCFG}=0.6	4.5%	4.5%	340 / 7	2	10 / 1	1	20	Y	
10B		Relative probability of harvesting a PCFG whale, ϕ_{PCFG}=0.6	4.5%	2%	340 / 7	2	10 / 1	1	20	Y	
11A		Struck & Lost (25%)	4.5%	4.5%	340 / 7	2	10 / 1	1	20	Y	
11B		Struck & Lost (25%)	4.5%	2%	340 / 7	2	10 / 1	1	20	Y	
12A		Struck & Lost (75%)	4.5%	4.5%	340 / 7	2	10 / 1	1	20	Y	
12B		Struck & Lost (75%)	4.5%	2%	340 / 7	2	10 / 1	1	20	Y	
13A	Y	Higher 1999-2000 Pulse	4.5%	4.5%	340 / 7	2	10 / 1	1	**30**		
13B	Y	Higher 1999-2000 Pulse	4.5%	2%	340 / 7	2	10 / 1	1	**30**		
13C	Y	Higher 1999-2000 Pulse	**4.5%**	**1%**	340 / 7	2	10 / 1	1	**30**		
14A	Y	Lower 1999-2000 Pulse	4.5%	4.5%	340 / 7	2	10 / 1	1	**10**		
14B	Y	Lower 1999-2000 Pulse	4.5%	2%	340 / 7	2	10 / 1	1	**10**		

Table 6

The *Robustness Trials*.

						Hypothesis	
Trial	Need to condition	Description	$MSYR_{1+}$ North	$MSYR_{1+}$ PCFG	Survey frequency	P	B
1A		6 year surveys	4.5%	4.5%	10 / 6	20	Y
1B		6 year surveys	4.5%	2%	10 / 6	20	Y
2A		Linear decrease in K^{1+} [K halves over years 0-99]	4.5%	4.5%	10 / 1	20	Y
2B		Linear decrease in K^{1+} [K halves over years 0-99]	4.5%	2%	10 / 1	20	Y
3A		Linear decrease in PCFG K [K halves over years 0-99]	4.5%	4.5%	10 / 1	20	Y
3B		Linear decrease in PCFG K [K halves over years 0-99]	4.5%	2%	10 / 1	20	Y
4A		Linear increase in M [M halves over years 0-99]	4.5%	4.5%	10 / 1	20	Y
4B		Linear increase in M [M halves over years 0-99]	4.5%	2%	10 / 1	20	Y
5A		Linear increase in PCFG M [M halves over years 0-99]	4.5%	4.5%	10 / 1	20	Y
5B		Linear increase in PCFG M [M halves over years 0-99]	4.5%	2%	10 / 1	20	Y
6A		Perfect detection; p_1 =0; p_2=0.01-0.05	4.5%	4.5%	10 / 1	20	Y
6B		Perfect detection; p_1 =0; p_2=0.01-0.05	4.5%	2%	10 / 1	20	Y
7A		p_1 = 0.5	4.5%	4.5%	10 / 1	20	Y
7B		p_1 = 0.5	4.5%	2%	10 / 1	20	Y
8B	Y	Survey bias PCFG + p_1 = 0.5	4.5%	2%	10 / 1	20	Y
9B	Y	Correlation (draw for N; same quantile in the range for PCFG)	4.5%	2%	10 / 1	20	Y
10B	Y	Double incidental catches	4.5%	2%	10 / 1	20	Y
11B	Y	Halve incidental catches	4.5%	2%	10 / 1	20	Y
12A		Sex ratio=0.2: 0.8	4.5%	4.5%	10 / 1	20	Y
12B		Sex ratio=0.2: 0.8	4.5%	2%	10 / 1	20	Y
13A		Relative probability of harvesting a PCFG whale, ϕ_{PCFG}=1	4.5%	4.5%	10 / 1	20	Y
13B		Relative probability of harvesting a PCFG whale, ϕ_{PCFG}=1	4.5%	2%	10 / 1	20	Y

Table 7

Final depletion and rescaled final depletion statistics for *SLA*s 1 and 2 for the trials with $MSYR_{1+}$=1% and the trials with $MSYR_{1+}$=2% for which conservation performance might be considered to be questionable.

Trial	*SLA* variant 1				*SLA* variant 2			
	Final depletion		Rescaled final depletion		Final depletion		Rescaled final depletion	
	Low 5%	Median	Low 5%	Median	Low 5%	Median	Low 5%	Median
$MSYR_{1+}$=1%								
GB01C	0.259	0.343	0.314	0.383	0.290	0.365	0.352	0.414
GP01C	0.382	0.461	0.400	0.472	0.438	0.515	0.460	0.528
GP02C	0.231	0.272	0.255	0.295	0.299	0.347	0.334	0.372
GI01C	0.378	0.446	0.399	0.459	0.434	0.497	0.457	0.513
$MSYR_{1+}$=2%								
GB08B	0.357	0.458	0.505	0.594	0.396	0.504	0.560	0.656
GB10B	0.492	0.556	0.492	0.557	0.575	0.633	0.576	0.635
GP08B	0.330	0.442	0.475	0.578	0.364	0.482	0.528	0.635
GP10B	0.475	0.536	0.476	0.538	0.556	0.619	0.557	0.621

8.1.9 Conclusions and selection of SLA*s*

In order to minimise the risk of taking PCFG whales, the management plan developed by the Makah Tribe restricts the hunt both temporally (to the migratory season for gray whales, i.e. 1 December-31 May) and geographically (to the Pacific Ocean region i.e. the Makah U&A except the Strait of Juan de Fuca). Some PCFG whales are present during the migratory season and thus the plan proposes an allowable PCFG limit (APL) during hunts that are targeting eastern North Pacific migrating whales with the aim of ensuring that accidental takes of PCFG whales do not deplete the PCFG. Whales struck in May might have a higher probability of being PCFG whales since they feed in this area in June. The management plan thus proposes an additional requirement that all animals struck-and-lost in May are assumed to be PCFG whales (i.e. count against the APL), whereas whales struck between December and April are not.

Weather conditions and availability of whales makes it likely that most hunting will occur in May. However, there are insufficient data to assess the number of strikes by month. Thus, it is not possible to reliably estimate the proportion of struck-and-lost whales that would count towards the APL. Given this uncertainty about how the plan would respond to failing to take into account struck-and-lost PCFG whales, the Tribe had proposed two *SLA* variants (1 and 2) spanning the options as to when the hunt might occur.

SLA variant 1 proposes that struck-and-lost whales do not count towards the APL i.e. there is no management response to PCFG whales struck but not landed. *SLA* variant 2 proposes that all struck-and-lost whales count to the APL irrespective of hunting month, i.e. the number of whales counted towards the APL may exceed the actual number of PCFG whales struck. A number of other *SLA* variants were proposed by the Tribe to explore additional management options. However, none of the variants precisely mimicked the final management plan proposed.

The trial results revealed:

(1) *SLA* variants 1 and 2 were potentially satisfactory and performed well in nearly all 72 *Evaluation Trials*; and
(2) *SLA* variants 1 and 2 performed acceptably for all *Robustness Trials*.

Given this, the Committee focused on those few trials for which conservation performance required further consideration. Trials with 1% $MSYR_{1+}$ are the most challenging and the conservation performance for some of these trials for both variants was not satisfactory (see Table 7). However, given the available information for the eastern North Pacific population as a whole (the observed recovery rate from severe historical depletion, as well as the current recovery rate from the 1999/2000 mortality event), the most recent assessment (Punt and Wade, 2012) resulted in an estimated MSYR rate of 4.6% [90% posterior interval 2.2%, 6.4%]. Therefore, the $MSYR_{1+}$=1% trials are at the lower bounds of plausibility and the Committee **agrees** that the conservation performance for these trials alone was not reason to preclude the conclusion that both variants have overall satisfactory conservation performance.

The Committee then focused on certain trials within the 2% $MSYR_{1+}$ set for which conservation performance might be considered questionable. Trial 8b (pulse and bias) involved 10% declines in abundance every five years as a proxy for random biological, environmental or anthropogenic events (e.g. disease or contamination). As noted in Annex E, item 2.5.1, these trials are in effect trials with lower $MSYR_{1+}$ than the nominal 2% of the trial. Given this, it **agrees** that both variants 1 and 2 had acceptable performance for these two trials.

Trial 10b (pulse and bias) involves an assumption that the relative probability of harvesting PCFG whales in the Makah U&A is double the observed ratio of PCFG whales to migrating whales observed in the available photo-identification (photo-ID) studies. The conservation performance of *SLA* variant 2 was considered acceptable for this trial but that for variant 1 was considered marginal (Table 7). In discussing the results of this trial, the Committee noted that the ratio of PCFG whales to migrating whales could be monitored directly from data collected during the hunting period allowing this assumption to be evaluated.

In conclusion, the Committee **agrees**:

(1) *SLA* variant 2 performed acceptably and met the Commission's conservation objectives for conservation while allowing limited hunting; and
(2) *SLA* variant 1 performed acceptably for nearly all the trials and could be considered to meet the Commission's conservation objectives provided that it is accompanied by a photo-ID programme to monitor the relative probability of harvesting PCFG whales in the Makah U&A, and the results presented to the Scientific Committee for evaluation each year.

The Committee **endorses** these conclusions and **recommends** them to the Commission. It also **agrees** that the *Implementation Review* is completed. Management advice is discussed under Item 9.2.3.

However, the Committee noted that the *SLA* variants tested did not correspond exactly to the management plan proposed by the Makah to the IWC. The Committee **agrees** to test such a variant intersessionally and examine the results at the next Annual Meeting.

8.1.10 Other business
Spatial mixing between eastern and western North Pacific gray whale stocks along the Pacific coast of North America outside the feeding season raises issues about the population structure within the Sakhalin feeding area (see SC/64/BRG10 and IWC, 2012k). The broad issue of stock structure of North Pacific gray whales is being addressed through a basinwide research programme (see Item 10.4). However, as noted last year, this finding raises concern about the possibility of whales feeding in the western North Pacific being taken during the proposed Makah Tribe hunt in northern Washington.

Last year (IWC, 2012f, p.16) the Committee had stressed three points.

(1) The new information on movements of gray whales highlighted the importance of further clarification of the stock structure of North Pacific gray whales. In particular, the matches of animals from the Sakhalin feeding grounds with animals seen in the PCFG area and other areas along the west coast emphasised the need for efforts to estimate the probability of a western gray whale being taken in aboriginal hunts for Pacific gray whales (noting that this did not require incorporation of western gray whales into the *Implementation Review).*
(2) It had strongly endorsed the basinwide research programme, noting that the results of the research may require further trials for future *SLA* testing; this would be a matter for consideration at the next *Implementation Review* if not before.
(3) The Committee will continue to monitor the situation and was willing to respond to any guidance or requests for further information from the Commission.

SC/64/BRG9 provided an initial modelling approach to address point (1) above. It was discussed extensively in Annex E, item 2.6 and although welcoming this work, a number of questions were raised and further work identified before any conclusions could be agreed. The Committee **recommends** that a revised document be developed for further review at next year's meeting, noting its potential importance for the provision of management advice. An Advisory Group (Annex Q6) was appointed to provide guidance to the authors of SC/64/BRG9.

8.2 Complete *Implementation Review* of Bering-Chukchi-Beaufort (B-C-B) Seas bowhead whales
The procedure and purpose of *Implementation Reviews* for aboriginal whaling *SLA*s is summarised under Item 8.4. The Committee's task is to assess whether there is any new information that would suggest that the range of trials used to evaluate the *Bowhead SLA* is no longer sufficient to ensure that the *SLA* meets the Commission's conservation and user objectives.

8.2.1 Consideration of new information with a focus on whether this implies a need for new trials
A number of papers were submitted presenting new information on a variety of scientific matters relevant to the *Implementation Review*. Full discussion of these papers is given in Annex E, item 3. The summary of discussions in the following sections is somewhat brief as it only focuses on the SWG's deliberations as to whether additional trials are required.

8.2.1.1 STOCK STRUCTURE
Four papers were relevant to stock structure issues.

SC/64/BRG1 reported on a satellite telemetry study of 57 B-C-B bowhead whales tagged during 2006-11. The Committee commended the authors for providing relevant data on bowhead whale migration patterns, and recognised the cooperation of native hunters who were closely involved in all aspects of this study and deployed most of the tags. It **recommends** that such tagging and telemetry efforts continue.

SC/64/AWMP3 compared the use of SNPs and microsatellites for studying population structure, assignment and demographic analyses of bowhead whale populations in the Sea of Okhotsk, B-C-B and eastern Canada, SC/64/AWMP9 presented sequences from three mtDNA genes from 350 bowhead whales from the B-C-B, eastern Canadian Arctic and the Sea of Okhotsk and discussed methods to calculate gene and site specific mutation rates, while SC/64/AWMP1 investigated the demographic history the B-C-B population of bowhead whales using a variety of analytical methods.

The Committee thanked the authors and **agrees** that the information in these papers provide no evidence to suggest that the trials evaluated during the previous *Implementation Review* (IWC, 2007b; 2008c; 2008h; 2008l) did not adequately address stock structure concerns.

8.2.1.2 ABUNDANCE AND RATE OF INCREASE
A new agreed abundance estimate is not required for completion of the B-C-B bowhead whale *Implementation Review*. When a new estimate becomes available it can be incorporated into the *Bowhead SLA* calculations to provide management advice.

SC/64/AWMP5 incorporates the 1985 and 2004 abundance estimates from aerial photography by Schweder *et al.* (2010) into the ice-based survey estimates to obtain an updated ROI for 1978-2004 (fig. 1 of Schweder *et al.*, 2010). The Committee **endorses** this estimate (3.5% with 95% CI of (2.2%, 4.8%)) as the best available estimate of annual rate of increase for the B-C-B bowhead whale population. It also **agrees** that the best estimate of current abundance is 12,631 (95% bootstrap percentile CI 7,900 -19,700; 5% lower limit 8,400) for 2004 (Schweder *et al.*, 2010).

The Committee was pleased to receive information from recent ice-based surveys (2011) that count whales migrating past Barrow, Alaska (SC/64/AWMP7). Full discussion of these surveys will occur in conjunction with the presentation of new abundance estimates within the next two years.

SC/64/BRG4 presented estimates of visual detection probabilities from the spring 2011 ice-based survey of bowhead whales migrating near Barrow, Alaska. The same methods will also be applied to similar data from the 2010 survey. These estimates are highly relevant since they constitute one foundation upon which a future population abundance estimate will be calculated from the 2011 survey counts. This abundance estimate will then be used as input to the *Bowhead SLA*. The authors intend to estimate 2011 abundance using detection probability estimates based only on the new independent observer data. The Committee **endorses** this approach, while also recognising that any possible implications of the shift to the superior IO method might merit future consideration in the context of long term trends. It **encourages** Committee members interested in abundance estimation to contact the authors of SC/64/BRG4 intersessionally with comments and suggestions so that the future abundance estimate for use in the *Bowhead SLA* can be based on an approved estimate of detection probabilities.

SC/64/BRG3 described an aerial photographic survey for B-C-B bowheads conducted from 19 April to 6 June 2011. The field season was very successful, both in terms of total flight days and the very large number of whale images (approximately 6,800) obtained. These photographs are a significant contribution to the bowhead whale photographic catalogue. The Committee recognised the importance of this work as potentially providing an estimate of population abundance for use with the *Bowhead SLA* that is entirely independent of the ice-based survey estimate described in SC/64/BRG4. Analyses of the photo-ID data may also provide better precision in estimates of bowhead whale life-history parameters such as adult survival rate. A detailed discussion of this paper is provided in Annex F.

8.2.1.3 CATCH DATA

SC/64/AWMP8 provides a preliminary summary of subsistence harvest of bowhead whales in Alaska from 1974 to 2011. Further discussion of the paper can be found in Annexes E and F. The Committee welcomes this information and noted that strikes have remained within the need envelope tested during development of the *Bowhead SLA*. It therefore **agrees** that no additional trials are warranted in this regard.

8.2.2 Discussion of new trials

In consideration of the evidence described above, the Committee **agrees** that there is no need for new trials or further simulation testing of the *Bowhead SLA*.

8.2.3 Conclusions and recommendations

The Committee thanked US scientists, the North Slope Borough, Alaska and the native communities for continuing to provide a considerable body of high-quality scientific work which facilitated the SWG's *Implementation Review* process. The Committee **agrees** that the *Bowhead SLA* continues to be the most appropriate way for the Committee to provide management advice for the B-C-B population of bowhead whales. This completes the *Implementation Review* for the B-C-B bowhead whales. Management advice itself is provided under Item 9.3.2.

8.3 Continue work on developing *SLA*s for the Greenlandic hunts (Annex E, Item 4)

In Greenland, a multispecies hunt occurs and the expressed need for Greenland is for 670 tonnes of edible products from large whales for West Greenland; this involves catches of common minke, fin, humpback and bowhead whales. The flexibility among species is important to the hunters and satisfying subsistence need to the extent possible is an important component of management for the hunters. For a number of reasons, primarily related to stock structure issues, development of *SLA*s for Greenland aboriginal hunts (especially for common minke and fin whales) will be more complex than previous *Implementations* for stocks subject to aboriginal subsistence whaling. The Committee has endorsed an interim safe approach to setting catch limits for the Greenland hunts in 2008 (IWC, 2009c), noting that this should be considered valid for two blocks i.e. the target will be for agreed and validated *SLA*s, at least by species, for the 2017 Annual Meeting (assuming that the Commission sets 5-year block quotas in 2012 as scheduled).

The Committee noted the benefits in previous *CLA* and *SLA* developments of a co-operative competition amongst more than one developer. Several members of the SWG indicated that they may be interested in proposing *SLA*s. The Committee noted the multi-species nature of the Greenland hunts and Greenland's desire for flexibility amongst species in meeting its subsistence needs. It **reiterates** that its approach will first be to develop *SLA*s for individual species before considering whether and how to address multispecies considerations (e.g. IWC, 2010a; IWC, 2011l).

In response to a request made at the intersessional Workshop (SC/64/Rep3), the Committee was pleased to receive four papers by Witting (SC/64/AWMP12-15) that summarised the available information on common minke, fin, humpback and bowhead whales off Greenland in the context of developing *SLA*s (summarised in Annex E, Appendix 6). In order to progress essential *SLA* development work, the Committee **agrees** that an intersessional Workshop (to be held at the end of 2012, probably in Copenhagen) was essential to maintain progress. As in previous years, the Committee also **recommends** maintenance of the AWMP Developer's Fund. Financial matters are discussed further under Item 23.

8.3.1 Common minke whales

The Committee notes that the SWG on the AWMP and the sub-committee on the RMP both have interest in North Atlantic common minke whales. It **endorses** the planned co-operative and collaborative process developed (Annex D, Appendix 6) that will culminate in a joint Workshop on the stock structure of this species in the North Atlantic in early 2014. This is planned to inform the RMP *Implementation Review* process for common minke whales in the North Atlantic scheduled for 2014, as well as the *SLA* development process. The operating models developed for the RMP *Implementation* (perhaps with minor adjustment to take account of focus on different populations) will also serve as the basis for the *SLA* development process. The Committee also notes that aspects of the work to be undertaken by Punt described in Annex E, Appendix 7 will assist developers of candidate *SLA*s for the Greenlandic hunts for common minke whales.

8.3.2 Fin whales

The Committee notes that the SWG on the AWMP and the sub-committee on the RMP both have interest in North Atlantic fin whales. A pre-meeting for the North Atlantic fin whale RMP *Implementation Review* is scheduled before the 2013 Scientific Committee meeting. The stock structure discussions at this meeting will provide useful input to the fin whale *SLA* development process. The operating models developed for the RMP *Implementation* (perhaps with minor adjustment to take account of focus on different populations) can also serve as the basis for the *SLA* development process. The Committee notes that aspects of the work to be undertaken by Punt described in Annex E, Appendix 7 will also assist developers of candidate *SLA*s for the Greenlandic hunts for fin whales.

8.3.3 Humpback whales and bowhead whales

Development of *SLA*s for these hunts is relatively simple compared to the common minke whale and fin whale cases. The Committee **agrees** that it should be possible to develop appropriate trial structures and operating models for the humpback and bowhead whale hunts before the next Annual Meeting to enable potential *SLA*s to be evaluated in the future. It **endorses** the proposal outlined in Annex E, Appendix 7 to support this work.

8.4 Guidelines for *Implementation Reviews*

An integral part of the AWMP process is the undertaking of regular or 'special' *Implementation Reviews*, as noted for example during the development process of the *Bowhead SLA* (IWC, 2003b).

The first B-C-B bowhead whale *Implementation Review* took place over two years and was completed in 2007 with most focus being on the issue of stock structure (IWC, 2007b; 2008c; 2008h; 2008l). No changes needed to be made to the *Bowhead SLA* after the review. The first *Implementation Review* for gray whales was completed in 2010 and the *Gray Whale SLA* was not changed with respect to providing advice on the Russian hunt off Chukotka (IWC, 2011h). However, as discussed above, during that review, information was received that led to the need to call for an immediate *Implementation Review* before providing advice for a potential hunt of gray whales by the Makah Tribe on the west coast of the USA. That review is now complete (see Item 8.1)

The Committee had agreed that it would be useful to develop guidelines for *Implementation Reviews*, given the experience gained thus far. The proposed guidelines are provided in Annex E, Appendix 8 and cover the following issues: (1) objectives; (2) timing of regular and special *Implementation Reviews*; (3) outcomes; (4) data availability; and (5) computer programs.

The Committee **adopts** these guidelines.

8.5 Scientific aspects of an Aboriginal Whaling Scheme (AWS)

In 2002, the Committee strongly recommended that the Commission adopt the Aboriginal Subsistence Whaling Scheme (IWC, 2003a). This covers a number of practical issues such as survey intervals, carryover, and guidelines for surveys. The Committee has stated in the past that the AWS provisions constitute an important and necessary component of safe management under AWMP *SLA*s and it **reaffirms** this view. It noted that discussions within the Commission of some aspects such as the 'grace period' are not yet complete.

8.6. Conversion factors for edible products for Greenland hunts

In 2009, the Commission appointed a small working group (comprising several Committee members) to visit Greenland and compile a report on the conversion factors used by species to translate the Greenlandic need request which is provided in tonnes of edible products to numbers of animals (Donovan *et al.*, 2010). At that time the group provided conversion factors based upon the best available data, noting that given the low sample sizes, the values for species other than common minke whales should be considered provisional. The group also recommended that a focused attempt to collect new data on edible products taken from species other than common minke whales be undertaken, to allow a review of the interim factors; and that data on both 'curved' and 'standard' measurements are obtained during the coming season for all species taken.

Last year the Committee had welcomed an initial report, recognising the logistical difficulty of collecting these kinds of data. However, it had noted that considerably more detail was needed, and requested that a detailed report be presented for consideration at the present meeting.

This year, a further report was received from the Greenlandic authorities that provided information on the data collected thus far. The Committee **welcomes** this report and the provision of data. A comparison of these values and the Recommended Conversion Factors Per Animal (RCFPA) from Donovan *et al.* (2010) showed reasonable agreement for humpback and bowhead whales (within 1 SD), but the yield for fin whales was lower than expected. It was not possible to examine this difference *inter alia* because no lengths of the animals included in the analysis were provided.

Although welcoming the report, the Committee expressed some concerns over the insufficient level of detail provided, some inconsistencies within the report, the efficiency of the sampling regime (relatively poor sample sizes) and the extrapolation procedure in which only one meat tote or bin is weighed.

In response to the concern over the lack of samples, it was noted that the Greenland Institute of Natural Resources (GINR) has been asked to investigate this and is working with the hunters and authorities to improve the sample size in the future. The Committee greatly **encourages** this and looks forward to a report on progress made. It also **encourages** the GINR to develop improved protocols including weighing as many of the meat, mattak, and qiporaq bins as possible. Providing a breakdown of products from bowhead whales would be valuable both for conversion factors and biological information.

Given these concerns, the Committee **reiterates** its recommendations from 2010 and 2011:

(1) the provision of a full scientific paper to the next Annual Meeting that details *inter alia* at least a full description of the field protocols and sampling strategy (taking into account previous suggestions by the Committee); analytical methods; and a presentation of the results thus far, including information on the sex and length of each of the animals for which weight data are available; and

(2) the collection and provision of data on Recommendation No. 2 of Donovan *et al.* (2010) comparing standard *vs* curvilinear whale lengths. This should be done for all three species on as many whales as possible. Guidelines and protocols are suggested in Donovan *et al.* (2010).

8.7 Work plan

The Committee's views on the work plan developed by the SWG on the AWMP are given under Item 21.

9. ABORIGINAL SUBSISTENCE WHALING MANAGEMENT ADVICE

The Commission is considering a change from Annual to Biennial Meetings. This has raised the issue within two Scientific Committee working groups as to whether there are any scientific implications for the Commission moving to setting block quotas for an even number of years rather than the present five-year intervals. This issue was addressed at the intersessional AWMP Workshop (SC/64/Rep3) and that report is **endorsed** by the Committee and the conclusions incorporated below.

The Committee recalled that trials for the B-C-B bowhead and eastern North Pacific gray whale *SLA*s had shown satisfactory performance for surveys at intervals of 10 years (and even for some *Robustness Trials* for 15 years). The Committee **agrees** that there are no scientific reasons for the Commission not to set catch limits for blocks of even numbers of years up to 8 years for these stocks. However, it **draws attention** to its discussions of the AWS where it noted that despite the trial results it would not be appropriate for catches to be left unchanged if new abundance estimates were not available after 10 years (IWC, 2004b).

The Committee notes that it does not require changing its regular process of *Implementation Reviews* approximately every five years (with the provision for 'special' reviews should circumstances arise) or an annual examination of new information and provision of advice if requested.

The Committee also notes that the interim safe *SLA* for the Greenland hunts (see Item 9.1 and Items 9.4-9.6 below) had also been tested for surveys at 10-year intervals and shown satisfactory performance and had been adopted by the Commission in 2008 (IWC, 2009a). However, as noted at the time, those tests had been for a restricted number of scenarios than the wider range of hypotheses customarily considered for such trials. It had thus been agreed that this *SLA* was appropriate for the provision of advice for up to two blocks or approximately 2018. The Committee **agrees** that there are no scientific reasons why the next quota block for the Greenland hunts could not be for a 6-year period, noting that the long-term *SLA*s will be available for *Implementation* for the following block quota.

9.1 Eastern Canada and West Greenland bowhead whales

9.1.1 Review new information on eastern Canada and West Greenland bowhead whales

Discussion within the Committee in recent years has focused on stock structure and associated abundance estimates. The present working hypothesis is that bowhead whales in eastern Canada-West Greenland comprise a single stock; the alternative hypothesis assumes two stocks, one in Hudson Bay-Foxe Basin and another in Baffin Bay-Davis Strait. However, the Committee agreed on the need for further genetic analyses last year (IWC, 2012k), recognising the complications arising out of the fact that existing data pertinent to the question of stock structure are held by a non-member nation, Canada.

The Committee was pleased to receive several papers on eastern Canada and West Greenland bowhead whales and details can be found in Annex F, item 2.2.

Alter *et al.* (2012) presented a study on genetic diversity and differentiation across all five putative stocks of bowhead whales, including Baffin Bay-Davis Strait (BBDS), Hudson Bay-Foxe Basin (HBFB), Bering-Beaufort-Chukchi, Okhotsk, and Spitsbergen. Ancient specimens (500-800 years old) from Prince Regent Inlet (PRI) in the Canadian Arctic were also compared with modern stocks. Results show low differentiation between Atlantic and Pacific, consistent with high gene flow between these areas in the recent past. No difference was observed between the two putative/hypothesised Canada-Greenland populations (HBFB/BBDS), which differ from previous results with more samples and a longer fragment of mtDNA. Significant genetic differences between ancient and modern populations were observed, which suggests that PRI harbored unique maternal lineages in the past that have been recently lost, possibly due to loss of habitat during the Little Ice Age and/or whaling. Unexpectedly, samples from this location show a closer genetic relationship with modern Pacific stocks than Atlantic, supporting high gene flow between the central Canadian Arctic and Beaufort Sea over the past millennium despite extremely heavy ice cover over much of this period.

The Committee **welcomes** this work, and noted that this type of collaborative effort across research groups is valuable in advancing the understanding of bowhead whale stock structure.

Spatial overlap of the extreme summer range of bowhead whales was identified from the eastern and western Arctic in the Canadian High Arctic (Heide-Jorgensen *et al.*, 2011). In the summer of 2010, one satellite tagged bowhead whale from West Greenland and one from Alaska entered the Northwest Passage from opposite directions and spent approximately 10 days in the same area but not at the same time.

Wiig *et al.* (2011b) updated on an abundance estimate for bowhead whales in the Disko Bay area of West Greenland. The study employed multi-locus genotype and sex to identify individual bowhead whales at four localities in eastern Canada (Foxe Basin, Pelly Bay, Repulse Bay and Cumberland Sound) and at one locality in West Greenland (Disko Bay).

9.1.2 Review recent catch information

In 2011, one female bowhead whale was landed in West Greenland and none were struck and lost (SC/64/ProgRepDenmark). Two bowhead whales were found dead in West Greenland in 2011, entangled in fishing gear for crabs.

During 2011, three bowhead whales were taken in Canada. More detailed information (e.g. sex, size) was made available by Canada to the Secretariat. The Committee is pleased to receive this information including catch as well as struck and lost data. It **requests** that in the future Canada also provides information on any strandings, entanglements and ship strikes of bowhead whales.

9.1.3 Management advice

In 2007, the Commission agreed to an annual strike limit of two animals (for the years 2008-12), with a carryover provision (IWC, 2008a). The Committee agreed an approach for providing interim management advice in 2008 and this was confirmed by the Commission (IWC, 2009a). The Committee recalled that the agreed abundance estimate for eastern Canada/West Greenland is 6,344 (95% CI: 3,119-12,906; IWC, 2009d) for 2002. The most recent agreed estimate (IWC, 2012k; Wiig *et al.*, 2011b) for the spring aggregation in the West Greenland area is 1,747 (95% CI: 966-2,528) for 2010.

Using the agreed interim safe approach and the 2010 estimate for West Greenland, the Committee **repeats its advice** that an annual strike limit of two whales in West Greenland will not harm the stock.

The Committee **agrees** that it will review the updated analysis for the 2010 estimate for West Greenland (Wiig *et al.*, 2011a) at next year's meeting, noting that although slightly lower, if adopted it does not alter the management advice. The Committee is also aware that catches from the same stock have been taken by a non-member nation, Canada. Should Canadian catches continue at a similar level as in recent years, this would not change the Committee's advice with respect to the strike limits agreed for West Greenland. Given the importance of this issue, the Committee **recommends** that the IWC Secretariat continues to contact Canada requesting information about catches and domestic catch limits for bowhead whales.

9.2 Eastern North Pacific gray whales

9.2.1 New information

SC/64/AWMP2 presented the results of comparison of the genetics of gray whales sampled off Vancouver, Canada (i.e. PCFG whales), and San Ignacio Bay, Mexico. Results supported the conclusion that PCFG and the larger population are from the same breeding group. However results from other studies of photo-ID and mtDNA indicate that during the summer, whales of the PCFG represent a seasonal subpopulation driven by maternally directed site fidelity. The Committee's work (Item 8.1) is based on treating the PCFG as a separate management stock.

There are at least two sets of genetic samples for PCFG whales, one is possessed by the research group in Canada, and the other by the Southwest Fisheries Science Center in

La Jolla, USA. The Committee **recommends** that the two groups consider merging these data sets as this will result in a more robust evaluation of PCFG gray whales. The Committee also **suggests** that future work uses a greater number of microsatellites and increased mtDNA length.

The Committee received two papers on photo-ID studies undertaken in Mexican waters. SC/64/BRG14 provided information about the number of eastern North Pacific gray whales using Laguna San Ignacio, Baja California during the 2011 and 2012 winter breeding season. High counts of female-calf pairs in 2011 and 2012 suggest that more females whales are using the Laguna San Ignacio region as a winter aggregation area than during the 2007-10 period. SC/64/BRG23 presented information on a new photographic identification programme in the Bahía Magdalena lagoon complex of gray whales in 2012 (there is little recent information from there). A total of 275 individual whales were photographically identified, of which 234 were single whales and 41 were mother-calf pairs. 83% of the mother-calf pairs were sighted in waters around the López Mateos, and the majority of singles (89%) were sighted in waters near to mouth of Bahía Magdalena.

The Committee **thanks** the authors for these studies in Mexican waters which are discussed further in Annex F, item 4.3.1, It noted the value of long-term datasets and **encourages** updates in future years.

SC/64/BRG18 presented results from a linear model relating the average ice cover over the Bering Sea during the first 15 days of May with estimates of northbound gray whale calves the following spring for the years 1994-2010 (ice years 1993-2009) and further used to predict calf estimates for 2011 to 2013. There is a negative relationship between the area of the Bering Sea covered by seasonal ice during the first two weeks of May and the number of gray whale calves estimated by shore-based counts off central California the following spring (Perryman *et al.*, 2011; Perryman and Rowlett, 2002). It is not clear whether an ice-shortened feeding season has a significant impact on overall population condition or health. Measurements of southbound gray whales in vertical aerial photographs collected in 2012 indicated that overall population condition was comparable to that in previous years when the observed strandings were about average.

The Committee **thanks** the authors for this analysis of data from an extremely valuable long-term dataset. The Committee **recommends** that continued annual shore-based counts be accorded high priority. It also **recommends** aerial photogrammetric body condition studies be continued next year, and results compared to existing data to test the hypothesis that ice conditions in May influence gray whale body condition and reproductive output. The Committee also **encourages** a more integrated analysis using ice cover data for spring in the Chukchi Sea and spring and autumn for the Bering and Chukchi seas.

Last year (IWC, 2012k) the Committee had encouraged the undertaking of a more quantitative integrated analysis for the lagoon counts in Baja California, Mexico and the northbound calf counts in California, given the length of the time series. It was also suggested that correlations between calf production in western and eastern gray whales be examined. The Committee **reiterates** its advice from last year.

SC/64/BRG21 provided information about coastal counts of gray whales off Chukotka Peninsula, Russia, and monitoring of the harvest. The Committee was pleased to see a variety of biological information collected from the harvested whales and **recommends** the collection of additional data and samples, such as tissue for genetic analyses, tissue samples for understanding the cause of 'stinky whales' (see also Item 12), and photographs for comparison with catalogues. Catch data are discussed further below.

9.2.2 Review of recent catch information

The Russian Federation reported that a total of 128 gray whales were struck in Chukotka, Russia in 2011[13]; two were lost and 126 were landed. Of the landed whales, two were 'stinky' and not used for human consumption.

9.2.3 Management advice

In 2007, the Commission agreed that a total catch of up to 620 gray whales was allowed for the years 2008-12 with a maximum of 140 in any year. No new data were presented this year to change the advice for the large eastern North Pacific population and therefore the Committee **agrees** that the *Gray Whale SLA* remains the appropriate tool to provide management advice for eastern North Pacific gray whales apart from the consideration of the PCFG and the Makah hunt (see Item 8.1). The Committee **reiterates** that the current strike limits will not harm the stock.

With respect to the management plan variants provided by the Makah Tribe, the *Implementation Review* was completed this year (Item 8.1) and the Committee **agrees**:

(1) hunt variant 2 performs acceptably; and
(2) hunt variant 1 performs acceptably provided that it is accompanied by a photo-ID programme to monitor the relative probability of harvesting PCFG whales in the Makah U&A, and the results presented to the Scientific Committee for evaluation each year.

Matters related to the possibility of an animal feeding in the western North Pacific being taken in the PCFG area are discussed under Item 8.

9.3 Bering-Chukchi-Beaufort (B-C-B) Seas stock of bowhead whales

9.3.1 New information

SC/64/BRG1 provided results of seasonal movements of the B-C-B stock of bowhead whales from a satellite telemetry study of 57 tagged whales during 2006-11. All but one tagged whale migrated past Point Barrow in spring and went to Amundsen Gulf. That remaining whale was tagged at Barrow in summer, wintered in the Bering Sea and then summered along the Chukotka coast in the Chukchi Sea. While most whales summered within the Canadian Beaufort Sea, extensive summer movements included travel far to the north and northeast. Autumn movements coincided in space and time with oil and gas activities and potentially with shipping activities. Likely important feeding areas included Amundsen Gulf in spring and summer; Barrow in summer and autumn; Wrangel Island (some years) in autumn; the northern Chukotka coast in autumn; and the western Bering Sea in winter.

Full discussion of this paper can be found in Annex F, item 2. It was noted that this work indicates that earlier estimates of bowhead whales off Cape Pe'ek on the Chukchi Peninsula (Melnikov and Zeh, 2007) were probably B-C-B bowhead whales and not a separate smaller stock. The Committee **encourages** the continuation of this work, including the future analysis of other environmental covariates (e.g. physical oceanography) relating to B-C-B bowhead whale migration and distribution.

[13]This updates the information in SC/64/BRG21 for 2011.

Results of a year-long acoustic study of B-C-B stock of bowhead whales were reported (Moore *et al.*, 2012). Calls from bowhead whales were recorded in October 2008, and from March-August 2009, on a recorder deployed on an oceanographic mooring near the Chukchi Plateau (*ca.* 75°N, 168°W). The rate of bowhead whale call detection was highest from May to August, when sea ice diminished from nearly 100% surface cover to zero and corresponded to a period of very high zooplankton backscatter signal from June to August.

SC/64/BRG3 reported the results of aerial photographic surveys of bowhead whales near Point Barrow, Alaska during 2011. Aerial surveys have periodically been flown in this area since 1984. Sufficient photo recaptures from the 2011 surveys are expected to calculate a mark-recapture abundance estimate with reasonable precision. SC/64/AWMP7 provided details about a successful ice-based survey in 2011 (see Item 8.2.1.2). An ice-based estimate of abundance is expected in 2014 and the photo-ID estimate thereafter. This would provide a rare opportunity to compare two independent large-whale abundance estimates in the same season.

SC/64/BRG4 presented estimates of visual detection probabilities from the spring 2011 ice-based survey of bowhead whales migrating near Barrow, Alaska, based on a new method first discussed last year (Givens *et al.*, 2011). This paper is also discussed under Item 8.2. In discussion, it was noted that the estimates in SC/64/BRG4 were slightly lower but generally consistent with those from earlier surveys, and the precision of the new estimates was better due to the new experimental design and a larger dataset. The Committee **agrees** that the estimation approach and application of the resulting detection probabilities to applicable years of survey data represents a methodological improvement over previous efforts. As noted under Item 8.2 it **encourages** Committee members with any detailed comments to submit those to the authors intersessionally.

SC/64/BRG8 reported on progress being made to sequence the bowhead whale transcriptome. It was noted in discussion that this research has the potential to provide insights into the life history, ecology, evolution and genetics of bowhead whales, with broader implications for other great whales.

9.3.2 Management advice

SC/64/BRG2 presented information on the 2011 Alaskan hunt. A total of 51 bowhead whales were struck resulting in 38 animals landed. No bowhead whales were reported struck and lost at Chukotka.

In 2007, the Commission agreed that a total of up to 280 B-C-B bowhead whales could be landed in the period 2008-12, with no more than 67 whales struck in any year and up to 15 unused strikes being carried over each year. In the light of the *Implementation Review* completed this year (see Item 8.2), the Committee **agrees** that the *Bowhead SLA* remains the most appropriate tool for providing management advice for this harvest. It **reiterates** that the present strike and catch limits are acceptable.

9.4 Common minke whales off West Greenland

9.4.1 New information

In the 2011 season, 174 minke whales were landed in West Greenland and 6 were struck and lost (SC/64/ProgRepDenmark). Of the landed whales, there were 133 females, 39 males, and two whales of unreported sex. Genetic samples were obtained from 90 of these whales. The Committee **re-emphasises** the importance of collecting genetic samples from these whales, particularly in the light of the proposed joint AWMP/RMP Workshop (see Annex D).

9.4.2 Management advice

In 2007, the Commission agreed that the number of common minke whales struck from this stock shall not exceed 200 in each of the years 2008-12, except that up to 15 strikes can be carried forward. In 2009, the Committee was for the first time ever able to provide management advice for this stock based on a negatively biased estimate of abundance of 17,307 (95% CI 7,628-39,270) and the method for providing interim management advice which was confirmed by the Commission. Such advice can be used for up to two five year blocks whilst *SLA*s are being developed. Based on the application of the agreed approach, and the lower 5th percentile for the 2007 estimate of abundance, the Committee **repeats** its advice of last year that an annual strike limit of 178 will not harm the stock.

9.5 Common minke whales off East Greenland

9.5.1 New information

Nine common minke whales were struck (and landed) off East Greenland in 2011 and one was struck and lost (SC/64/ProgRepDenmark). All landed whales were females. Catches of minke whales off East Greenland are believed to come from the large Central stock of minke whales. No genetic samples were obtained from minke whales caught in East Greenland. The Committee **re-emphasises** the importance of collecting genetic samples from these whales, particularly in the light of the proposed joint AWMP/RMP Workshop (see Annex D).

9.5.2 Management advice

In 2007, the Commission agreed to an annual quota of 12 minke whales from the stock off East Greenland for 2008-12, which the Committee stated was acceptable in 2007. The present strike limit represents a very small proportion of the Central stock – see Table 8). The Committee **repeats** its advice of last year that the present strike limit would not harm the stock.

Table 8

Most recent abundance estimates for minke whales in the Central North Atlantic.

Small Area(s)	Year(s)	Abundance and CV
CM	2005	26,739 (CV=0.39)
CIC	2007	10,680 (CV=0.29)
CG	2007	1,048 (CV=0.60)
CIP	2007	1,350 (CV=0.38)

9.6 Fin whales off West Greenland

9.6.1 New information

A total of five fin whales (all females) were landed, and none were struck and lost, in West Greenland during 2011 (SC/64/ProgRepDenmark). No genetic samples were obtained from caught fin whales in 2011. The Committee **re-emphasises** the importance of collecting genetic samples from these whales, particularly in the light of the proposed work to develop a long-term *SLA* for this stock.

9.6.2 Management advice

In 2007, the Commission agreed to a quota (for the years 2008-12) of 19 fin whales struck off West Greenland. This was subsequently modified and at the 2010 Annual Meeting

Greenland voluntarily reduced the limit to 10 until 2012 (IWC, 2011c). The Committee agreed an approach for providing interim management advice in 2008 and this was confirmed by the Commission. It had agreed that such advice could be used for up to two blocks whilst *SLA*s were being developed. Based on the agreed 2007 estimate of abundance for fin whales (4,539 95%CI 1,897-10,114), and using this approach, the Committee **repeats** its advice that an annual strike limit of 19 whales will not harm the stock.

9.7 Humpback whales off West Greenland

9.7.1 New information

A total of eight (three males; five females) humpback whales were landed (none were struck and lost) in West Greenland during 2011 (SC/64/ProgRepDenmark). Genetic samples were obtained from three of these whales. The Committee **re-emphasised** the importance of collecting genetic samples and photographs of the flukes from these whales, particularly with respect to the YoNAH and MoNAH initiatives (Clapham, 2003; YoNAH, 2001).

9.7.2 Management advice

In 2007, the Committee agreed an approach for providing interim management advice and this was confirmed by the Commission. It had agreed that such advice could be used for up to two five year blocks whilst *SLA*s were being developed (IWC, 2008e). Based on the agreed estimate of abundance for humpback whales (3,039, CV 0.45, annual rate of increase 0.0917 SE 0.0124) and using this approach, the Committee **agrees** that an annual strike limit of 10 whales will not harm the stock.

9.8 Humpback whales off St. Vincent and The Grenadines

9.8.1 New information

Last year the SWG noted that it had received no catch data from St. Vincent and The Grenadines for 2010/11. This year the Secretariat received information from the Government that a 35-foot whale was taken on 18 April 2011 (IWC Secretariat, 2011) and a 33.75 foot female taken on 14 April 2012. After the meeting it was also informed of a struck and lost animal during the 2011 hunt. The Committee was pleased to hear that genetic samples and photographs were taken and that the USA and St. Vincent and The Grenadines are discussing the transfer of tissue samples from this whale for analysis and storage at SWFSC (the IWC archive where *inter alia* SOWER samples are stored). Iñíguez reported information on a hunt on the 11 April 2012 and a struck and lost animal on the 22 March 2012.

The Committee also repeats its previous strong **recommendations** that St. Vincent and The Grenadines:

(1) provide catch data, including the length of harvested animals, to the Scientific Committee; and
(2) that genetic samples be obtained for any harvested animals as well as fluke photographs, and that this information be submitted to appropriate catalogues and collections.

9.8.2 Management advice

In recent years, the Committee has agreed that the animals found off St. Vincent and The Grenadines are part of the large West Indies breeding population (11,570, 95% CI 10,290-13,390; Stevick *et al.*, 2003). The Commission adopted a total block catch limit of 20 for the period 2008-12.

The Committee **repeats** its advice of last year that this block catch limit will not harm the stock.

10. WHALE STOCKS

10.1 Antarctic minke whales (Annex G)

The Committee is in the process of undertaking an in-depth assessment of the Antarctic minke whale. The primary abundance data are those collected from the 1978/79 to 2003/04 IWC-IDCR/SOWER cruises (e.g Matsuoka *et al.*, 2003) that had been divided into three circumpolar series (CPI, CPII and CPIII). Two different methods for estimating minke whale abundance from the last two circumpolar data series have been developed in recent years. Although they gave different estimates of abundance, both were consistent in estimating a decline in circumpolar abundance between CPII and CPIII (IWC, 2012l). The Committee has been working to resolve the differences between the estimates for some time and last year believed that it would be possible to present an agreed abundance estimate at this year's meeting. The Committee has also been discussing uncertainties about stock structure, especially in the Indian Ocean and Pacific sectors, which are the sectors where catches have been taken in recent years (IWC, 2008d).

10.1.1 Stock structure

Two genetically distinct populations of Antarctic minke whales have been identified in the Area IIIE-VIW feeding grounds (IWC, 2008d). There is no sharp boundary between them, only a 'soft' boundary; the two populations overlap, but one predominates in the east, called the Pacific or P-stock, and the other in the west, called the Indian Ocean or I-stock. The extent and location of the overlap is an important issue for assessment.

SC/64/IA4 presented a new integrated analysis of three different sources of data: morphometrics; microsatellites; and mitochondrial DNA. The goal is to estimate longitudinal segregation of the breeding populations on the Antarctic feeding grounds. The model is intended to allow the location of the soft boundary to move from year to year. The method was applied to the extensive data for the Antarctic minke whales taken by the JARPA and JARPA II surveys. The results indicated that the spatial distribution of the two populations have soft boundary in Area IV-E and V-W, which does vary clearly and significantly by year. The results also suggest that the boundary is sex-specific.

The Committee noted that the approach used is simple and potentially powerful. Aside from the general relevance of the results to understanding Antarctic minke whale dynamics, it might in the future prove useful in allocating historical catches to stocks. The Committee **endorses** the specific investigations for further statistical analysis given in Annex G item 5.1.

10.1.2 Abundance estimation of Antarctic minke whales

In order to reach its goal of having agreed abundance estimates by the 2012 Annual Meeting, an intersessional Workshop was held in Bergen, Norway, in May 2012 (SC/64/Rep4). It made substantial progress in identifying reasons for the large differences between earlier 'trackline conditional independence' and 'hazard probability based' estimates of Antarctic minke whale abundance (the 'SPLINTR' model, Bravington and Hedley, and the 'OK' model, Okamura and Kitakado, respectively). It also identified aspects of the OK model that needed adjustment related to plausibility of mean dive-time estimates from fits of the model and the resultant effects on *g*(0), compared to independent estimates of *g*(0). A work programme was agreed for completion by the 2012 Annual Meeting which resulted in three papers - SC/64/IA2, SC/64/IA12 and SC/64/IA13. The Committee thanked the authors for completing the work plan. Detailed discussions can be found in Annex G, item 5.3.

SC/64/IA12 analysed data from the IWC/SOWER 2004/05 video dive time experiments. The Committee was pleased to receive these estimates, which after discussion within the intersessional Steering Group became key inputs for the OK method. SC/64/IA2 presented a revision of the 'Norwegian Product' formulation of the OK model and investigated sensitivity to a number of factors. The abundance estimates were lower than previously estimated by versions of the OK model, after incorporating the new mean dive-times and the resultant lower $g(0)$ values. SC/64/IA3 presented a 'Norwegian Product' version of SPLINTR, also using the externally-estimated dive-times. The authors noted that their fits showed some problems and counterintuitive results but also noted that they had insufficient time to investigate the model. They thus considered that although the framework of the model therein seemed reasonable, the actual estimates were not ready for consideration.

Based on considerable experience from previous years, the intersessional Workshop had identified a core set of diagnostics most capable of revealing important model deficiencies when modelling IDCR/SOWER minke whale data (SC/64/Rep4). The main issue for SC/64/IA2, the OK model, was that the observed proportion of near-simultaneous compared to delayed duplicates was considerably lower than the predicted; this is potentially important in terms of estimating $g(0)$ and thus overall abundance, because of the close link to mean dive-time. The likely cause of the misfit is the aggregation-over-time that is required in order to deal with rounding and measurement errors in timing and distance estimates in IDCR/SOWER, in conjunction with the clumped nature of real whale dive patterns (in contrast to the independence of successive dive-times assumed by OK models). For the reasons discussed in Annex G, however, the Committee **agrees** that the within-duplicate lack-of-fit was unlikely to imply serious bias in abundance estimates.

Given the progress made and results presented and discussed in Annex G, it was agreed that there was no need to consider further the process of averaging estimates from the two models proposed last year (IWC, 2012l). It was reassuring that two completely independent implementations of the Norwegian Product (NP) model appear to be giving consistent results and showed little sensitivity to the input values for mean dive-time in the neighbourhood of the best independent estimates of dive time from SC/64/IA12.

The starting point for determining the best available consensus estimate, was the authors' 'preferred estimates' in SC/64/IA2 using the best estimates of mean dive-time from SC/64/IA12, and then applying the appropriate adjustment factors agreed last year (IWC, 2012e) with some minor changes. All the adjustments are estimates, but are modest enough that their impact on CV can reasonably be neglected. A CPII spatial adjustment of 15% is the largest adjustment, and reflects some imbalance of coverage within survey strata in CPII, something that was much reduced in CPIII. All other adjustments are minor.

The resulting estimates are shown in Table 9. Because the northern extent of the surveyed regions differs between CPII and CPIII, two sets of estimates are given, 'survey-once' and 'CNB' (Common Northern Boundary). The survey-once estimates cover all of the surveyed regions in each CP series (using the most recent or most complete survey in cases of duplication). The CNB estimates exclude part of the surveyed regions in each series to ensure a consistent northern limit; these are the most appropriate estimates for a comparison of abundance estimates between CPII and CPIII. The CNB estimates are also the basis for the Additional Variance (AV) calculations (IWC, 2010j) which address the non-synoptic nature of the surveys, i.e. that whales may move into and out of any given surveyed area from year to year. The 'CV internal' row reflects the uncertainty associated with the abundance estimate of whales in the surveyed region at the time of the survey, whereas the 'CV with AV' row reflects the uncertainty associated with the average number of whales present in the surveyed region across the whole of that CP series, and is more useful for most subsequent analyses. CVs are approximately the same for survey-once as for CNB, so only one set is shown. Note that there are also correlations between the estimates (not shown) in different *Management Areas* within each CP (but not between CPs) since model parameters are estimated jointly for each whole CP.

The Committee **agrees** that the numbers in Table 9 represent the best available abundance estimates of Antarctic minke whales in the surveyed areas during the years of CPII and CPIII. The potential sources of bias have now been much more thoroughly addressed than in the existing 'standard method' estimates (Branch, 2006), and the results are consistent with recent external datasets (e.g. the post-2004 SOWER cruise experiments on school size estimation, video dive time and BT mode). The explanation for the large difference between the estimates from original OK (e.g. Okamura and Kitakado, 2011) and original SPLINTR (e.g Bravington and Hedley, 2009) methods has been identified as the interaction between diving behaviour and timing errors and the difference has been reduced to plausible levels by imposing direct estimates of mean dive-time in the NP models. The Committee agrees that it is unlikely that any remaining bias is substantial.

Table 9

Best estimates of Antarctic minke whale abundance by *Management Area* adjusted by the factors agreed in Table 1. See text for explanation.

CP		IWC *Management Area* I	II	III	IV	V	VI	Total
II	Survey once	85,688	130,083	93,215	55,237	300,214	55,617	720,054
	CNB	84,978	120,025	86,804	51,241	285,559	49,885	678,493
	CV internal	0.16	0.14	0.20	0.17	0.13	0.22	0.08
	CV with AV	0.34	0.40	0.44	0.39	0.31	0.39	0.18
III	Survey once	38,930	57,206	94,219	59,677	183,915	80,835	514,783
	CNB	34,369	58,382	68,975	55,899	180,183	72,059	469,866
	CV internal	0.20	0.19	0.15	0.34	0.11	0.14	0.09
	CV with AV	0.39	0.38	0.35	0.49	0.36	0.37	0.18
CPIII:CPII		0.40	0.49	0.79	1.09	0.63	1.44	0.69

The new **agreed** estimates for the survey-once case are 720,000 for CPII (1985/86-1990/91) with 95% CI [512,000, 1,012,000], and 515,000 for CPIII (1992/93-2003/04) with 95% CI [361,000, 733,000]. The estimates are subject to some degree of negative bias because some minke whales would have been outside the northern and southern (surveyable, ice edge) boundaries. The improved analyses have resulted in many estimates differing appreciably from the 'Standard Method' estimates (Branch and Butterworth, 2001; IWC, 2006b, p.21). For CPII, the new best estimate of total abundance is slightly lower (720,000 compared to 769,000 standard estimate) whereas for CPIII the new best estimate is substantially higher (515,000 compared to 362,000). There are two primary reasons for the differences: (1) the spatial adjustment required for CPIII is much less than for CPII; and (2) the mean school size is appreciably smaller in CPIII than CPII which affects the net adjustment for *g*(0). The ratio of total abundance in CPIII to CPII, formerly 0.47 with the standard method, is now estimated to be 0.69 with 95% CI [0.43, 1.13] for the 'CNB' estimates.

Annex G, item 5.3.2 identified some future work, partly to check and deal with any small remaining bias issues, and also for the benefit of other abundance estimation in general. A valuable aspect of SOWER/IDCR is the consistency of its protocols and its large sample size, unparalleled amongst cetacean sightings datasets, which allow the development of realistic tests and sophisticated estimation methods applicable to many cetacean abundance estimation cases beyond Antarctic minke whales.

The Committee **expresses** its thanks to the Abundance Estimation Working Group for its tremendous collaborative efforts in obtaining agreed estimates after several years of intensive and innovative work. The developers (Bravington, Hedley, Kitakado and Okamura) are to be particularly commended as is the recent input and enthusiasm of Butterworth, Skaug and Walløe. The Committee now has confidence in these open-water estimates and a more comprehensive understanding of the modelling requirements for IDCR/SOWER data. The Committee also places on record its considerable appreciation to all those involved in the IDCR/SOWER cruises (1978/79-2009/10) – the Japanese Government (and in the early years the government of the then USSR), the IWC, the originators of the programme, the scientists and crews of the participating vessels, the planners of the cruises and the analysts, whose dedication and hard work over many years have led to this agreed result.

10.1.3 Reasons for differences between estimates from CPII and CPIII

The confidence interval for the ratio of the total estimated abundance from CPII and CPIII included 1.0 and thus a null hypothesis of no change in overall abundance between the two periods would not be rejected. Nevertheless, the Committee considered that a change was quite likely, and discussed possible reasons for a decline in the estimated abundance of whales in the surveyed areas.

Between CPII and CPIII, the point estimates of Antarctic minke whale abundance show a large decline in three *Management Areas* (I, II, and V) and an increase in Areas IV and VI (Table 9). Overall, the circumpolar estimates are 30% lower between CPII and CPIII. Since the Committee is now satisfied that the remaining biases in the agreed estimates are unlikely to vary greatly over the duration of the CPII and CPIII cruises. Therefore the differences seen in Table 9 probably do reflect real changes in abundance in the open-water areas surveyed.

The Committee is exploring possible reasons for this. Noting that the IDCR/SOWER cruises were neither synoptic nor did they cover the entire range of potential minke whale habitat, one hypothesis is that the decline in estimated abundance was due to more whales being in unsurveyed regions during CPIII than in CPII. This suggests the following (not mutually exclusive) possibilities:

(1) a much higher proportion of whales in the pack ice or in open-water areas (polynyas) within the pack ice in CPIII, as compared to CPII;
(2) extensive longitudinal (east-west) whale movements from year to year, and surveys conducted as part of CPII happened to encounter higher densities in certain areas, as compared to those during CPIII;
(3) a much higher proportion of the total population was north of 60ºS during CPIII;
(4) intra-year movements in open water within the surveyed areas that were not adequately covered by the trackline design in space and time, with respect to environmental variables; and
(5) a genuine decrease in abundance of Antarctic minke whales.

In order to examine (1) above, an intersessional sea ice group was established last year to: (a) consider technical aspects of sea ice data which will be used to bound or estimate the abundance of Antarctic minke whales in the south of the ice edge; and (b) consider appropriate analysis methods to bound or estimate the abundance of whales south of the ice edge.

SC/64/IA3 reviews some technical aspects of the sea ice data obtained by IDCR/SOWER, ASPeCt (Antarctic Sea Ice Processes and Climate), satellite sensors and NIC (National Ice Center). The definitions of the sea ice edge vary between the different data sources because their objectives and applied techniques are different. The IDCR/SOWER definition of the sea ice edge is somewhat operational compared to that for other data sources. However, its definition is believed to be consistent for the period 1978 to 2003, and the authors believe it is the most appropriate boundary for abundance estimation in years and areas where IDCR/SOWER surveys were undertaken. They also conclude that the sea ice concentrations derived from passive microwave (PM) remote sensing are probably the best sea ice data to be used for the purpose of estimating abundance of Antarctic minke whales to the south of sea ice edge in areas where IDCR/SOWER observations are not available (the PM records date back to 1979).

SC/64/IA10 is an appraisal of methods and data to estimate abundance of Antarctic minke whales within sea ice covered areas of the Southern Ocean. With new estimates of densities of Antarctic minke whales (from aerial surveys) in certain areas of sea ice (i.e. Weddell Sea and east Antarctica), and model-based abundance methods which allow extrapolation, there is an opportunity to compare bounds and magnitudes of abundances, both inside and outside of the sea ice region, to assess how likely the 'moved-into-sea-ice' hypothesis is. In the first instance, the authors recommended that comparisons of inside/outside abundances be made for areas and years where the aerial surveys were conducted. If these analyses are inconclusive from the perspective of the 'moved-into-sea-ice' hypothesis, there is a recommendation to extend the analysis to estimating circumpolar densities, and extrapolating back over the period of CPII and CPIII. The recommended analysis will give full consideration to how variable minke whale densities can be over space and time. Furthermore it should be recognised that such analyses will involve a great deal of work and may not yield helpful results.

Since Antarctic minke whales congregate along the ice edge, potential problems in estimating abundance inside/outside of an ice region using satellite data were discussed in Annex G, item 5.3.3. The Committee **recommends** that sensitivity analyses as to the position of the sea ice boundary on Antarctic minke whale abundances derived from aerial survey data be assessed before any in-depth calibrations and analyses of operational sea ice boundaries be attempted.

It is not possible to obtain reliable absolute abundance estimates of Antarctic minke whales in sea ice regions corresponding in space and time with IDCR/SOWER surveys. The Committee thus **recommends** that relatively simple analyses be conducted to generate abundances using aerial survey data. These abundances, with a range of potential availability biases, will help in producing an overall magnitude or upper bound on the numbers of Antarctic minke whales in sea ice regions during CPII and CPIII.

At present, the Committee is unable to exclude the possibility of a real decline in minke whale abundance between CPII and CPIII. Population dynamics analyses of catch-at-age data from Area IIIE to VIW (e.g. as in SC/64/IA1) can potentially account for the changes in overall abundance in terms of variations over time in mortality and recruitment. Such explanations are descriptive but they do not attempt to explain why, for example, recruitment might have dropped commencing in the 1970s. There is a second class of more mechanistic explanations concerned with, for example, why pregnancy rates might fall; this is where ecosystem effects, competition, climate, etc. would need to be considered.

As noted in Annex G, item 5.3.3, Murase and Kitakado suggested that the difference in abundance estimates between CPII and CPIII can (to a large extent) be attributed to process error (i.e. additional variance), reflecting a large inter-annual variation in distribution of the Antarctic minke whales (Kitakado and Okamura, 2009). However, they also suggested that systematic environmental changes observed in some areas do not alone account for the process error. Others suggested that the that JARPA and JARPA II data can assist the interpretation of the CPII and CPIII differences given the long time series data in Areas IIIE, IV, V and VIW (e.g see Matsuoka *et al.*, 2011). Hakamada will present information on some diagnostics from analyses to estimate minke whale abundance from JARPA next year.

In conclusion, the Committee noted that after many years work it had now been able to **agree** on estimates of minke whale abundance within the areas surveyed in CPII and CPIII. As yet, though, there was no conclusion on whether (and if so to what extent) these numbers indicate a real decline in abundance of Antarctic minke whales between the periods of the two surveys. Time constraints meant that it was possible to have only preliminary discussions of this question this year; discussions will continue at next year's meeting.

10.1.4 Continue development of the catch-at-age models

Population dynamics modelling provides a way to explore possible changes in abundance and carrying capacity within Areas IIIE-VW, where appropriate data are available. The inputs are catch, length, age, and sex data from the commercial harvests and both JARPA programmes, as well as abundance estimates from IDCR/SOWER. Early attempts used the ADAPT-VPA approach of Butterworth and Punt (1999), Butterworth *et al.* (2002) and Butterworth *et al.* (1996). A number of issues and concerns were raised with respect to that particular modelling framework for Antarctic minke whales, and it was concluded that an integrated statistical catch-at-age (SCAA) model was the most appropriate modelling framework (IWC, 2003c). Punt and Polacheck (2005; 2006) developed such a model and it has been refined over the last few years. The SCAA approach allows for errors in catch-at-age data, more than a single stock, time-varying growth, multiple areas, environmental covariates, fleet-specific vulnerabilities and changes over time in vulnerability. The technical problems and inconsistencies identified in previous years have largely been resolved (IWC, 2012l, p.180).

SC/64/IA1 provides a summary of the specifications of the current SCAA. The approach allows for multiple breeding stocks, which can be allowed to mix across several spatial strata on the summer feeding grounds where catches are taken. It also allows carrying capacity and the annual deviations in juvenile survival to vary over time. The model is fitted to length and conditional age-at-length data collected from the Japanese commercial and scientific permit catches, as well as indices of abundance from the IDCR/SOWER and JARPA/JARPA II cruises. The results provided in the paper are illustrative primarily because the IDCR/SOWER abundance estimates used had not been finalised, and the age-at-length data for recent years from JARPA II are not yet available.

As noted in Annex G, item 5.2, a number of suggestions for further work were made in this regard. Until now, application of the SCAA has been held up by the lack of agreed IDCR/SOWER abundance estimates, but that obstacle has now been removed, and the application of the SCAA in testing hypotheses concerning changes between CPII and CPIII abundance estimates has become a high-priority task. The time series of earplug age data, which is an important input that would improve the resolving power of the SCAA, has not been updated since 2004 or 2005 although samples are available through to 2011/12, because of difficulties in finding and validating age-readers. Preliminary age readings have been made from the 2006-08 samples, but have not yet been validated. Last year, the Committee had recommended that these preliminary data be made available and included in the SCAA on a provisional basis pending validation (IWC, 2012l, p.180). This year, the Committee **reiterates** this recommendation; the recent age data should be incorporated into the SCAA model as soon as possible. The Committee recommends the SCAA modellers request the new data via the Data Availability Group and the data owners provide it as soon as possible.

10.2. Southern Hemisphere humpback whales

The IWC Scientific Committee currently recognises seven humpback whale breeding stocks (BS) in the Southern Hemisphere (labelled A to G; IWC, 2011n), which are connected to feeding grounds in the Antarctic. An additional population that does not migrate to high latitudes is found in the Arabian Sea. Assessments of BSA (western South Atlantic), BSD (eastern Indian Ocean) and BSG (eastern South Pacific) were completed in 2006 (IWC, 2007d) although it was concluded that BSD might need to be re-assessed with BSE and BSF in light of mixing on the feeding grounds. An assessment for BSC (western Indian Ocean) was completed in 2009 (IWC, 2010f) and for BSB in 2011 (IWC, 2012m).

10.2.1 Begin assessment of breeding stocks D, E and F

Last year, the sub-committee on other Southern Hemisphere whale stocks initiated the re-assessment of BSD, and the assessment of BSE and BSF (IWC, 2012m). These stocks correspond, respectively, to humpback whales wintering off Western Australia (stock D), Eastern Australia (sub-stock E1) and the western Pacific Islands in Oceania including New Caledonia (sub-stock E2), Tonga (sub-stock E3) and French Polynesia (sub-stock F2) (Fig. 1). For simplicity the combination of BSE2, BSE3 and BSF2 will be referred to as Oceania.

10.2.1.1 ABUNDANCE, TRENDS AND POPULATION STRUCTURE

SC/64/SH6 presented a POPAN open model abundance estimate of 562 whales (CV=0.19, CI 351-772) from the New Caledonia humpback whale breeding ground (BSE2) using fluke photo-ID data collected over 16 years (1996-2011). Beginning in 2006 through to the current estimate, all population models examined show a trend of increasing abundance with a large 'pulse' after 2008. Whether these whales represent part of the New Caledonia sub-stock or permanent or temporary immigration from different regions is currently unclear.

In discussion, it was noted that a phenomenon similar to that observed in New Caledonia in the late 2000s had also been recorded off Eastern Australia in the late 1980s (Chaloupka *et al.*, 1999). To attempt to examine this apparent increase, the Committee noted that a possible movement of Eastern Australia whales to New Caledonia was consistent with an observed decrease in the rate of population growth of whales migrating off the Australian coast (Noad *et al.*, 2011) and levels of F_{ST} differentiation between E1 and E2 (0.01, Olavarría *et al.*, 2006) were the lowest among any pair of populations in Oceania. However, at this time the available data are not sufficient to explain the observed patterns.

Salgado Kent *et al.* (2012) provided new estimates of abundance and trends for Western Australian humpback whales. A number of statistical issues were raised in discussion as can be seen in Annex H. The Committee

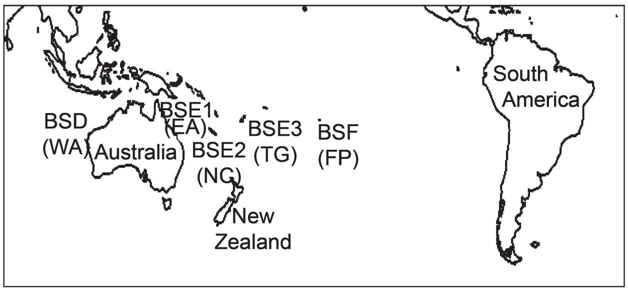

Fig 1. Distribution of Southern Hemisphere humpback whales breeding stocks grounds for BSD, BSE1, BSE2, BSE3 and BSF2 (WA = Western Australia, EA = Eastern Australia, NC = New Caledonia, TG = Tonga and FP = French Polynesia).

encourages further analyses and intersessional contact with the authors and that, if necessary they are invited to SC/65 for further discussion of their work.

SC/64/SH28 reported on the outcome of a Workshop held in November, 2011 to discuss future surveys and analyses of breeding stock D humpback whales at two locations off Western Australia - North West Cape and Shark Bay. The Workshop proposed a pilot survey to trial both cue-counting and racetrack aerial abundance survey methods, in conjunction with land-based work at both locations, to determine the most appropriate survey method for a full-scale absolute abundance survey in the near future. Prior to the survey, simulation work will be conducted to determine the operational protocols for the racetrack abundance estimation method as applied to humpback whales. The Committee **concurs** that a pilot study is the appropriate next step in method development for the provision of an absolute abundance for the Western Australian stock of humpback whales.

Four documents were available for discussion of stock structure issues, SC/64/SH5, SC/64/SH15, SC/64/SH22, and Pastene *et al.* (2011). These documents were reviewed by the Working Group on Stock Definition and their conclusions are reported in Annex I, item 3.1.1.

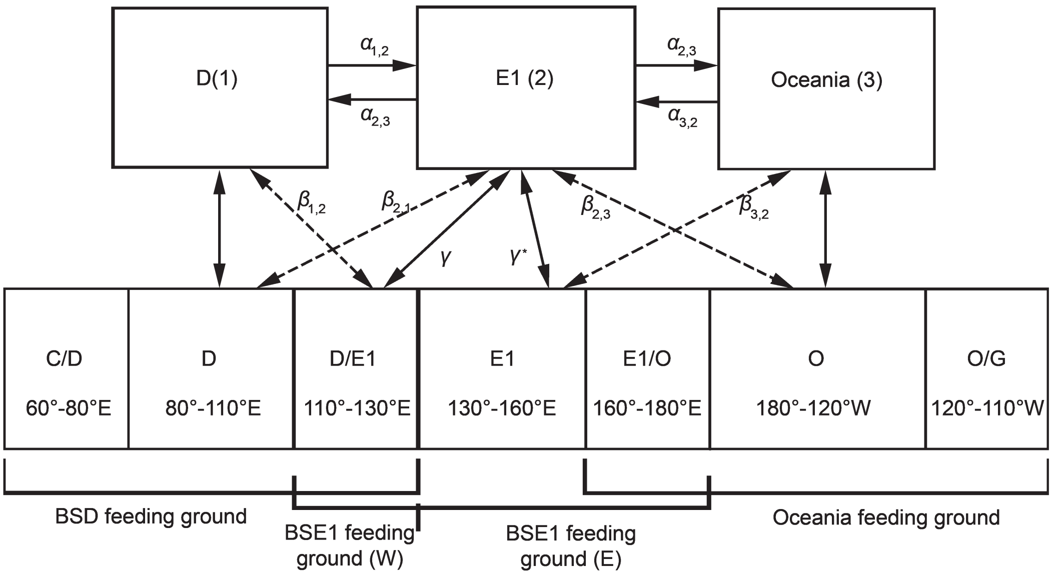

Fig. 2. Proposed model structure for breeding stocks D, E1 and Oceania. Arrows indicate possible interchange between stocks. These interchange rates will be estimated in the model, informed by data given in Table 1 of Annex H. Solid lines indicate movement of a breeding population to its own feeding ground, while dashed arrows indicate whales moving to a neighbouring feeding ground. Note that in order to avoid three breeding stocks mixing in the E1 feeding ground, an artificial boundary for catch allocation has been imposed. No catches taken east of this boundary will be allocated to BSD, while no catches taken west of the boundary will be allocated to Oceania. The longitude 130°E was chosen based on the longitudinal range of documented connections between BSD, Oceania and the Antarctic (J. Jackson, *pers. comm.*).

10.2.1.2 ASSESSMENT MODELS

In order to facilitate discussions and identification of further model runs, SC/64/SH29 provided initial results of population model fits to the Southern Hemisphere humpback whale breeding grounds D (West Australia; BSD), E1 (East Australia; BSE1) and Oceania (BSE2, BSE3, and BSF2). As anticipated, this led to considerable discussion and the details can be found in Annex H. As a result, the Committee **agrees** on a series of recommendations (details are in Annex H) regarding future work to facilitate the assessment:

(1) authors of some of the abundance estimates should be contacted to learn more about the estimates and how they might be incorporated into the assessment;
(2) a multinomial likelihood should be incorporated into the Bayesian population dynamics model;
(3) the new movement model structure (Fig. 2) should be incorporated to take into account the documented connectivity between breeding grounds in Western (D) and Eastern Australia (E1) and Oceania (E2+E3+F2) and between the breeding and feeding grounds;
(4) a two stock model for Eastern Australia and Oceania should be explored;
(5) catches should be allocated to the feeding areas associated with each of the three breeding stocks according to Hypothesis 1 of (IWC, 2010f);
(6) 'Discovery' mark data from the whaling period which contains information on movements between breeding grounds, between feeding grounds, and between breeding and feeding grounds, should be explored in the context of the assessments; and
(7) the Pastene *et al.* (2011) analysis on relative proportions of mixing in the feeding grounds should be expanded to include samples from Eastern Australia (E1).

The Committee also **endorses** the input data for the population dynamics model given in table 1 of Annex H and **agrees** that any additional datasets must be provided by 31 December 2012, after which time no more new data will be used for this assessment. The results of the analyses using the agreed model will be presented for discussion at the 2013 Annual Meeting. To ensure this work is completed, a work plan has been developed which identifies who will do each task (table 2 in Annex H) and an intersessional Working Group has been appointed, convened by Muller (Annex Q12). The Committee anticipates that the assessment of these stocks should be completed in 2014.

Reconciliation of the large photo-ID catalogue (6,500+ IDs from 1984-2011) held by Pacific Whale Foundation with existing catalogues from Western Australia, Oceania and the Antarctic Humpback Whale Catalogue is also encouraged to inform estimates of interchange for future assessments.

10.2.2 Review new information on other breeding stocks

10.2.2.1 BREEDING STOCK A

SC/64/SH17 reported 58 stranded humpback whales that were recorded between 1981 and 2011 off the coast of Rio de Janeiro, southeastern Brazil (annual mean 2.6, maximum 13 records in 2010). Reported strandings have increased over the past 20 years, which is consistent with the population increase observed for this stock. Three cases of entanglement were found (two were calves). Bacteriological agents in three live stranded whales assessed indicated evidence of animal impairment that resulted in or were associated with the cause of death.

The Committee **welcomes** this information but expressed concern that information is available from only a small part of the total Brazilian population. It **encourages** the provision of information from the full range of animals passing along the coast.

10.2.2.2 BREEDING STOCK B

SC/64/SH4 described a newly-discovered humpback whale wintering ground off northwest Africa with a seasonal signature consistent with a South Atlantic stock; the presence of adult/calf pairs suggests it may be a nursery ground. Since the observations were six months out of phase with the nearest (and only) known breeding ground in the northeast Atlantic – the Cape Verde Islands – these sightings possibly comprise the most northwestern component of the Southern Hemisphere BSB.

During a joint cruise organised by the South African Department of Environmental Affairs and the University of Pretoria in November 2011, a total of 107 biopsies were collected and numerous images obtained from humpback whales on the west coast of South Africa.

In discussion, numerous sightings of humpback whales have been made alone on the Atlantic African coast. The Committee **recommends** that the location and timing of all the existing Atlantic African records of distribution, seasonality and timing of sightings should be synthesised in a single map/database to show the extent of range and movements for humpback whales within a calendar year.

10.2.2.3 BREEDING STOCK C

SC/64/SH3 provided the first description of humpback whale movements between breeding grounds in the Comoros Islands and coastal western Madagascar. During 11-14 October 2011, five satellite transmitters were deployed on humpbacks off Moheli Island (12°24'S, 43°45'E) in the Comoros Archipelago. Three individuals were tracked successfully: mean tracking duration was 18 days (range 8-28 days); mean distance travelled was 467km (146-749km) and mean travelling speed 26.7 ± 22.3km/day. This is the first record of whales visiting different islands of the Comoros and western Madagascar in the same season.

Ersts *et al.* (2011) reported that between 1996 and 2006, nine whales (six males and three females) were identified using two breeding areas in separate years: the northern Mozambique Channel, currently the breeding region for sub-stock C2; and eastern Madagascar, currently a breeding region for sub-stock C3. This led the authors to believe that sub-stocks C2 and C3 were probably the same breeding sub-stock.

10.2.2.4 BREEDING STOCK D

Information was presented on examinations of eight neonatal humpback whales stranded on the Western Australian coast in 2011, all at least 1,000km south of the currently known major breeding grounds off the Western Australian northwest coast (see Annex H, item 2.3.4). Examinations indicated that all but one of the eight neonates was severely malnourished, and were believed to be non-viable from birth due to a lack of energy reserves and a compromised ability to thermoregulate and control buoyancy. Similar examinations are expected to be conducted on strandings on the Western Australian coast in 2012 and, hopefully, in future years.

10.2.2.5 BREEDING STOCK G

SC/64/SH16 provided information collected from whale-watching boats on distribution and behaviour of humpback whales from the south Pacific coast of Costa Rica, as discussed in Annex H, item 2.3.5.

In discussion, attention was drawn to the unusually high number of cow/calf pods reported together; nine groups with three or more adults with calves. The Committee **encourages** structured surveys to more completely document the distribution of these animals and **recommends** comparisons with catalogues from other areas, including breeding grounds, in the Southern Hemisphere.

SC/64/SH23 presented information on 1,580 individually photographed humpback whales off Ecuador that were compared with 611 animals identified in the southeast Pacific in four different catalogues. This confirmed Antarctica as the main feeding ground for humpback whales found off Ecuador and suggested that feeding areas for whales identified off Ecuador may extend as far east within Area II as the South Orkney Islands. The Committee was also informed that individual animals may migrate either to the Magellan Strait or the Antarctic Peninsula, but not to both. Comparison with the catalogue of animals found off Chiloe Island, Chile, had yet to be undertaken, and the Committee **recommends** that this comparison be undertaken and looks forward to receiving further information.

Information on 15 long-term resightings of humpback whales off Ecuador was reported in SC/64/SH24. One animal was resighted over a 26 year time span. The paper also provided the earliest connection from Ecuador to Antarctica and further supports the findings that waters around the Antarctic Peninsula are the main feeding area of humpback whales migrating to Ecuadorian waters. The Committee **endorses** plans to extend comparison of the Ecuadorian catalogue with animals from around South Georgia and Area II and looks forward to receiving a report at next year's meeting.

SC/64/O15 discussed observations from small boats during 2006-12, within the Golfo Duce, Costa Rica and the surrounding area of Osa Peninsula. It was shown the area is an important wintering ground, where the whales' distribution was determined by bathymetry, water temperature and possibly currents. For example, whales seem actively to avoid areas with eddies. The area seems to be used mainly by singing adults and there were competitive groups present in depths less than 60m, suggesting that mating occurs there.

The Committee **endorses** the view that spatial distribution information obtained from this study should be taken into account in establishing guidelines for appropriate management of this important Costa Rican marine coastal habitat.

10.2.2.6 FEEDING GROUNDS

SC/64/SH21 presented new information about abundance, population structure, demographic, and reproductive trends of humpback whales from the Strait of Magellan feeding area using long-term data on sightings, photo-ID and molecular analysis. The waters of Chilean Patagonian fjords and the Strait of Magellan remain today as the only recorded Southern Hemisphere feeding area for humpback whales of breeding stock G outside Antarctic waters.

The Committee thanked the authors for bringing this new information forward. It noted that it could not fully evaluate the abundance estimates with the information provided in the document and looked forward to seeing additional documentation next year. The Committee **expresses concern** regarding the potential for ship strikes and habitat displacement if the coal mining development results in a substantial increase of ship traffic in the region. It **recommends** that potential impacts are carefully assessed and that effective mitigation measures are adopted where necessary.

10.2.2.7 ANTARCTIC HUMPBACK WHALE CATALOGUE

SC/64/SH1 provided an update on the Antarctic Humpback Whale Catalogue (AHWC). The recent submissions bring the total number of catalogued whales identified by fluke, right dorsal fin/flank and left dorsal fin/flank photographs to 4,635, 414 and 409, respectively. Opportunistic data represent a significant portion of the AHWC. Progress continues in efforts to stimulate submission of opportunistic data from eco-tourism cruise ships in the Southern Ocean and from research organisations and expeditions working throughout this region and the Southern Hemisphere.

The Committee thanked the authors for their hard work and **recommends** that the AHWC continue. This item has financial implications as discussed under Item 23.

10.2.3 Work plan

The work plan for the assessment of Southern Hemisphere humpback whales is described in table 2 of Annex H and will be furthered by an intersessional Working Group (Annex Q12). The Committee's discussions of the work plan are discussed under Item 21 and financial implications under Item 23.

10.3. Southern Hemisphere blue whales

10.3.1 Review new information

10.3.1.1 PHOTO-ID CATALOGUES

SC/64/SH8 provided an update on the Antarctic Blue Whale Photo-ID Catalogue (ABWPIC), which includes photographs collected during 20 years of IWC IDCR/SOWER cruises (1987/88 to 2009/10). In 2011 and 2012 the photographs of eight new whales and one re-sighted whale (2007-10) were added. Currently the catalogue contains a total of 227 identified whales. Seven whales were re-sighted in multiple years. Mark-recapture analysis of Area III in the 3-year time period 2004/05-2006/07 yielded estimates of abundance ranging from 818 to 1,097 whales.

The Committee welcomed this update and recognised that the data have also been submitted to the Southern Hemisphere Blue Whale Catalogue. Photographs of blue whales from the JARPA programme has not yet been included in the ABWPIC but have been submitted to the IWC Secretariat. The Committee **reiterates** that the photographs should be added to the catalogue and reconciled and a proposal to achieve this has been developed. This is discussed further under Item 23.

SC/64/SH20 presented an update on the Southern Hemisphere Blue Whale Catalogue that holds photo-ID catalogues of research projects from major areas off Antarctica, Eastern South Pacific and the Eastern Tropical Pacific (ETP). A total of 822 and 826 individual blue whales photographed from left and right sides respectively are held in this Catalogue. Left-side comparisons have been completed and right-side comparisons are underway for ETP and the other areas. There are re-sightings both within Chile and in the Southern Ocean. However, none of the 84 whales photographed off ETP have been re-sighted within or outside of the ETP.

The Committee **encourages** contributions of regional catalogues not yet in the Southern Hemisphere Blue Whale Catalogue (e.g. eastern and western Australia) to facilitate full reconciliation of the catalogue for the Southern Hemisphere blue whales and a proposal to achieve this has been developed. This is discussed under Item 23.

10.3.1.2 ANTARCTIC BLUE WHALES

SC/64/SH14 reported methodological developments for estimating relative abundance from historic Antarctic whaling records using catch per unit effort data (CPUE). Once the work has been completed and accepted by the Scientific Committee, the Committee welcomed the commitment of the authors to submit the datasets and script to the IWC Secretariat.

SC/64/SH11 summarised two voyages conducted by the Australian Antarctic Division off southeastern Australia to refine acoustic tracking methodologies to address the aims of the Southern Ocean Research Partnership's Antarctic Blue Whale Project (see Item 19 and Annex H, item 3.1.2.1). The primary aim of this project is to estimate the circumpolar abundance of Antarctic blue whales using mark-recapture methods. The passive acoustic tracking system, using DIFAR sonobuoys, operated continuously during the voyages recording nearly 500 hours of audio, while acousticians processed over 7,000 blue whale calls in 'real-time'. The two voyages yielded 52 sightings (104 animals) of blue or like-blue whales; 48 animals were identified photographically (one on both voyages). Some blue whales that had been seen were not heard.

SC/64/SH12 summarised the methodological development of the use of DIFAR sonobouys for real-time tracking of blue whales. The results indicate that acoustic surveys may offer increased effective range over purely visual surveys of blue whales.

SC/64/SH26 presented an exploration into what encounter rates are plausible using acoustic-assisted tracking of whales, as opposed to a traditional visual-only survey (such as IDCR/SOWER). Given the lack of data, and the number of assumptions, abstractions, and approximations required in this simulation exercise, the authors stressed that the estimates in the paper should not be considered accurate or precise.

SC/64/SH10 presented a great advancement on the feasibility study of methods to obtain a new estimate of circumpolar abundance of Antarctic blue whales. Using the seasonality and location of sightings and acoustic detections from IWC-SOWER surveys, and historical catch data, it was concluded mark-recapture surveys should target putative hotspots and make use of passive acoustic tracking to increase encounter rates. With a reasonable level of effort a viable estimate of circumpolar abundance could be obtained for Antarctic blue whales within a ten-year period (and see Item 19).

The Committee recognises that the longer-term timeline to estimate abundance of Antarctic blue whales is more appropriate and logistically more feasible than the shorter periods considered earlier in the project's development. It **welcomes** the suite of papers linked to the Antarctic Blue Whale Project and the considerable advancement in the project's development. Further mark-recapture simulation studies may be valuable to investigate the effects of variability in effort between years within the suggested ten year timeframe and also to investigate the interaction between spatial variability in effort and possible population structure. This simulation could assess the consequences of only targeting 'hotspots' and the potential heterogeneity in capture probability potentially generated through this approach.

Further the Committee **encourages** ships contributing to the ABWP to, whenever possible, also collect environmental data for habitat modelling and data on other whale species sighted. In some circumstances environmental data can be collected through remote sensing but this is often problematic around Antarctica due to extensive cloud cover. Gliders and floats may provide another opportunity to collect high resolution water column data.

10.3.1.3 PLANNING OF FUTURE RESEARCH

The Committee was pleased to receive a number of papers on future blue whale research (see Annex H, item 3.1.2.2 for full discussion of these).

SC/64/SH13 presented a preliminary plan for an Australian funded voyage to contribute to the SORP Antarctic Blue Whale Project. The aim of the Antarctic Blue Whale Project is to develop technologies and collect data that will ultimately deliver a new circumpolar abundance estimate for Antarctic blue whales. The voyage will focus on blue whales in waters west of the Ross Sea (i.e. 135-175°E), an area that has been associated with higher densities of blue whales. The plan will be further developed and reviewed once the project management structure for the Antarctic Blue Whale Project is established which includes the formation of technical committees on passive acoustics, individual identification, and survey design.

The Committee **emphasises** the importance of collecting opportunistic data on other whales (sightings, faecal collection, biopsies) and environmental data, while recognising the value of clear priorities, particularly when the number of days 'on-site' in good weather can be few, even for longer Antarctic voyages.

SC/64/O16 presented the South African Blue Whale Project which is intended to initiate a long-term monitoring programme of blue whales in the Antarctic sector east of the Greenwich meridian, coupled with investigations of their seasonal pattern of abundance at lower latitudes. Acoustic technology will be combined with traditional line transect sighting survey and mark-recapture methodology to study the distribution, abundance and movements of blue whales in the southeast Atlantic. This joint study is conducted by the University of Pretoria and the University of Washington, and has received funding for 3 years from the South African National Antarctic Programme, starting in 2012/13. One team member will receive training in AAR deployment during a cruise off Greenland this summer (SC/64/O17) under the SORP programme. Although data valuable to the SORP Antarctic Blue Whale Project will be collected on this voyage (photo-ID and biopsy samples), the project is more closely linked with another SORP project 'Acoustic trends in abundance distribution and seasonal presence of Antarctic blue whales and fin whales in the Southern Ocean (see SC/64/O13).

SC/64/SH25 proposed a project on the genetics of Antarctic blue whales in part using IWC samples. The contemporary Antarctic blue whale has been described by a relatively high mitochondrial DNA (mtDNA) haplotype diversity, and may have escaped a greater loss of genetic diversity due to its long life span, overlapping generations and the brief period of the bottleneck. The impact of 20th century commercial whaling on genetic diversity can be explored through a comparison of historic and contemporary genetic diversity. The Committee **recommends** that access to the samples continues for this work and encourages further sampling in South Georgia.

The Committee **endorses** these research projects and looks forward to reviewing the results.

10.3.1.4 PYGMY BLUE WHALES

SC/64/SH27 presented a study on the identity of blue whales that are regularly sighted in the Geographe Bay region of Western Australia. Preliminary results based on measures of genetic structure indicate that the whales were all of the pygmy subspecies. Further samples from Geographe Bay are required to clarify whether these blue whales have fine scale genetic differentiation.

The Committee **welcomes** this paper which is discussed fully in Annex H, item 3.1.3, noting the contribution made by IDCR/SOWER samples to the study.

10.3.1.5 CHILEAN BLUE WHALES
The Committee was pleased to receive three papers on blue whales in Chilean waters and a full discussion can be found in Annex H, item 3.1.4.

Galletti Vernazzani *et al.* (2012) described the results of a collaborative research programme (the Alfaguara Project) conducted by Centro de Conservacion Cetacea on Chilean blue whales. From 2004 to 2010, eight aerial and 85 marine surveys were conducted off Isla de Chiloe, southern Chile, where a total of 363 individual blue whales were photo-identified. Recapture data support the hypothesis that the feeding ground off southern Chile is extensive and dynamic. Blue whale distribution off southern Chile was assessed and relative abundance, using sighting per unit effort and kernel density estimators was obtained.

SC/64/SH18 provided an update on the 2012 blue whale field season that reported the occurrence of a shift in blue whale distribution during 2012 from the southern Chile feeding area (Isla de Chiloe), as reported in previous years, to an additional feeding aggregation of blue whales in northern Chile (Isla de Chanaral). The Committee recognised the value of such long-term datasets for understanding blue whale populations and **recommends** that they continue.

SC/64/SH19 presented an abundance estimate of Chilean blue whales by mark-recapture and line-transect techniques.

The Committee recognised that the area covered by the line-transect survey does not include the entire range of the population and so will underestimate the total population size. There are also issues related to possible structure among feeding groups and sampling that require further consideration with respect to mark-recapture estimation. The Committee **encourages** further work on this and looks forward to receiving additional analyses.

10.4 Western North Pacific gray whales
10.4.1 New scientific information
Results regarding mixing of western (WNP) and eastern (ENP) North Pacific gray whales illustrate the great conservation and management importance of a more comprehensive examination of gray whale movement patterns and population structure in the North Pacific. At last year's meeting the Committee noted that for such an effort to be successful it must be international and collaborative (Weller *et al.*, 2012). To facilitate this, and noting the existing safeguards for collaborators provided under the Committee's Data Availability Agreement, it recommended that a collaborative Pacific-wide study be developed under the auspices of the IWC, recognising that *inter alia* this will contribute to the Committee-endorsed Conservation Plan for Western North Pacific Gray Whales and incorporate previous recommendations made by the Committee. Appendix 7 of Annex F provides an update on progress made to date.

The Committee **commends** the highly collaborative, international research effort for the progress made to date and look forward to future updates. The Committee also received several papers on stock structure and movements of north Pacific gray whales that resulted from this or other related programmes. Details can be found in Annex F, Item 4.1.

10.4.1.1 SATELLITE TAGGING
Mate summarised results regarding the recent collaborative efforts between Russian and US scientists to satellite track western gray whales under a programme undertaken with guidance from the IWC Scientific Committee and the IUCN WGWAP (Western Gray Whale Advisory Panel). The main goal of the project was to determine migration routes and breeding areas of tagged gray whales from the western North Pacific in order to develop improved conservation measures for this very small population. A total of seven whales were tagged in 2010 and 2011. The three longest tracked whales moved east across the Bering Sea and into the northeast Pacific where they overlapped with the range of eastern gray whales. Each animal followed a different route. The transmitter for a whale tagged in 2011 has lasted almost a year and continues to transmit. It travelled to near the southern tip of Baja California, Mexico during the winter and returned to near Sakhalin Island, Russia this spring. The autumn and spring migratory routes differed. These results, along with those from photo-ID matches from the eastern and western Pacific have caused the Committee to examine overall stock structure of gray whales in the North Pacific and to initiate the ocean wide research programme referred to above.

Mate also presented information on a plan for the A.N. Severtsov Institute of Ecology and Evolution of the Russian Academy of Science (IPEE) and Marine Mammal Institute of the Oregon State University to continue tagging western gray whales following the guidelines already developed by the IWC (IWC, 2012k). It is intended to tag up to 20 animals off Kamchatka (there is some interchange between animals off Kamchatka and Sakhalin) beginning in early July. The objective is to provide additional information on stock structure and to assist in developing conservation measures. The programme will also involve photo-ID and biopsy work. Photos will be made available to all catalogues and genetic samples will again be submitted to the IWC archive.

There was some discussion about whether tagging in Kamchatka was as beneficial as further tagging off Sakhalin as detailed in Annex F. The Committee **agrees** on the value of future telemetry work off Kamchatka and Sakhalin and **reiterates** its previous guidelines for such work (IWC, 2012k). Advice from the IWC/IUCN Steering Group chaired by Donovan on the full proposal will be provided to the research team in sufficient time to assist preparations for the field programme. The Committee also **recommends** that an evaluation of healing of the wounds caused by the satellite tags be undertaken and provided at next year's meeting.

The Committee also received information on plans for telemetry work on eastern gray whales. Quakenbush and her colleagues plan to tag up to 10 gray whales near Barrow and Saint Lawrence Island in 2012. The main goal is to document the distribution, movements, and feeding areas of gray whales relative to oil and gas activities in the Chukchi Sea. The project will include the collection of photographs and biopsies. Data will be shared with other gray whale research groups. Mate plans to tag some additional PCFG gray whales in 2012 in Oregon and northern California. The objective is to investigate if the variable migratory timing, routes, and Baja California destinations are similar to those found in 2009 and 2010.

10.4.1.2 PHOTO-IDENTIFICATION
SC/64/BRG13 provided results from a photographic comparison of gray whales off Sakhalin Island, Russia with animals in lagoons of Baja California, Mexico. Additional information about another match was reported subsequent to the submission of SC/64/BRG13. In total, photographs of 217 identified gray whales were obtained from the Sakhalin Island feeding grounds and compared with 6,546 photo-

identified individuals from the Baja California breeding lagoons. The research team found a total of 14 matches from the 217 Sakhalin whales, including six males, six females and two animals of unknown sex. Thirteen whales had sightings in Russia prior to and after their respective sighting in Mexico. Five females with calves were sighted in the winter in Mexican waters and in the next summer off Sakhalin, three of them without calves suggesting that these females had either separated from their calves or that their calves did not survive. The matches made between whales sighted off Sakhalin and the Mexican Pacific are the first results of the multinational collaboration.

The Committee **thanks** the authors and their colleagues for reconciling the Mexican photo catalogue. This will be a useful tool to address many questions, such as the relationship between Sakhalin and Mexico gray whales. The Committee also **acknowledges** the collaboration among the international group of gray whale researchers as a great example of how scientists can work together to address questions of great importance.

Another example of the multinational collaboration involves the photo comparisons being conducted among three catalogues: the Russia-US Sakhalin catalogue; the Institute of Marine Biology (IBM) Sakhalin catalogue; and the IBM Kamchatka catalogue (Appendix 9 of Annex F presents preliminary results from this study).

Updated information on research and conservation in Japan was presented in SC/64/O8. In March 2012, a gray whale was sighted on the Pacific coast of Aichi Prefecture, in the middle of Japan and some photographs of the animal were taken. No stranding or entanglement of this animal occurred. The Committee was also informed that there are some photographs (and genetic samples) in Japan that might contribute to a better understanding of stock structure of north Pacific gray whales. Japan expressed interest in joining the international collaboration and named Kato as the contact person. The Committee welcomes this news and **encourages** sharing of photographs and genetic samples with existing catalogues and genetic databases.

The Committee **commends** the above highly collaborative, international research effort for the progress made to date and **encourages** enhanced collaboration, if at all possible. The Committee **strongly recommends** the continuation of the IWC collaborative programme as outlined in Annex F, especially the plans to collect additional biopsy samples for genetic comparisons and photographs for catalogue comparisons. It was suggested that analyses be conducted to assess whether any patterns in the genetic data could be identified when Sakhalin whales known to have overwintered in the Eastern North Pacific are compared to the other sampled animals off Sakhalin as well as to those sampled in the Eastern North Pacific. The Committee also **recommends** that existing data be used to attempt to estimate the proportion of animals that regularly feed off Sakhalin and also migrate to the eastern North Pacific in the winter.

10.4.1.3 OTHER

SC/64/BRG10 provided a summary of past and current records of gray whales off the coasts of Japan, China and Korea. There are only 13 known sighting or stranding records in Japanese waters between 1990 and 2007 (Nambu *et al.*, 2003). Observations of gray whales in China are also exceptionally rare. Gray whales were once common and hunted off the coast of the Korean Peninsula but the last reported commercial catches were in 1966 and the last known sighting off Korea was in 1977. This suggests that they have abandoned the migration corridor along the Korean Peninsula or that a subpopulation using the Korean Peninsula is now extinct. The evidence that some Sakhalin animals migrate to the west coast of North America during the winter/spring, along with observations off Japan, Korea and China during the winter/spring, in combination with significant genetic differences between the eastern and western populations (Lang *et al.*, 2011) suggest that the number of whales in the western North Pacific population is potentially smaller than the currently estimated ~150 whales that use the Sakhalin summer feeding area.

This paper stimulated considerable discussion as can be seen in Annex F. The Committee emphasises the importance of the collaborative oceanwide programme and the need to review stock structure of gray whales throughout the North Pacific. It was noted that photographs (albeit low quality) of a gray whale that died in fishing gear in China in November 2011 have been compared with several catalogues (i.e. the Russia-US, IBM Sakhalin, and IBM Kamchatka) but no matches have been made.

In conclusion, the Committee **welcomes** all of the information on this critically endangered population and the broader question of stock structure. It **encourages** further work and as in previous years, **re-emphasises** the importance of continued long-term monitoring. Recognising some difficulties of interpretation given the new information on movements, the Committee also **encourages** Cooke to complete and publish his assessment of the gray whales feeding off Sakhalin using the combined photo-ID datasets. This rich dataset can provide valuable information for assessing possible anthropogenic impacts on animals feeding in the area.

10.4.2 Conservation advice

As in previous years, the Committee **acknowledges** the important work of the IUCN Western Gray Whales Advisory Panel. This year's update on the panel's activities is given in Appendix 10 of Annex F. The Committee **re-emphasises** its view of the importance of the Panel's work and reiterates its support. Furthermore, the Committee **recommends** that appropriate monitoring and mitigation plans be implemented for all oil and gas activities that occur in the range of western gray whales, especially if another platform is to be built or installed off Sakhalin.

The Committee again **recognises** that the problem of net entrapment of western gray whales is a range-wide issue. It **welcomes** Japan's administrative actions related to conservation of gray whales (SC/64/O8) and the efforts of other range states to reduce mortality, such as net entrapments that occur in other range states, including Canada, the USA and Mexico on the eastern side of the Pacific. Continued international collaboration to elucidate population identity and stock structure, as emphasised above, will provide valuable information for future management advice.

10.5 Southern Hemisphere right whales

10.5.1 Review report from intersessional Workshop

Bannister introduced the report of Workshop, held in Buenos Aires, Argentina, from 13-16 September 2011 (see SC/64/Rep5). He noted that although substantial progress had been made on much of the agenda, additional work was needed on some sections, especially the completion of analyses related to abundance and assessment. It was also noted that subsequent revisions of some analyses meant that sections of the report required clarification or amendment. As a consequence, two groups (an assessment group and a drafting group) were established to complete this work.

The Committee recognises the substantial work undertaken at the Workshop and **welcomes** the report, thanking particularly the Chair, rapporteurs and the host. It noted the large number of recommendations the report contained and prepared the following consolidated version incorporating additional comments and recommendations from the Committee as appropriate.

10.5.1.1 LONG-TERM POPULATION MONITORING

The Committee has long recognised the value of long time-series in informing, prioritising and evaluating conservation and management actions for whales, including monitoring the effectiveness of mitigation measures and Conservation Management Plans. In particular, it stresses the value of maintaining annual data sets, especially those that include information on the calving intervals of individual females, for their potential importance in analysing the influences of climate and environmental variables on southern right whale reproduction. The Committee therefore **strongly recommends** that all existing southern right whale data sets of this nature (e.g. in Argentina, Australia and South Africa) be continued on an annual basis and that similar programmes be established wherever possible for other areas.

In this connection, the Committee received a proposal requesting interim relief funding for the 2012 aerial survey off South Africa (Annex F, Appendix 2) and **recommends** its support (see Item 23). In addition, the Committee **recommends** that the annual CENPAT programme of aerial surveys around Península Valdés, which is independent of the long-term aerial photo-ID programme and substantially increases the areal and temporal survey coverage, should be continued on an annual basis.

10.5.1.2 POPULATION STRUCTURE AND LINKAGES

The population structure and stock identity of southern right whales remain incompletely described. A particular challenge is to distinguish adjacent stocks with different demographic histories and apparent rates of recovery. To address this, the Committee **recommends** that a circumpolar collaboration proceed to assemble standard genetic information from all available samples (see SC/64/Rep5, table 5), that could *inter alia* update the previous analysis by Patenaude *et al.* (2007) of the genetic structure of southern right whales on their calving/nursery grounds.

A number of standard genetics protocols are **recommended,** including standardisation of mtDNA preparation and nomenclature, standardisation of microsatellite loci and the exchange of samples between laboratories to establish allelic standards and provide quality control (see SC/64/Rep5). Further tissue sampling is also **strongly recommended** in a number of areas including Australia, Chile/Peru, Southern Africa and Brazil (see Annex F and SC/64/Rep5 for more details). In addition, to investigate relationships with other southern populations, further analysis of existing genetic samples from South Africa (n=~600) is **recommended**.

Recognising the importance of being able to allocate offshore ('pelagic') catches in the Southern Ocean and in low-latitude areas to the appropriate calving/nursery/breeding grounds, the Committee **recommends** that genetic (biopsy), photo-ID and satellite tagging data are applied to identify linkages. Further investigation is **recommended** of: (a) connections between whales in the New Zealand sub-Antarctic and those in mainland New Zealand; and (b) philopatry to mainland New Zealand (for details see Annex F and SC/64/Rep3). It is also **recommended** that biopsy samples, satellite tagging data and photo-ID data be linked, where possible.

While recognising the value of genetic analyses in solving the problems of population structure and linkages, the Committee also **recommends** other approaches such as inter-catalogue comparisons. Similarly, the value of strategically deployed satellite tags in depicting movements has already been demonstrated for southern right whales, and the Committee **recommends** that such studies continue.

10.5.1.3 MODELLING

The Committee **recommends** further investigation of the conversion factor used to estimate total population size from the estimated adult female component. Such investigation needs to consider that there has been only a relatively short period of recovery and that therefore the age distribution is unlikely to be steady and the estimated survival rate is likely to be biased upwards from the average that would apply in a steady situation.

10.5.1.4 JOINT ARGENTINA/BRAZIL ASSESSMENT

Noting the preliminary nature of Cooke's analyses, the Workshop had decided not to append the results to their report. It had recommended that progress towards the 'joint assessment', using data from both Argentina and Brazil, be made as quickly as possible and that an update also be presented on this work at the 2012 Scientific Committee meeting. Cooke provided an assessment of the 2010 Argentine population including a rate of increase from 2000-10 to the meeting (Annex F, Appendix 3). The Committee **welcomes** this and **agrees** to include the results in the Workshop's assessment of the status of the southern right whale population in 2009, appreciating that until a joint Argentine/Brazilian assessment had been completed these results must be considered preliminary in nature. The Committee **recommends** that the joint Argentine/Brazilian assessment be completed as soon as possible, and the results presented to the 2013 Annual Meeting.

10.5.1.5 ASSESSMENT OF THE CHILE/PERU POPULATION

In order to obtain information on the distribution and abundance of this Critically Endangered population, to clarify its status and identify any threats and possible mitigation actions, the Committee **recommends** that surveys, photo-ID and genetic studies should be conducted as a priority. Specifically, the following steps should be taken:

(1) determine geographical/temporal areas where quantitative studies can best be conducted, through analysis of existing historical whaling and sighting data and appropriate temporal/geographical spatial modelling;
(2) design a systematic survey programme (aerial surveys may be the most efficient) to cover potential calving or nursery areas, bearing in mind logistical and practical limitations; and
(3) further consider stock structure issues by examining existing genetic samples (including museum specimens where possible) and collect new samples in southern Chile/Argentina.

10.5.1.6 IDENTIFICATION OF CONCERNS AND THEIR MONITORING

Given that there was evidence of continuing direct removals via entanglements in fishing gear and ship strikes, the Committee **recommends** all countries to include reports of ship strikes and entanglement events in their annual Progress Reports to the IWC through the new online portal (see Item 3.2).

The Committee **strongly reiterates** the research and management recommendations made at the Workshop on the Southern Right Whale Die-off (IWC, 2011k). In addition, in view of the severe impacts of gull attacks documented at Península Valdés and the risk that this learned behaviour on the part of gulls could proliferate, the Committee **recommends** that Brazilian authorities consider taking immediate action if and when similar gull behaviour is observed. Some members felt that this action should specifically include the removal of attacking gulls, following similar steps being undertaken by Argentina in the Península Valdés area.

The Committee noted that some concerns have been raised about the potential effects of fishing and climate change on krill and hence on krill predators. The Committee also noted that the CCAMLR Scientific Committee was investigating these matters and encourages further collaboration between IWC and CCAMLR on the development of relevant ecosystem models.

10.5.1.7 DEVELOPMENT OF CONSERVATION MANAGEMENT PLANS (CMPS)

The Committee **recommends** that any draft CMPs take into account the recommendations made at the Buenos Aires Workshop and the Workshop on the Southern Right Whale Die-off and use these as the basis of action development (IWC, 2011k). The Committee was pleased to note that this was the case for the two draft CMPs it received (see below).

10.5.1.8 CONCLUSION

The Committee noted that the Workshop Report (SC/64/Rep5) had reached conclusions on the current status of the overall Southern Hemisphere right whale population based on a modelling exercise undertaken during the Workshop using the best available parameter values. However, the Workshop had recognised that the calculations were very dependent on: (1) the results of the as yet incomplete analysis of the Argentinian/Brazilian population to be provided by Cooke; and (2) on different conversion factors from mature female to total population size derived from the Argentine and South African populations.

Cooke advised that the parameter values for Argentina he had provided during this meeting (Annex F, Appendix 3) still required some updating. However, he agreed that he would forward them by 1 July 2012 to Butterworth and his colleagues so that a revised circumpolar analysis using the same approach as in Buenos Aires could be completed. It was agreed that the updated analysis would be incorporated into the Buenos Aires Workshop report with an appropriate editorial note. This full report would then be circulated to Workshop participants for any final comments and included in the published version in the *Supplement* to *J. Cetacean Res. Manage.*.

Cooke reported that it was impossible to undertake the recommended joint Argentina/Brazilian assessment until matching between photo-ID catalogues had been completed. However, he confirmed that excluding Brazil from the overall assessment was unlikely to have a major effect on the resultant circumpolar estimate because of its relatively small size (some other small populations for which no estimates exist are also excluded from the assessment). It was also noted that updated calculations using the Argentina and South African data had resulted in a convergence of conversion factors (Annex F, Appendix 3) so that these are no longer a major issue in estimating total population size for use in the assessment.

10.5.2 Review new information

10.5.2.1 SOUTHWEST ATLANTIC

The Committee received three papers on this population. They are briefly summarised below but a full discussion can be found in Annex F, item 3.3.2.

SC/64/BRG12 presented updated information on the southern right whale die-offs at Península Valdés, Argentina for the 2010/11 seasons. Systematic efforts to study the strandings have continued since 2003. A total of 482 dead whales were recorded at Península Valdés between 2003 and 2011. At least 55 whales died in 2010 and 61 died in 2011. As in previous years, the vast majority of strandings were calves of the season.

SC/64/BRG7 reported an analysis of metal levels in the skin of living southern right whales at Península Valdés, Argentina, as part of efforts to investigate the recent die-offs. The levels of non-essential and essential metals in the skin of 10 animals were on the low end of the spectrum of measured concentrations when compared to other studies. The authors cautioned that these low levels should not necessarily be interpreted as being safe since the effects of metals in marine mammals are largely unknown.

There was lengthy discussion on the possible reasons for changes in the observed calving interval. In conclusion, the Committee **reiterates** the recommendations of the southern right whale die-off Workshop (IWC, 2011k) and **encourages** the continuation of the studies presented in SC/64/BRG7 and SC/64/BRG12 to better understand the mechanism(s) behind the observed mortality.

SC/64/BRG20 presented an abundance estimate of southern right whales by aerial line-transect surveys for a bay area of Bahía San Antonio, Argentina, from late summer to autumn in 2009-11. A corrected abundance estimate using $g(0)$ is 207 (CI=99-315) in 2010, which is the maximum among the three years. These aerial surveys resulted in the first specific estimates of southern right whale abundance in this north Patagonian bay although more consistent aerial surveys should be conducted.

10.5.2.2 SOUTHERN AFRICA

SC/64/BRG24rev applied the three-mature-stages (receptive, calving and resting) model of Cooke *et al.* (2003) to photo-ID data available from 1979 to 2010 for southern right whales in South African waters. The 2010 mature female population is estimated to be 1,309, the total population is 4,725, and the annual population growth rate 6.8%. Information from re-sightings of grey blazed calves as adults with calves allows estimation of first year survival rate of 0.914 and an age at 50% maturity of 6.4 years. In contrast, the relative proportions of grey blazed animals amongst calves and amongst calving adults suggest rather a value of 10% (SE 8%). If the proportion losing markings is in fact 10%, first year survival rates estimate drops to [0.859] and the population growth rate to [6.6%] per year.

Best presented an analysis in which he had assembled data from foetuses, biopsied calves and stranded calves to test the assumption that the neonatal sex-ratio in southern right whales was 50:50. The most appropriate data set suggested a ratio closer to 46 male:54 female (Annex F, Appendix 4). The base case model of SC/64/BRG24 with this alternative sex ratio of 54:46 resulted in the total population 4,359 (Annex F, Appendix 5). The main differences in the parameter estimates were a lower first year survival rate with a corresponding higher value of the estimate for the probability that a grey-blazed calf maintains its markings until becoming an adult.

10.5.2.3 SOUTHWEST PACIFIC AND NEW ZEALAND

Carroll (2012) provided results on paternity assignment and 'gametic recapture' to examine the reproductive autonomy of southern right whales on their New Zealand calving grounds. The 'gametic mark-recapture' estimate of male abundance was 1,001, directly comparable with the 'census estimate' of male abundance, n=1,085, for the stock, based on standard genotype mark-recapture modelling. Simulations indicated the assumption of equal reproductive success amongst males was not violated. Power analyses suggested that these findings would be highly unlikely if the population was open to gene flow from other, larger populations in the Indo-Pacific region. The authors concluded that these findings are consistent with the hypothesis that southern right whales returning to the New Zealand calving ground are reproductively autonomous on a generational timescale, as well as isolated by maternal fidelity on an evolutionary timescale.

10.5.2.4 AUSTRALIA
SC/64/ProgRepAustralia provides information on southern right whales obtained on survey flights off the southern Australian coast between Cape Leeuwin and Ceduna in August 2011. The most recent updated increase rate for this Australian 'southwest stock' for 1993-2011 is 6.82% for all animals (CI 4.24-9.47), and 7.21% for cow/calf pairs (CI 3.70-10.85) with current population size *ca* 2,900; including the much smaller 'south east' Australian stock, the Australian population as a whole is likely to number *ca* 3,500.

10.5.2.5 SOUTH EAST PACIFIC RIGHT WHALES
Off northwestern Isla de Chiloe, four sightings of the critically endangered Chile/Peru 'sub-population' between September and November 2011 were documented, including the first incidence of reproductive behaviour and the first resighting of a known individual in Chile. In addition, some 30km north, the southernmost record of a mother-calf pair was recorded. These observations suggest that northwestern Isla de Chiloe is part of a breeding area with undetermined boundaries. This highlights the importance of these coastal waters and the need to continue long-term studies, both dedicated and opportunistic, to monitor this critically endangered population.

10.5.2.6 GENETIC RESEARCH
SC/64/BRG15 reported on progress with the investigation of the worldwide genomic diversity and divergence of right whales. Through collaborative agreements, the investigators have obtained representative samples from all three oceanic species. The investigators have used next-generation sequencing technology to develop genomic profiles by sequencing the complete mitochondrial genomes and multiple nuclear genes for each individual. To date, the results provide greatly increased resolution of the divergence between the three recognised species, and the diversity within each oceanic population.

The Committee noted that the project was generally methodologically sound and the objectives of the study were likely to be achieved. Although some concerns were expressed about limited number of samples and a possible need for more emphasis on the nuclear aspect of the survey, the Committee **recommends** funding the final stage of the project (see Item 23).

10.5.2.7 REVIEW OF 'DRAFT CONSERVATION MANAGEMENT PLANS FOR SOUTHERN RIGHT WHALES'
The Commission has agreed that southern right whales of South America should be candidates for IWC Conservation Management Plans (IWC, 2012b). As discussed in Annex F, two draft plans were available, one for southwest Atlantic southern right whales (IWC/64/CC7rev1) and one for southeastern Pacific southern right whales (IWC/64/CC9).

The Committee examined these draft CMPs for their scientific content and related actions and found them to be in accord with the results and recommendations from the IWC Workshops on the status of southern right whales (SC/64/Rep5) and the southern right whale die-off (IWC, 2011k).

10.6 Other stocks of right whales and small stocks of bowhead whales
An update was provided on North Atlantic right whales for the period November 2010-October 2011, reflecting the work of North Atlantic Right Whale Consortium, 2011. A collaborative photographic catalogue suggested that there were 490 North Atlantic right whales in 2010. Five right whale deaths were documented during the report period. Additionally, there were 11 new entanglement cases documented. The Committee **thanks** the authors for this update and looks forward to receiving further information next year.

SC/64/ProgRepJapan reported that in February 2011, a right whale was found dead in a set net in Oita prefecture. A skin sample was sent to the Institute of Cetacean Research (ICR), where DNA was extracted and it was confirmed as a right whale. However, the ICR branch in the Tohoku region was hit by the tsunami on 11 March 2011 and the sample was lost.

SC/64/O6 reported sighting information for North Pacific right whales from sighting surveys conducted in May 2011 in the western North Pacific. A total of 13 schools (20 individuals) was sighted, from which 19 individuals were photographed and 14 biopsied successfully.

The Committee **welcomes** new information on North Pacific right whales, noting that such sightings were rare. It looks forward to receiving a fuller report of the sighting survey at the next meeting.

No update was available for the small stock of bowhead whales in the Sea of Okhotsk.

Moore *et al.* (2012) provided results of a year-long acoustic study of the Spitzbergen stock of bowhead whales from September 2008 to September 2009 in western Fram Strait (79°N, 5°W). The rate of bowhead whale call detection was high from September 2008 through May 2009, including calls detected on every day of the month from November through February when sea ice was 90-100% surface cover.

The Committee continues to **reiterate** its grave concern over these small stocks and **encourages** continued or expanded research on these small populations.

10.6.2 Work
The Committee's views on the work plan for these stocks are given under Item 21.

10.7 Arabian Sea humpback whales
10.7.1 Review intersessional progress
The Scientific Committee has in the past (most recently in IWC, 2012m), recommended further research to help address the serious conservation status of the Arabian Sea humpback whale which is recognised as an isolated resident sub-population of humpback whales with an estimated population size of 82 (95% CI 60-111; Cerchio *et al.*, 2008; Minton *et al.*, 2011).

SC/64/SH30 provided details of surveys, shore-based observations, and passive acoustic monitoring conducted in Oman during October 2011-March 2012. A total of 36 humpback whales was encountered, 33 of which were photographed and 16 were newly identified individuals. No feeding was observed in the southern survey site and there were nearly three times fewer whales encountered this year. Differences in relative density and feeding may be due to annual fluctuations in food availability as a result of variable oceanographic conditions. Three mother-calf pairs were recorded in Oman during 2011-12, one of which entered the newly operational multi-purpose Port of Duqm. These are the first documented records of humpback whale calves in Oman since 2000. Two mortalities were recorded in January and April 2012. An adult female floating at sea was photographed by local fishermen and a juvenile that stranded live on a remote stretch of shoreline and was subsequently buried by the local municipal authority before scientific investigation could be conducted.

Observations of severe entanglement scarring, as well as coastal road development, operation of a large new port at Duqm, and the planned inauguration of several fast ferry routes through known humpback whale habitat are cause for concern. Efforts are underway to highlight the population's conservation needs with local, national and regional governments as well as the general public, and progress is being made toward the formation of a network of researchers and managers responsible for the design and implementation of a Conservation Management Plan, as recommended last year (IWC, 2012f, p.25).

The Committee **expresses concern** over the relatively large number of strandings from this small population (9 over a 12-year period). Given its endangered status under the IUCN red list and the potential for growth of unregulated whale watching in the region, the Committee **recommends** that whalewatching vessel operator training Workshops should be conducted with a view to promoting best practice for whalewatching and to support the need for development of whalewatching guidelines (see Item 23).

The Committee further noted plans to produce an updated mark-recapture estimate of population size. It **reiterates** its earlier recommendation (see IWC, 2011i), regular abundance surveys to be repeated on a regular basis, with assistance in planning and analysis from relevant experts.

10.7.2 The development of a CMP

The Committee has previously noted that this population is a likely candidate for an IWC Conservation Management Plan (CMP). An intersessional Working Group was formed at last year's IWC meeting to facilitate this process in accordance with the guidelines adopted last year by the Commission (IWC, 2012b). A key component of any plan is that it is supported by a broad range of stakeholders including range state governments. The Committee welcomes the progress that has been made in assembling the documentation required to submit a proposal to the IWC for a candidate CMP. It **strongly recommends** that discussions between scientists and relevant range state governments continue to further progress the CMP process.

10.7.3 Work plan

The Committee's views on the work plan are given under Item 21.

10.8 Cruises

10.8.1 The IWC-POWER programme

10.8.1.1 PLANNING THE IWC-POWER[14] PROGRAMME

The Scientific Committee has been discussing the objectives and priorities of the IWC-POWER programme since 2009 (e.g. IWC, 2012v) and this culminated in the discussions given in IWC (2012l).

[14]North **P**acific **O**cean **W**hale and **E**cosystem **R**esearch programme.

The Committee and the Commission agreed the long-term objectives for the programme in IWC (2012l).

> 'The programme will provide information to allow determination of the status of populations (and thus stock structure is inherently important) of large whales that are found in North Pacific waters and provide the necessary scientific background for appropriate conservation and management actions. The programme will primarily contribute information on abundance and trends in abundance of populations of large whales and try to identify the causes of any trends should these occur. The programme will learn from both the successes and weaknesses of past national and international programmes and cruises, including the IDCR/SOWER programme.'

IWC (2012v) provided an extensive review of current knowledge in the region, and a list of medium-term priorities by species for the programme was developed.

SC/64/Rep1 presents the report of a meeting of the Technical Advisory Group (TAG) established last year. The report builds upon the extensive work already undertaken to provide an overall strategy and detailed 5-year plan for the IWC-POWER programme, including statistical power calculations. The TAG workshop initially focused on methodological issues to investigate distribution, abundance and trends. It made a number of practical recommendations for visual methods (SC/64/Rep1, item 3.1) regarding survey mode, track design, and angle and distance experiments. Initial power analyses suggest the need for increased future effort (at present only one vessel is available) to be able to detect trends. The results of the short-term programme (see below) will allow improved power analyses and a better determination of required effort for the medium-long-term. Other techniques examined included mark recapture and acoustic methods and recommendations for further investigative and collaborative work were made. It also examined past data to investigate the amount of effort required to obtain photo-IDs and biopsy samples; this information is valuable for both short- and medium-term planning.

After reviewing the available information, an integrated short-term strategy (for the years up to 2015) was developed in light of the medium-long-term objectives (SC/64/Rep1, item 7.1). The objective is to complete an initial survey of the remaining poorly covered areas (SC/64/Rep1, fig. 1) to facilitate choice of appropriate survey blocks and strata for a long-term monitoring plan along with the essential undertaking of a more specific power analysis of the effort required to detect trends in abundance should they occur.

The TAG also made recommendations on the need for improved data collection systems, archiving of all kinds of data collected during the programme and a mechanism to ensure prompt collaborative analyses of the data collected (SC/64/Rep1, item 6). A detailed proposal for how to address these issues will be made at the 2013 Annual Meeting.

The Committee welcomes this report and **endorses** its recommendations. Noting the valuable contributions already made by Japan, Korea, the USA and Australia, it **strongly encourages** range states and others to consider more active participation in the IWC-POWER programme.

10.8.1.2 REPORT ON THE 2011 IWC-POWER CRUISE

The 2nd annual IWC-POWER survey was successfully conducted from 11 July to 8 September 2011 in the eastern North Pacific (north of 40°N, south of the Alaskan Peninsula, between 170°W and 150°W) using the Japanese Research Vessel, the *Yushin-Maru No.3*. The cruise had five main objectives:

(1) to provide information for the proposed future in-depth assessment of sei whales in terms of both abundance and stock structure;

(2) to provide information relevant to *Implementation Reviews* of whales (e.g. common minke whales) in terms of both abundance and stock structure;
(3) to provide baseline information on distribution and abundance for a poorly known area for several large whale species/populations, including those that were known to have been depleted in the past, but whose status is unclear;
(4) to provide biopsy samples and photo-ID photos to contribute to discussions of stock structure for several large whale species/populations, including those that were known to have been depleted in the past but whose status is unclear; and
(5) to provide essential information for the intersessional Workshop to plan for a medium-long term international programme in the North Pacific.

Plans for the cruise were endorsed by the Committee (IWC, 2011f) and the Committee agrees that it was duly conducted following the guidelines of the Committee.

On behalf of the Committee, Kato thanked the Cruise Leader, researchers, captain and crew for completing the second cruise of the POWER programme. The Government of the USA had granted permission for the vessel to survey in its waters, greatly contributing to the success of the cruise. The Government of Japan generously provided the vessel and crew for the survey.

Recognising the tremendous effort and expense in conducting the IWC-POWER survey, the Committee was yet again disappointed that potentially valuable data on stock structure was not able to have been collected as it had not been possible to resolve CITES permit issues regarding collection of biopsy samples collected outside of Japanese waters. The Committee **strongly recommends** that these issues are resolved. In planning for the 2013 survey, Hiruma reported that some initial progress on this front had been made, and would continue. He hoped to be able to report a positive outcome to ongoing talks between the governments of Japan and the USA in the near future. Brownell explained that the Japanese research vessel with biopsy samples collected on the high seas can enter and exit the US EEZ without a CITES permit, but biopsy samples cannot yet be collected in the USA.

10.8.1.3 THE 2012 IWC-POWER CRUISE

SC/64/Rep7 presented the report of the detailed planning meeting for the 2012 IWC-POWER cruise that had been endorsed last year (IWC, 2012l). The cruise will take place north of 40°N to the north American coast between 140°W and 135°W. The vessel kindly supplied by Japan will depart on 13 July 2012. The Committee **endorses** the report and looks forward to receiving the report of this cruise next year.

10.8.1.4 PLANS FOR THE 2013 IWC-POWER CRUISE

SC/64/O7 presented the research plan for the fourth survey in the IWC-POWER programme. The research area will be from the area from 160°-135°W, between 30°-40°N latitude. The plan was drawn up following guidelines agreed at the 2010 and 2011 Tokyo Planning Meetings (IWC, 2012v and SC/64/Rep1) and in light of the objectives developed in SC/64/Rep1. The cruise will collect line transect data, to estimate abundance, and biopsy/photo-ID data. Biopsy sampling will be undertaken on priority species (sei, fin, right, blue and humpback whales) and on other species on an opportunistic basis. Some dedicated research time will also be allocated to photo-ID and/or video-taping of fin, right, blue and humpback whales. Final planning will take place at a planning Workshop to be held in Tokyo in October 2012.

The Committee thanks the Government of Japan for its generous offer of providing a vessel for this survey.

10.8.2 Other North Pacific cruises (and see Item 6)

10.8.2.1 REPORT OF JAPANESE CETACEAN SIGHTING SURVEYS IN THE NORTH PACIFIC IN 2011

Three systematic dedicated cetacean sighting surveys were conducted in 2011 by Japan (ICR) as a part of JARPN II to examine the distribution and abundance of large whales in the Western North Pacific. The total searching distance was 4,060.3 n.miles. The sei whale was the main species sighted. The plans for these surveys were endorsed in the last year (IWC, 2012f) and the surveys were conducted as planned (SC/64/O6).

10.8.2.2 PLANS FOR JAPANESE CETACEAN SIGHTING SURVEYS IN THE NORTH PACIFIC IN 2012

SC/64/IA6 reports on plans for three systematic dedicated sighting surveys by Japan (ICR) as a part of JARPN II in the North Pacific in 2012, the first of which is currently underway. The main objective is to examine the distribution and estimate the abundance of common minke and Bryde's whales for the management and conservation purposes. Distance and angle estimation experiments will be conducted on all cruises. Biopsy skin samples of blue, fin, humpback and right whales will be collected on an opportunistic basis. Photo-ID experiments on blue, right and humpback whales will be also conducted opportunistically. Reports of the three sighting surveys will be submitted to the 2013 Annual Meeting.

10.8.3 Cruises in the Antarctic Ocean

10.8.3.1 PROGRESS ON IDCR-SOWER CRUISES PUBLICATIONS

An intersessional email correspondence group (IWC, 2012u, Annex R) worked by correspondence and also met at this meeting. Its terms of reference were to consider:

(a) updating the IWC website; and
(b) creating a special volume of the *Journal of Cetacean Research and Management.*

Plans are already underway with respect to (a) including inclusion of photographs, video, acoustic recordings and links to key publications and reports. Pertaining to (b), the Group prepared a proposed outline for the volume, with suggested authors/lead persons for each topic identified (see Annex G).

The Committee endorses the approach proposed. It **agrees** to the appointment of Bannister to lead the creation of the commemorative volume. An Editorial Board was nominated and tasked with responsibility for the volume's preparation.

The Committee **agrees** that the work contributing to the volume would be greatly facilitated by the preparation of some standard sighting datasets (for species other than Antarctic minke whales). The Secretariat kindly agreed to prepare such datasets from DESS in collaboration with knowledgeable scientists.

10.8.3.2 REPORT OF THE 2011/12 CETACEAN SIGHTING SURVEY IN THE ANTARCTIC

Plans for a dedicated sighting survey in the Antarctic in the 2011/12 austral summer season were presented last year and subsequently endorsed by the Committee (IWC, 2012f). The research vessels *Yushin-Maru No 2* and *Yushin-Maru No 3* were to survey in Area IIIE, Area IV and western part of Area V. The survey methods were to be the same as in IWC-SOWER surveys, and trackline design was improved to provide approximately uniform coverage probability. Furthermore, the planned sighting procedure was in accordance with the guidelines agreed by the Scientific Committee (IWC, 2012x). Unfortunately no research activity could be conducted due to external violent interference by an anti-whaling group (SC/64/IA8).

The Committee **expresses regret** that these actions had prevented the sighting survey from being conducted as reportedly planned. Following the cessation of the IDCR/SOWER programme in 2009, these surveys now provide the only dedicated cetacean sighting data in this region of the Southern Ocean that might be used for abundance estimation, and as such are extremely valuable to the work of the Scientific Committee.

10.8.3.3 PLANS FOR CETACEAN SIGHTING SURVEYS IN THE ANTARCTIC IN THE 2012/13 SEASON

A systematic two-vessel sighting survey for abundance estimation is planned in the Antarctic in the 2012/13 season (SC/64/IA7) as part of JARPA II. The research area is south of 60°S in the Antarctic, in the eastern part of Area III, throughout Area IV and in the western part of Area V, between 35°E and 175°E from December 2012 to March 2013. Details of the cruise, which also incorporates biopsy sampling and photo-ID work are incorporated in Annex G, item 6.5. The cruise report will be prepared by researchers and submitted to next year's Annual Meeting.

The Committee reviewed and endorses the plans for the proposed sightings survey. Noting the insight gained in SC/64/Rep4 on internally-estimated cue rates, it suggests that efforts be taken to ensure accurate times of sightings in IO mode, so that delayed and simultaneous duplicates could be more readily distinguished. The Committee **agrees** that this will be useful for estimating abundance from these data, and also invited any further suggestions for improved survey protocols from the developers of the methods described in SC/64/IA2 and SC/64/IA13, based on lessons learned in completing their analyses.

10.9 Progress towards an in-depth assessment of North Pacific sei whales

SC/64/IA11 presented an abundance estimate of North Pacific sei whales using data from the 2011 IWC-POWER cruise. Standard line transect methodology was applied to estimate abundance, assuming $g(0)=1$. In order to examine the robustness of the abundance estimate to alternative stratification options and detection functions, a sensitivity analysis was conducted. The abundance estimate for the surveyed area in the eastern North Pacific (north of 40°N, south of the Alaskan Peninsula, between 170°W and 150°W), was 6,587 (CV=0.420). When data from recent cruises become available, a revised abundance estimate for North Pacific sei whales will be presented using the IWC-POWER sighting data from the period 2010-12.

The Committee also received the report of the intersessional Working Group that had been appointed last year to prepare for the assessment. The group saw no impediment to conducting the In-Depth Assessment (IDA) as planned in 2013. It is anticipated that analyses of sei whale sightings from the POWER surveys through 2012 will be available for the assessment. The IDA will not address the question of suitability of data for use in the RMP.

Work on the historical catch series has proceeded. Allison has received new data on Canadian historic catches that is being entered into the IWC database. The findings of a new analysis of Soviet North Pacific catch records are also being incorporated. Sei whale catches in the IWC database are higher than the true catches because protected species like fin and humpback whales were reported as sei whales.

The Committee was informed that Mizroch and Ohsumi have recently analysed a sample of Japanese coastal whaling log books, and found that the catches of sei and Bryde's whales are differentiated in the log books, while this is not the case in the IWC individual catch database, although the total numbers agree. The Committee **recommends** that this work be extended, in collaboration with Allison, to cover the years for which the IWC and Japanese figures differ. The Committee also **recommends** that the Secretariat be requested to consolidate other historical catch series for this species, and together with the Working Group, begin collating all available information in order to complete this assessment.

The Committee **recommends** that the sei whale IDA proceed as planned at the 2013 Annual Meeting. An intersessional Steering Group was appointed to oversee preparations (Annex Q14).

11. STOCK DEFINITION

This Agenda Item was established in 2000, when a Working Group was established (IWC, 2001c). This year, updated Terms of Reference were adopted by the Working Group to reflect the evolving needs of the Committee (Annex I, Appendix 2). Continuing its original purpose, the Working Group will develop a reference glossary of stock related terms, to aid consistent definition of 'stocks' in a management context for the Committee (see Item 11.4). The Working Group will also continue to develop guidelines for preparation and analysis of genetic data within an IWC context (see Item 11.1), and software that evaluates the management utility of various population genetic analyses (see Item 11.3). A major change stems from the Committee's request for the Working Group to discuss high-priority Committee papers related to population structure. The Working Group will now provide the Committee with feedback and recommendations concerning stock structure related methods and analyses used in those papers (see Item 11.2). The Report of the Working Group is given as Annex I.

11.1 Guidelines for DNA data quality and genetic analyses

Two sets of reference guidelines have been developed and endorsed by the Committee (IWC, 2009e) and form 'living documents' that can be updated as necessary. The first set addresses DNA validation and systematic quality control in genetic studies (SC/64/SD2). The second set provides guidelines for some of the more common types of statistical analyses of genetic data used in IWC contexts, and contains examples of management problems that are regularly faced by the Committee. Substantial progress on these latter guidelines was made during a small Workshop in April, and this document will now be completed intersessionally (see Item 11.5). Both guidelines will also be published in the peer-reviewed literature.

11.2 Statistical and genetic issues related to stock definition

A number of stock related papers were discussed by the sub-group at the request of the following sub-committees and Working Groups: Revised Management Procedure (Annex D), Aboriginal Whaling Management Procedure (Annex E), *pre-Implementation Review* of western North Pacific common minke whales (Annex D1), and Other Southern Hemisphere Whale Stocks (Annex H). Technical comments on these papers are given in Annex I.

Some general comments were made which are relevant to many papers submitted to the Scientific Committee. Firstly the Committee noted that uncertainty around point estimates is not always considered and urged that, where available, confidence intervals should always be reported in order that precision of estimates can be evaluated. Secondly, failure to reject a hypothesis, e.g. panmixia, is not equivalent to support for that hypothesis; strong statements of support should not be given to any null hypothesis that has not been rejected. Thirdly, there is often inconsistent treatment and interpretation of the genetic differentiation metric 'F_{ST}' amongst papers. Simplistic interpretations of this statistic should be avoided, such as conversion into migration rates, as these can misinform management scenarios.

The Committee **agrees** to compile results from past RMP trials of various species intersessionally, in order to try to identify where there were 'tipping points' in inter-population migration rates which made significant differences to trial outcomes, i.e. at what level does migration make a difference for each species? Such information may help to better define the parameter space over which inter-population migration rates are informative to management. This work will be presented at the 2013 Annual Meeting (see Item 11.5) and can be carried out in conjunction with projects being undertaken by the sub-committee on the RMP and the SWG on the AWMP (see Annexes D and E respectively).

11.3 Progress on the Testing of Spatial Structure Models (TOSSM)

The aim of TOSSM (IWC, 2007a) is to facilitate comparative performance testing of population structure methods intended for use in conservation planning. From an IWC perspective, the TOSSM software package allows evaluation of methods for detection of genetic structure, in terms of how well the methods can be used to set spatial boundaries for management. It is available for all to use and simulated datasets exist for three of the five stock-structure Archetypes previously proposed by the Committee (IWC, 2010d, p.51).

TOSSM is also a flexible simulation tool for investigating how certain observed genetic phenomena might arise among animals such as whales whose life histories are not well described by classical genetic theory. A practical example of this is provided by the Pacific Coast Feeding Group (PCFG) of eastern gray whales (see Annex E), which appears to be genetically different from the northern Aleutian feeding ground, yet also receives immigrants from it (which would be expected to influence observed genetic differentiation). Simulation testing of various immigration scenarios in the TOSSM framework was carried out in SC/64/AWMP4 (Annex E). The Committee welcomes this paper and noted its value in exploring the range of scenarios compatible with the observed differentiation, as it investigates a range of factors, including the degree and timing of isolation and effective population size of the PCFG. The results have informed the current *Implementation Review* of gray whales (Annex E, item 2.2.2). Some longer term work items were suggested for this study: (1) to incorporate a minimum female calving interval into the most realistic (9-stage) life history model; (2) to report results using summary statistics that are as independent as possible (and therefore provide multiple checks on the similarity between the simulations and the observed data); and (3) to identify research needs for future field surveys in order to improve current parameterisation of the models.

11.4 Terminology and unit-to-conserve

Defining and standardising the terminology used to discuss 'stock issues' remains a long standing objective of the Working Group, in order to help the Committee report on these issues according to a common reference of terms. A suite of definitions for Committee terms such as 'population', 'subpopulation', 'stock', 'sub-stock' and 'management unit' was provided in SC/64/SD3 as a first effort to build a 'living' glossary of stock related terms, with reference to past discussions within the Working Group and to terminology applied in other management contexts. This glossary will be developed intersessionally by members of the Committee, who will also try to come up with a series of agreed criteria for classifying population units by these terms, with reference to their usage in other management and conservation contexts (see Item 11.5).

11.5 Work plan

The Committee's view of the work plan is given under Item 21.

12. ENVIRONMENTAL CONCERNS (E)

The Commission and the Scientific Committee have increasingly taken an interest in the possible environmental threats to cetaceans. In 1993, the Commission adopted resolutions on research on the environment and whale stocks and on the preservation of the marine environment (IWC, 1994a; 1994b). A number of resolutions on this topic have been passed subsequently (e.g. IWC, 1996; 1997a; 1998; 1999a; 1999b; 2001b). As a result, the Scientific Committee formalised its work on environmental threats in 1997 by establishing a Standing Working Group that has met every year since then. Its report this year is given as Annex K.

12.1 State of the Cetacean Environment Report (SOCER)

SOCER provides an annual update, requested by the Commission, on: (a) environmental matters that potentially affect cetaceans; and (b) developments in cetacean populations/species that reflect environmental issues. It is tailored for a non-scientific audience. The 2012 SOCER (SC/64/E2) was restricted to the Indian Ocean as the regional focus, due in part to reduced funding. A primary source of information was the International Indian Ocean Cetacean Symposium, held in 2009 in the Maldives[15]. Overall, the awareness of environment-related threats to cetaceans is high in the region, but implementation and control measures are poor. However, this provides an opportunity to introduce best practices, state-of-the-art procedures for critical issues such as fisheries interactions, ship strikes, whalewatching, and new, well-thought-out Marine Protected Areas.

During discussion, it was noted that marine research in the Indian Ocean region is focused in a few locations, despite having expanded over the past five years. Cetacean, or indeed environmental, research is scant or absent in many areas and there are few peer-reviewed reports from the region. The Committee was pleased to learn that the next issue of *J. Cetacean Res. Manage.* (published this year) contains 15 peer-reviewed papers from the Indian Ocean.

Highlighting specific issues in the region, there are clearly 'hotspots' in terms of pollution, fisheries bycatch and environmental degradation (e.g. Arabian Gulf). Reports of mass mortality events (152 small cetaceans in Iran in

[15]*http://www.mrc.gov.mv.*

September 2007, spinner dolphins and striped dolphins in two events, and 200-250 pantropical spotted dolphins in Pakistan in March 2009) on the northern coast of the Indian Ocean are particularly concerning because these three species do not usually mass strand in these numbers and the latter event occurred the day after the commencement of a multi-national naval exercise (AMAN 09) in Pakistani waters.

Next year the focus of the SOCER will be the Atlantic Ocean region and the SOCER editors request Committee members provide input, preferably in the form of pdf files, of papers published between 2011 and 2013.

12.2 Pollution

POLLUTION 2000+ is a long standing programme of the Committee. Three goals were identified at the IWC Intersessional POLLUTION 2000+ Phase II Workshop (IWC, 2011e):

(1) develop integrated modelling approaches and risk assessment framework for evaluating the cause and effect relationship between pollutant exposures and cetacean populations;
(2) identify data needs and available datasets or case studies that would be appropriate for the models that are exposure driven, source driven or effects driven; and
(3) develop a prioritisation framework to evaluate the broad number of environmental pollutants.

12.2.1 Update on POLLUTION 2000+ Phase II progress

At the intersessional POLLUTION 2000+ Phase II Workshop held in 2010 (IWC, 2011e), four objectives for the cetacean pollutant exposure and risk assessment modelling component were agreed: (1) improve the existing concentration-response function for PCB-related reproductive effects in cetaceans (completed in 2011); (2) derive additional concentration-response functions to address other endpoints (e.g. survival, fecundity) in relation to PCB exposure; (3) integrate improved concentration response components into a population risk model (individually-based model) for two case study species: bottlenose dolphin and humpback whale (completed in 2011); and (4) implement a concentration-response component for at least one additional contaminant of concern. The authors of SC/64/E5, funded by the IWC, investigated how contaminant-induced effects on immune function could be incorporated into the existing individual-based population framework constructed to assess the impact of polychlorinated biphenyls (PCBs) on cetacean populations (Objective 2).

By determining how the blubber PCB annual accumulation rates relate to concentrations in breeding females, comparisons with empirical data can be made and predictions about effects on various populations formulated. For example, based on the current blubber PCB concentrations determined in breeding females from two bottlenose dolphin populations in Sarasota Bay and St Joseph Bay, Florida, the model predicts that these populations would remain stable or increase slightly over the 50-100 year timescales projected. Conversely, the bottlenose dolphin population in Brunswick, Georgia, where PCB levels in breeding females are 10 times higher, is predicted to decline over the same period without external population inputs through immigration.

In the future, impacts on other populations and species, such as humpback whales from the Gulf of Maine will be investigated (e.g., Hall *et al.*, 2011), as additional contaminant data for females become available. In addition, future developments of this model will include a sensitivity analysis; incorporation of a bioaccumulation model to estimate blubber concentrations for populations or species in which only levels in prey are known; and making the model available online with a user-friendly interface.

During discussion (see Annex K), it was noted that body condition of cetaceans may have a significant effect on susceptibility to impacts from contaminant exposure. For example, body condition could affect immune function independently so when food is limited and animals are in poor condition this will further affect their ability to fight off pathogens. Furthermore, if PCBs are released from the blubber during periods of increased energy demand then more may be bioavailable. Although the current model does not account for body condition, the final phase of the project will incorporate a toxicokinetic model that will include body condition parameters, similar to an approach taken by Hickie *et al.* (1999).

The Committee **recognises** that cetaceans are exposed to a mixture of environmental contaminants. It **suggests** that, if possible, mixtures of contaminants should be added to the model. Due to the extremely high levels of PCBs measured in the bottlenose dolphins in Brunswick, Georgia, USA, the Committee **strongly recommends** the continued monitoring of this population. The Committee **commends** the authors for the most recent results from the IWC's POLLUTION 2000+ programme and **strongly supports** their continued work to develop the necessary tools for analyses of pollutant exposure risk to cetaceans.

12.2.2 Oil spill impacts

12.2.2.1 UPDATE ON RESPONSE TO DEEPWATER HORIZON OIL SPILL IN THE GULF OF MEXICO

An update on the 2010 Deepwater Horizon (DWH) oil spill in the Gulf of Mexico was provided, where the injury assessment for cetaceans continues. The Natural Resource Damage Assessment (NRDA), a formal process in the USA to assess damages to natural resources, has included photo-ID, remote biopsy, live capture health assessments and evaluation of stranding data for common bottlenose dolphins in nearshore waters. Analyses of tissue, blood, and urine samples from cetaceans in the Gulf of Mexico for PAHs and PAH metabolites have also continued, as outlined in the NRDA plans.[16]

In addition to the NRDA, an Unusual Mortality Event (UME) is ongoing in the northern Gulf of Mexico principally involving bottlenose dolphins[17]. The UME involved 745 cetacean strandings in the Northern Gulf of Mexico from 1 February 2010-10 June 2012, which started before the DWH oil spill. The historical average (2002-09) for this area is 74 dolphins per year. The vast majority (95%) of stranded dolphins have been found dead; however, 35 stranded alive and seven were taken to facilities for rehabilitation. The UME is still ongoing, however stranding rates in the Northern Gulf in April and May 2012 were near-average.

Although it is typical to see strandings of dolphins less than 115cm (perinates) in the spring, there was a marked increase in strandings of this age class in spring 2011. Of these perinatal dolphin strandings, most were found to have died *in utero*. Twelve of 51 cases targeted for testing were positive for *Brucella,* and 8 cases were confirmed to have died of brucellosis. Compared to 2011, the number of stranded perinatal dolphins was lower during the spring of 2012. Three additional cetacean studies related to the DWH

[16]*http://www.gulfspillrestoration.noaa.gov.*
[17]*http://www.nmfs.noaa.gov/pr/health/mmume/cetacean_gulfofmexico 2010.htm.*

spill are underway in the Gulf of Mexico, including two passive acoustic surveys and one tagging study of sperm whales.

The Committee **commends** this research related to the DWH oil spill and **strongly recommends** continued investigations into the impacts of the DWH oil spill on cetaceans, including exposure to oil spill related contaminants, biomarker investigations and health assessments. Furthermore, it **encourages** the early and full reporting of the findings of DWH studies into the public domain.

12.2.2.2 CAPACITY BUILDING REGARDING OIL SPILL IMPACTS ON CETACEANS

In 2011, the Committee agreed that there was significant need and interest in cross-training between the oil spill and marine mammal communities and established an intersessional e-mail group to evaluate the possibilities for such training (Annex Q19; IWC, 2012o). As part of an effort to better understand and be prepared for oil spills and their impacts on marine mammals particularly cetaceans, workshops and planning exercises are underway or have taken place including: (1) an oil spill response workshop held at the International Conference on Marine Mammal Protected Areas (ICMMPA)[18]; and (2) dissemination of information and data on marine mammals at international meetings on oil spill response or with oil spill responders.

The ICMMPA workshop included presentations from the Regional Marine Pollution Emergency Information and Training Centre (REMPEITC) in the Wider Caribbean Region and the Oiled Wildlife Care Network, industry, oil spill responders, and marine mammal scientists and managers. A number of recommendations developed at the workshop were reviewed and found similar in nature to those discussed last year (IWC, 2012o), in particular the desirability of companies, agencies, stakeholders and international organisations to work in cooperation with marine mammal specialists on oil spill response plans.

In discussion, the Committee noted that some response plans that are currently under development, especially those related to the Arctic, focus on identifying sensitive areas for marine mammals. However, in most areas, important baseline data are lacking and the Committee **recommends** that these data gaps be filled. It also **recommends** that oil spill response efforts throughout the world should include pelagic as well as coastal areas; further information on current capacities and mechanisms of oil spill recovery will be valuable. Last year, the Committee noted that a review of the capacity for oil spill response in the Arctic was an urgent priority in the aftermath of the DWH oil spill (IWC, 2012o). The Committee **agrees** that the recommendations from the 2011 MMPA workshop in Martinique will provide guidance on oil spill prevention and response in the Arctic at the upcoming intersessional Arctic Anthropogenic Impacts Workshop (see Item 12.5.3).

12.2.3 Other pollution related issues

Fossi provided information on Mediterranean odontocetes exposed to environmental stressors, in particular to persistent organic pollutants, emerging contaminants, polycyclic aromatic hydrocarbons (PAHs) and trace elements. In Panti *et al.* (2011), the response of 'gene expression biomarkers' was evaluated in Mediterranean striped dolphin in three sampling areas: the Pelagos Sanctuary (Ligurian Sea), the Ionian Sea, and the Strait of Gibraltar. The mRNA levels of five putative biomarker genes were measured for the first time by quantitative real-time PCR in cetacean skin biopsies. Striped dolphins from the Pelagos Sanctuary are more exposed to ecotoxicological hazards than those inhabiting the Ionian Sea and the Strait of Gibraltar. This evidence focuses attention on the potential risk to cetaceans inhabiting the largest pelagic MPA in Europe and the Committee **stresses** the importance of effective and long-term management of MPAs in order to preserve species in their habitats.

The sources of these contaminants in the study areas are unknown. The Committee **recommends** that the sources be identified, particularly for animals within the Pelagos Sanctuary, to enable the development and implementation of mitigation measures.

In 2005, the Conservation Committee agreed that a research programme to address the issue of inedible 'stinky' gray whales caught by the Chukotkan aboriginal subsistence hunters should be established (IWC, 2006a). This year, the Committee examined IWC/64/CC10, which presented information on the various chemical compounds measured in tissues of malodorous ('stinky') and clean gray whales collected from 2005 through 2011. These included PAHs, persistent organochlorines, benzene derivatives and chlorinated PAHs. The authors commented that the odorous carbonyl compounds measured in tissues of 'stinky' whales may be a result of slow metabolism of petroleum hydrocarbons that occur in the Pacific Ocean. They also noted concentrations of persistent organochlorines in the gray whale tissues were low or not detected (DDT).

It was noted (see Annex F) that the finding of non-detectable DDTs is in contrast to the finding of measurable DDT levels in gray whale calves and mothers sampled in the lagoons in the Baja California region reported in SC/64/E4. Differences in DDT levels among these gray whales are most likely due to differences in contaminant levels on their feeding grounds although levels are generally low. The Committee **emphasises** that a clearer indication of which samples were 'stinky' and which samples were controls would make the information provided easier to interpret. Due to the lack of clarity in this regard (IWC/64/CC10), no new conclusions could be drawn regarding 'stinky'gray whales. The Committee **reiterates** its previous **recommendations** (e.g. IWC, 2006c; 2007f; 2008j; 2009f) that futher efforts be made to determine the cause of the 'stinky' whale condition.

12.3 CERD (Cetacean Emerging and Resurging Disease)

In 2007, the Committee recognised the need for increased research and standardised reporting in a wide range of disciplines dealing with cetacean health (IWC, 2008j), which led to the creation of the Cetacean Resurging and Emerging Disease (CERD) Working Group.

12.3.1 Update from CERD Working Group

An update to the CERD Work Plan agreed last year (IWC, 2012p) was presented. This work plan included:

(1) identification of regional and national experts/points of contact via Steering Committee membership;
(2) creation of a listserve and a website;
(3) creation of a Framework Document; and
(4) identification of and contact with organisations synergistic with the goals of CERD.

The CERD working group (WG) made significant progress on all tasks, except on the Framework Document, where work is now underway to better define the long-term vision and goals for the CERD working group.

[18]*http://www.second.icmmpa.org.*

12.3.2 Progress on CERD website

The CERD website is being developed in two phases. The first phase focuses on large cetacean species and relies on a 'consultation and sharing' approach. The second phase is intended to include all cetacean species and incorporate a potential 'reporting' role. This website will have 'public' and 'registered user' levels. The public level will provide basic information on diseases in cetaceans, as well as access to selected discussion forum content. Registered users will have full access to the site, including in-depth information on cetacean disease, as well as to discussion forums with posting ability. On the main page, a 'map it' feature will allow registered users to record geographic locations of disease incidents, while a 'current events' header will alert website visitors to recent events in cetacean disease and facilitate international communication. Links will be provided for quick access to discussion boards that can be shared with groups focused on other topics such as pollution, ship strikes and marine debris.

It was noted that researchers examining photographs on the website may be able to distinguish between wounds from entanglements, ship strikes or marine debris and this discussion underlined the overlap among these areas. The Committee **agrees** that it will be useful to incorporate standardised tissue collection protocols on the CERD website. The Committee thanked the CERD WG and the Secretariat for their efforts on developing the website and **encourages** continued development of this tool.

12.3.3 Other disease related issues

SC/64/E1 presented the results of a study of six *Morbillivirus*-infected cetaceans stranded along the Italian coastline between 2009 and 2011. The authors concluded that: (1) *Morbillivirus* infection continues to represent a major threat to cetacean health and conservation in the Mediterranean Sea with an increasingly expanding 'host range' of the virus; and (2) the cases of morbilliviral infection characterised by an apparently exclusive involvement of the animal's brain tissues are a matter of concern, both from the conservation and from the comparative pathology standpoints, thereby underscoring the role of cetaceans as models for the study of their human neurological disease counterparts.

Discussion (Annex K) focused on the types of tests and assays performed on these animals and the need for increased surveillance for neurologic diseases in cetaceans. The Committee welcomed this study and **encourages** further studies on these pathogens in cetaceans.

The Committee also noted that there was worldwide press coverage over the recent (February-May) unusual mortality event (UME) of about 900 dead long-beaked common dolphins, *Delphinus capensis*, in Peru, but based on these press reports there remains considerable uncertainty about the cause of this UME. However, no scientific reports were available on this UME for the Committee to review, but the they look forward to receiving reports on the UME next year.

In SC/64/E4 preliminary results were presented on contaminant levels (Organochlorine Compounds - OCs) and biomarkers from biopsies in the San Ignacio Lagoon (Mexico). These preliminary data reveal an accumulation of OCs in gray whale calves resulting from the lactational transfer of these compounds from their mothers. Exposure to OCs (such as DDTs) at early life stages may have toxic impacts on their developing endocrine, immune and neural systems. The paper is discussed fully in Annex K.

The Committee welcomed this paper, noting its relevance to the IWC's POLLUTION 2000+ programme and **encourages** continued studies.

SC/64/E8 provided a review of diseases and micro-organisms, as well as the public health and conservation impacts from cetaceans that stranded in Costa Rica during 2004-11. Humans and cetaceans affected by marine *Brucella* can develop severe disease such as neurobrucellosis and osteomyelitis, and the authors concluded that conservation policies should support research that investigates incidence, prevalence, geographic distribution and host range of *Brucella* infection in cetaceans. The paper is discussed fully in Annex K.

The Committee **welcomes** this paper, noting that data obtained from studies such as this are part of 'The One Health' concept - a worldwide strategy for expanding interdisciplinary collaborations and communications in all aspects of health care for humans, animals and the environment[19]. The Committee recognised *Brucella* as an important zoonotic pathogen and **encourages** additional research on this disease agent.

12.4 Anthropogenic sound

In 2010, the Committee reviewed evidence of masking of cetacean calls from anthropogenic sound, with an emphasis on low-frequency sounds (<1kHz) from commercial shipping and airguns used during seismic surveys (IWC, 2011j). It had recommended that: (1) the masking potential of anthropogenic sources be quantified and acoustic measurements be standardised; and (2) IWC member governments work to develop a quantitative approach for assessing cumulative impacts of anthropogenic sound on cetaceans.

12.4.1 Mitigation of effects of anthropogenic sound on cetaceans

US federal regulations require scientists and representatives of offshore industries to acquire incidental harassment authorisations for activities that may disturb marine mammals, but the potential impacts of sound are often considered on a project-by-project basis in isolation from one another. This precludes meaningful analysis of cumulative impacts from multiple sources. In response to consideration of offshore industrial activities in the Alaskan Arctic, Moore *et al.* (2012) proposed a three-step assessment framework based development of *acoustic habitats*, which constitute the aggregate sound field from multiple sources compiled at spatial and temporal scales consistent with the ecology of Arctic marine mammals. Assessment framework steps include: (1) the development of acoustic habitat maps depicting anticipated sound fields from multiple sources; (2) an overlay of acoustic-habitat maps with marine mammal seasonal distribution and density maps to identify areas or periods of concern and data gaps; and (3) development of precautionary measures to protect marine mammals from potential impact and a prioritisation of data gaps and research needed to address those gaps.

In the US, the Cetaceans and Sound (CetSound) project is now working toward mapping products envisioned in the first two steps of this framework[20]. The CetSound project consists of two working groups convened to develop mapping tools: the Underwater Sound-field Mapping (SoundMap) and the Cetacean Density and Distribution Mapping (CetMap). The overarching objective of the SoundMap group is to create maps depicting the temporal, spatial and spectral characteristics of both chronic (e.g. shipping) and episodic

[19]*http://www.onehealthinitiative.com/index.php* and *http://www.oie.int/en/.*
[20]*http://www.cetsound.noaa.gov/index.html.*

(e.g. seismic survey) underwater noise. The overarching objective of the CetMap group is to create regional cetacean density and distribution maps that are time- and species-specific, using survey data and models that estimate density using predictive environmental factors. To augment the more quantitative density mapping and provide additional context for impact analyses, the CetMap group is also identifying known areas of specific importance for cetaceans, such as reproductive areas, feeding areas, migratory corridors, and areas in which small or resident populations are concentrated. The Committee **commends** the initial development of these powerful mapping tools, **endorses** this work and **strongly recommends** support for further development and improvement of these tools.

The Committee also **welcomes** the information on work being undertaken regarding noise by IUCN's Western Gray Whale Advisory Group and especially its Noise Task Force[21] (see Annex F).

12.4.2 Other anthropogenic sound related issues

Underwater noise from commercial shipping is chronic (IWC, 2011j). The IMO has established a correspondence group (CG) to develop non-mandatory guidelines to address noise from commercial ships; the IWC Secretariat participates in this group (IWC/64/4G). The IMO CG will finish the first draft of their report by the end of 2012 and it will be presented to the IMO in early 2013. The Committee **commends** the continued discussions between the IMO and IWC regarding efforts to reduce noise of newly built vessels. Further, it noted the importance of identifying ship acoustic signatures and **encourages** the collection of these data, as well as the coupling of this information with the appropriate automatic identification system data.

At past meetings, the Committee has received updates on the development of a modelling effort to determine the Population Consequences of Acoustic Disturbance (PCAD) on marine mammals initially proposed by the US National Research Council in 2005. In 2009, the US Office of Naval Research supported a Working Group whose objectives included building a formal mathematical structure for the framework, which led to key adaptations to the original framework, including the incorporation of other sources of disturbance, physiological change and the use of health as the primary metric through which changes in individuals can potentially impact the population. Combined, this led to the framework being renamed the Population Consequences of Disturbance (PCoD). The SWG noted that PCoD is a significant improvement on the PCAD model. Although the current model focuses on single stressors, accumulative effects, behavioural responses and other factors (e.g. acoustic masking) that could potentially affect health could also be added to the model. The SWG **strongly encourages** further work on this model and looks forward to progress updates.

12.5 Climate change

12.5.1 Progress on recommendations from the 2nd climate change Workshop

At the 2nd climate change Workshop (IWC, 2010k), three themes were recommended with regard to the study of cetaceans in the Arctic: (1) single species-regional contrast; (2) trophic comparison; and (3) distribution shift. With regard to the first theme, results of passive acoustic sampling in 2008/09 provided a means to compare seasonal patterns in call detection from bowhead whales in the B-C-B and Spitzbergen stocks, providing a contrast in seasonal occurrence for this species between the Atlantic and Pacific sectors of the High Arctic (Moore *et al.*, 2012). Details of this work are discussed in Annex K.

As also discussed in Annex K, an overview of a new programme was received which was called the Synthesis Of Arctic Research (SOAR). It is a US-based activity, which aims to bring together a multidisciplinary group of Arctic scientists and Alaskan coastal community representatives to explore and integrate information from completed and ongoing marine research in the Pacific Arctic sector[22]. While SOAR is not focused specifically on cetaceans, eight projects under its auspices will focus on aspects of beluga and bowhead whale ecology, which are related to the three study themes of the 2nd climate change Workshop.

The Committee **welcomes** these updates on cetacean-related science in Arctic waters, **endorses** the work undertaken thus far and requests future updates.

12.5.2 Small cetacean restricted habitats Working Group

Building upon the work of an intersessional working group to further recommendations made at the IWC Climate Change Workshop in 2010 (IWC, 2012w), the Committee **agrees** to the following definition:

The spatial extent of the range occupied by these populations may vary by orders of magnitude, but one or more of the following conditions apply: (1) the species/population has narrow habitat requirements; (2) the habitat is bounded by physiographic or oceanographic barriers; and (3) other suitable habitat which the population might be able to access is unavailable because it is occupied by competitors. The first two conditions might apply to fixed populations, such as the vaquita - the third condition in particular requires further consideration and development. These conditions may also apply to populations of large whales (e.g. fin whales in the Mediterranean Sea and the Gulf of California) and it was agreed that large whales would be considered in future discussions on this topic.

The Committee **welcomes** this effort to further advance our understanding of the potential impacts of climate change in cetaceans. However, it also **urges** caution with regard to which populations and species should be focused upon with respect to climate change, so as not to detract from efforts to address more imminent threats and stressors such as bycatch. Creating a list of species or populations to which this definition might apply was suggested as one way to further develop the topic. The Committee also noted the importance of integrating and considering the findings of climate change-related analyses that have been conducted for other marine mammal species (e.g. polar bears and ice seals) when considering the issue for cetaceans.

12.5.3 Planning for an intersessional arctic anthropogenic impacts Workshop

In 2010, the Commission asked the Committee to develop an agenda for a Workshop on Arctic Anthropogenic Impacts on Cetaceans (IWC, 2011a). Last year, a draft agenda was completed and a Steering Group formed (IWC, 2012q) to further develop a plan for the Workshop. A revised agenda that focused on anthropogenic activities related to oil and gas exploration, commercial shipping and tourism was developed intersessionally. The Committee noted that the Workshop agenda should be expanded to include consideration of other anthropogenic activities such as commercial fishing and scientific research. Given rapid

[21] *http://www.iucn.org/wgwap/wgwap/task_forces/.*

[22] *http://www.arctic.noaa.gov/soar/.*

environmental changes and increasing human activities in the Arctic, the Committee **encourages** the continued development of an arctic anthropogenic impacts Workshop focused on climate change, but **strongly recommends** that it:

(1) carefully define the geographical area to be addressed;
(2) focus only on Arctic cetacean species (i.e. bowhead whales, white whales, and narwhals);
(3) consider a broad suite of anthropogenic activities; e.g. oil and gas development, commercial fishing, commercial shipping, tourism, continental shelf mapping and scientific studies;
(4) specifically include possible impacts from underwater sounds, spilled oil, dispersants, invasive species and discharges (including dumping of ballast water) related to exploratory drilling and shipping; and
(5) include a discussion about assessing the cumulative and synergistic impacts of anthropogenic activities.

The topic of anthropogenic impacts to cetaceans in the Arctic is broad and complex and the Committee **recommends** that the process should involve an initial scientific Workshop followed by a more inclusive Commission meeting that addresses management and policy aspects of arctic anthropogenic impacts on cetaceans. It is anticipated that final specification for the scope, agenda and schedule for the Workshop will be undertaken jointly by the Workshop Steering Group and representatives of the IWC and Secretariat.

12.5.4 Other climate change related issues

The IMO is working to develop a mandatory Polar Code to manage the increases in ship traffic in Arctic and Antarctic waters anticipated with the reduction of sea ice associated with climate change (IWC/64/4). The Polar Code work is coordinated by the sub-committee on Ship Design and Equipment, as is the work regarding ship quieting (see Item 9.2). The IWC's endorsement of noise reduction goals (i.e. 3dB in 10 years; 10dB in 30 years) advanced at an international Workshop on shipping noise and marine mammals (Wright and Okeanos Foundation for the Sea, 2008) were re-iterated in a document entitled *Status on Implementation of the Arctic Marine Shipping Assessment 2009 Report Recommendations*, available on the Arctic Council website[23]. The Committee **welcomes** this information, **reiterates its endorsement** of noise reduction goals and looks forward to continued collaborations between the IWC and the IMO on this topic.

12.6 Interactions between MREDs and cetaceans

Given information and a review provided last year, the Committee had endorsed a proposal for a Workshop on interactions between marine renewable developments (MREDs) and cetaceans. That Workshop was held immediately prior to the present Annual Meeting and its report is given as SC/64/Rep6.

Simmonds presented the report and noted that a variety of MREDs are now being deployed worldwide, with the highest concentrations in the Northern Hemisphere, especially in northern Europe. The three main forms of MREDs at this time are: (1) wind farms; (2) tidal-stream driven devices; and (3) wave energy converters. Each of these, as well as their supporting infrastructure, has the potential for interaction with cetaceans during the construction, operation and decommissioning phases (Simmonds *et al.*, 2010).

[23]*http://www.arcticcouncil.gov/pame/amsa/.*

The Workshop received detailed reports on the current state of development and management of marine renewable energy in waters of Germany, the UK, Belgium and the USA, including trans-boundary issues now arising in the busy waters of Europe (SC/64/Rep6, fig. 1). The Workshop focused on the three main types of MREDs and considered potential impact to cetaceans on aspects of 'supporting infrastructure' for MREDs. A number of papers and websites informed discussions throughout the Workshop (SC/64/Rep6, Appendix 2); of particular use was a special synthesis of the work on MREDs conducted by ICES (Murphy *et al.*, 2012).

The Committee noted that MREDs may well play a major role in the mitigation of climate change, which may profoundly affect cetacean populations as discussed at prior climate change Workshops (IWC, 1997b; 2010k). The Committee thanked Simmonds for the successful Workshop. In particular it **endorses** the Workshop's conclusions and recommendations (see especially SC/64/Rep6, item 5). These are briefly summarised below.

1. Strategy to minimise risk

Risks from both lethal and sub-lethal effects can be minimised via a series of actions; the collection, collation and analysis of appropriate baseline cetacean data and appropriate industrial data will allow the identification and quantification of threats and their potential implications for conservation objectives. All stakeholders need to be involved from the outset such that impacts from all factors are considered, ensuring that appropriate mitigation measures and associated monitoring programmes are developed. Suitable scientific evaluation and compliance mechanisms are needed to ensure that mitigation and monitoring are adequate.

2. Broad management

Governments, managers and other stakeholders need to co-operate in strategic planning for MREDs taking into account the trans-boundary nature of cetaceans. Uncertainties over the level of impacts require a staged approach to developments taking into account lessons learned from other developments and other human activities that affect cetaceans, in order to be adequately precautionary. IWC member governments can assist in encouraging the development of international collaboration in this regard, and in particular, they can assist in emphasising the importance of incorporating consideration of cetaceans from an early stage and the value of following the broad strategy and principles outlined in the Workshop report and summarised in Fig. 3.

3. 'Fundamental' research

International collaboration will be required to determine population structure, status, distribution and procedures for assessing impacts. The Committee can assist with design and evaluation of population and impact assessments. While there are established methods for assessing lethal takes, data on the effects of (sub-lethal) stressors on cetaceans are also needed.

4. Evaluation of threats

All lethal and non-lethal impacts of human activities should be considered in an integrated manner, e.g. using modelling approaches that take into account the cumulative impacts from all threats when evaluating whether conservation objectives are likely to be met.

The Committee has considerable expertise in developing management frameworks and testing their performance against specified objectives.

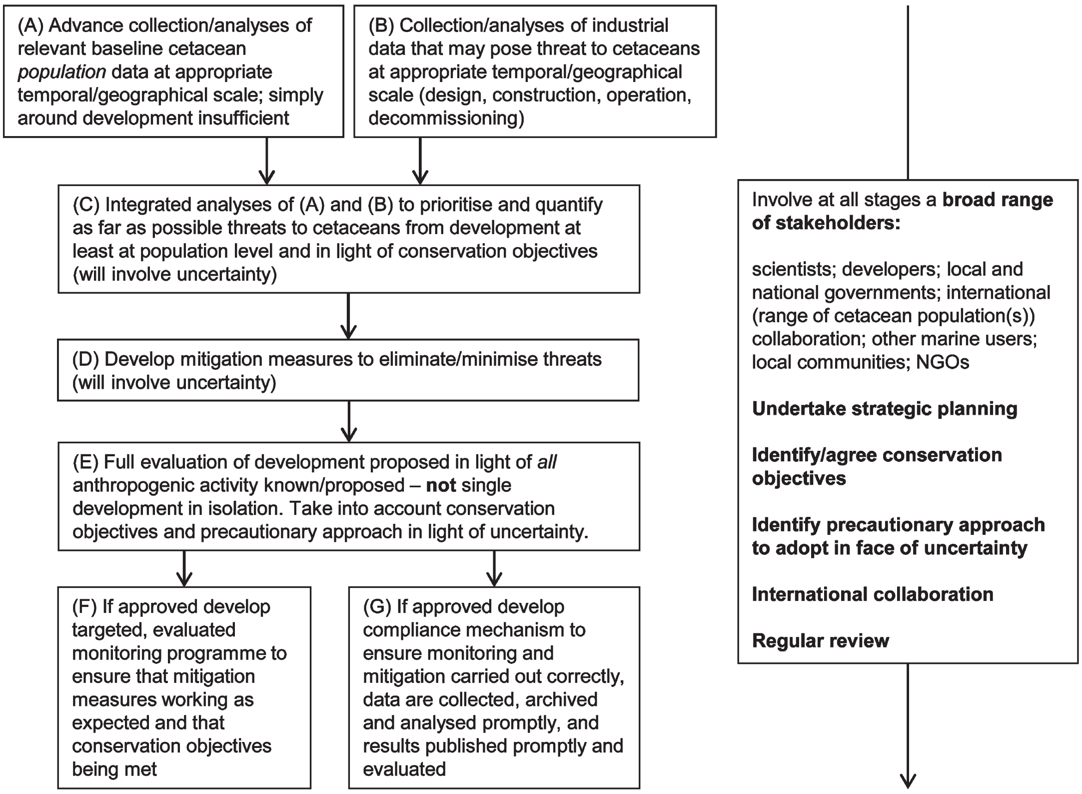

Fig. 3. Simplified schematic summary of a general strategy and principles to minimise environmental threats posed by MREDs. Some stages will occur in parallel and will involve feedback. See report for details.

5. Monitoring
Monitoring should be designed carefully, to assess impacts against pre-determined conservation objectives and to measure the efficacy of any mitigation measures that are implemented.

6. Data sharing and the future role of the IWC Scientific Committee in the consideration of MREDs
Improved information and data-sharing were identified as key and the Workshop encouraged the Committee to continue to act as a forum to review the development of MREDs and their implications for cetaceans, including promoting the sharing of data. Countries were encouraged to help in this by providing appropriate information.

In addition to the Workshop report, the Committee received information from two papers on the topic of interactions between cetaceans and MREDs focused on waters offshore of Scotland (SC/64/E3) and a preliminary assessment of the effectiveness of small Marine Protected Areas (MPAs) to protect dolphins in offshore Wales (SC/64/E6).

It also received an update on Chilean renewable energy projects (SC/64/E12) and noted that consideration should be given on the impacts of coastal wind farms, particularly in regions that support critical habitats for cetaceans. The Committee **strongly recommends** urgent development of environmental impact studies in this area of Chile and urges that a precautionary approach should be used with regard to critical cetacean habitats.

The Committee also **agrees** that there is an urgent need to develop or improve effective noise mitigation measures or quieter foundation installation methods, as noted in past reviews of anthropogenic sound (e.g. IWC, 2010g; IWC, 2012o).

12.7 Other habitat related issues
Primary papers submitted on topics related to other habitat related issues, included potential impacts of marine debris, cumulative impacts and results of a large-scale aerial survey programme in the French tropical EEZ.

12.7.1 Cetaceans and marine debris
In addition to receiving five papers on the topic of marine debris (SC/64/E7, SC/64/E10, SC/64/E13, SC/64/E15 and Fossi *et al.*, 2012), the SWG received the results from an intersessional Working Group (Debris WG) that had considered the issue of both ingestion and entanglement of cetaceans in marine debris. The intersessional group offered the following conclusions and recommendations:

(1) marine debris is a growing concern for marine wildlife in general, but its interactions with cetaceans are poorly understood;
(2) to better evaluate the potential impacts of marine debris on cetaceans and to provide a forum where relevant data can submitted, a Workshop on marine debris and cetaceans should be convened; and
(3) the primary aim of this Workshop would be to determine how to best investigate quantitatively the ways in which marine debris is affecting cetaceans and how best to monitor and mitigate for these effects. The Workshop could also consider how best to develop a centralised database to collate cases of debris interactions, including the development of standardised criteria for data to allow more certain identification of the types of debris and the interactions involved.

Two key issues fundamental to assessing impact of marine debris on cetaceans were identified: (1) how to distinguish cetaceans that have died in active fishing gear versus those entangled in debris (including abandoned, lost, discarded - or 'ghost' - fishing gear) and the need to identify the 'worst culprit' types of fishing gear causing entanglement; and (2) how to investigate the potential accumulation of debris in the deep sea feeding areas of beaked and sperm whales. In addition, more effort is needed to investigate the impacts of microplastics on cetaceans, including baleen whales, which potentially ingest micro-litter by filtration feeding (see Fossi *et al.*, 2012).

The Committee **recommends** that a Workshop on marine debris and cetaceans be held (Annex K, Appendix 3) noting also its relevance to the Working Group on Bycatch with regard to entanglement issues (see Item 7.8). A number of potential data sources for data on marine debris were identified including those of international bodies such as CCAMLR and well as national and local bodies in several countries. SC/64/Rep1 noted the work being undertaken by the USA, Korea and Japan and the Steering Group for the IWC-POWER cruises who are investigating how those cruises can contribute to international efforts to gather information on marine debris (see also Annex G).

12.7.2 Issues related to the March 2011 tsunami in the northwestern Pacific

Concerns have been raised with regard to increased marine debris transport to the eastern Pacific Ocean, as well as radioactive contamination of marine debris a result of the 2011 tsunami in Japan. Modelling efforts estimate that the bulk of the debris related to this event is probably dispersed north of the main Hawaiian islands and east of Midway Atoll[24]. Furthermore, as predicted by these modelling efforts, some buoyant debris reached the east Pacific coast from Oregon to Alaska during winter 2011-12 and continues to occur in the region. It is highly unlikely that debris transported from Japan to the eastern North Pacific poses a radioactive risk. However, transport of non-native, invasive species or pathogenic micro-organisms on tsunami-released debris could occur and pose a threat to eastern Pacific coastal ecosystems. Details of potential impacts of the tsunami-released marine debris on marine mammals and the potential increase in either ingested marine debris or risk of entanglement are summarised in Annex K. Discussion of some Japanese work related to the effects of the tsunami on the marine ecosystem also occurs under Item 17.

12.7.3 Cumulative impacts of anthropogenic activities

SC/64/E11 reported on cumulative impacts of several anthropogenic activities on cetaceans. While there are a number of quantitative processes for assessing the combined impacts of multiple stressors being developed, some are active and used in management. For example, five actions to mitigate cumulative impacts were developed during the permit cycle of the Greenland Bureau of Minerals and Petroleum for the mitigation of cetacean exposures to disturbance from seismic surveys, as given in Annex K.

The Committee **welcomes** information on efforts to develop effective tools to address concerns regarding cumulative impacts of anthropogenic activities on cetaceans. It was noted that the effects of climate change on marine ecosystems may compound the cumulative impacts of anthropogenic stressors, such as chemical pollutants and noise.

12.7.4 REMMOA aerial surveys in the French EEA

The Committee received an update of the REMMOA project (Mannocci *et al.*, Submitted; SC/64/E14), aimed at providing maps of hot spots for pelagic megafauna in the French tropical EEZ and some EEZs of neighbouring countries. The long-term objective of the REMMOA surveys are to establish a baseline of information on cetaceans and other pelagic megafauna diversity and relative abundance and to build up a monitoring strategy to be implemented in the future. Mannocci *et al.* (Submitted) presented analyses of the Caribbean-Guiana survey where the aim of the study was to document top predator communities in terms of encounter rates, composition, abundance and spatial distribution and to compare them between these two contrasting ecosystems. SC/64/E14 presented the analysis of the southwest Indian Ocean survey with a focus on comparing cetacean and other pelagic megafauna communities in areas characterised by contrasted oceanographic conditions. The Committee **welcomes** these updates and **encourages** the results of their work to be presented next year.

12.8 Work plan

The Committee expressed its great appreciation to Moore for her superb guidance and chairing of the SWG over the 5-year period of her service as Chair.

The Committee discussions of the work plan developed in Annex K are given under Item 23.

13. ECOSYSTEM MODELLING

The Ecosystem Modelling Working Group was first convened in 2007 (IWC, 2008i). It is tasked with informing the Committee on relevant aspects of the nature and extent of the ecological relationships between whales and the ecosystems in which they live. This advice is important to a number of other responsibilities of the Committee and the Commission has stated their interest in such work in a number of resolutions (IWC, 1999a; 2001b; 2002).

The Working Group's topics to address at this year's meeting were:

(1) review of ecosystem modelling efforts undertaken outside the IWC;
(2) explore how ecosystem models contribute to developing scenarios for simulation testing of the RMP; and
(3) review of other issues relevant to ecosystem modelling within the Committee.

The report of the Working Group on Ecosystem Modelling is given as Annex K1.

13.1 Review of ecosystem modelling efforts undertaken outside the IWC

13.1.1 Ecosystem modelling in the context of ecosystem-based fisheries management

SC/64/EM1 outlined several ecological questions relevant to whale populations that can be addressed by ecosystem models. These included: (1) what species and fisheries can potentially compete with whale feeding? (2) how would one evaluate the potential magnitude of such competition? (3) what are the potential indirect food web effects on whales? (4) what are the ecosystem tradeoffs that most warrant evaluation? (5) what are the best scenarios (to model) to mitigate any of these concerns? and (6) how well do such (simulated) scenarios perform? The author also provided a review of the major classes of ecosystem model being employed globally in an ecosystem-based management context, provided a map of ecosystem models as they relate to these and similar questions, and described how global best practices are being adopted in the use of these ecosystem models. A key message was that the choice of

[24] *http://www.marinedebris.noaa.gov/info/japanfaqs.html.*

model depends strongly on the questions being addressed. It is probably better to start with the simple multi-species models (with few components) or extended single-species models. The more complex multi-species models, food-web models or whole-system models are more suited to addressing broader questions.

SC/64/EM2 reported on efforts to place initial quantitative bounds on consumption estimates for a suite of marine mammals in the northeast US large marine ecosystem, including baleen whales, odontocetes and seals. Daily individual consumption rates were compiled from the literature and explored with sensitivity analyses to derive feasible ranges for each species which then could be raised to annual population-level consumption based on existing population abundance estimates. The results indicated that marine mammal consumption in this region might be similar in magnitude to commercial fishery landings for small pelagic and groundfish prey groups, although previous studies have indicated that targeted sizes may differ. Marine mammals probably consume as much prey as finfish predators, thus meriting continued evaluation despite the inherently wide confidence intervals of their consumption estimates.

The Committee **welcomes** this information, noting that with the move toward ecosystem-based management, consumption by marine mammals warrants inclusion as a source of natural mortality in assessments of mammal prey stocks. It also noted that reference points for marine mammal management, such Optimum Sustainable Production, had yet to be suitably defined in a multi-species context.

13.1.2 Ecosystem models of the effect on predators of fishing forage fish

Recent studies (Cury *et al.*, 2008; Fulton *et al.*, 2011; Pikitch *et al.*, 2012) have addressed the effects of exploitation of forage fish on their predators in several ecosystems, indicating that fishing of forage fish down to their MSY level can have major impacts on predators, including birds and marine mammals. In view of the importance of this issue to cetaceans, the Committee **agrees** that this should be a priority topic for next year.

13.1.3 Status update on NAMMCO ecosystem modelling

At last year's meeting, the Committee received an update on NAMMCO's initiative to implement a series of ecosystem modelling exercises in the Barents Sea and the waters around Iceland. This year, the Committee was informed that the efforts have been delayed due to a lack of funding. However, the Committee remains interested in receiving information on these exercises as it becomes available.

13.2 Explore how ecosystem models contribute to developing scenarios for simulation testing of the RMP

Recent discussions in the sub-committee on the RMP (e.g. IWC, 2011g) on variation of *r* and *K* values in the face of environmental variability has shown that it can be useful to try to model the effects of food availability more explicitly, because this can have implications for the effects of prey abundance on whale population dynamics. The Committee **emphasises** the value of implementing this in small steps rather than going immediately to complex models and **agrees** that consideration of simple models of whales and prey should be a priority issue for next year.

13.3 Review of other issues relevant to ecosystem modelling within the Committee

13.3.1 Update on Antarctic minke whale body condition analyses

Last year, the Committee discussed issues regarding the statistical significance of a decline (of about 0.2mm per year) in mean blubber thickness of Antarctic minke whales over the 18-year JARPA period reported by Konishi *et al.* (2008). The issues had been raised by de La Mare (2011), who found that the methods used by Konishi *et al.* (2008) could result in spurious apparent significance of trends because the nature of the sampling process and the associated components of the variance structure of the data were not taken into account. A reanalysis of the data at last year's meeting by Skaug (2012) using mixed-effect regression models to account for some of the additional variance structure resulted in a much higher variance of the estimated trend, but the point estimate changed little, and the estimated trend was still significant. Given the relevance of body condition indices to its work, the Committee agreed that further analysis of the data was warranted to determine: (1) whether the models fitted so far captured all the main features of the data; and (2) whether the estimate of trend (whose confidence limits using the best fitting model ranged from near zero to values that could be of appreciable biological significance) could be made more precise. The Committee requested, *inter alia*, results from analysing the two sexes separately and the inclusion of slopes by latitudinal band as a random effect. It also suggested that the authors of de la Mare (2011) and Konishi *et al.* (2008), apply for access to the data under Procedure B of the Data Availability Agreement, so that further analyses of these data could be reviewed by the Committee this year.

This year, de la Mare reported that he had applied for access to data through the Data Access Group but that a mutually satisfactory agreement was not reached. The generic data access questions raised in this case is discussed under Item 24. Pastene noted that Japan had offered to make available all data that had been requested by the Committee last year under the conditions of Procedure B (see Attachment B of SC/64/SCP1). De la Mare responded that conditions attached to the offer were in his opinion not in accordance with Data Access Agreement Protocol B and so were unacceptable.

In SC/64/EM3, he also presented an analysis of sex ratio and female length at 50% maturity using the JARPA data available in the IWC's catch database that showed unlikely trends and much higher levels of variability than would be expected in these parameters from a biological population. He noted that this indicated the presence of 'lurking variables' that had important effects on the dependent variable but that were not included in the predictor variables under consideration. Similar adverse effects could be present in the analyses of body condition described above, with possible sources of unaccounted variance including inter-annual variability in the locations and dates on which whales were taken, the spatial distributions of one or more biological populations and the co-effects of seasonality by sex and reproductive state. Using a statistical simulation of catches along random transects, SC/64/EM3 further showed that standard errors calculated using individual animals as the sample size underestimates the true variability because of spatial/temporal pseudo-replication, and that transects are the basic sampling units, not the individual catches.

There was considerable discussion of SC/64/EM3 and the implications for inferences on biological parameters derived from JARPA data. Some members emphasised that failing to estimate the variance associated with random transect placement means that the variances in the analyses of biological parameters will be underestimated such that hypothesis tests will be invalid. They further noted that the reported catch locations in the IWC database show that clearly identifiable transects that can be treated as replicates have not been realised and where transects are identifiable they have not been traversed in random time order. Consequently these members considered that the conditions for the appropriate analysis of the data have not been met.

Other members considered that non-independence can be accounted for by using jack-knife methods, as was done during last year's meeting with the blubber thickness data, using one year as the jack-knifing unit (IWC, 2012n). This approach showed that while the estimated SE increased from 0.0225 to 0.0836 on the regression slope (-0.213 mm/yr^{-1}), the slope estimate itself did not change and thus was still significantly different from zero at the 5% level. This jack-knife result should, according to these members, take care of concerns about dependence between observations. In addition, as mentioned above, mixed-effects models were also applied during last year's meeting to account for some of the additional variance structure resulting in a best model (based on the AIC criterion) with a slope of -0.19mm/yr^{-1} and SE=0.07; (Skaug, 2012, pp.259-62). In discussion, these members understood de la Mare to have claimed that these results did not take care of all possibilities for statistical dependence between whales (e.g. whales sampled on the same track line), but they considered it highly unlikely that such dependence could be so large as to destroy the findings of negative trends in blubber thickness, fat weight, girth or weight of stomach contents.

The Committee noted that valid conclusions can often be drawn from non-random samples as long as this is accounted for in the analysis. It further **recommends** that the authors of Konishi *et al.* (2008) investigate independence issues by using mixed-effects models with trackline as a random effect to address the concerns raised above. These authors will consider carrying out such analyses before next year's meeting.

13.3.2 Other issues

A decline in energy storage in Antarctic minke whales over almost two decades (Konishi *et al.*, 2008) suggests that food availability may have been declining recently. To test this hypothesis, at this year's meeting Konishi presented a paper (Konishi *et al.*, In review) that examined whether there was any annual trend in the stomach contents of the whales using catch data from 20 seasons in JARPA and JARPA II (1990/91-2009/10). Results from linear mixed-effects analyses showed a 39% (95% CI 3.2-47.3%) decrease in the weight of stomach contents over the 20 years. A similar pattern was found in both males and females, except in the case of females sampled at higher latitude (particularly in the Ross Sea), suggesting a decrease in the availability of Antarctic krill for Antarctic minke whales in the lower latitudinal range of the JARPA/JARPA II research area. However, prey availability has not changed in the Ross Sea, where both Antarctic krill (*Euphausia superba*) and ice krill (*E. crystallorophias*) are available. The decrease in Antarctic krill availability could be due to environmental changes or to an increase in the abundance of other krill-feeding predators. The latter appears more likely, given the rapid recovery of the humpback whale in the area and the fact that humpback whales are not found in the Ross Sea, where no change in prey availability was observed for minke whales.

There was considerable discussion of this paper, focusing on two main areas:

(1) statistical issues, similar in nature to those discussed above with respect to the blubber thickness analysis, in particular as to whether the analysis takes account of all components of variance and whether the statistical significance of the apparent trends is reliable; and
(2) the biological issues associated with the relationship between stomach fullness and food intake and between stomach fullness and prey availability.

With respect to the statistical issues, members repeated many of the points summarised above with respect to the blubber thickness analysis and made a number of suggestions regarding additional statistical treatment of the data (see Annex K1). The Committee **recommends** that these analyses be conducted if possible.

With respect to the biological issues, some members noted the importance of considering the stomach evacuation rate and its relationship to the timing of feeding. The strong decline in mean stomach contents over the day, as shown in the results, is indicative that most feeding is occurring at night. It is possible to envisage a situation where high food abundance would lead to whales being satiated relatively early in the night, such that by the next day their stomachs are not very full. Conversely, during periods of lower food abundance, feeding may be spread over a longer period, such that more food tends to be found in the stomach during the day. Thus, the direction of the relationship between food availability or intake and observed stomach content weight is not obvious *a priori*. In response, other members drew attention to information such as the negative trend in blubber thickness, which supported the lower food availability hypothesis. Data collected during JARPA on the freshness of food in the forestomach may provide further information on the timing of feeding, and the Committee **recommends** that these data be analysed.

The Committee **agrees** that for an understanding of the possible relationships between food intake and stomach fullness, analyses of the consequences of the diurnal patterns of food intake should be reported. Furthermore, alternative models for stomach evacuation (such as linear and exponential models) should be examined. The Committee **agrees** to keep the issue on the agenda for next year and **encourages** submissions on this issue.

13.4 Review new information on ecosystem model skill assessment

No new information was available for discussion on this topic.

14. SMALL CETACEANS (SM)

The Committee has been discussing issues related to small cetaceans since the mid-1970s (IWC, 1976). Despite the differences of views over competency (IWC, 1993a, p.31), the Commission has agreed that the Committee should continue to consider this item (IWC, 1995a).

14.1 Review status of ziphiid whales in the North Pacific and northern Indian Ocean

The last worldwide assessment on the status of ziphiids was in 1988 (IWC, 1989). Last year the Committee reviewed the status of ziphiids in the North Atlantic and adjacent waters (IWC, 2012r, Annex L). At this meeting, the priority is to review the status of the ten beaked whale species in the North Pacific and northern Indian Ocean (see text table over page). Considerable information was submitted for the review and details can be found in Annex L (see table overleaf for agenda items). Only a general overview is given here.

Ziphiids in the North Pacific and northern Indian Ocean.

Beaked whale species	Distribution	Item in Annex L
Cuvier's	Worldwide except polar waters	3.1
Blainville's	Tropical and warm-temperate waters worldwide	3.5
Baird's	Cold-temperate waters of the North Pacific Ocean	3.2
Hubbs'	Cold-temperate waters of the North Pacific Ocean	3.4
Stejneger's	Cold-temperate waters of the North Pacific Ocean	3.9
Pygmy	Mainly in the Eastern Tropical Pacific (ETP)	3.8
Perrin's	Poorly known – few California specimens	3.7
Ginkgo-toothed	Poorly known – tropical and warm-temperate Indian and Pacific Oceans	3.6
Longman's	Poorly known – tropical and warm-temperate Indian and Pacific Oceans	3.3
Deraniyagala's	Poorly known – tropical and warm-temperate Indian and Pacific Oceans	3.10

SC/64/SM21 analysed passive archival acoustic data from across the North Pacific. Species-specific frequency modulated (FM) echolocation pulses made by Baird's, Blainville's, Cuvier's, Longman's and Deraniyagala's beaked whales at Palmyra Atoll, have been recorded and described, with visual confirmation of species identity. The species-specific features appear to be consistent within all sequences labelled to signal type level, making possible the discrimination of species. It was agreed that Cross Seamount was a good site to identify ginkgo-toothed beaked whale call signatures.

The Committee **welcomes** the report on the spatio-temporal distribution of species-specific acoustic echo-location signals of beaked whales in the North Pacific. Future research using visual sightings with biopsies in conjunction with acoustic recordings will be necessary to link several species and signal types.

SC/64/SM11 provided estimates of abundance and trends for Baird's beaked whale, Cuvier's beaked whale and *Mesoplodon* spp. in the California Current from 1991-2008 using a Bayesian hierarchical modelling approach. The analysis indicated declining abundance for Cuvier's beaked whale (2.9% per year) and *Mesoplodon* spp. (7.0% per year) in the study area but no evidence of a trend for Baird's beaked whales. The Committee **agrees** that these results should be interpreted cautiously given the variability in ocean conditions in the region since the early 1990s. In the 1990s, both *M. stejnegeri* and *M. carlhubbsi* occurred as far south as San Diego, but since the late 1990s, previously rare warm-water ziphiids appear to have moved into the area which is thought to be near the northern end of their range. An analysis of the pattern of strandings of *Ziphius* along the US west coast might be informative for evaluating the apparent decline suggested in SC/64/SM11.

SC/64/SM13 summarised records of five documented ziphiid species in the EEZ of Costa Rica. There are only a few scattered records of all species except Cuvier's beaked whale, which is sighted relatively frequently, and *Mesoplodon* sp. A (almost certainly *M. peruvianus*), which could mean Costa Rican waters are a significant part of the range of this poorly known mesoplodont.

14.1.1 Cuvier's beaked whale (Ziphius cavirostris)

SC/64/SM34 reviewed current knowledge of Cuvier's beaked whale in the North Pacific and northern Indian Ocean. It occurs in deep waters worldwide and ranges from equatorial tropical to cold-temperate waters in the North Pacific, north to the Gulf of Alaska, along the Aleutian and Commander Islands in the Bering and Okhotsk Seas. It is commonly found where the steep continental slope occurs close to shore, such as around the Hawaiian Islands, San Clemente Island (California), Isla de Guadalupe (Mexico – see SC/64/SM18) and the Aleutian Islands.

Few estimates of density or abundance are available, primarily due to the rarity and difficulty of detecting and identifying beaked whales. In addition large-scale cetacean abundance surveys are often focused in areas such as continental shelf waters where beaked whales usually do not occur.

14.1.1.1 CONCLUSIONS AND OTHER CONSIDERATIONS OF STATUS

Cuvier's beaked whale is classified in the IUCN Red List as of Least Concern. Abundance estimates are available only for the Eastern Tropical Pacific, the Hawaii EEZ and the west coast of the USA (to 300 n.miles offshore). Numbers in the California Current appear to have declined in recent years. Some anthropogenic mortality is known from fisheries in waters off California and Japan and probably occurs elsewhere (e.g. in driftnet fisheries off Mexico). This species is vulnerable to noise produced by naval sonar and seismic research. Research priority should be given to understanding population trends off California and studying population structure. The Committee **agrees** that there is no basis for revising the status of Cuvier's beaked whale at the species or population level at this time.

14.1.2 Baird's beaked whale (Berardius bairdii)

Reviews of published (and some unpublished) information on Baird's beaked whales in the North Pacific were provided in SC/64/SM8 and by Brownell and Allen. Additional information on distribution and abundance was provided in SC/64/SM5, SM11 and SM21 and by Wade.

Baird's beaked whale is endemic to the cold temperate waters of the North Pacific. It appears to be more abundant in the western than the eastern part of the basin despite the long history of exploitation in the west and relatively little exploitation in the east.

SC/64/SM5 reported on a study of Baird's beaked whales at the Commander Islands in the western Bering Sea. Baird's beaked whales were found within about 12km of the coast, and mostly on the continental slope at depths of 100-1,000m (maximum depth at sighting about 3,000m). A total of 78 individuals was identified. Photo-ID confirmed associations over several years and the authors suggested that Baird's beaked whales live in a fission-fusion society. Evidence of killer whale predation was provided. More than half of the whales had marks the authors attributed to fishing gear and 3/75 had scars of possible anthropogenic origin, one apparently from harpooning.

Wade provided information on Baird's beaked whale sightings (n=25) made during nine killer whale surveys in nearshore waters of the Aleutian Islands, between 2001 and 2010. Baird's beaked whales were seen on every survey, generally close to the continental shelf edge break, in deeper waters on the continental slope. The extent of predation by killer whales on beaked whales might be considerable and ongoing stable fatty acid analyses may elucidate the importance of beaked whales in their diet.

14.1.2.1 LIFE HISTORY PARAMETERS

There are considerable data on life history parameters obtained from carcasses of whales taken on the Chiba ground and processed at the Wadaura station in the 1975 and 1985-

87 summer seasons (Kasuya *et al.*, 1997). This information has been interpreted assuming annual deposition of tooth growth layers (Kasuya, 1977). Full details are given in Annex L, item 3.2.4.

14.1.2.2 ABUNDANCE AND TRENDS
Abundance estimates for Baird's beaked whales are given in table 2 and item 3.2.5 of Annex L.

14.1.2.3 TAKES INCLUDING BYCATCH
Baird's beaked whales have been hunted by hand harpoon in Japan since around 1600 and by Norwegian-type whaling since 1907. Kasuya (2011) reviewed published information on the Baird's beaked whale fishery in the Chiba Prefecture.

Recent catch statistics by Japanese small-type whaling are summarised in Annex L, table 3. Official statistics since 1932, except 1943-46, are given in Annex L, Appendix 2. The reported statistics for the 1950s may be unreliable because of the likely inclusion of illegally caught and misreported sperm whales at Wadaura, Chiba between 1959 and 1974 (Kasuya, 2011). Similarly, illegal catches of sperm whales by small-type whalers in Ayukawa on the Pacific coast of northern Honshu (Kondo and Kasuya, 2002) may have been reported as Baird's beaked whales, thus contributing to the surprisingly high numbers of the latter reported in the catch statistics in the 1950s and 1960s. The reported annual take of Baird's beaked whales in Japan (mostly along the Pacific coast) ranged between 107 and 322 during the period 1950-69 (3,896 animals in 20 years).

The number of catcher boats operating for Baird's beaked whales off Chiba has been regulated by the prefectural government since 1920. The government introduced a licensing system to the small-type whale fishery in 1947 to limit the total number of boats operating. A voluntary quota system was introduced for Baird's beaked whales in 1983. The initial quota of 40 has since been increased to 66 (Annex L, table 3). In 1985, the Committee noted (IWC, 1986) that such a catch level represents about 1% of the estimated population size but was unable to determine whether this was sustainable. To investigate this question further it was agreed that studies on school structure would be desirable (IWC, 1986) - see above regarding the study in the Commander Islands. The Government of Japan has increased the quota several times and whaling operations have expanded since the late 1990s into the Sea of Japan (Appendix 1 and table 3 in Annex L).

In the eastern Pacific, small numbers of Baird's beaked whales were taken by whaling stations in California (15) and British Columbia (29) between 1956 and 1970 (Rice, 1974).

Five cases of stranded Baird's beaked whales in Japan were categorised as incidental fishery takes (table 4 in Annex L).

14.1.2.4 OTHER ACTUAL AND POTENTIAL THREATS
High concentrations of mercury, HDBPs and/or PCBs have been found in this species (Endo *et al.*, 2005; Endo *et al.*, 2003; Haraguchi *et al.*, 2006; also see SC/64/SM3). Concern has been raised since the accidents at Fukushima No.1 nuclear power plant but there is no evidence yet for exposure to Baird's beaked whales. Their range is mainly to the north of Fukushima.

14.1.2.5 CONCLUSIONS AND OTHER CONSIDERATIONS OF STATUS
The species is classified in the IUCN Red List as Data Deficient. Abundance estimates for the US west coast reported in SC/64/SM11 showed no trend for the period 1991-2008. The three populations off Japan have been assessed as Rare by the Japan Fisheries Agency and Mammalogical Society of Japan. The Committee **agrees** that there is no basis for revising the status of the Baird's beaked whale at the species or population level at this time.

The Committee **recommends** the following.

(1) It is especially important to clarify population structure and geographical boundaries of the stocks off Japan, particularly as long as hunting continues there.
(2) Improved and updated abundance estimates are needed for each population, and trends in abundance should be assessed. These needs particularly apply to exploited stocks.
(3) Better understanding is needed of the movements of animals from the respective stocks into and out of the three sea areas of Japan (Sea of Japan, Sea of Okhotsk, Pacific coast).
(4) The study in the Commander Islands (SC/64/SM5) should be expanded to include biopsy sampling for determination of sex and paternity and maternity in order to support studies of social and population structure, as well as satellite tagging to learn about movements and stock relations.
(5) The limited information suggests a peculiar life history and social structure - it is uncertain whether the characteristics of Baird's beaked whales are common, rare or even unique among the *Ziphiidae*, but further studies such as those recently initiated in the Commander and Aleutian Islands are encouraged to continue.

14.1.3 Longman's beaked whale (Indopacetus pacificus)
Published information on this species was reviewed in SC/64/SM26. It is probably endemic to tropical waters of the Indian and Pacific Oceans. The west- and southernmost record is Natal, South Africa, the northernmost is Hakodate, Hokkaido, Japan, and the easternmost is Maui, Hawaii.

Two stranded specimens in northeastern Taiwan on 22 July 2005, provided the first genetic and external morphological descriptions in the western Pacific (SC/64/SM32).

14.1.3.1 CONCLUSIONS AND OTHER CONSIDERATIONS OF STATUS
Longman's beaked whale is classified in the IUCN Red List as Data Deficient. The Committee **agrees** that there is no basis for revising the status of Longman's beaked whale at either the species or population level as no abundance estimates are available, except around the Hawaiian Islands, and there is no information on trends. The species is best known from the western North Pacific. Some anthropogenic mortality is known to have occurred in fisheries around Sri Lanka and strandings in Taiwan may have been associated with naval activities. Ingestion of plastic debris and exposure to morbillivirus are also of concern.

No high-priority research needs were identified but efforts are needed to better document the species' overall range, especially in the Indian Ocean. Continued efforts are encouraged to investigate and sample stranded animals at every opportunity following standardised protocols for beaked whale necropsy. Necropsy results should be made available in the literature and in relevant publicly accessible databases as quickly as possible.

14.1.4 Hubbs' beaked whale (Mesoplodon carlhubbsi)
SC/64/SM27 reviewed published information on Hubbs' beaked whale from the seas around Japan and from North America (<60 records). It is endemic to the North Pacific

and found in cold temperate currents off Japan and along the west coast of the USA and southern British Columbia, Canada. It has rarely been reported at sea.

14.1.4.1 CONCLUSIONS AND OTHER CONSIDERATIONS OF STATUS

Hubbs' beaked whale is classified in the IUCN Red List as Data Deficient. The Committee **agrees** that there is no basis for revising the status of Hubbs' beaked whale at either the species or population level. Some concern was expressed at the apparent decline of mesoplodonts off the US west coast (SC/64/SM11) as this probably includes Hubbs' beaked whales. No species-specific abundance estimates are available. Some anthropogenic mortality is known to occur in fisheries off both Japan and the USA and these whales may be vulnerable to anthropogenic noise from naval sonar and seismic research.

The Committee **agrees** that priority should be given to studies of possible population differences between Japan and the USA (genetics primarily but also external and internal parasites and cookie-cutter sharks scars). Acoustic studies (e.g. SC/64/SM21) may help to better determine the range of Hubbs' beaked whale, if a species-specific signal is found.

14.1.5 Blainville's beaked whale (M. densirostris)

Published information on this species (primarily from strandings) was reviewed in SC/64/SM33. This has the most extensive distribution of any *Mesoplodon*. Its acoustic signal type (the same as in the North Atlantic) was the predominant signal type in the Pacific Islands region (SC/64/SM21). It is found in tropical and warm temperate waters of all oceans, including deep offshore waters, tropical oceanic archipelagos and continental or insular coasts bordered by warm waters. There are no records from polar or other high latitude regions. It is reported infrequently at sea and positive field identification can be difficult unless key diagnostic characters of the head are observed.

14.1.5.1 CONCLUSIONS AND OTHER CONSIDERATIONS OF STATUS

Blainville's beaked whale is classified in the IUCN Red List as Data Deficient. The Committee **agrees** that there is no basis for revising the status of Blainville's beaked whale at either the species or population level. Some anthropogenic mortality is known to occur in fisheries off both Japan and the USA and this species may also be vulnerable to anthropogenic noise from naval sonar and seismic research.

In addition to the general recommendations under Annex K, item 3.12, the Committee **recommends** expanded photo-ID and tagging efforts in Hawaii to monitor movement patterns (seasonal as well as ranges) to determine whether there is site fidelity to specific types of habitat.

14.1.6 Ginkgo-toothed beaked whale (M. ginkgodens)

There is only limited information on this species which is found in warm temperate and tropical waters of the Pacific and westward into the Indian Ocean. It is classified in the IUCN Red List as Data Deficient. The Committee **agrees** that there is no basis for revising the status of the ginkgo-toothed beaked whale at either the species or population level. No abundance estimates exist. Some anthropogenic mortality is known from fisheries in at least Japan, Sri Lanka, Taiwan and Micronesia, and from anthropogenic noise from naval sonar (Wang and Yang, 2006). It is important to confirm the species identifications of all available specimens because a number have been misidentified in the past. Its status and abundance in its apparent 'hotspot' around southern Japan and Taiwan should be investigated.

14.1.7 Perrin's beaked whale (M. perrini)

SC/64/SM30 reviewed the existing information on Perrin's beaked whale. Very little is known about this species that was described in 2002 by Dalebout *et al.* (2002) based on five stranded specimens from south and central California – it remains known only from strandings in California and may have the most restricted range of any species of *Mespolodon*. Many or most of the unidentified mesoplodonts observed in ship surveys off California (SC/64/SM11) may be Perrin's beaked whales.

The species is classified in the IUCN Red List as Data Deficient. The Committee **agrees** that there is no basis for revising the status of Perrin's beaked whale at either the species or population level. As with all of the beaked whales, Perrin's beaked whales are probably at risk from anthropogenic noise produced by military sonar and seismic surveys as well as to fishery bycatch in areas of overlap. There is a need is to determine distribution and abundance in the eastern North Pacific including opportunistic biopsy sampling and correlated acoustic sampling.

14.1.8 Pygmy beaked whale (M. peruvianus)

SC/64/SM30 reviewed the existing information on pygmy beaked whales, which appear to be endemic to the eastern tropical Pacific. Most sightings are from the 'Eastern Pacific Warm Pool', an area with sea surface temperatures >27.5°C (Fiedler and Talley, 2006). It may be particularly abundant in the southern Gulf of California, Mexico (e.g. Ferguson *et al.*, 2006). There are a few records from Mexico (Urban-R, 2010) and it may be relatively common off Costa Rica (SC/64/SM13). The northernmost record is Moss Landing, California, the southernmost record in the eastern Pacific is from northern Chile (Sanino *et al.*, 2007) and the only record outside the eastern Pacific was from South Island, New Zealand (Baker and van Helden, 1999). Whether this latter specimen is indicative of a wider distribution for this species, or just an errant individual, is uncertain.

14.1.8.1 CONCLUSIONS AND OTHER CONSIDERATIONS OF STATUS

This species seems be fairly common within its range (Ferguson and Barlow, 2001). It is classified in the IUCN Red List as Data Deficient. The Committee **agrees** that there is no basis for revising the status of pygmy beaked whale at either the species or population level given the sparseness of information. Confirmation is needed that *Mesoplodon* sp. A is *M. peruvianus*; while biopsy samples (male) seem unlikely, a colour-pattern description of a freshly stranded adult male *M. peruvianus* would suffice. The southern Gulf of California seems to be a promising region for either of these events.

14.1.9 Stejneger's beaked whale (M. stejnegeri)

SC/64/SM25 reviewed information on this species, mainly from waters around Japan but including data from North America. It is endemic to the cold temperate North Pacific and has not been reported from any of the central Pacific islands. Four mass strandings occurred in Kuluk Bay, Alaska between 1975 and 1989 (Walker and Hanson, 1999). It is the most commonly stranded ziphiid in Japan although rare on the Pacific coast of Japan (Brownell *et al.*, 2004). Park (1999) reported five strandings and two incidental catches along the east coast of South Korea (35° to 38°N).

The presence of cookie-cutter shark bites on animals around the Aleutian Islands but not the Sea of Japan, suggest some population structure in the central and western North Pacific. Brownell *et al.* (2004) suggest that the northern Sea of Japan should be considered as a provisional management unit.

14.1.9.1 CONCLUSIONS AND OTHER CONSIDERATIONS OF STATUS

Stejneger's beaked whale is classified in the IUCN Red List as Data Deficient. The Committee **agrees** that there is no basis for revising the status of Stejneger's beaked whale at either the species or population level. No species-specific abundance estimates are available. Some anthropogenic mortality is known to occur in fisheries off both Japan and the USA and at least one case of a ship strike has been confirmed. The mass strandings in the Aleutian Islands were suspected of being related to naval sonar.

In addition to the general recommendations under Item 14.1.11, the Committee **recommends** regular and extensive sample collection from stranded or bycaught specimens (especially off Japan) in order to better understand the species' ecology, life history and vulnerability to threats. Genetic research is needed to determine whether western and eastern populations can be differentiated. Better understanding of its biology and abundance in the apparent 'hot spot' in the Sea of Japan off Honshu could be accomplished by: (1) strengthening the stranding programme in order to collect specimens in fresher condition; (2) acoustic monitoring; and (3) small-scale surveys to assess abundance.

14.1.10 Deraniyagala's beaked whale

SC/64/SM3 presented new genetic and morphological data supporting the recognition of a previously described but unnamed *Mesoplodon* sp. in the tropical Indo-Pacific. Genetic identification has related new specimens, including those initially described by Baker *et al.* (2007), to a type specimen in Colombo, Sri Lanka described as *M. hotaula*, in 1963. Known from at least seven specimens it is genetically distinct but closely related to (and possibly conspecific with) *M. ginkgodens.* Its distribution seems to be tropical in both the Indian and Pacific Oceans. SC/64/SM3 argued that available evidence was sufficient to accept the revised taxon as a new subspecies of *M. ginkgodens* and that further characterisation could result in the resurrection of *M. hotaula* Deraniyagala, 1963 as a full species. The Committee suggested the provisional common name 'Deraniyagala's beaked whale' for this taxon, in recognition of the original description.

Further genetic investigation, including biopsy sampling of live animals, is required to clarify the systematics and taxonomy. Visual and acoustic reports from around Palmyra Atoll have been attributed to this new taxon (see SC/64/SM21) and this area clearly provides the opportunity to collect fresh tissue samples for genome-level analyses.

SC/64/SM4 reported on the species identity and local use of Deraniyagala's beaked whales (and Blainville's and Cuvier's beaked whales) in the Gilbert Islands, Republic of Kiribati. This investigation, conducted with the help of government agencies, visited several of the outer Gilbert Islands in June-July 2009 and collected bones and artefacts.

It is important to obtain new specimen material from oceanic islands and atolls in the central tropical Pacific and and to confirming the identities and provenances of existing museum specimens attributed to *M. ginkgodens*. Consideration should be given to the possibility that there are island-associated nearshore populations that are geographically and demographically isolated or semi-isolated from offshore populations of both Deraniyagala's beaked whales and ginkgo-toothed beaked whales, as is the case with Blainville's beaked whales.

Almost nothing is known about overall distribution, population structure, life history, abundance or takes of Deraniyagala's beaked whales, with the exception of those in Kiribati (SC/64/SM4). The five beaked whale strandings from Palmyra Atoll and Kingman Reef between 2002 and 2007 is high for such a small area and high compared to the number of beaked whale strandings reported on other Pacific Islands.

14.1.10.1 CONCLUSIONS AND OTHER CONSIDERATIONS OF STATUS

No IUCN Red List entry has been made for Deraniyagala's beaked whale at either the species or population level. The Committee **agrees** that there was insufficient data to assess this status at either the species of population level. The Committee expressed concern about the apparently high numbers of strandings around Palmyra Atoll in recent years. Deraniyagala's beaked whales are probably vulnerable to sound from naval sonar and seismic research, similar to other beaked whales. Assuming that the beaked whale recorded both acoustically and visually around Palmyra Atoll is Deraniyagala's beaked whale, the first priority is to make this determination genetically.

14.1.11 Common issues and threats

14.1.11.1 MILITARY SONAR AND OTHER NOISE SOURCES

Evidence of gas bubble lesions (gas embolism) and fat emboli have been reported at necropsy in beaked whales from atypical mass stranding events (MSEs), which were coincidental with nearby use of mid-frequency sonar (Fernandez *et al.*, 2004). Exposure to sonar may alter the behaviour and/or physiology of beaked whales, potentially resulting in decompression sickness (DCS) in some circumstances.

Bernaldo de Quirós and Fernandez Rodriguez (2011) studied gas presence and composition in order to compare decompression vs. decomposition gases present at necropsy. Bubbles alone cannot be used to determine cause of death and it is important to differentiate between gas embolism and putrefaction gases. They recommended scoring gas bubble presence and sampling bubbles for gas composition analysis within 24 hours, but preferably within 12 hours, to minimise the masking effects of putrefaction gases.

The Committee **recommends** that groups working on mass strandings make all reasonable efforts to examine dead animals within 12 hours (or at most 24 hours) after death. Response teams should, if at all possible, include a veterinarian, a veterinary pathologist or a responder with experience in necropsy and sample collection. Routine necropsy protocols should include examination of bubbles present in tissues, scoring relative prevalence and sampling for gas composition analysis, particularly to detect and describe intravascular and peri-renal subcapsular emphysema bubbles.

The Committee took note of the latest investigations of MSEs in the Canary Islands, Spain associated with the use of naval sonar (Fernandez *et al.*, 2004). No further atypical MSEs have occurred since international naval exercises ended in 2004 following a recommendation of the parliament of the European Union and a Spanish government resolution banning the use of military sonar around the Canary Islands. This supports the inference that the atypical MSEs before the ban were caused by mid-frequency sonar.

Noting the ample evidence about the vulnerability of beaked whales to military sonar and seismic surveys and the potential for impacts at the population level (including not only animals that strand and are detected but also the potentially large number that die at sea and do not strand), the Committee **strongly recommends** that military exercises and seismic surveys should avoid areas of important habitat for beaked whales; that further effort should be made to mitigate their impacts; and that further efforts should be made to identify such areas (MacLeod and Mitchell, 2006; Cañadas *et al.*, 2011).

The Committee also reiterates two previous recommendations.

(1) The continuation and expansion of studies of how anthropogenic noise, especially from naval sonar and seismic survey airguns, affects ziphiids. These should include efforts to determine if and how vulnerability differs between species, habitat types, animal activities (e.g. travelling, foraging) etc.
(2) Collaborative arrangements with military and industry authorities should be made to ensure researchers have advance notice of sonar exercises, seismic surveys and other activities so that the possibility of beaked whale stranding events can be anticipated with enhanced beach surveillance etc.

14.1.11.2 MARINE DEBRIS
Available data from the North Pacific and northern Indian Ocean (SC/64/E10; Simmonds, 2012) indicates that beaked whales may be especially vulnerable to the ingestion of plastics and other marine debris; this can cause pathology and mortality. The population-level and long-term implications of the ingestion of plastic debris are unknown. The Committee **recommends** that this issue is further investigated via the collection, collation and analyses of relevant data from around the world concerning ingestion rates, debris types and associated pathology. It also **recommends** that standardised protocols are developed for pathology investigations. Consideration should also be given to investigating marine debris accumulation and associated processes in areas of important habitat for small cetaceans.

14.1.11.3 GENERAL RECOMMENDATIONS
The Committee **recommends** that for all North Pacific and northern Indian Ocean ziphiid species, further efforts are made to define population structure, delineate population boundaries, obtain estimates of abundance and identify and rank threats. Attention should be given to populations known or suspected to be small and/or exploited. The available evidence suggests that most ziphiid species occupy relatively narrow ecological niches and occur as local, largely isolated groups, which should be regarded as putative subpopulations (in the IUCN Red List sense).

The Committee **recommends** that more effort be made to investigate and validate methods of estimating population size for ziphiids, including those that incorporate passive acoustics for application in areas where the local species are acoustically distinguishable. Further data are needed to adjust density estimates from line transect surveys to account for visibility bias (given that these deep-diving whales spend relatively little time at the surface and species are difficult to distinguish) and for responsive movement. Consideration should also be given to interrupting line transect surveys (closing mode) in order to obtain photographs and biopsies as a way of reducing the 'unidentified ziphiid' component of abundance estimates.

Initial efforts have been made to map high-use areas for ziphiids on a global scale (MacLeod and Mitchell, 2006) to provide guidance for mitigation measures to reduce the risks from naval sonar and seismic survey operations. However, a more detailed examination is needed of these 'hotspots', including fine-scaled habitat characterisation and predictive habitat modelling. The Committee **recommends** that collaborative efforts similar to those described last year in Cañadas *et al.* (2011) be made by the relevant scientists and research groups in the North Pacific and northern Indian Ocean where anthropogenic sound is considered a problem.

Ziphiids are at risk of entangling in nets, especially pelagic driftnets, which tend to be deployed in or near their habitat. They are also known to get hooked or entangled in longline gear. The Committee **recommends** that methods be developed and applied to estimate fishery-related mortality, giving special attention to areas where there is direct evidence of incidental mortality as well as to areas where driftnetting and longlining operations overlap known concentrations of ziphiids.

Evidence of beaked whale population decline along the North American coast (SC/64/SM11) raised concern that beaked whales, and particularly resident populations, may be negatively affected by large-scale environmental change. The Committee **recommends** efforts be devoted to understanding impacts of changes in habitat on the distribution and abundance of beaked whales. This could involve pursuing an improved understanding of beaked whale feeding ecology and deep-water oceanographic processes as well as prey-community dynamics.

The Committee further **recommends** broad-scale collaborations to generate integrated results from analyses of genetic material, photograph collections and survey data. Particularly for *Mesoplodon* species, biopsies should be obtained from live animals to verify species identification. This is especially important for females and young males. Efforts are also needed to validate acoustic signatures of *Mesoplodon* species by collecting biopsies (and good photographs) along with acoustic recordings at sea.

14.2 Report on the voluntary fund for small cetacean conservation research

14.2.1 Status of the voluntary fund for small cetacean conservation research
In 2009, Australia made a generous donation toward the IWC Small Cetacean Conservation Research Fund of about £250,000 which enabled eight grant awards to research and conservation projects on small cetaceans (IWC, 2012r). At the Commission meeting in 2011 and during the interessional period, France, Italy, the UK and a number of NGOs provided extra funding of £73,000 which allowed: (1) the full funding of the two remaining projects recommended by the Committee in 2011; (2) support for invited participants in 2011 and 2012; and (3) a chance to start rebuilding the Fund. The Committee **thanks** the above governments and the NGOs for their generous contributions to the fund and hopes that the next Conservation Committee and Commission meetings will generate new funding that will allow another call for projects by the end of 2012.

14.2.2 Review on progress on funded projects
The Committee reviewed brief project reports on five of the nine projects selected in 2011 and received more extensive reports on three of them, which are presented in Annex L (Solomon Islands, under this item; franciscana, Item 14.3.3; Atlantic humpback dolphin, Item 14.3.5).

SC/64/SM23 presented preliminary results of an assessment of dolphins in the Solomon Islands where there is a long history of exploiting dolphins through traditional drive-hunts. More recently, the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), has been live-captured for export, with a current annual export quota of 50. This Committee as well as several intergovernmental bodies (CITES, CMS, IUCN, SPREP) have expressed concern in the past about the potential conservation implications of these removals.

The Committee expresses its appreciation for this work and acknowledges the constructive involvement of the Solomon Islands Fisheries and Environment Ministries in collaborating and providing support. The preliminary results reinforce previously expressed concerns regarding the sustainability of past and ongoing live-capture removals of *T. aduncus* from what appear to be small island-associated populations. The Committee **encourages** the authorities responsible for conservation management (e.g. under CITES) to carefully consider the information from this study. It recommends that efforts to integrate the current and historical photo-ID catalogues be pursued as a priority.

14.3 Progress on previous recommendations

14.3.1 Vaquita

The Committee has expressed its grave concern over the status of this species and its continuing decline over many years. Last year, the Committee was informed about the pilot phase of implementation of an acoustic monitoring programme to track future changes in vaquita abundance in the Upper Gulf of California (IWC, 2012y). SC/64/SM19 provided further information on the implementation of the scheme in the first full sampling season. An overall loss rate of 44% of the detectors resulted in data being available for 38 sampling sites within the refuge. Deployment of buoys is the only way to obtain year-round information so an alternative method of deployment that reduces loss must be found. An analysis of the acoustic encounter rates in 2008 (0.74 encounters/day, CV 0.44) compared to those from the current study in 2011 (0.58 encounters/day, CV 0.05) is indicative of further decline of the population since 2008, i.e. when strategies to reduce fishing effort by the Federal Government were already being implemented.

Jaramillo-Legorreta noted that redeployment of the array in late spring of 2012 was delayed because the presence of 87 boats fishing illegally within the refuge at that time presented too great a risk of loss of equipment; deployment was underway at the time of the Committee meeting.

The sub-committee considered the report[25] of the fourth Meeting of the International Committee for the Recovery of Vaquita (CIRVA) held in Ensenada, Mexico from 20-23 February 2012. The role of CIRVA has been recognised by the Government of Mexico in the agreement for the creation of the Vaquita Protection Refuge and in the current federal Action Program for the Conservation of Vaquita (PACE-Vaquita). Hence, the recommendations of CIRVA are important in terms of driving recovery actions. The report notes that the population has continued to decline, with an estimated reduction of nearly 60% between 1997 and 2008 and possibly as few as 220 porpoises remaining in 2008 (CIRVA, 2012). The report is discussed in detail in Annex L.

CIRVA's assessment of progress is that switch-out programmes (conversion to vaquita-safe gear) have been poor with only a very small proportion of the total fleet using such gear. Fishermen using such alternative trawl gear would have great difficulty operating safely in the middle of the large gillnet fleet. A working group has been engaged in a public process to amend the Mexican Official Standard 002-PESCA that regulates shrimp fishing. A three-year process beginning in 2013/14 to ban shrimp gillnets and exchange them for the new small artisanal trawl net design has been approved but not yet published in the Federal Register.

Details on the CIRVA recommendations are given in Annex L and the Committee **strongly endorses** these recommendations.

At last year's meeting the Committee concluded, as it has in several previous meetings, that the only reliable solution for vaquita conservation is to eliminate vaquita bycatch by replacing gillnets with alternative fishing gear. In a detailed recommendation, the Committee strongly supported robust gear trials to assess alternative gear effectiveness and economic viability (IWC, 2012r).

The Committee again **reiterates its extreme concern** for the status of this species and, as stated in 2011 (IWC, 2012r), **reaffirms** that the only reliable approach for saving the species is to eliminate vaquita bycatch by removing entangling gear from areas where the animals occur. It **strongly recommends** that, if extinction is to be avoided, all gillnets should be removed from the upper Gulf of California immediately. This is in accord with the Committee's strong recommendation made in 2009 (IWC, 2012f, p.66) regarding the extinction of the vaquita.

In light of reports on the successful development of an alternative shrimp trawl and the CIRVA recommendations summarised in Annex L, the Committee also **recommends** that vaquita conservation efforts focus on:

(1) expedited approval and adoption of the small shrimp trawls as an alternative to gillnets and prohibition of shrimp fishing with gillnets throughout the entire range of the vaquita; and
(2) continued research on technologies to replace gillnetting for finfish or otherwise to remove all gillnets from the vaquita's entire range.

In this regard the Committee **notes** the ongoing project funded under the Voluntary Fund for Small Cetacean Conservation Research 'Supporting the assessment of alternative fishing gears for replacing gillnets that cause bycatch of vaquita (*Phocoena sinus*) in the Upper Gulf of California, Mexico' and **looks forward** to a progress report at next year's meeting.

14.3.2 Harbour porpoise

In 2001, the Committee acknowledged the efforts by ASCOBANS to address serious harbour porpoise bycatch problems in the Baltic, Kattegat/Belt and North Sea areas and encouraged further efforts in that regard (IWC, 2010h). Since then, the ASCOBANS Jastarnia Group has met and considered new analyses of survey and bycatch data, which have had the effect of reinforcing and increasing concern about sustainability of bycatch as well as other factors potentially affecting the porpoise populations in the region, including declines in availability of prey, ship traffic, construction work, seabed exploitation, contaminants, and diseases.

The Committee remains concerned about the status of harbour porpoises in the western Baltic, the Belt Seas and the Kattegat ('Gap' area, also known as Belt Sea stock according to the ASCOBANS Jastarnia Group). Although the abundance estimates for harbour porpoises from SCANS

[25] *http://www.iucn-csg.org/index.php/downloads/.*

and SCANS II were almost identical for the wider North Sea area, there was a southward shift in density distribution of porpoises between SCANS and SCANS II. However, there are indications of a possible decline in abundance in the Gap area. Bycatch is the major source of anthropogenic mortality and should be monitored and mitigated. EC Regulation 812/2004 does not adequately protect harbour porpoises from bycatch in this area because it requires bycatch monitoring only on boats >15m and pinger use only on boats >12m.

In the current state of scientific uncertainty, the Committee looks forward to receiving the results of a planned dedicated shipboard survey to be conducted in the Gap area in the summer of 2012 with the intention of obtaining a new abundance estimate.

The Committee recommends with regard to the Gap area to:

(1) assess porpoise bycatch levels;
(2) monitor porpoise abundance on a regular basis;
(3) introduce measures to mitigate bycatch and other anthropogenic mortality;
(4) monitor the health status of the porpoises;
(5) ensure all bycaught and stranded animals are reported and delivered to qualified institutions for necropsy and sampling; and
(6) implement the recovery plan for harbour porpoises which is currently being developed by ASCOBANS for the Gap area.

The Committee also repeats its longstanding concern regarding the critically endangered harbour porpoise population in the inner Baltic ('Baltic proper') and encourages all possible efforts to eliminate the bycatch there and address other factors that may be preventing this very small population's recovery. The current process of developing management plans for Special Areas of Conservation under the European Habitats Directive, offers a concrete chance to implement monitoring and mitigation as foreseen by the Jastarnia Plan. The Committee urges that effective monitoring and mitigation measures focusing on harbour porpoises be included in such national management plans.

14.3.3 Franciscana

SC/64/SM17 describes results of a project conducted with funding from the IWC Small Cetacean Conservation Fund. The main goal of the study was to assess distribution and obtain an abundance estimate of franciscanas inhabiting the region known as Franciscana Management Area I (FMA I), as recommended in IWC (2004a). In December 2011 and January 2012, design-based aerial surveys were conducted to assess distribution and to estimate abundance of franciscanas in FMA I. The fully corrected abundance estimate was 1,998 (CV=0.48, 95% CI: 796-5,013). The most recent (2001-02) estimate of incidental mortality in FMA I (Di Beneditto, 2003) corresponds to 5.5% of the estimated population size presented here. This indicates high and unsustainable bycatch if current mortality is similar to that in the early 2000s.

The Instituto Chico Mendes para a Conservacao da Biodiversidade (ICMBio) is the government agency responsible for establishing management and conservation strategies for endangered species in Brazil. In 2010, ICMBio published the 'National Action Plan for the Conservation of the Franciscana' (Di Beneditto *et al.*, 2010) and made a series of general recommendations for research and monitoring (summarised in Annex L) which the Committee endorsed.

The Committee further recommends the following with respect to FMA 1.

(1) Additional aerial surveys with increased sampling effort in order to:
    (a) produce more robust (lower CVs, estimates for the northern range of FMA I) population estimates;
    (b) further assess distribution (e.g. offshore limits, discontinuity); and
    (c) evaluate potential habitats that could be protected (e.g. by one or more no-take zones, marine protected areas) to improve conservation.
(2) Resume systematic and long-term bycatch monitoring in northern Rio de Janeiro and Espírito Santo, in order to produce more up-to-date mortality estimates.
(3) Studies should be conducted to assess areas within the range of the species where other human activities could pose a threat to the long-term viability of franciscanas in FMA I.

Melcon *et al.* (2012) illustrated the potential for the use of autonomous acoustic detectors or towed arrays designed specifically for the identification of porpoise-like signals (e.g. C-PODs or A-tags) in franciscana research.

14.3.4 Narwhal and white whale

Bjørge reported on progress towards organising and convening a proposed global review of the monodontids (IWC, 2001d, p. 279). The NAMMCO Secretariat has indicated interest in organising and convening such a review jointly with the IWC Scientific Committee and the intersessional correspondence group has identified a list of scientists interested in attending from four of the five range states (Norway, USA, Canada, Russia). Broader involvement of other scientific groups and individual scientists for a range-wide workshop or symposium on monodontid science may be appropriate. The involvement of groups as disparate as oceanaria and environmental NGOs as co-conveners might bring greater organisational motivation and financial resources to support such a workshop or symposium. The Committee recommends that a steering committee (Bjørge, Reeves, Suydam, a scientist from Canada, Donovan, and Aquarone from the NAMMCO Secretariat) be established to meet intersessionally to discuss these issues and report back at next year's meeting.

14.3.5 Atlantic humpback dolphin

SC/64/SM22 presents a brief update on the project funded by the IWC Small Cetacean Conservation Research Fund for Atlantic humpback dolphins in Gabon and Congo. There have been some challenges and shifts in focus and priorities over the last year, given boat failures and the discovery of a significant bycatch problem in Congo. As the project is ongoing, more complete reporting will be provided next year. The Committee thanks the authors for this preliminary report and expresses its appreciation for their perseverance in the face of the difficult challenges faced to date in this research.

14.3.6 River dolphins

IWC (2001d) recommended that 'scientists with appropriate theoretical and/or analytical skills should be directly involved in river cetacean studies, so that surveys result in statistically robust estimates of abundance'. In 2002, two biologists and two statisticians led a pilot survey (line and strip transect data and some photo-ID data) of boto (*Inia geoffrensis*) and tucuxi (*Sotalia fluviatilis*) in portions of the Amazon in Colombia and Peru (IWC, 2003d). SC/64/SM24 revisited this dataset and reported on preliminary analyses.

Participants drew attention to the existence of both older and more recent abundance estimates for the study area and suggested that a three-way comparison of abundance estimates would be of great value. The Committee expresses its appreciation to the Government of Brazil for supporting a proposed PhD studentship to work on this issue.

14.3.6.1 BOTO AND TUCUXI

Two largely sympatric endemic cetaceans, the tucuxi and the boto, inhabit the Amazon basin and both are increasingly killed for use as bait in the piracatinga (*Calophysus macropterus*) fishery (IWC, 2007g; 2008k; 2009g; 2012r). Catches in this fishery, primarily for export to Colombian markets but also for sale in domestic markets, have increased in Brazil in recent years. Alves *et al.* (2012) reported on an interview study with fishermen and traders, to elucidate interactions between fishermen and river dolphins, including the occurrence of illegal, indiscriminate killing and the growing trade in dolphin carcasses. In the view of fishermen, botos damage gear and steal (and also probably damage) catches. Botos are negatively portrayed in numerous traditional Amazonian folk myths and superstitions. These factors make them extremely unwanted or even hated and they are considered as pests. Now they have also become an economic resource as bait in the increasing piracatinga fishery. Additional information suggests that the true extent of the area of the piracatinga fishery and the area of direct takes is unclear, although the reported expansion of the piracatinga market and fishing effort add to concerns regarding the impacts on dolphins.

As previously noted (IWC, 2001d), the population status of botos and tucuxis has been assessed in only relatively small portions of their Amazonian range. The Committee reiterates its serious concerns with the potential population implications of the intentional killing of botos and tucuxis for use as bait in the piracatinga fishery. It welcomes the information provided at this year's meeting but notes that the true extent of this exploitation throughout Amazonia is poorly understood. It also emphasises that this relatively new and rapidly growing problem is in addition to other historical and ongoing threats to these dolphins, e.g. from incidental mortality in fisheries, vessel traffic, construction of hydroelectric dams, mining and other development.

In view of these concerns and the information gaps, the Committee recommends the organisation of an international scientific workshop involving scientists and managers from the range states, with the goals of addressing research and conservation priorities, standardising methodologies and planning long-term strategies. The following specific topics could be discussed at the workshop:

(1) geographic and temporal extent of the piracatinga fisheries and associated dolphin use;
(2) methods to assess abundance and mortality (rapid assessment as well as longer-term approaches);
(3) improved understanding of dolphin movements and habitat use (including population structure); and
(4) ways to reduce (or preferably eliminate) the pressure on dolphin populations from exploitation as bait for the piracatinga fishery.

The Committee agrees that the status of the boto and tucuxi should be added as a recurrent item on its agenda.

14.3.6.2 INDUS RIVER DOLPHIN

WWF-Pakistan hosted the Indus River Dolphin Conservation Strategy Planning Workshop in Lahore (Pakistan) last April. The objective was to lay the groundwork for development of a ten-year strategic action plan for conservation of endangered Indus River dolphins (*Platanista gangetica minor*), which are restricted to the Indus River system in Pakistan. Details can be found in Annex L, section 5.6.2.

14.3.6.3 MEKONG RIVER POPULATION OF IRRAWADDY DOLPHINS

A Mekong Irrawaddy Dolphin Conservation Workshop was held in Kratie, Cambodia, last January. The workshop was jointly hosted by the Commission for Dolphin Conservation and Development of Mekong River Dolphin Ecotourism, the Fisheries Administration of the Ministry of Agriculture, Forestry and Fisheries, and WWF-Cambodia. Participants reviewed the available evidence on possible causes of mortality of Irrawaddy dolphins in the Mekong in particular, the high and as-yet-unexplained level of calf mortality. Details can be found in Annex L, item 5.6.3.

All freshwater populations of Irrawaddy dolphins (*Orcaella brevirostris*) are listed on the IUCN Red List as Critically Endangered. The Mekong River population is estimated at 85 individuals (95% CI 78-91), excluding young calves (Ryan *et al.*, 2011) with recruitment close to zero. Although births occur, few animals survive to adulthood. The available information, suggests a slow decline (2.2^{-1} during the study period). If confirmed, the current population composition has serious implications for the long-term viability of the Mekong River population.

Last year, the Committee expressed grave concern about the rapid and at least partially unexplained decline of this riverine population. Unfortunately, the high mortality of young calves has continued as has the occasional mortality of adults from entanglement. The Committee **recognises** and **commends** Cambodian government agencies and WWF-Cambodia for making serious, concerted efforts since the last meeting to diagnose the cause(s) of calf mortality and further reduce the risk of entanglement. The Kratie Declaration[26] is a major step forward and the Committee recommended that it be fully implemented as quickly and as effectively as possible.

14.3.7 Killer whales

The Committee was pleased to receive information on the first photo-ID catalogue of killer whales in Adélie Land, East Antarctica (SC/64/SM6) as discussed in Annex L. This catalogue will be augmented in coming years and made available for regional matching and for a global Antarctic killer whale catalogue.

14.3.8 Clymene dolphin

The Committee was pleased to receive information a study underway on the first molecular characterisation of the Clymene dolphin (*Stenella clymene*) a recently rediscovered dolphin species. It has been suggested that the species could have had a hybrid origin, with *S. coeruleoalba* and *S. longirostris* acting as parental species (see Annex L).

14.4 Takes of small cetaceans

Annex L, Appendix 3 presents information on catches and associated quotas for small cetaceans from 1997-2010 obtained by Funahashi from the Japanese National Research Institute of Far Seas Fisheries website. The Secretariat developed the summary of catches of small cetaceans in 2009-11 from this year's national Progress Reports, where available.

[26] *http://www.iucn-csg.org/wp-content/uploads/2010/03/Kratie-Declaration-signed-with-appendices-1.pdf.*

The importance of these reports was noted, but concern was expressed that the Committee was not doing enough to take advantage of the significant information therein. The Committee **agrees** to explore intersessionally more specific terms of reference for evaluating direct take data, including the idea of developing case studies (e.g. assessing sustainability of bycatch in Europe) or other analyses from this information.

The Committee **thanks** Funahashi and the Secretariat for their work in compiling this information for the Scientific Committee each year and reiterated the importance of having complete and accurate catch and bycatch information and encourages all countries to submit data, appropriately qualified and annotated.

The Committee **expresses** its continuing concern about the lack of assessment of the exploited stock or stocks of killer whales in Greenland where reported catches were 14 in 2009 and 15 in 2010.

14.5 Local studies

SC/64/SM20 reported on the presence of long-beaked common dolphins in coastal waters of northern Colombia for the first time. These sightings extend the known range in the Caribbean, previously known primarily from the eastern Caribbean, some 700-800km.

Bolaños-Jiménez reported on: (1) work to gather records and sightings of killer whales in the Caribbean Sea and adjacent waters in collaboration with other North Atlantic killer whale studies and databases; (2) preliminary abundance estimates of Atlantic spotted and common bottlenose dolphins in the State of Aragua, central Venezuela, on the basis of mark-recapture models and photo-ID techniques as part of efforts to provide a stronger foundation for proper management and monitoring of dolphin-watching activities; and (3) new records of common dolphins in central-western Venezuela. Common dolphins have recently been recorded on the Colombian side of the Guajira Peninsula (SC/64/SM20).

SC/64/BC2 reported on unusual strandings of two species of oceanic dolphins on the Pacific coast of Costa Rica. The first was a mass stranding of 38 rough-toothed dolphins in 2002, 34 of which were returned to the sea. The second was of an adult female Fraser's dolphin in 2006. Both strandings are the only ones known for each of these species in Costa Rica.

SC/64/SM10 reported on studies to identify critical habitats for coastal pantropical spotted dolphins in Golfo Dulce, Costa Rica, as the foundation of the design and implementation of Marine Spatial Planning and Marine Protected Areas. The current study investigates the underlying behavioural mechanisms that govern patterns of niche differentiation and the resulting conservation implications.

The Committee expresses its gratitude to the presenters of local research papers and noted that such work to establish baselines, distribution records, and habitat requirements is essential to addressing the concerns of the Committee.

14.6 Hector's dolphins

Slooten reported on a number of recent findings and processes in New Zealand concerning Hector's dolphins. Bycatch in gillnet and trawl fisheries is the most serious threat to this endangered species. A substantial increase in survival rates (5.4%yr^{-1}) has been detected in one of the protected areas created to reduce the overlap between dolphins and these fishing methods (Gormley *et al.*, 2012). The Banks Peninsula population was declining at approximately 6%yr^{-1} before 2008 and is now declining at about 1%yr^{-1} (Gormley *et al.*, 2012; Slooten and Dawson, 2010). The population was predicted to recover if the boundaries of the protected areas were extended to the 100m depth contour. Slooten explained that the survival rate increase demonstrates that protected areas can work if: (1) they are large enough and in the right place; (2) key threats are managed by removing rather than displacing them; (3) no new threats are added (e.g. in this example marine mining, tidal energy generation); and (4) effective monitoring and enforcement is in place.

Bycatch in 'exemption' areas without protection measures, and in areas with incomplete protection, is causing continued population declines and population fragmentation (Davies *et al.*, 2008; DOC and MoF, 2007; Slooten and Dawson, 2010; SC/64/ProgRepNewZealand). Weak protection on the west coast of South Island, a lack of protection on the north coast of South Island and 'exemption' areas in other regions are slowing or preventing species recovery (Davies *et al.*, 2008; Slooten and Dawson, 2010). There is also continued bycatch from illegal setnetting inside protected areas.

Full details are given under item 7.2 of Annex L.

The Committee expresses particular **concern** about the low abundance of Maui's dolphins (North Island subspecies of Hector's dolphin). The latest abundance estimate of 55 individuals over one year old (CV 0.15) was calculated from a genetic mark-recapture analysis (Hamner *et al.*, 2012).

The Committee **recommends** the immediate implementation of the proposal by the New Zealand Ministry for Primary Industries to extend the North Island protected area to approximately 80km south of the latest dolphin bycatch site (Maunganui Bluff to Hawera), offshore to the 100m depth contour, including the harbours, for gillnet and trawl fisheries. This would protect part of an area with high gillnet and trawl fishing effort between the North and South Islands. Further population fragmentation could be avoided by also protecting the north coast of the South Island, providing safe 'corridors' between North and South Island populations (Hamner *et al.*, 2012).

Adequate observer coverage across all inshore trawl and gillnet fisheries is important in order to obtain robust scientific data on continuing bycatch as a means of assessing the effectiveness of protection measures.

14.7 Work plan

The Committee's views on the work plan for the sub-committee on small cetaceans are given under Item 21.

The sub-committee reviewed its schedule of priority topics which currently includes:

(1) status of ziphiids in the Southern Hemisphere; and
(2) systematics and population structure of *Tursiops*.

There is a need for extensive preparatory work for the proposed *Tursiops* review. Therefore the Committee agrees that the review of the systematics and population structure of *Tursiops* should be conducted in 2014 and an *ad hoc* group (Brownell, Perrin, Fortuna) was established to prepare for this. The Committee will need to carefully manage other agenda items to allow sufficient focus on the priority topics.

The Committee agrees that ziphiids of the Southern Hemisphere will be the priority topic at the 2013 Annual Meeting.

The sub-committee on small cetaceans convened an intersessional group evaluating the feasibility of having the so-called 'marine bushmeat' issue as a future priority topic. The group agreed on a number of attributes important for defining and delineating the issue (see Annex L). The Committee agrees to proceed with planning for a workshop characterised along the lines of 'poorly documented hunts of small cetaceans for food, bait or cash' although this may change somewhat at the discretion of the Convenor. It was emphasised that terminology and definitions as well as the scope and purpose of any workshop should be clarified in advance. A Steering Group was established under Ritter (Annex Q26).

15. WHALEWATCHING

The report of the sub-committee on whalewatching is given as Annex M. Scientific aspects of whalewatching have been discussed formally within the Committee since a Commission Resolution in 1994 (IWC, 1995c). The Commission also has a Standing Working Group on Whalewatching (IWC/64/CC6) that reports to the Conservation Committee (see Item 15.4.1).

15.1 Assess the impacts of whalewatching on cetaceans

SC/64/WW1 reviewed recent advances in whalewatching research. Steckenreuter *et al.* (2012a) investigated the impact of vessel interactions on the behaviour of a genetically distinct population of Indo-Pacific bottlenose dolphins; Steckenreuter *et al.* (2012b) examined the effectiveness of two Speed Restriction Zones (SRZs) in a dolphin-watching area; and Harris *et al.* (2012) documented interactions between cruise ships and humpback whales at Glacier Bay National Park (GBNP) in Alaska. Summaries are presented in Annex M, item 5.

SC/64/WW2 reported on a resident population of bottlenose dolphins in Bocas del Toro, Panama, of 100-150 animals. Their predictability and site fidelity has encouraged the development of several dolphin-watching operations. Resolution ADM/ARAP No. 01 (2007) regulates whalewatching activities but few operators are well-informed about the regulations and their importance. This preliminary study found that group size and group presence decrease with increasing number of dolphin-watching boats (although this trend was not statistically significant) and that overall, dolphins interacting with boats showed more avoidance behaviour. Future studies in the region will increase survey effort and include new data collection parameters to better characterise effects of dolphin-watching boats on these animals. Discussion and concerns expressed by some members of the sub-committee regarding SC/64/WW2 are detailed in Annex M, item 5.

The discussion further noted that one factor influencing the high volume of operators watching dolphins at the same time is that all operators have similar tour schedules. This results in competition among boat captains, little compliance with the regulations, and an increased risk of boat strikes (three dolphins were killed by dolphin watching boat strikes in 2011). The Committee **draws attention** to the need for developing strategies that minimise the impact of dolphin watching on the dolphin population, including staggering departure times to even out boat presence at any one time of day.

The Committee thanks the author for her presentation regarding a relevant situation in the host country and expressed concern regarding the intense and uncontrolled dolphin watching in Bocas del Toro. The Committee **strongly recommends** that Panamanian authorities enforce the relevant whalewatching regulation (ADM/ARAP No. 01) and in particular promote adherence to requirements regarding boat number and approach speed and distances. It also **welcomes** the continuation of the Cooperative Agreement between Argentina and Panama to develop and conduct operator training workshops. The Committee **recommends** continued research to monitor this dolphin population and the impacts of tourism on it.

SC/64/WW7 presented a controlled study on the swim-with-whale operations targeting humpback whales in Tonga. Up to five swimmers approached the whales while behaving in one of three ways: quietly slipping into the water and approaching at the surface making minimal noise; approaching whales at the surface making loud vigorous splashes; or, approaching whales with surface swimming and subsurface diving. The control treatment involved the boat approaching whales with no swimmers entering the water. The measure of disturbance was the time until the whales moved from their original location. Preliminary analyses suggest there was no significant difference between the quiet approach and the control, whereas there was a significantly shorter time to departure when the swimmers were loud and splashing, suggesting the management of swimmer behaviour could reduce the disturbance. Discussion is detailed in Annex M, item 5.

SC/64/WW3 presented a modelling approach to examine the potential effects of dolphin watching. Health was used to link individual behavioural changes to vital rates, since health can moderate survival and reproduction. Behaviours had a cost-benefit relationship with dolphin motivations (e.g. foraging reduces hunger), and health was linked to hunger to avoid biologically unrealistic variation. Trade-offs between motivations (e.g. hunger versus fear) then determines behaviour. Application to a bottlenose dolphin population in New Zealand found increased time foraging and decreased time resting leading to a negative shift in the population's health. A theoretical, larger population was then considered, looking at the potential loss of foraging time due to whalewatching vessels. Population-level impacts were dependent on population size and the intensity of whalewatching activities: larger populations required greater disturbance intensity to realise a population-level effect. These results highlight the need to consider whalewatching impacts and management at the population level. Short-term changes in behaviour can be significant, but do not automatically indicate a threat to the population's long-term health. Discussion and concerns over some aspects of SC/64/WW3 are detailed in Annex M, item 5.

The Committee **welcomes** the use of modelling to address the effects of whalewatching on cetaceans. It was suggested that Bocas del Toro, Panama, might be a location where this model could be tested.

15.2 Review whalewatching off Central America

SC/64/SH16 reported on whalewatching operations used as platforms of opportunity in Costa Rica, mainly offering trips to Marino Ballena National Park and Isla del Caño Biological Reserve, areas used by humpback whales during the winter. It was noted that this is a location where, without action, whalewatching could expand without sufficient oversight or control. It was suggested that this could be an important location for future focused work to assess the development and evaluation of regulations, monitoring efficacy and compliance. The Committee **expresses concern** that whalewatching operators appear to target mothers and calves, especially as the season progresses.

A survey investigating whalewatching tourists' attitudes toward cetacean conservation issues was undertaken in Blackbird Caye, Turneffe Atoll, Belize in 2007 and 2008

(Patterson, 2011), an area that provides year-round habitat to approximately 200 coastal bottlenose dolphins. Two main types of whalewatching were identified: dedicated cetacean research and incidental cetacean watching. Information relevant to the Committee is detailed in Annex M, item 6.

Annex M, Appendix 2 presents information summarising the known whalewatching operators, areas and targeted species in Central America. All Central American countries have whalewatching activities, primarily concentrated in the Pacific, but only Costa Rica and Panama have organised their industries with tour operator associations. In the south Pacific coast of Costa Rica, workshops to train and certify operators in best practices are being held twice a year. In Panama, operator training started in 2006 and will continue this year. In Guatemala and Nicaragua, whalewatching operators are becoming organised. Belize, Honduras, and El Salvador do not yet have organised whalewatching operators or associations or whalewatching regulations.

The Committee **welcomes** the information provided in Annex M, Appendix 2. It was noted that more whalewatching may be occurring in the region, but it is likely to be incidental or opportunistic.

15.3 Reports from intersessional working groups

15.3.1 Large-scale whalewatching experiment (LaWE) Steering Group

The Convenor for this intersessional correspondence group was unable to attend this year's meeting. A detailed progress report of this group's intersessional work is provided in the appendix of SC/64/WW6.

SC/64/WW6 introduced a meta-analysis to test for significant changes in speed, activity budget, inter-breath intervals and cetaceans' paths during whalewatching events. These changes could lead to increased energy expenditure and reduced foraging. In a call for participants, 10 ultimately provided data, after accounting for quality assurance and control procedures. A random effects model allowed for incorporation of heterogeneity due to moderators, such as study quality and body size. Only presence versus absence of vessels was modelled due to data limitations. Whalewatching activities had an impact in all studies, although the magnitude of the response varied. The only consistent response across species was path linearity and changes in resting behaviour. The only significant moderator was the effect of body size: smaller species and populations were less likely to rest in whalewatching vessels' presence. Researchers were receptive to suggested protocols meant to improve the quality of data collected.

15.3.2 LaWE budget development group

This intersessional group was unable to make progress. The Convenor sought information on budget requirements from the LaWE principals, but did not receive sufficient information to develop a budgetary framework. The Committee **strongly recommends** that the principal researchers on the LaWE Steering Group provide concrete information on budget requirements to the Convenor of the budget development intersessional group well before the next Annual Meeting, to allow this group's work to progress.

15.3.3 Online database for worldwide tracking of commercial whalewatching and associated data collection

Work continued intersessionally to develop a database to keep track of the details of whalewatching operations worldwide. The database developer is working towards putting the current version on the Commission's server for evaluation by the Committee.

15.3.4 Swim-with-whale operations

The questionnaire for operators (Rose *et al.*, 2007) was field-tested on three companies in the Dominican Republic in early 2012. Their responses indicated that the questionnaire was appropriate and sufficient to present more widely to operators. Further work will be undertaken intersessionally to distribute the questionnaire to more operators. The Committee thanks Rachel Ford, who conducted the field test of the questionnaire and the Pacific Whale Foundation which funded Ford's trip to the Dominican Republic.

15.3.5 In-water interactions

The Committee discussed the issue of human-cetacean in-water interactions in the wild in 2011 and an intersessional correspondence group was established (see IWC, 2012s). In order to examine potential risks to both cetaceans *and* humans, key points will be to identify for whom these in-water interactions are dangerous and what is considered dangerous. Definitions are elaborated in Annex M, item 7. In its work plan, the group proposes to work on a comprehensive list of human-cetacean in-water interactions, based on Scheer (2010), and to elaborate a list of areas and operations where in-water interactions take place.

In discussion, the Committee noted that the Commission's Five Year Strategic Plan for Whalewatching (see Item 15.4.1) may not adequately account for swim-with-whale and in-water interactions as forms of whalewatching. The Committee **recommends** that the Commission address issues that arise uniquely from operations that allow customers to swim with or feed cetaceans. It was suggested that the Commission refer to the Committee's definitions of types of whalewatching, as reported in Parsons *et al.* (2006), as well as the General Guidelines[27] as it progresses its work on whalewatching.

15.4 Other issues

15.4.1 Review scientific aspects of the Commission's Five Year Strategic Plan for Whalewatching

The Committee **agrees** that the goal of its review was to offer the Commission advice that will lead to results that benefit both the work of the Conservation Committee's SWG on whalewatching as well as the Scientific Committee's work. It was clarified that while the Committee focused its input on Objectives 1 (Research) and 2 (Assessment), all five objectives of the Strategic Plan could benefit from further cooperation between the two Committees, particularly in regards to elements such as regulatory frameworks, where this Committee could contribute expertise, data, and other work.

The Committee again recognises the ambitious scale of the science-related work programme found in the Strategic Plan and noted that the Commission should consider which actions would require additional time to address (see Annex M, Appendix 3). A Working Group was convened to formulate the Committee's comments back to the Commission. The Committee **endorses** the results of their consultation, which can be found in Annex M, Appendix 3.

An intersessional correspondence group (see Annex Q29) was established to discuss and develop guiding principles per Action 1.1 in the Strategic Plan. Action 1.2 should be completed intersessionally, with results reported to the next meeting.

[27] *http://www.iwcoffice.org/conservation/wwguidelines.htm.*

15.4.2 Consider information from platforms of opportunity of potential value to the Scientific Committee

The United Nations Environment Programme-Caribbean Environment Programme (UNEP-CEP), through the Specially Protected Areas and Wildlife Protocol and with the support of the National Environmental Authority of the Government of the Republic of Panama, convened a regional Workshop on marine mammal watching on 19-22 October 2011 in Panama City, Panama (Anon., 2011), bringing together marine mammal tour operators and government regulators from across the wider Caribbean region (WCR). The participants concluded that the data collected during marine mammal watching operations have the potential to answer questions about marine mammal populations in the WCR. Furthermore, these data should involve a network of collectors that cover larger field areas and should be archived so that they can be accessed and facilitate collaborations. Acknowledging the importance of standardised data, a template data form was developed. A copy of the proposed data form for the WCR may be found in Appendix V of the Workshop report.

The Committee **welcomes** this report on UNEP-CEP's activities and encouraged the submission of work related to this initiative to future meetings (and see Item 15.4.3)

Sollfrank and Ritter (2012) presented results from a study conducted on La Gomera (Canary Islands). Boat-based studies have been ongoing for several years, but little effort has been made to observe cetaceans systematically from land. This study demonstrated that it is possible to direct whalewatching boats to cetaceans spotted from land, allowing comprehensive and simultaneous data collection from land-based stations and boat-based platforms of opportunity. Land-based observations are the best way to monitor compliance with whalewatching regulations and to measure impacts from whalewatching vessels, as the presence of a research vessel does not influence operators or confound impact results.

M.E.E.R. (2012) laid out a model for a marine protected area (MPA) for sustainable whalewatching in the Canary Islands. Almost 15 years of cetacean data collected exclusively on whalewatching vessels (platforms of opportunity) were used to elaborate a marine protected area model. With anthropogenic threats increasing, the MPA model is especially designed for long-term development of whalewatching and other uses in a sustainable way. It is hoped that this report will contribute to the process of designating effectively managed marine protected areas within the European Union and elsewhere.

The Committee **welcomes** this presentation, as it represents the type of data most relevant to this agenda item and the work of the Committee as it can be applied toward science-based management decisions and actions.

SC/64/O12 reported on the situation in Samaná Bay, Dominican Republic, part of a national marine mammal sanctuary (along with the Navidad and Silver Banks). The Samaná Bay Boat Owners Association provides space aboard whalewatching vessels as platforms of opportunity. Data obtained over a period of 12 years were analysed to determine the spatial and temporal distribution of humpback whales in Samaná Bay. This information has played a vital role in the marine spatial planning of Samaná Bay and the creation of a conservation zone with restricted fisheries and tourism activities during the whale calving season. Details on the results of the study and discussion are found in Annex M, item 8.2

In particular given the expanding development of tourism in Samaná Bay, the Committee **recommends** that monitoring and research continue, especially in light of the increasing number of cruise ships entering the bay during the calving season.

SC/64/SH16 reported that along the South Pacific coast of Costa Rica, whalewatching boats have been used as platforms of opportunity to collect data on distribution and behaviour of humpback whales from breeding stock G from 2009-11. The results indicated a high number of mother-calf pairs and the use of coastal waters as a breeding ground. It was suggested that this location might be a good place to study the efficacy of an MPA by conducting research on the behaviour of animals inside and outside the MPA.

15.4.3 Review whalewatching guidelines and regulations

Carlson noted that the compendium of regulations and guidelines[28] on the Commission website was open, as always, to additions and updates. The Committee thanks Carlson for her committed work in this regard and **agrees** that the compendium is a valuable tool and should be continued. SC/64/WW5 analysed the compendium. The analyses, like the compendium, are intended as a reference, in this case to demonstrate both the diversity and similarities in existing rules. The Committee **agrees** that this analysis would also be a useful reference for the Commission and **recommends** that it also be posted on the Commission website.

The Committee reviewed the General Principles[29] and considers them robust. However, it **recommends** that they be renamed 'General Guidelines' (to avoid confusion with the term 'guiding principles'). It **agrees** to revisit them on a more regular basis to ensure they remain representative of 'best practices' and to address them under the standing agenda item on reviewing whalewatching guidelines and regulations.

SC/64/WW1 reviewed several studies that addressed whalewatching guidelines and regulations: Howes *et al.* (2012) investigated the effectiveness of the Ticonderoga Bay Sanctuary Zone to mitigate pressures of dolphin-swim operations on a small population of bottlenose dolphins; Alves *et al.* (2011) report on tourists swimming with and feeding Amazon river dolphins in Brazil; Ponnampalam (2011) collected baseline data on the nature of whalewatching in the Sultanate of Oman; and Pacheco *et al.* (2011) describe the success rate of sighting humpback whales from a marine wildlife-watching vessel operating in the coastal waters off northern Peru. Summaries are found in Annex M, item 8.3.

A product of the regional Workshop on marine mammal watching held in Panama (Anon., 2011) was the development of overarching principles and best practice guidelines for marine mammal watching in the WCR (UNEP-CEP, 2011a; 2011b). These principles and guidelines take into consideration pre-existing codes of conduct and regulations from countries within, and outside, the WCR and closely follow the steps and language used in the document *Pacific Islands Regional Guidelines for Whale and Dolphin Watching* (IFAW, 2008). All of the principles and guidelines developed for the WCR were agreed upon by the tour operators and regulators present at the Workshop and may serve as the basis upon which each country's own codes of conduct and regulations may be developed.

Galletti reported that the Chilean Government enacted whalewatching regulations in 2012. Many of the

[28]*http://www.iwcoffice.org/conservation/whalewatching.htm#regulations.*
[29]*http://www.iwcoffice.org/conservation/wwguidelines.htm.*

recommendations made by the Scientific Committee in 2007 were included, such as a maximum 300m approach distance for blue whales and allowing only land-based whalewatching for critically endangered southern right whales. Regulations will be translated into English and submitted for the compendium. The Committee **welcomes** this news.

15.4.4 Review of collision risks to cetaceans from whale-watching vessels

No new information was presented under this item.

15.4.5 Swim-with-whales operations

SC/64/WW1 presented information on swim-with programmes: Mangott *et al.* (2011) reported on swim-with dwarf minke whales on the Great Barrier Reef. The summary is found in Annex M, item 8.5. The Committee **reiterates its recommendation** from Item 15.3.5.

15.4.6 Emerging whalewatching industry in Oman

Oman's whalewatching industry has experienced gradual growth over the last 10 years, reflecting a steady increase in tourism and a growing awareness of cetacean fauna. The Arabian Sea humpback whale has recently become a target of opportunistic and unregulated whalewatching in southern Oman. The Committee has previously expressed concern over the status of this population which is discussed further under Item 10.7; unregulated whalewatching represents an additional potential threat to this population.

Existing, unofficial whalewatching guidelines in Oman are now over 10 years old. Progress has been made on updating these guidelines as well as gathering data on whalewatching operations, but further technical support is required to finalise the new guidelines as well as to assist with the training of operators.

The Committee **strongly recommends** that operator training workshops should be conducted with a view to promoting best practice for whalewatching and to aid the interpretation and implementation of revised whalewatching guidelines (see also Item 21).

15.5 Work plan

This is discussed under Item 21.

15.6 Other matters

It was noted that the development of general data requirements on the effects of whalewatching would be valuable in situations where a country is considering whether it would be sustainable to increase the level of whalewatching (e.g. a proposed increase in whalewatching permits for Kaikoura, New Zealand). The concept of assessing 'whalewatching carrying capacity' is of interest in the management and scientific communities and the Committee **encourages** presentation of a paper outlining the situation in New Zealand at the next meeting of the Committee to facilitate its discussions of the broader issue.

16. DNA TESTING

The report of the Working Group on DNA is given as Annex N. This particular agenda item has been considered since 2000 in response to a Commission Resolution (IWC, 2000).

16.1 Review genetic methods for species, stock and individual identification

No documents were presented this year. The Committee encourages the preparation of technical documents on methods for species, stock and identification for discussion at the next year meeting (see also Item 16.5).

16.2 Review results of the amendments of sequences deposited in GenBank

During the first round of sequence assessment (IWC, 2009h, p.347) some inconsistencies were found that appeared to be due to a lag in the taxonomy recognised by *GenBank* or uncertainty in taxonomic distinctions currently under investigation: 23 labelled as *Balaenoptera acutorostrata* in *GenBank* were identified as *B. bonaerensis*, 9 labeled as *B. edeni*, and 10 labeled as *Eubalaena glacialis* were identified as *E. australis* and *E. japonica*. The Committee had recommended notifying the original submitter about the inconsistency and encouraging an amendment to be made to the entry.

Following 2010/11 intersessional work, amendments were made for four cases of Bryde's whale and one case of minke whale, respectively (IWC, 2012f, p.52). In view of the limited responses, the Committee had requested that an official letter be sent from the Secretariat requesting the submitters to make the amendments in *GenBank*. This was done for three scientists for which addresses were available, involving nine cases of right whale (one scientist), one case of right whale (one scientist) and one case of Bryde's whale (one scientist). Unfortunately no responses have yet been received and thus no amendments have been made in *GenBank* during the intersessional period.

In view of this, for the next period, the Committee **reiterates** its previous suggestion on the addition of a field in *GenBank* where comments on taxonomy updates of the entries can be made (IWC, 2012f; p.52). The Committee **agrees** that Cipriano should make a request to *GenBank* and that he should inform the IWC Secretariat and the Convenor of the DNA Testing Group if a more formal request is required.

16.3 Collection and archiving of tissue samples from catches and bycatches

Last year, the Committee endorsed a new format for the updates of national DNA registers to assist with the review of such updates (IWC, 2012f, p.53). The updates of the DNA registers by Japan, Norway and Iceland this year were based on this new format.

The collection of tissue samples in Japan is from special permit whaling in the North Pacific (JARPN-JARPN II) and Antarctic (JARPA-JARPA II), and from bycatches. It includes coverage for 1994-2011 (JARPN-JARPN II), 1987/88-2011/12 (JARPA-JARPA II). In the case of bycatches it includes coverage for 2001-11 (see Annex N, Appendix 2).

The collection of tissue samples in Norway is from the commercial catches of North Atlantic common minke whales. It includes coverage for the period 1994 to 2011 (see Annex N, Appendix 3).

The collection of tissue samples in Iceland is from scientific whaling and from commercial catches. It includes coverage for 2003-07 (permit whaling) and 2006-11 (commercial whaling) (see Annex N, Appendix 4).

16.4 Reference databases and standards for diagnostic registries

In the Japanese register, almost all common minke whale sampled by JARPN-JARPN II in 1994-2011 were screened for mtDNA and microsatellites. Almost all minke whales bycaught in 2001-10 were screened for mtDNA and microsatellites. For animals bycaught in 2011, the percentage for microsatellite is lower (77.8%). This lower percentage is a result of the loss of 26 samples after the 2011 tsunami in Japan (see Annex N, Appendix 2).

Almost all Bryde's whales sampled by JARPN II in 2000-11 were screened for mtDNA and microsatellites. Genetic work for mtDNA and microsatellite was completed for four whales bycaught in 2001-10. Almost all sei whales sampled by JARPN II in 2002-11 were screened for mtDNA and microsatellites (see Annex N, Appendix 2).

Almost all sperm whales sampled by JARPN II in 2000-10 were screened for mtDNA and microsatellites. The single animal sampled in 2011 was screened for mtDNA. Microsatellite work has not been completed yet. All sperm whales bycaught in 2001-10 were screened for mtDNA and microsatellites (see Annex N, Appendix 2).

In the case of Antarctic minke whales, 16.5% and 92.3% of the whales sampled by JARPA in 1987/88-2004/05 were screened for mtDNA and microsatellites, respectively. Work for mtDNA is ongoing. Many of the samples of JARPA II (2005/06-2010/11) were lost after the 2011 tsunami in Japan. DNA work is ongoing on the recovered samples. For animals sampled in 2011/12, the mtDNA and microsatellite work has not yet been completed. For Antarctic fin whales, the 17 samples collected by JARPA II in 2005/06-2010/11 were screened for mtDNA and microsatellites. The DNA work on the single animal sampled in 2011/12 is ongoing (see Annex N, Appendix 2).

All North Pacific humpback whales bycaught in 2001-11 were screened for mtDNA and microsatellites. Two North Pacific right whales and three North Pacific fin whales bycaught from 2001-10 were screened for both mtDNA and microsatellites (see Annex N, Appendix 2).

Almost all samples in the Japanese DNA registry have been sexed (see Annex N, Appendix 2).

A suggestion was made that the genetic data of bycaught humpback whales could be of use for testing hypotheses on stock structure of this species in the western North Pacific.

In the Norwegian register, after discounting for duplicates, missing samples and laboratory problems, 100% of the North Atlantic common minke whale caught in 1997-2011 were screened for mtDNA and microsatellite (see Annex N, Appendix 3). The Committee **commends** the analyses on quality control carried out on the Norwegian DNA register (Glover *et al.*, 2011).

In the Icelandic registry, all common minke whales sampled under scientific permit whaling in 2003-07 were screened for mtDNA and microsatellites. The percentage for both markers is 6.1% for whales taken by commercial whaling in 2007-10. The percentage is 3.5% for whales taken by commercial whaling in 2011. All fin whales caught by commercial whaling in 2006-10 were screened for both mtDNA and microsatellites (see Annex N, Appendix 4). A question was raised on the low percentage for the commercial samples of common minke whale. In response, Víkingsson noted that while not required by IWC rules or regulations, tissue samples had been collected for the DNA register from all animals caught in the Icelandic commercial hunt. The delay in the laboratory analyses of samples collected since 2007 is due to funding restrictions but these will be completed before the *Implementation Review* of North Atlantic common minke whales scheduled for 2014.

The Committee appreciates the efforts of Japan, Norway and Iceland in compiling and providing detailed information on their registries in the new format. The Committee **agrees** that the information provided in the new format greatly facilitated the annual review.

16.5 Work plan

The Committee **encourages** the submission of papers in response to requirements placed on the Committee by IWC Resolution 1999-8 (IWC, 2000). Relevant information in documents submitted to other groups and sub-committees of the Committee will be reviewed next year. Results of the 'amendments' work on sequences deposited in *GenBank* will be reported next year.

17. SCIENTIFIC PERMITS

This Agenda Item was discussed by the Working Group on Special Permits in two late afternoon sessions to enable all Committee members who wished so to attend. Bjørge was elected Chair of the Working Group. Weller acted as Rapporteur, and the Working Group report has been directly incorporated here.

17.1 Review of results from existing permits

As in previous years, the Committee received short cruise reports on activities undertaken but spent relatively little time on discussion of the details. For long-term programmes the Committee has agreed that regular periodic detailed reviews (following 'Annex P') were more appropriate.

17.1.1 JARPN II

17.1.1.1 AUTHORS' SUMMARIES

SC/64/O3 presented the results of the 2011 Japanese Whale Research Program under Special Permit in the Western North Pacific - Second Phase (JARPN II) offshore component survey in sub-areas 7, 8 and 9 of the western North Pacific. There were three main research components: the whale sampling survey; the dedicated sighting survey; and the whale prey species survey. Two sighting/sampling vessels (SSVs), one research base vessel (NM whale sampling survey component), one whale prey survey vessel equipped with scientific echo sounder (PSV) and three dedicated sighting vessels (SVs) were used. The whale sampling survey took place from 11 June to 5 September 2011. A total of 5,156 n.miles was surveyed in 76 days (by the SSVs and NM) sightings included, 53 common minke, 476 sei, 149 Bryde's, 295 sperm, 66 fin and eight blue whales. A total of 49 common minke, 95 sei, 50 Bryde's and one sperm whale were sampled by the SSVs. Sampled whales were examined on board the research base vessel. In July, common minke whales fed mainly on Japanese anchovy near Syiriya and they fed mainly on walleye pollock around the east of Hokkaido. There were geographical changes of prey species of minke whales in sub area 7. Sei whales fed mainly on copepods and Japanese anchovy from June to August in sub areas 8 and 9. Bryde's whales fed mainly on krill in sub area 7 in July. Dominant prey species in the stomach of the sperm whale included mid- and deep-water squid. The dedicated sighting surveys took place from 28 April to 6 June 2011 in sub areas 8 and 9. During 4,060 n.miles surveyed three common minke, 51 sei, six Bryde's, 116 sperm, 31 fin and four blue whales were sighted. The prey species survey was carried out from 13 to 28 June in 2011. In parts of sub areas 8 and 9 by the PSV. Its objective was to estimate sei whale habitat and prey preference in relation to oceanographic and prey environments as well as productivity in early summer. Data obtained in this research will be used to elucidate the role of whales in the marine ecosystem through the study of whale feeding ecology in the western North Pacific.

SC/64/O4 presented the results of the 2011 JARPN II - coastal component - survey in spring. Usually the coastal spring survey is carried out in the locality of Ayukawa. On March 11 2011 the Ayukawa town, including all research facilities of JARPN II there, was destroyed by a large earthquake and tsunami. For this reason, the 2011 spring coastal survey was conducted in Kushiro, from 25 April to 10 June, using three vessels. Sampling occurred within 50 n.miles from Kushiro port, and animals were landed at the JARPN II research station. A total of 3,867.4 n.miles was surveyed and 36 schools (43 individuals) of common minke whales were seen and 17 common minke whales were sampled. Average body length was 6.70m (SD=0.84, n=9) for males and 6.29m (SD=1.02, n=8) for females. Dominant forestomach prey species were walleye pollock (*Theragra chalcogramma*) throughout all of the survey period, and krill (*Euphausia pacifica*) which was observed less frequently. Walleye pollock is one of the most important food items for common minke whales in Kushiro in both spring and autumn seasons. Distribution of common minke whales appears to differ between spring and autumn surveys in Kushiro, at least for some years.

SC/64/O5 outlined the results of the autumn survey of the JARPN II coastal component off Kushiro, northeast Japan (the sub-area 7CN) in 2011. The survey was conducted from 9 September to 30 October 2011, using four vessels. During 5,367.8 n.miles searched, 144 schools and 150 individual common minke whales were sighted and 60 whales were sampled. Average body length was 6.24m (SD=1.06, n=35) for males and 6.05m (SD=1.08, n=25) for females. Overall, 19 of the 35 males (54.3%) and three of the 25 females (12.0%) were sexually mature. The dominant forestomach prey species was Japanese anchovy (*Engraulis japonicas*) (61.7%), followed by walleye pollock (26.7%), and krill (8.3%). Pacific saury (*Cololabis saira*) and Japanese common squid (*Todarodes pacificus*) were not observed. The frequent sightings of whales in combination with the slightly higher ratio of mature and larger whales in the 2011 survey, as compared to the 2010 survey, as well as more whales comsuming Japanese anchovy suggested that the abundance and distribution of this prey item may have attracted whales to the coastal waters off Kushiro in autumn 2011. During the survey, no apparent impact due to the earthquake in March 2011 was detected in the distribution, density or catch composition of common minke whales. This implied that effect of the earthquake on the migration of common minke whales in the coastal waters off Kushiro might be negligible.

17.1.1.2 DISCUSSION

Following the cruise report presentations, there was some discussion of how the cruise tracks for the coastal survey off Kushiro were designed and if the intent was to obtain a representative sample or rather to increase the probability of encountering whales. The authors of SC/64/O5 explained that survey vessels used during the coastal component of the programme departed port each day following a number of predetermined lines with 15° radials that were selected on a daily basis after review of weather, oceanographic conditions and the distribution of whales. Survey tracks were concentrated relative to whale distribution and differed from standard line transect methods in that the first 30 n.miles were dedicated to survey search mode followed then by the vessels moving freely within the study area.

In further discussion, the Working Group was reminded that at last years meeting it was suggested that whales taken during coastal operations be examined for radionuclides, especially caesium-137, for use in stock elucidation (IWC, 2012f). The authors of SC/64/O4 stated that one of the three objectives of the JARPN II programme was to monitor environmental pollutants in cetaceans and the marine ecosystem. Data collection for radionuclide assessment is being undertaken and data are available on the website of the Fisheries Agency of Japan.

17.1.2 JARPA II

17.1.2.1 AUTHORS' SUMMARY

SC/64/O2 presented the results of the 2011/12 survey of the Second Phase of the Japanese Whale Research Program under the Special Permit in the Antarctic (JARPA II). Two dedicated sighting vessels (SV), one sighting and sampling vessel (SSV) and one research base vessel engaged in the research for 66 days, from 1 January to 6 March 2012 in Areas V (130°E-170°W) and VI West (VIW: 170°W-145°W). Unfortunately, the research activities were interrupted several times by the violent sabotage activities of an anti-whaling group. The planned dedicated sighting survey had to be cancelled so that the vessels could undertake security tasks. The research activity of the SSV was also interrupted several times. The total search distance by the SSV of 3,040.5 n.miles, was approximately one-third of the search distance in 'normal' years. Eight species including six baleen whales (blue, fin, sei, Antarctic minke, humpback and southern right whale) and two toothed whales (sperm and southern bottlenose whales) were seen. The most common species seen (284 schools, 684 individuals) was the Antarctic minke whale followed by the humpback (112 schools, 208 individuals) and fin whales (11 schools, 31 individuals). A total of 266 Antarctic minke whales (99 males and 167 females) and one fin whale (female) were sampled examined on the research base vessel. A total of five blue, six humpback and four southern right whales were photo-identified. Two biopsy samples were collected from humpback whales and four from southern right whales. In March, satellite tags were deployed on two southern right whales. Oceanographic surveys to investigate vertical sea temperature profiles were also implemented using XCTD. In summary:

(1) whale composition in the research area was stable compared to previous JARPA and JARPA II surveys in the same area;
(2) the ice-free extent in Area VIW was substantially larger than in previous seasons;
(3) high density areas of Antarctic minke whales were observed near the ice edge;
(4) mature female Antarctic minke whales were dominant in the southern part of Area VIW (66.8%); and
(5) Antarctic minke whales in the 'transition area between 130°E and 165°E (area of stocks mixing), were successfully sampled.

17.1.2.2 DISCUSSION

Following the presentation of the 2011/12 JARPA II cruise report, it was noted that the lack of discussion did not imply there is agreement on the issue of scientific whaling under special permits. Differing views on this activity remain and the Working Group was referred to the statements made in Annex P1 and Annex P2.

17.1.3 Planning for a final review of results from Iceland - North Atlantic common minke whale

The results from the Icelandic programme on common minke whales will be subject to final review during the coming intersessional period. 'Annex P' (IWC, 2009i) documents the review process. The only time this procedure has been used was to review the JARPN II Special Permit in 2009 (IWC, 2010b). While the process worked well in general (IWC, 2010d), improvements on some aspects of the implementation of the process have been agreed and are detailed in Annex P4 of last year's report (IWC, 2012t). One change in implementing the 'Annex P' procedure (IWC, 2009i) will be the presence of observers. The general outline of the Workshop includes an initial session where a restricted number of scientists associated with the proposal will present results of their research and answer questions. Then the main part of the review Workshop will be closed sessions where the expert panel evaluates the results. At the end of the Workshop there will be a short open session where the expert panel can ask scientists associated with the proposal questions for clarification. Observers will be allowed to the open sessions. In light of these modifications, the timetable to be used for the Iceland and JARPA II reviews is presented in Table 3 of Annex P4 (IWC, 2012t).

Víkingsson stated that Iceland will meet the requirements of the time schedule of Annex P4 (IWC, 2012t) for a review in 2013. The Working Group **agrees** that the review of results from Iceland will occur in February/March 2013.

SC/64/SCP1 addressed the data availability under Procedure B of the Data Availability Agreement. A small group was set up to consider this document. The Committee **agrees** the clarifications to 'Annex P' (IWC, 2009i) included as Annex P3.

17.1.4 Planning for a periodic review of results from JARPA II

The Working Group **agrees** that the review of results from JARPA II will occur in February/March 2014.

17.2 Review of new or continuing proposals

17.2.1 JARPA II

Japan reported that there was no plan to change the JARPA II programme.

17.2.2 JARPN II

Japan reported that there was no plan to change the JARPN II programme.

18. WHALE SANCTUARIES

The Committee received no new proposals for sanctuaries this year. The report of an international Workshop on Marine Protected Areas (SC/64/O20) was discussed in Annexes K and M.

19. SOUTHERN OCEAN RESEARCH PARTNERSHIP (SORP)

The Southern Ocean Research Partnership (SORP) was proposed by the Australian Government to the IWC in 2008 (IWC, 2008b) with the aim of developing a multi-lateral, non-lethal scientific research programme to improve the coordinated and cooperative delivery of relevant scientific information to the IWC. The Partnership now includes ten countries: Argentina, Australia, Brazil, Chile, France, Germany, New Zealand, Norway, South Africa, and the USA. A framework and set of objectives for SORP have been endorsed by the Committee (IWC, 2011f) and six SORP research projects were endorsed last year (IWC, 2012f). Progress of these research projects was reviewed this year. The IWC has a budget specifically related to the work of SORP established with a contribution from Australia in 2008 and supplemented by additional voluntary contributions from Australia and the USA in 2011. This budget is administered by the IWC Secretariat.

SORP was originally discussed in an open session, chaired by Gales and rapporteured by Bell. The report of that session is incorporated directly into the Plenary report here.

The Committee noted that in April 2012, Bell was appointed the Southern Ocean Research Partnership coordinator replacing Childerhouse and Wadley was appointed the Antarctic Blue Whale Project coordinator.

19.1 Review of progress since IWC/63

SC/64/O13 summarised the progress of SORP since IWC/63. Progress was made on the following major items.

(1) *Overall support and progress of the six SORP research projects* – progress reports for the 2011/12 period are available in SC/64/O13.
(2) *Provision of interim funding* – funding was provided for all six SORP projects to support research during 2011/12 (IWC, 2011f).
(3) *Further development of the* SORP Antarctic Blue Whale Project *(formerly known as the SORP Year of the Whale Project)*.
(4) *Planning and implementation of collaborative SORP Antarctic blue whale expeditions* – two expeditions led by Australia were undertaken in the austral summer of 2011/12 (SC/64/SH11) to develop and test methodologies that will be employed during the SORP Antarctic Blue Whale Voyage planned for early 2013 (SC/64/SH13). Further development of acoustic methods (SC/64/SH12) and survey design (SC/64/SH10, SH14, SH26) was also undertaken.
(5) *Completion of the core SORP project*: the Living Whales Symposium and Workshops, held in Chile in March 2012 (SC/64/O14).

These items are covered in more detail below. The Committee was **pleased** to note that SORP is being successfully implemented and **welcomes** the results.

19.1.1 SORP Antarctic Blue Whale Project

The title 'Antarctic Blue Whale Project' (ABWP) now replaces 'The Year of the Whale' (YOTW) to reflect the fact that the proposed research will require a multi-year, multi-platform, integrated and coordinated research effort. This became clear following discussions within the Committee and intersessionally, particularly given the extensive methodological development (IWC, 2012m; Kelly *et al.*, 2011; SC/64/SH10-14, SC/64/SH26) reported. A single season effort is not an appropriate strategy to deliver an estimate of circumpolar abundance, given logistical constraints and the preferred sampling regime under a mark-recapture approach.

The specific objectives of this initiative are to:

(1) provide a circumpolar abundance estimate for Antarctic blue whales;
(2) improve understanding of Antarctic blue whale population structure;
(3) improve understanding of connectivity between blue whale feeding and breeding grounds; and
(4) characterise foraging habitat of blue whales.

SC/64/O13, SC/64/SH10-14 and SC/64/SH26 were discussed in Annex H. The project was very well received as an investigation to determine the viability of ideas and methods. Gales welcomed the maturing ideas and methods under development and their implementation in the Southern Ocean during 2012/13. Results from the ABWP have been presented at international scientific meetings, including the International Polar Year conference in Montreal, April 2012.

The importance of SORP as a means to engender international cooperation was noted. There are encouraging signs that estimating the circumpolar abundance of blue whales will be possible.

19.1.2 Ways to expand Antarctic Blue Whale Project (ABWP) work

SC/64/O16 provided information about the South African Blue Whale Project (SABWP) and it was discussed in Annex H. Despite evidence of recent increase, the population of Antarctic blue whales remains severely depleted from commercial whaling. Both the high concentrations of sightings of Antarctic blue whales in the 0-20°E sector of the Antarctic in recent years (IDCR/SOWER sighting records) and the high historic catches of some 12,000 probable Antarctic blue whales off the west coast of South Africa, Namibia and Angola prior to 1930, suggest that the southeastern Atlantic Ocean and neighbouring Southern Ocean region should provide exciting opportunities for research on Antarctic blue whales. The South African Blue Whale Project (SABWP) has been recently funded by the South African National Antarctic Programme (SANAP) and the National Research Foundation (NRF) to investigate the seasonality, distribution and relative abundance of this species in these areas with the long-term aim of determining relative abundance indices to measure the population trend. Research efforts will be concentrated in two regions; 67°S to the ice edge and 0-20°E region in summer, and off the south-western Cape coast in winter. Autonomous Acoustic Recorders (AARs) will be deployed in both the high and low latitude regions to determine distribution and seasonality patterns of this migratory species. Line-transect surveys (incorporating photo-ID, biopsy sampling and ship-based passive acoustic monitoring) will be carried out in the Antarctic region during summer to provide abundance and call-rate measurements for 'broadbrush' ground-truthing of Antarctic AAR data. Low-latitude AAR data will provide information on where and when to concentrate future research efforts off the southwestern Cape coast. Data from this voyage will contribute to the ABWP and other SORP projects. A proposal for one of the team to receive training in AAR deployment during a cruise off Greenland this summer (SC/64/O17) has been adopted.

Norway joined SORP two years ago. Norway may contribute to SORP in the following manner.

(1) Financially: upon provision and favourable review of a budget and research proposal from existing or new SORP projects, Norway would be willing to fund research. Norway does not have to be involved in the research proposal.
(2) In kind support: annually, Norway sends scientists on fishing vessels that work in the Southern Ocean, in 2012/13 primarily around the South Orkney Islands. Biannually, the Norwegian vessel R/V *G O Sars* operates in the Southern Ocean I.A. in the area around Bouvet Island. This is a dedicated research vessel that can be directed to other areas. It will next sail in 2013/14 (to be confirmed). Berths on these vessels could be made available to SORP researchers.
(3) Personnel: the expertise of Norwegian scientists could be provided for collaboration on SORP research projects.

Particular interest was expressed in contributing to the Antarctic Blue Whale Project. The Committee **greatly welcomes** Norway's offer of monetary, in kind and personnel support for SORP and **agrees** that it will be resolved intersessionally how it will be managed and administered.

The Committee was informed of France's intention to use the R/V *l'Astrolabe* to carry out a photo-ID and sightings surveys of blue whales in Terre Adelié. Surveys will be carried out over the next two years and it is hoped it can be continued for up to four years. A marine science voyage is also being considered in the southern Indian Ocean, south of Kerguelen on the Marion Dufresne. It is hoped that time may be allocated on this to perform blue whale research but it is a highly competitive process.

The Committee was informed of Germany's intention to perform its fifth cetacean survey from January to mid-March 2013 in the western Weddell Sea. This will be a repeat of the 2006/07 survey. The aim is to relate krill abundance to hydrography and oceanography. Helicopters will be used as the survey platform.

The Committee was also informed of plans by the International Fund for Animal Welfare for a Southern Ocean voyage that may be able to contribute to the Antarctic Blue Whale Project through combined acoustic surveys and photo-ID.

It was noted that collaboration with the wider Antarctic community is underway with SCAR, COMNAP, IAATO and CCAMLR to pursue the objectives of the ABWP.

The Committee **encourages** international involvement in the SORP Antarctic Blue Whale Project in the form of research, ship time or personnel. The Committee also stressed the importance of standardised protocols and shared data access across a range of data types, and **encouraged** their adoption across international cetacean research programmes.

19.1.3 Killer whales in the Southern Ocean

The principal investigators once again participated as 'visiting scientists' on board the tour vessel M/V *National Geographic Explorer*, during four consecutive trips to the Antarctic Peninsula from 7 January to 15 February 2012; approximately 3,000 photo-ID images of over 200 individually-recognisable animals for future mark-recapture analyses were obtained; two skin biopsy samples were obtained (samples archived at SWFSC), and three individuals were satellite-tagged. Data are presented in the full project report in Annex 1 of SC/64/O13. Other tour ships operating in the Antarctic Peninsula area were also canvassed for killer whale photographs and thousands of images were obtained from over two dozen killer whale encounters. The principal investigators feel confident that within the next year or two they should have enough images to estimate population sizes for the three types of killer whales that are recognised in the Peninsula Area.

The Committee **commends** the work of the principal investigators.

The Committee was also informed of new killer whale photo-ID data from the Institut Polaire Française (IPEV) Cétacés Terre Adélie project that is available for 35 individuals in Terre Adélie, eastern Antarctica (SC/64/SM6).

19.1.4 Foraging ecology and predator prey interactions of baleen whales and krill

During the funding period, significant progress was made towards the overall goal of understanding the foraging ecology and predator-prey interactions between baleen whales and krill in the waters around the Western Antarctic Peninsula. Analysis was completed describing the diving behaviour of humpback whales from suction-cup tags deployed in 2009 and 2010. These results were presented at numerous scientific meetings including the Biennial Conference on the Biology of Marine Mammals (Tampa, FL, November 2011), and the recent SORP Workshop on non-lethal research techniques for studying cetaceans (Puerto Varas, Chile, March 2012). A full project report is included in Annex 1 of SC/64/O13.

The main findings of the project to date are summarised below.

(1) Humpback whales were found to feed almost exclusively during night-time hours in late autumn (May/June), spending daylight hours either resting or travelling. The initiation of feeding was often proceeded by deep exploratory dives that are hypothesised to sample the water column to determine where prey are distributed.
(2) Humpback whales appear to achieve or conform to ecological predictions of optimal foraging theory in two significant ways: by increasing the number of feeding lunges executed per dive with increased dive depth; and by targeting higher densities of krill as feeding depth increases.
(3) While both of these findings are significant, the fact that the principal investigators have been able to quantify increases in prey density concurrent to whale feeding is novel. The information provided from this relationship will be a substantial component of the manuscripts that are currently in preparation to be submitted for peer review.
(4) Humpback whales vary the depth of their feeding in relation to the diel vertical movement of krill in the water column.

The Committee **welcomes** these results and **encourages** further work to enhance understanding of humpback whales that overwinter in Antarctica. Gales noted that additional satellite and datalogger work on humpback and minke whales was planned.

19.1.5 Oceania humpback whale mixing
The focus of this project has been on preparing for the proposed 2013 satellite tagging work at the Kermadec Islands and American Samoa (Childerhouse, 2011). The Oceania humpback whale population estimate has been published (Constantine *et al.*, 2012) with a sex-specific POPAN super-population model, which accounted for residents and whales migrating through the survey areas, giving an estimate of 4,329 whales (3,345-5,313) in 2005.

In the winter of 2011, satellite tagging work was undertaken in New Caledonia (Garrigue in collaboration with Zerbini and Clapham) adding to the 2007 (Garrigue *et al.*, 2010) and 2010 tagging efforts. The general trend observed was for the majority (~75%) of whales to head in a south-southeasterly direction once they left the New Caledonia breeding grounds. Some whales stopped at seamounts or other undersea geographic features along the way for varying lengths of time.

The Raoul Island (Kermadec group) single day four hour survey conducted between 08:00 and 12:00hrs was conducted on the 8 October 2011. This adds to the previous three years of October surveys using a standard set of seven land-based locations (Brown, 2009; 2010; Potier, 2008)[30]. Previous whale-counts from these surveys have ranged from 62-153 whales and the 2011 survey counted 126 individual whales (Potier and Shanley, 2012)[30]. The consistently high number of humpback whales observed migrating past Raoul Island, peaking in October, confirms the Kermadec Islands as the southernmost location in Oceania with regular whale sightings and the ideal site to attach satellite tags as the whales migrate south. Constantine will visit the Kermadec Islands in August 2012 to consider this research site. Research in American Samoa conducted in the 2011 field season continued preparation for the planned satellite tagging in 2013.

Future work will focus on addressing two questions.

(1) What is the connection between the humpback whales from Area V feeding grounds and their migratory corridors and breeding grounds in Australia and Oceania?
(2) Do whales from Area V represent a single breeding ground or are they a mix of individuals from several distinct breeding grounds?

A full project report is included in Annex 1 of SC/64/O13.

19.1.6 Fin and blue whale acoustics
Understanding baleen whale distribution and abundance in the Antarctic, particularly blue and fin whales, is complicated by the pelagic distribution of both species, the difficulty of working in the Southern Ocean (SO) and the massive decline of both due to commercial whaling. After a half-century of protection, little is known about the present-day status of each species. Blue and fin whales are congeners that are the largest mammals on earth. Both occur in all oceans of the world with similar distribution patterns. In particular, each species occurs in high latitudes in the Southern Hemisphere. In the Antarctic, blue whales are generally thought to occur closer to the ice edge than fin whales. Blue whales are designated as different subspecies, i.e. Antarctic (*B. m. intermedia*) and pygmy types (*B. m. brevicauda*), and Chilean blue whales are also considered an unnamed subspecies, or at least a separate management unit. In the case of fin whales in the Southern Hemisphere, two subspecies have been considered: *B. physalus quoyi* for the Southern Ocean form; and the pygmy fin, *B. p. patachonica,* found in the northern parts of the Southern Hemisphere.

Both blue and fin whales were targets of commercial whaling, particularly from the early 1900s through the 1930s, leading to heavy depletion. Blue whales were protected internationally from whaling in 1966 and fin whales in 1985. At present, both species are listed as Endangered by the IUCN and there are no reliable population estimates for either species globally. A recent examination of almost 40 years of sighting data resulted in an estimate of 2,280 (CV=0.36) Antarctic blue whales, which is less than 1% of the original population (Branch, 2007). There are no equivalent estimates for Southern Hemisphere fin whales.

From 1978 to 2010 the IWC supported the annual IDCR/SOWER Antarctic cruises that consisted of three circumpolar sets of cruises over multiple years that focused primarily on minke whale abundance but that also provided an estimate of abundance for Antarctic blue whales (Branch, 2004). Only two of the recent cruises focused on fin whales (Ensor *et al.*, 2006; 2007). Given the amount of effort, ship time, high risk of poor weather and cost of sighting cruises, it is unlikely that the tremendous shipboard effort of IDCR/SOWER will be repeated. In order to continue to monitor Antarctic blue and fin whales, the use of a network of long-term passive acoustic recorders has been proposed *in lieu* of dedicated circumpolar visual surveys.

Passive acoustic monitoring is a robust means of monitoring blue and fin whales in remote areas over long time periods, including around the Antarctic. The present analysis of all the available data shows the geographic and seasonal occurrence of blue and fin whales around the Antarctic. However the lack of overlap in the years and

[30]Unpublished field reports.

locations monitored, the differences among instruments and analysis methods used, underlines the need for coordinated effort. To best exploit passive acoustic data long term, a pan-Antarctic monitoring system needs to be put in place and maintained. Thus far there has been a positive response from many countries regarding this project. In the near term the principal investigators need to find the finances and continue instrument development to facilitate a coordinated research effort. Further a single method either for each species or for both needs to be adopted for analysing the data. A review of existing methods for estimating relative abundance from passive acoustic sensors demonstrates that the scientific question of interest will drive the analysis methods chosen. The principal investigators suggest that the Australian Marine Mammal Centre, based at the Australian Antarctic Division, Hobart, maintain a database of the metadata and data from hydrophones and make these freely available if possible.

Acoustic data from a single hydrophone present unique challenges to density estimation: to overcome these, the principal investigators need to improve their knowledge of call rate, acoustic behavior and source level of whales; detection distance and sound propagation (environmental parameters and ambient noise level). Methodology to estimate the density of whales from acoustic data is advancing rapidly and it is anticipated that if understanding of the parameters above is improved, density estimation using passive acoustic data will become the state of the art for monitoring Antarctic blue and fin whales. A full project report is included in Annex 1 of SC/64/O13.

The Committee **commends** the work of the principal investigators and it was noted that this project addresses the research priorities identified by SORP to meet the overall objectives of the IWC.

It was highlighted that it will provide valuable data for blue whales and may provide the only practical way to obtain data about fin whale abundance, information that the scientific community currently does not have. From this data it may be possible to estimate trends in blue and fin whale populations over decadal scales.

This work is closely aligned with the objectives of the Antarctic Blue Whale Project. It was also noted that that the global economic situation is very likely to reduce the amount of ship time available to researchers in the future, therefore the development of acoustic methods such as these are essential for continued, non-lethal cetacean research.

19.1.7 Living Whales Symposium and non-lethal research techniques Workshops

SC/64/O14 summarised the SORP Symposium and Workshops entitled 'Living whales in the Southern Ocean: advances in methods for non-lethal cetacean research'.

The Symposium and accompanying Workshops were held in Puerto Varas, Chile from 27-29 March 2012, to discuss recent advances in methods for non-lethal research on whales in the Southern Ocean. The Symposium was attended by 124 registered participants from 16 countries and was also live streamed on the web, allowing 1,553 simultaneous viewers.

The first day was an open Symposium with invited experts who showcased new non-lethal research methods for whales in the Southern Hemisphere. The Symposium talks were divided across five sessions that covered an overview of the history of whaling, evolution of non-lethal techniques and the role of whales in Southern Ocean ecosystem. These were followed by sessions on molecular techniques, biologging, remote sensing and long-term non-lethal research. A PDF of the talks are already available[31] and videos of each talk, in English and Spanish, will soon be available.

The Symposium was followed by two days of Workshops that covered specific research areas. The Workshops were each one day in duration and covered the following topics:

(1) health assessment of live cetaceans;
(2) advances in long term satellite tagging techniques for Cetaceans;
(3) population dynamics and environmental variability; and
(4) estimation of diet and consumption rates from non-lethal methods.

The Workshop health assessment of live cetaceans reviewed several techniques obtained from blow samples, biopsy samples, collection of faeces, visual health assessment, photogrammetry, blow intervals and respiration rates, among others. The Workshop identified two main aspects:

(1) health assessment data and studies should be integrated with population dynamics data, where possible; and
(2) integration of live animal health assessment with studies on dead and stranded animals, particularly within the same geographical region, is highly informative and should be a priority. The priority areas for further consideration in health assessment include nutritive stress and body condition; feeding and fasting or starvation state; skin lesions; stress; emerging issues and exposures; and particularly, standardisation of methodologies.

The Workshop on large whale population dynamics and environmental variability explored which life history parameters can be connected with environmental variability and highlighted the need for researchers to collect data on body condition, mortality and reproductive output, among others. The Workshop also evaluated different analytical and simulation techniques to incorporate environmental variability into population models and recognised the need of long term data sets to detect such effects. The Workshop recommended that long-term studies, photo-ID and biopsy sampling be routinely collected and promoted the use of geochemical tracers (e.g. stable isotopes) and other 'eco-markers', including DNA, since this approach can help to identify foraging locations of populations.

The Workshop 'Advances in Long-Term Satellite Tagging Techniques for Cetaceans and their Application to Address Research Questions in the Southern Ocean' reviewed advances on tag development and dedicated studies to address possible physical and physiological effects of satellite tags on cetaceans. The Workshop highlighted that effort could be directed to minimise the size and diameter of body-penetrating satellite tags in order to minimise trauma of implant and water ingress and promoted the use of an alternative to body-penetrating tags, such as new designs with external electronics and a long anchoring system. It was agreed that new designs for cetacean tags ought to be developed and that priority should be given to accelerometer and dive/surface interval data and to the development of algorithms that can compress data for transmission via ARGOS. The Workshop also recognised that some devices have the potential to cause considerable tissue damage and that studies on carcasses derived from incidental mortality should be conducted, as well as monitor tagged animals. Finally, the

[31]*http://www.simposioballenas.cl.*

Table 10

SORP funding requests and allocations for 2012/13.

Project	PI	Line item	Requested (GBP)	Allocated (GBP)
SABWP	Best	Travel	2,500	2,500
SORP 1: ABWP	Wadley	-	0	11,700
SORP 2: Killer whales	Pitman	Travel	2,235	2,235
		6 x wildlife computers on location-only tags	10,360	10,360
		6 Wildlife Computers depth and location tag	17,267	0
SORP 3: Baleen whales	Friedländer	Coordinator's salary[#]	13,430	0
SORP 4: Blue and fin whales	Stafford	Salary	7,963	7,963
		Support for coordination and development activities	15,926	15,926
		Steering Committee meeting*	4,778	0
SORP5: humpback whales	Constantine	Photo-ID and tissue sampling	9,548	9,548
		Project assistant**	6,376	6,376
		Steering Committee meeting*	3,819	0
SORP 6: Symposium	Baker/Galletti	-	0	0
Total requested 2012/13			94,202	
Total allocated 2012/13				**66,608**

[#]The Committee requested clarification of the use of the money requested for consideration intersessionally. *No money was allocated to individual projects for Scientific Steering Committee meetings because of proposals to hold a SORP conference in 2013 (see work plan item 6). **The principal investigators also requested £182,748 GBP to support research in 2013/14. It was noted that SORP cannot support such large requests for money. Therefore, the Committee **encourages** that SORP funds allocated for 2012/13 be used in part to allow the project assistant to write proposals for additional project funding.

Workshop highlighted the need to create awareness on the use of these techniques within local communities, regulatory agencies and the general public prior to any tagging project.

The Workshop on 'Estimation of Diet and Consumption Rates' highlighted several techniques that might be used to achieve this difficult objective. Tagging studies could provide information about foraging effort, photogrammetric techniques about individual fitness and steroid-hormone samples (from faeces or biopsy) about reproductive status. Understanding interspecific differences in prey preference will help to predict how climate driven changes affect krill and, ultimately whales. The value of understanding how local oceanographic conditions and prey availability affect the foraging behaviour and distribution was highlighted. Also recognised was the need to improve understanding of foraging strategies, prey choices, feeding destinations, etc. and recommended the use of several dietary tracers, such as stable isotope analysis, and molecular techniques, for diet reconstruction alongside fecal sampling and fatty acid analysis.

In summary, the Symposium and Workshops were very successful. The event drew a large audience and the Symposium organisers recommend the use of live broadcast technologies alongside simultaneous translation as a means to reach a wider audience in future events. The Workshops gave an excellent overview of existing and new research techniques and contributed enormously toward setting guidelines and prioritising research needs for improving our current scientific understanding and techniques.

The Symposium organisers and the SORP Scientific Steering Committee thanked the sponsors of the Symposium and Workshops: the Ministry of Foreign Affairs, Chile; the directorate of Maritime Territory and Merchant Marine of Chile; the Australian Government; the National Oceanic and Atmosphere Administration of the United States (NOAA); Oregon State University; the International Fund for Animal Welfare; the South Pacific Research Whale Consortium; Altavoz; and the Cetacean Conservation Center Chile. The Symposium and Workshops represent a completed Southern Ocean Research project. The full report can be found in SC/64/O14.

The Committee **thanks** the Symposium organisers, in particular Galletti, Baker and their teams for their work and congratulated them on their success. The usefulness of the Symposium and Workshops for improving current non-lethal techniques for cetacean research was stressed. It was noted that some of these will be applied to research to be conducted in the coming field season, e.g. by Argentinean researchers. It was also noted that useful recommendations came out of the Workshops with regard to research on climate change impacts on cetaceans, e.g. southern right whales in the southwest Atlantic, in line with wider SORP objectives.

19.2 Budget

The IWC has a budget specifically related to the work of SORP established with a contribution from Australia in 2008 and supplemented by additional voluntary contributions from Australia and the USA in 2011. This budget is administered by the IWC Secretariat.

19.2.1 Budget overview

Bell presented a summary of the SORP money spent to date and remaining funds. A total of £76,947 remains unallocated and unspent. A figure of approximately £37,730[32] remains in the SORP budget allocated but unspent.

19.2.2 Request for funds from projects

Table 10 summarises the requests for SORP funds received from existing SORP projects for 2012/1.

SC/64/O17 requested £2,500 for the South African Blue Whale Project (SABWP; SC/64/O17) to support travel for one investigator, Meredith Thornton, from South Africa to Greenland to participate in a week-long cruise cruise in which five Autonomous Acoustic Recorders (AARs) will be deployed west of Disko Bay in August 2012. The cruise will be led by the Greenland Climate Research Centre and Applied Physics Laboratory of Washington University. The intention is that the investigator gain the necessary technical experience in deployment of AARs at sea, that otherwise might entail an experienced person accompanying a long supply voyage from Cape Town to the ice and back just for a few days' work. An official response from the organisers of the cruise has still not been received.

[32]This figure has not been finalised because of possible outstanding invoices from the 2011/12 allocation to SORP Project 6.

The Committee **approved** this request for funding.

Funding requests from existing core SORP research projects for 2012/13 are outlined in Table 10 alongside the agreed allocations.

19.2.3 Reallocation of funds

A small group was formed consisting of the SORP Scientific Committee and other interested parties to discuss reallocations of remaining SORP funds to projects in 2012/13.

A figure of £37,730 remains in the SORP budget allocated but unspent. The Committee **agrees** that £11,700 of this be reallocated to the Antarctic Blue Whale Project and the remaining £26,030 be rolled-over into the general SORP budget for reallocation in the future.

19.2.4 Allocation of funds

The Committee **agrees** to allocate SORP funds for 2012/13 as outlined in Table 10.

19.2.5 Seeking additional funding

Following the reallocations and 2012/13 allocations, £48,069 will remain in the SORP budget administered by the IWC Secretariat.

The Committee **thanks** the Governments of Australia and the USA for their generous contributions to the SORP and **encourages** support and voluntary contributions from other nations to ensure the continuation of this exciting initiative.

19.3 Requirements for formalising participation in SORP and development of new projects

The Committee is keen to promote continued and new involvement in SORP. Partners are **encouraged** to formalise their involvement in the form of a letter to the SORP Secretariat. If Partners require more formal protocols, such as a Memorandum of Understanding, this can be arranged by the SORP Secretariat. The Committee **encourages** the involvement of new and existing Partners in SORP scientific steering committees, working groups and technical committees.

19.4 Work plan

The work plan is discussed under Item 21. The Committee **agrees** that data management and sharing was an important issue to consider. Gales reiterated the importance of work plan item 7.

20. RESEARCH AND WORKSHOP PROPOSALS AND RESULTS

20.1 Review results from previously funded research proposals

Research results from previously funded proposals are dealt with under the relevant agenda items.

20.2 Review proposals for 2012/13

No unsolicited research proposals were received this year. Proposals for the voluntary fund for small cetaceans were discussed under Item 14.3 and those relating to SORP are discussed under Item 19.

Table 11 lists the proposed intersessional meetings and Workshops. Financial implications and further details are dealt with under Item 23.

21. COMMITTEE PRIORITIES AND INITIAL AGENDA FOR THE 2013 MEETING

As in recent years and with the Scientific Committee's agreement, the Convenors met after the close of the Committee meeting and finalised the following basis for an initial agenda for the 2013 meeting. The same criteria as previous years were taken into account and this was based on the recommended work plans developed by sub-committees and the general discussion of these within the Committee. The Committee **recognises** that it is the Commission who establishes the Committee's overall priorities. Thus priorities may have to be reviewed in light of decisions made by the Commission. Items of lower priority on sub-committee agendas will only be discussed if time allows. Therefore, the Committee **stresses** that papers considering anything other than priority topics will not be addressed at next year's meeting. This information will be included on the website when the information about document submission is published next year. Convenors will receive timely information on the titles of papers intended for the discussion within their groups, and may contact authors if they believe the papers are unlikely to be discussed.

Revised Management Procedure (RMP)

The following issues are high priority topics:

(1) review new information on western North Pacific Bryde's whales;
(2) conduct an *Implementation Review* for North Atlantic fin whales starting during a pre-meeting before SC/65 and continuing during the 2013 Annual Meeting;
(3) prepare for the 2014 *Implementation Review* for the North Atlantic minke whales; and
(4) review information available for North Atlantic sei whales in the context of a *pre-Implementation assessment.*

Western North Pacific common minke whales (NPM)

Complete *Implementation Review* (including hold inter-sessional Workshop).

Bycatch and other human induced mortality (BC)

The focus of the group will remain in estimating mortality due to bycatch and ship strikes. The work plan will include:

Table 11

Proposed Workshops for the intersessional period.

Subject	Agenda item	Venue	Dates
Review of MSYR Workshop and WNP common minke whale Second Intersessional Workshop	5.1; 6.6	La Jolla, CA, USA	Late Feb.-Apr. 2013
AWMP Greenland hunt *SLA* development	8.3	Copenhagen, Denmark	3 days within 12-18 Dec. 2012
Planning for the 2013 IWC-POWER cruise	10.8.1.3	Tokyo, Japan	25-27 Oct. 2012
Workshop on Arctic anthropogenic impacts on cetaceans	12.5.3	Anchorage, Alaska	Late Feb.-Mar. 2013
Workshop on assessing the impacts of marine debris	12.7	Korea (SC meeting venue)	4 day pre-meeting; mid-May-mid Jun 2013
'Marine bushmeat' Workshop	14.6	Korea (SC meeting venue)	2 day pre-meeting; mid-May-mid Jun. 2013
Icelandic Special Permit expert panel review Workshop	17.1.3	Reykjavík, Iceland	Feb.-Mar. 2013

(1) reviewing progress in including information in online National Progress Reports;
(2) estimating risk and rates of bycatch and entanglement;
(3) development of methods to estimate mortality from ship strikes;
(4) continuing development and use of the international database of ship strikes; and
(5) review of information on other sources of mortality.

Special Permits
(1) Review results of the expert Workshop on the Icelandic special permit programme;
(2) plan for expert Workshop on JARPA II; and
(3) review new and existing proposals as appropriate.

Bowhead, right and gray whales (BRG)
High priority items will include:
(1) perform the annual review of catch information and new scientific information for B-C-B stock of bowhead whales and eastern gray whales;
(2) review any new information on all stocks of right whales, especially results of assessments for southern right whales;
(3) review North Pacific gray whale stock structure and movement; and
(4) review any other new information on western and eastern North Pacific gray whales and other stocks of bowhead whales.

Environmental concerns (E)
(1) Receive the SOCER (focus: Atlantic Ocean);
(2) pollution issues;
(3) Cetacean Resurging and Emerging Diseases (CERD);
(4) impacts of anthropogenic sound;
(5) climate change issues;
(6) marine debris and cetaceans (including report from the marine debris Workshop);
(7) other habitat-related issues:
MREDs;
cumulative impacts; and
(8) unusual mortality events including Peru.

Ecosystem modelling (EM)
(1) Modelling of the direct relationship between baleen whale populations and the abundance of their prey; and
(2) coordination with CCAMLR's Ecosystem Monitoring and Management Programme will also be sought on its efforts to advance krill-predator models.

Aboriginal Subsistence Whaling Management Procedure (AWMP)
(1) Highest priority will be to work towards the development of long-term *SLA*s for the Greenland hunts:
   (a) develop trial structures and operating models for the Greenland hunts of bowhead and humpback whales to be presented initially at an intersessional Workshop;
   (b) develop an AWMP/RMP-lite program to assist developers of *SLA*s for the Greenland hunts of fin and common minke whales; and
   (c) review a full scientific paper on the work in Greenland related to the collection of information on conversion factors;
(2) present *Evaluation* and *Robustness Trial* results to the SWG of an *SLA* variant that corresponds exactly to the management plan proposed by the Makah Tribe to the US Government;
(3) review a revised document on the probability of a gray whale that regularly feeds in the western North Pacific being taken in a Makah hunt; and
(4) review a document that provides advice on the development of *SLA*s and their evaluation.

In-depth assessment (IA)
High priority will be given to:
(1) the development and application of the SCAA models to the agreed estimates and the most recent aging data;
(2) further work examining reasons for the differences between estimates from CPII and CPIII; and
(3) further development of the IWC simulated datasets, specifically to:
   (a) provide a testing framework for hazard probability models for internally-estimated cue rates from Antarctic minke whale schools; and
   (b) provide one realistic scenario for testing variance estimation.

Now that minke whale abundance estimates had been agreed, the main remaining issues are listed as follows:

(4) modify the Hazard Probability model to cope better with real diving patterns;
(5) improve remaining misfits, for example, to the way that the simultaneous/delayed duplicate fit changes with school size (linked to item 4 above); and
(6) embed refined Hazard Probability models into a spatial framework.

Lower priority items are:

(7) data management:
   (a) further validation of IDCR/SOWER data;
   (b) curation of experimental IDCR/SOWER data;
   (c) production of standard datasets for analyses of species other than Antarctic minke whales; and
(8) review of abundance estimation data collected during CPII and CPIII; their utility for estimating abundance of Antarctic minke whales; and review of data insights.

Southern Ocean Research Partnership (SORP)
Work plan items include:
(1) establishment of ABWP management structure and Committee;
(2) establishment of intersessional technical committees for methodological development;
(3) refinement of the ABWP survey plan for the 2013 ABW voyage(s);
(4) development of uniform sampling protocols for ABW sampling and voyage(s);
(5) continuation of five ongoing SORP research projects;
(6) planning and implementation of an intersessional SORP conference prior to the next annual meeting; and
(7) intersessional development of a paper on data management and legacy.

22. DATA PROCESSING AND COMPUTING NEEDS FOR 2012/13

The Committee agrees the requests for intersessional work by the Secretariat given in Table 12.

23. FUNDING REQUIREMENTS FOR 2012/13

Table 13 summarises the complete list of recommendations for funding made by the Committee. The total required to meet its preferred budget is £327,000. The Committee recommends all of these proposed expenditures to the Commission.

Table 12

Computing tasks/needs for 2012/13.

RMP – PREPARATIONS FOR *IMPLEMENTATION*

(1) Work with the Norwegian Computing Centre to modify the Norwegian CatchLimit program so that only standard FORTRAN-95 statements are used (Annex D, item 2.4).

(2) Work to specify and run additional trials for testing amendments to the *CLA* (Annex D, item 2.2).

(3) Work related to the *Implementation Review* for North Atlantic fin whales (Annex D, item 3.2)

(4) Run a full set of trials using the Norwegian 'CatchLimit' program for North Atlantic fin whales, western North Pacific Bryde's whales; and North Atlantic minke whales and place the results on the IWC website (carried over from last year).

NPM

Complete conditioning of the North Pacific minke whale trials and run a full set of trials (Annex D1).

AWMP

Work arising from the proposed workshop (see Annex E, item 4).

IN-DEPTH ASSESSMENT

Prepare a catch series for North Pacific sei whales including incorporation of additional information from Japanese log book records and a new analysis of Soviet North Pacific catch records (see Annex G, item 7).

Validation of the 2011 POWER cruise data (see Annex G, item 8).

Complete validation of the 1995-97 blue whale cruise data and incorporate into the DESS database.

WHALE STOCKS

Documentation of the catch data available for Antarctic minke whales in preparation for the *pre-Implementation assessment* (see item 10.1, carried over from last year).

However, it understands that the projected amount available for funding is about £315,000. Following some initial suggestions produced by the Convenors group, the Committee therefore carefully reviewed the proposed full list, taking into account its work plan, priorities and the possibility that some of the work requiring funding could be postponed to a future year or years. Such considerations are difficult and the Committee **stresses** that projects for which it has had to suggest reduced funding are still important and valuable. Should the Commission be unable to fund the full list of items in Table 13 the Committee agrees that the final column given in the table represents a budget that will allow progress to be made by its sub-groups in its priority topics. Progress will not be possible in some important areas, as outlined below and the Committee **strongly request** that the Commission or individual member governments provide additional funding in these areas. The Committee **strongly recommends** that the Commission accepts its reduced budget of £315,000.

A summary of each of the items is given below, by sub-committee or standing Working Group. Full details can be found under relevant Agenda Items and Annexes as given in Table 13.

Aboriginal Whaling Management Procedure (AWMP)

(1) DEVELOPMENT OF AN OPERATING MODEL FOR WEST GREENLAND HUMPBACK AND BOWHEAD WHALES

The Committee developed interim *Strike Limit Algorithms* (*SLA*s) for the minke, fin, humpback and bowhead whales off West Greenland. These *SLA*s need to be reviewed and perhaps revised, ideally by the 2017 Annual Meeting. Development of *SLA*s for the hunts of minke and fin whales can be coordinated with the *Implementation Reviews* for these whales which are being conducted by the RMP sub-committee. In contrast, the situations for humpback and bowhead whales are relatively straightforward (essentially single-stock situations), but without a fully-specified and coded operating model progress on these cases will be limited. The first step in the process of developing *SLA*s is constructing an operating model and associated trials, and this project aims to make sufficient progress that an AWMP Workshop (in late 2012) could finalise trials and initiate testing.

The key activities covered by the proposal:

(1) extend the single-stock gray whale trials so that trials can be conducted for humpback and bowhead whales;

(2) outline a set of *Evaluation* and *Robustness Trials* which could form the basis for the evaluation of *SLA*s for these two groups of whales;

(3) present the trial specifications and results for: (a) the interim *SLA*s; and (b) an alternative *SLA* at an intersessional AWMP Workshop; and

(4) develop an AWMP/RMP-lite to assist developers of *SLA*s for the cases of fin whales and common minke whales.

(2) WORKSHOP ON DEVELOPMENT OF *SLA*S FOR GREENLANDIC HUNTS

The existing interim safe procedure for the Greenlandic hunts agreed in 2008 (IWC, 2009c) was agreed to be valid for quota blocks up to 2018. The Committee has identified completion of the development of long-term *SLA*s for these hunts as high priority work. With the completion of the B-C-B bowhead and gray whale *Implementations* this year, the SWG on the AWMP will give highest priority to the Greenland work, particularly for the complex cases of common minke whales and fin whales. In addition to the proposal for work by Punt (Annex E, Appendix 6), to meet the proposed timeframe an intersessional Workshop is required. The objectives of the Workshop are to: (1) review the work undertaken by Punt to develop proposed operating models and trial structures for the relatively easy cases of the bowhead and humpback whale hunts with a view to finalising these at the 2013 Annual Meeting; and (2) review the work undertaken by Punt to develop simple (AWMP/RMP-lite programs) to facilitate initial work on developing potential *SLA*s to allow the development of *SLA*s for West Greenland fin and common minke whales in light of the current operating models used in RMP *Implementations*. The Workshop will be held in winter 2013 for four days in Copenhagen, Denmark and the costs are for IP travel.

(3) AWMP DEVELOPERS FUNDS

The developers fund has been invaluable in the work of *SLA* development and related essential tasks of the SWG. It has been agreed as a standing fund by the Commission. The primary development tasks facing the SWG are for the Greenlandic fisheries. As noted above these tasks are of high priority to the Committee and the Commission. The fund

Table 13

Budget requests (see text). Note that in addition, the budget request for SORP is given in Table 10.

	Title	Agenda Item	Full (£)	Reduced (£)
(1)	Development of an operating model for West Greenland humpback and bowhead whales	8. AWMP	5,000	5,000
(2)	Workshop on development of *SLA*s for Greenlandic hunts	8. AWMP	8,000	8,000
(3)	AWMP developers funds	8. AWMP	3,000	3,000
(4)	Ship strike database coordinator	7.8 Ship strikes	10,000	8,000
(5)	Right whale survey off of South Africa	10.5 SH right whales	21,730	21,730
(6)	Genomic diversity and phylogenetic relationships among right whales	10.6 N Pacific right whales	7,000	0
(7)	Photographic matching of gray whales	9.2 E Pacific gray whales	9,000	9,000
(8)	Contribution to the preparation of the State of the Cetacean Environment Report (SOCER)	12.1 SOCER	3,000	3,000
(9)	Pre-meeting Workshop on assessing the impacts of marine debris	12.8 Habitat related issues	20,500	20,500
(10)	Develop simulation of Southern Hemisphere minke line transect data	10.1 Antarctic minke whales	9,000	5,000
(11)	IWC-POWER cruise	10.8.1 IWC-POWER cruise	60,754	60,754
(12)	Preparation for the application of the statistical catch-at-age assessment method for Southern Hemisphere minke whales	10.1 Antarctic minke whales	4,000	4,000
(13)	'Second' intersessional workshop on the *Implementation Review* for WNP common minke whales	6.3 N Pacific common minke whale *Implementation Review*	20,000	18,500
(14)	Essential computing for RMP/NPM and AWMP	22. Data processing and computing needs	25,000	25,000
(15)	MSYR review Workshop	5.1 MSY rates review	5,000	5,000
(16)	Review and guidelines for model-based and design-based line transect abundance estimates	5.7 Abundance estimates	5,000	5,000
(17)	Modelling of Southern Hemisphere humpback whale populations	10.2 SH humpback whales	3,000	3,000
(18)	Antarctic humpback whale catalogue	10.1 Antarctic minke whales	15,000	13,000
(19)	Photo matching of Antarctic blue whales	10.3 SH blue whales	3,000	3,000
(20)	Southern Hemisphere blue whale catalogue 2012/13	10.3 SH blue whales	3,000	3,000
(21)	Expert Workshop for final review of Iceland's Special Permit programme on common minke whales	17.1 Review of existing scientific permits	30,000	24,000
(22)	Whalewatching guidelines and operator training in Oman	10.7 Arabian Sea humpback whales	3,500	3,500
(23)	Invited Participants (IPs) funds	All	64,000	64,000
Total			337,484	314,984

is essential to allow progress to be made. It now stands at £12,000 and a request of £3,000 is made to restore it to the initial target level of £15,000.

Bycatch and other human-induced mortality

(4) SHIP STRIKE DATABASE COORDINATOR

The ongoing development of the IWC ship strike database requires data gathering, communication with potential data providers and data management. The Working Group on Bycatch and Other Human Induced Mortality recommended a part-time post initially for three months a year to undertake the tasks described in Annex J. This includes:

(1) identify national contact points, organisations or groups that hold data on ship strikes that have not been contributed to the database and facilitate and encourage contributing data to IWC database;
(2) monitor and respond to emails addressed to the *shipstrikes@iwcoffice.org* email address, including reports of new incidents, giving feedback to data providers and dealing with requests for summary information from the database;
(3) keep IWC ship strike website pages up to date including updating publicly available summaries from the database;
(4) develop and document a communication strategy;
(5) provide an annual update to the Scientific Committee;
(6) data entry of new records including data presented in meeting papers and National Progress Reports at Annual Meetings of Scientific Committee;
(7) work with the data review group to ensure that all new records are appropriately reviewed including identification of potential duplicate reports;
(8) further development of database handbook including criteria for determining whether ship strike was a cause of death;
(9) ensure database documentation remains up to date; and
(10) maintain database and data entry system, making adjustments as appropriate in response to user problems and suggestions.

Bowhead, right and gray whales

(5) RIGHT WHALE SURVEY OFF SOUTH AFRICA

The southern right whale population visiting the South African coastline (arguably the largest in the Southern Hemisphere) has been monitored annually by aerial surveys since 1971 and since 1979 by a photo-ID survey. The results have been presented to several meetings of the Scientific Committee, such as the Buenos Aires Workshop in September 2011, where four papers were presented (Best, 2011; Brandão *et al.*, 2011; Butterworth *et al.*, 2011; Roux *et al.*, 2011). Since its inception the photo-ID surveys have concentrated on adult females with calves: the catalogue (at 2010) stands at 1,217 adult females, of which resighting rates average 70% annually, leading to very precise estimates of population size and growth rate, adult survival rate, age at first parturition and juvenile female survival rate. The application of an individual-based model has now allowed estimation of the probability of females calving at various intervals (SC/64/BRG24), which can be correlated in turn with the occurrence of oceanographic anomalies to determine the influence of environmental variation on reproductive success. The project has been funded domestically almost since its inception and has just completed a 3-year funding cycle. Unfortunately an application to the South African National Antarctic Programme for renewed funding was rejected as being geographically inappropriate, so interim funding is being sought to enable the 2012 survey to take place while an application is made for a new cycle commencing in 2013. The survey is scheduled to take place in mid-October. All images should be matched by 1 April 2013 and results ready for the 2013 Scientific Committee meeting.

(6) GENOMIC DIVERSITY AND PHYLOGENETIC RELATIONSHIPS AMONG RIGHT WHALES

The investigators request supplemental funding, as described in SC/64/BRG15, to do the following:

(1) assess genetic diversity and estimate N_{min} within the central North Pacific right whale population, represented by 27 individuals (including three from Russia), using complete mitochondrial genomes and sequence from 23 nuclear loci;
(2) compare mtDNA diversity in eastern North Pacific right whales with other oceanic populations based on complete mitochondrial genomes (16,386 base pairs), rather than the limited resolution currently based on control region sequences (286 base pairs); and
(3) confirm reciprocal monophyly and phylogenetic relationships among right whale species using sequence from complete mitochondrial genomes and 23 nuclear loci.

The primary funding for this project, provided by the Pacific Life Foundation, has support the development of the primary datasets but this funding is now exhausted. This proposal seeks supplemental support for two months for a postdoctoral fellow to complete analysis of the primary dataset and estimation of N_{min} for the central population of the North Pacific right whale.

(7) PHOTOGRAPHIC MATCHING OF GRAY WHALES

Results regarding mixing of western (WNP) and eastern (ENP) gray whales illustrate the great conservation and management importance of a more comprehensive examination of gray whale movement patterns and population structure in the North Pacific. The Committee noted that for such an effort to be successful it must be international and collaborative. To facilitate this, and noting the existing safeguards for collaborators provided under the Committee's Data Availability Agreement, it recommended that a collaborative Pacific-wide study be developed under the auspices of the IWC, recognising that *inter alia* this will contribute to the Committee-endorsed Conservation Plan for Western North Pacific Gray Whales and incorporate previous recommendations made by the Committee. Such a study should involve collaborative analysis and sharing of existing data as well as the collection of new data (IWC, 2011f). This is the second year of the project. The report of the results of the first year was presented in the document SC/64/BRG13. The funds requested for this year are to match gray whale photographs to photographs from Sakhalin and Kamchatka.

Environmental concerns

(8) CONTRIBUTION TO THE PREPARATION OF THE STATE OF THE CETACEAN ENVIRONMENT REPORT (SOCER)

SOCER is a long-standing effort to provide information to Commissioners and Scientific Committee members on environmental matters that affect cetaceans in response to several Commission Resolutions. The focus for 2012 will be on the Indian Ocean. Funds are for salaries, library services and printing.

(9) PRE-MEETING WORKSHOP ON ASSESSING THE IMPACTS OF MARINE DEBRIS

In 2011, the IWC agreed to: (1) endorse the Honolulu Commitment; (2) establish a standing item on marine debris on the Conservation Committee agenda; and (3) request the Scientific Committee continue reviewing potential threats to cetaceans arising from marine debris. It is proposed that a Workshop be held on marine debris and cetaceans where the primary aim is to develop tools that allow quantification of whether or how marine debris is affecting cetaceans and how best to monitor and mitigate for these effects.

The objectives of the Workshop are to:

(1) better understand the effects of debris interactions at an individual and population level;
(2) identify and classify key types and sources of debris that contribute to entanglements, or are ingested by cetaceans and examine the mechanisms by which they arrive in the marine environment, with the goal of identifying possible mitigation measures;
(3) design and develop a centralised database to collate cases of debris interactions to obtain more accurate estimates of the incidence of mortality and injuries, help detect trends over time and identify hotspots; and
(4) contribute towards a quantitative assessment of the extent of the threats for cetaceans.

The report of the Workshop will, in addition to providing the analyses, review and recommendations listed under item 2 above, develop: (1) a series of research and conservation actions that will include a rationale, actions required and proposed responsible persons/groups; and (2) a two-year work plan to be considered. The report will be submitted to the IWC and made publicly available on the website. It is proposed to publish the results of the Workshop in a peer-reviewed journal. Funds are to assist some of the expected 20 participants for a four-day pre-meeting held before the 2013 Scientific Committee meeting.

In-depth assessments

(10) DEVELOP SIMULATION OF ANTARCTIC MINKE WHALE LINE TRANSECT DATA

This year an abundance estimate for Antarctic minke whales had been agreed upon. As discussed this estimate had to use externally-estimated cue rates from a small sample of Antarctic minke whales, though an internally estimated cue rate would be preferred to estimate a more accurate and perhaps precise estimate. However, additional methodological development is needed to achieve this. To test these newly developed methods, it was proposed to use simulated line transect data where the true abundance estimate is known to validate the new methods are working correctly. These funds are proposed to further develop the IWC simulated datasets to: (a) provide a testing framework for hazard probability models for internally-estimated cue rates from Antarctic minke whales schools; and (b) provide a realistic scenario to test variance estimation methods.

(11) IWC-POWER CRUISE

The Committee has strongly advocated the development of an international medium- to long-term research programme involving sighting surveys to provide information for assessment, conservation and management of cetaceans in the North Pacific, including areas that have not been surveyed for decades. The finalisation for the integrated mid-long-term program (IWC-POWER; the Pacific Ocean Whales and Ecosystem Research programme) that will provide information on stock structure, abundance and ultimately trends has been completed. The focus of the 2013 cruise is defined as the area bounded by longitudes 135°W and 160°W, and latitudes 30°N and 40°N. Line transect sightings, abundance data collection, biopsy sampling, and photo-ID of cetaceans is planned. The cruise will last approximately 60 days between July and August 2013. By far the most important component of the cost, the provision of a research vessel, crew and fuel (up to US$1m) and that is generously being provided by Japan. The IWC funding will provide for international researchers, equipment and a meeting to finalise the details of the 2013 cruise.

(12) PREPARATION FOR THE APPLICATION OF THE STATISTICAL CATCH-AT-AGE ASSESSMENT METHOD FOR ANTARCTIC MINKE WHALES

This year the Committee received a full description of the statistical catch-at-age (SCAA) developed by Polacheck and Punt, along with initial suggestions for a baseline analysis and sensitivity tests (SC/64/IA1). This approach allows for errors in CAA data, more than a single stock, time-varying growth, multiple areas, environmental covariates, fleet-specific vulnerabilities, and changes over time in vulnerability. The SCAA can be used to evaluate various hypotheses regarding the reason (or reasons) for the change in abundance estimates from CPII to CPIII, as well as other questions regarding the dynamics of the Antarctic minke whale, such as whether growth and carrying capacity have changed. This proposal is to obtain the latest datasets and update the outputs and reference models to conduct baseline and key sensitivities. A final report will be presented to the 2013 Annual Meeting and the final code, data sets and documentation will be lodged with the Secretariat.

North Pacific minke whales

(13) 'SECOND' INTERSESSIONAL WORKSHOP ON THE *IMPLEMENTATION REVIEW* FOR WESTERN NORTH PACIFIC COMMON MINKE WHALES

The *Implementation Review* for western North Pacific minke whales is more complex than any previous *Implementation*. The Committee is one year behind the normal Schedule for *Implementations*. The Committee is not ready to undertake the tasks allocated to the 'second' intersessional Workshop according to its guidelines (IWC, 2012h). The priority tasks are to run and evaluate all trials in accordance with guidelines and present the results at the 2013 Annual Meeting to enable the Committee to complete its review in 2013.

Revised Management Procedure

(14) ESSENTIAL COMPUTING FOR RMP/NPM AND AWMP

The approach used to evaluate RMP variants during *Implementations* as well as candidate *SLA*s involves two main steps: (1) specification and conditioning of trials; and (2) projecting simulated populations forward under alternative RMP variants/*SLA*s. The complexity of the operating models on which simulation evaluations are conducted has increased in recent years. Unfortunately, the relatively simple optimisation methods included in current control programs (which was more than adequate in the past), combined with a complicated objective function, has led to problems producing conditioned trials quickly. This proposal will provide the Secretariat with the essential support required to complete this issue during the intersessional period. It will also continue the arrangement of recent years by which essential support is provide to the Secretariat, particularly in the key area of estimating stock mixing proportions in input to the trials, both intersessionally, and during meetings. Without this support it will be impossible for the Committee to undertake its present work on RMP *Implementations* and development of *SLA*s.

(15) MSYR REVIEW WORKSHOP

Since 2007 the Committee has been discussing maximum sustainable yield rate (MSYR) in the context of a general review of the plausible range to be used in population models used for testing the *Catch Limit Algorithm* (*CLA*) of the RMP. The Committee has agreed that it will finish work on this topic in 2013 whether or not the review can be completed. It has developed a work plan to try to ensure completion of the review. As part of this it is essential that a three-day intersessional meeting be held, with at least five participants, ideally back-to-back with another intersessional meeting, thus reducing overall costs of this Workshop.

All sub-groups using abundance estimates

(16) REVIEW AND GUIDELINES FOR MODEL-BASED AND DESIGN-BASED LINE TRANSECT ABUNDANCE ESTIMATES

The RMP's 'Requirements and Guidelines for Conducting Surveys' (IWC, 2012x) were written when the only realistic paradigm for planning and analysing good sighting surveys was the design-based approach. However, there is now potentially a legitimate alternative to design-based estimates; model-based estimates using spatial modeling (smoothers), which unlike design-based approaches, also give some basis for limited spatial extrapolation. In addition, many surveys resemble design-based surveys but do not strictly meet the design-based criterion, and in such cases there is a question regarding the adequacy of design-based estimates. The Committee has frequently considered model-based and quasi-design-based estimates, but without explicit criteria and not necessarily in the context of the RMP. This proposal will: (1) review statistical aspects of design-based estimators for surveys which do not strictly adhere to design-based principles; and (2) review past and current issues related to model-based abundance estimators, drawing on examples from experience with these types of models. Empirical and simulation-based diagnostics will be suggested, and a quantitative description of pitfalls when extrapolating estimates beyond the surveyed area will be given. The intended outcome of the project is: (1) propose a basis to assess the reliability of an abundance estimate either from a design-based analysis for which the statistical criteria are not met, or from a model-based analysis; and (2) provide draft text for inclusion in the 'Requirements and Guidelines for Conducting Surveys' document. The work will be presented to the 2013 Annual Meeting and the request is for salary to complete this project.

Other Southern Hemisphere whale stocks

(17) MODELING OF SOUTHERN HEMISPHERE HUMPBACK WHALE POPULATIONS

The project will focus on a combined assessment of Southern Hemisphere humpback breeding stocks D, E and Oceania using the model proposed at this year's meeting, SC/64. Methods used will be based upon the Bayesian methodology as developed and presented for breeding stock C and breeding stock B comprehensive assessments recently completed. Initial results will utilise the data agreed at SC/64, and results will be presented at the 2013 Annual Meeting. Further model developments and refinements in association with the final set of agreed data (and their sensitivities) would be presented at the 2014 Annual Meeting should the Scientific Committee decide to so request.

(18) ANTARCTIC HUMPBACK WHALE CATALOGUE

The Antarctic Humpback Whale Catalogue collates photo-ID information from Southern Hemisphere humpback whales. Increasing awareness of the project among research organisations, tour operators and other potential contributors has widened the scope of the collection; research efforts in areas that had not previously been sampled have extended the geographic coverage. This catalogue has grown by 25% in the last two years, adding 1,127 new individuals and increasing the time required to analyse photographs. In addition to these requested IWC funds will also be sought from other sources to provide the remaining funds required. Additional resources are provided by College of the Atlantic, including equipment, student assistants and time donated by principal investigators of this proposal. As a result this catalogue is in an excellent position to make a substantial contribution to SORP and other research and management initiatives.

(19) PHOTO MATCHING OF ANTARCTIC BLUE WHALES

The goal of this project is to compare the existing IWC-SOWER Antarctic blue whale catalogue (about 160 individuals) and the existing photo-ID material collected from JARPA which are already digitised. This project may add new individuals to the Antarctic blue whale catalogue and provide new data on the movements of Antarctic blue whales both within and between years. The Committee has requested for several years that this work be undertaken.

(20) SOUTHERN HEMISPHERE BLUE WHALE CATALOGUE 2012/13

The Southern Hemisphere Blue Whale Catalogue is an international collaborative effort to facilitate cross-regional comparison of blue whale photo-ID catalogues. Results of comparisons among different regions in Southern Hemisphere will improve the understanding of basic questions relating to blue whale populations in the Southern Hemisphere such as defining population boundaries, migratory routes and model abundance estimates. In 2008, the Committee endorsed a proposal to establish a central web-based catalogue of blue whale identification photographs, known as the Southern Hemisphere Blue Whale Catalogue (IWC, 2008e).

Currently this catalogue holds photo-ID catalogues of researchers from major areas off Antarctica, Australia, eastern South Pacific and the eastern Tropical Pacific (IWC, 2011i). Comparisons among catalogues off Chile found one match over ten years (Vernazzani and Cabrera, 2011). Preliminary results of the 2011/12 catalogue comparisons between the eastern South Pacific Ocean, Eastern Tropical Pacific Ocean (ETP) and Southern Ocean found no matches (SC/64/SH20).

During 2012/13 it is expected that comparisons between Australian catalogues and with the ETP, southeast Pacific and Antarctica will be finalised. Results of these comparisons will be presented to the 2013 Annual Meeting.

Special Permits

(21) EXPERT WORKSHOP FOR FINAL REVIEW OF ICELAND'S SPECIAL PERMIT PROGRAMME ON COMMON MINKE WHALES

Activities under Article VIII of the Convention should be reported to the Committee for review. The Committee has agreed a procedure for periodic and final reviews of results from Special Permit research (IWC, 2009i). This procedure outlines an intersessional review meeting by an expert panel. The report from the intersessional expert meeting will be reviewed and discussed at the 2013 Annual Meeting, SC/65. The Icelandic Special Permit progamme on common minke whales is complete and thus is subject to a review by an expert panel during the 2012/13 intersessional period. The experts to the review Workshop will be identified by September 2012 and the expert Workshop will be convened during four days in February/March 2013. The requested funds are for travel for the invited experts.

Whalewatching

(22) WHALEWATCHING GUIDELINES AND OPERATOR TRAINING IN OMAN

Oman's whalewatching industry has experienced gradual growth over the last 10 years reflecting a steady increase in tourism in the country and a growing awareness of the rich and accessible cetacean fauna, especially around the capital city of Muscat. Currently, dolphins are the main target of the industry, whilst sperm whales and other large whales are increasingly sighted as operators become more knowledgeable of their presence and distribution. The Arabian Sea humpback whale has recently become a target of opportunistic whale watching by a SCUBA dive operator in southern Oman. The precarious status of this species, represented by a resident and discreet sub-population numbering fewer than 100 individuals, and the identification of escalating anthropogenic impacts and threats has led to expression of serious concern by the IWC and recommendation for the development of a Conservation Management Plan (work in progress). Unregulated whale-watching represents another potential threat to Arabian Sea humpback whales.

Most operators are currently unaware of (unofficial) guidelines for whalewatching in Oman. Recognising the need to complete the drafting of new guidelines for Oman with appropriate technical assistance, and to train operators to enable interpretation and implementation of guidelines, this proposal includes a request for funding to complete the revision of whalewatching guidelines in Oman and to hold a training workshop for operators on the interpretation and implementation of the guidelines to promote best practice in the industry. Travel for relevant experts to Oman has already been secured and expert and other participant time will be donated and/or covered by other on-going projects.

All groups

(23) INVITED PARTICIPANTS (IPS) FUND

The Committee **draws attention** to the essential contribution made to its work by the funded IPs. The IWC-funded IPs play an essential role in the Committee's work, including the critically important role of Chairs and rapporteurs. They represent excellent value as they receive only travel and subsistence costs and thus donate their time, which is considerable. As was the case for previous meetings, where possible, effort will be made to accommodate scientists from developing countries.

24. WORKING METHODS OF THE COMMITTEE

24.1 Reducing the costs of Committee meetings

In 2011 the Commission asked the Secretariat to continue exploring opportunities for cost savings. One source of cost savings is to reduce freight charges and increase use of electronic documents at Annual Meetings of the Scientific Committee and Commission. A review of expenditures in 2011 indicated the costs of maintaining a paper based infrastructure for the meetings was around 5% of the IWC core budget. Particular costs arise because of packing and air freight of the pigeonholes and pre-prepared documents which are both heavy and bulky and also the hire of high volume copiers which are usually dramatically more expensive than low volume copiers.

The Committee discussed the advantages and dis-advantages of moving to electronic distribution of primary papers, working papers and reports. If there was to be electronic distribution of paper, then the memory sticks with the primary documents will need to still be available in a timely manner. Members would be encouraged to submit meeting papers as soon as possible to allow other members to make their own copies at home before the meeting. There would also need to be a number of modern desktop laser printers available to members and especially a local high bandwidth secure wi-fi network and document server that would be available to only the Committee members and so would be independent to local internet access and thus be robust to local IT issues.

After much discussion, the Committee **agrees** that primary documents should be distributed wholly electronically both on the IWC website and on memory sticks. In contrast, the Committee **agrees** that draft and final reports of sub-groups and plenary should be distributed by paper to ensure these reports are properly edited. The Committee also **agrees** that working papers should, at least for a trial period, be distributed mostly by paper, with the option of some working papers, particularly very long ones, be distributed mostly electronically. To reduce freight costs of the pigeonholes, the Committee suggests the Secretariat consider having pigeonholes for sub-groups as a means to distribute working papers rather than having personal pigeonholes.

24.2 Clarifying information on data availability for Procedure B requests

The present description of the process for obtaining data for issues that fit under Procedure B is described in the Data Availability Agreement (DAA; IWC, 2004c). SC/64/SCP1 described a recent incident where it became evident that the DAA process needed additional clarification. The Committee notes that the DAA process has generally worked well and especially so when the Committee has been able to properly specify the data request during the Committee meeting. Procedure B is designed for cases where the Committee itself believes that particular analyses (whether completely new analyses or revised analyses) are important in providing advice to the Commission. In such cases, it is important that the Committee takes the necessary time to complete and explicitly including the following within the report: objectives of the data request; details of the data required addressing the objectives; broad overview of the methods; and the principal investigators recommended by the Committee. With such report text, the Data Availability Group (DAG) can then complete and endorse a DAA request following the appropriate protocol in a timely manner. This would have, for example, removed the ambiguity that arose out of interpretation of the recommendation made last year on the blubber thickness analysis (IWC, 2012n).

As the requests under Procedure B relate to Committee recommendations, it also seems appropriate that all correspondences between researchers and data holders are channelled through the DAG until a request has been granted. It should also be emphasised that DAG involvement in data requests applies only to requests based on recommendations by the Committee. Requests by individual scientists should occur at the bilateral level without DAG involvement.

In addition, there appears to have been some uncertainty over what is meant by collaboration and offers of co-authorship under the DAA. This has also been considered under Item 17, Special Permit reviews and 'Annex P'.

The Committee has always encouraged collaboration in all research projects. In the context of Annex P this was clarified in a footnote. For a more formal clarification, the Committee recommends an additional point be added to the DAA Procedure B text as follows, where the text under Item 2 is new:

Procedure B

This applies to data required for analyses deemed important in providing advice to the Committee other than catch limits (e.g. on the status of stocks not subject to whaling). For data not subject to Procedure A, the data owners shall produce, in collaboration with the Committee, a published protocol for data access that applies to requests generated by the Committee, to ensure clarity and a mutual understanding of the process.

(1) The Committee shall specify the nature of the work and the data required during the meeting at which the recommendation is made, to the fullest extent possible in the time available at the meeting and in accordance with the published protocol. It should also name the appropriate scientists to undertake the work and designate an appropriate timeline.
(2) The Committee encourages collaboration between the data requestors and data providers, although this is not mandatory. As a minimum, data requestors and providers should discuss the data sufficiently to avoid misinterpretations over the nature of the data themselves. When the data requestors send their draft paper to the data providers in accordance with the timetable, they must provide an offer of co-authorship to them. The data providers may or may not accept this offer. If data requestors and data providers do not agree with the contents of the paper then they may present separate analyses or comments to the Committee. This then allows the Committee to review all analyses. The Committee will then get a balanced single conclusion from the analyses for advice to the Commission. This is in line with the spirit of collaboration the Committee encourages.
(3) Applications to the data owners following the published protocol referred to above, should be submitted by the Data Availability Group assisted by a nominated member of the relevant delegation or institute. The Data Availability Group will consult with relevant members of the Committee if further explanation or clarification is required.
(4) If the above process is followed, then the data owners will normally approve the applications within a specified time period in accordance with the published protocol.
(5) Applications shall only be granted under the conditions given above.

24.3 Updating the Committee's guidelines and Handbook

After discussion last year, the Committee agreed that the Chair of the Scientific Committee should develop a review document for consideration at this year's meeting that discusses whether or not there is a need to expand on the guidelines related to Convenors, in particular with respect to further details about the roles of Convenors and co-Convenors, time frames of service etc., as well as the roles of Heads of Delegation and, if so, to provide proposed text. This review document provided background information that clarified some of these issues and suggested additional text to be considered by the Committee that could be added to the Scientific Committee's Handbook (SC/64/SCP2).

This year the Committee discussed this review document and **recommends** the basic responsibilities of Convenors and co-Convenor's as described in the Handbook did not need changing. However, it **recommends** that the full Committee should receive the list of proposed projects to be funded by the Commission in a timely manner to allow everyone to fully consider the prioritised list. Following this recommendation, the guidelines on the role of Convenors should include a new item 'f' and move the present 'f' to 'g', where the new item 'f' should read:

'To develop with other members of the Convenors' Group a prioritised list for funding that should to be made available to the full Committee at least by 6pm on the penultimate day of the Scientific Committee Annual Meeting.'

Co-Convenors were created three years ago to assist some of the busier sub-groups and provide an opportunity to create a pool of experienced people that could become future Convenors. This concept has worked well, so the Committee recommends the following text on the eligibility of Convenors and co-Convenors be added to the Handbook:

'All Committee members are eligible to become Convenors or co-Convenors. A co-Convenor may be appointed to assist the Convenor of a sub-group, gain experience in chairing and learn Committee procedures. Requirements include appropriate scientific background and/or chairing experience, knowledge of Committee procedures and appropriate communication skills.'

The Committee discussed at length the time frame of Convenors' service. Some members suggested a general, though flexible, time frame could be added to the Committee's guidelines, where this time frame would not a fixed length and would not be mandatory. However, other members considered the existing guidelines were sufficient and have worked effectively in the past and so did not need to be modified. Consequentially no changes to the Committee's guidelines were recommended this year. However, as noted in the existing guidelines, it was agreed that the Chair of the Committee would take carefully into account the length of service when choosing Convenors. If necessary this issue can be revisited in future years.

The roles of Heads of Delegations were also discussed and the Committee agrees that the present guidelines are adequate as provided in the Handbook. The Committee also agrees that the Handbook, when updated, will also be available as a pdf file.

24.4 Assistance to new members on the working of the Committee

In order to assist new members, the Committee recommends that an introductory lecture should be given during the first or second day for new (and indeed any) members that would cover primarily practical issues including: methods of working; background history of the sub-groups; and commonly used acronyms (the latter will also be added to the Handbook). In addition, the Committee **recommends** that all attendees are reminded of the website location of the Scientific Committee's Handbook when registering for the Annual Meeting.

24.5 Other

Galletti noticed that while management recommendations are widely given in some sub-committees, especially when addressing whaling issues, in other sub-committees and/or standing working groups, the attention seems to be more focused on scientific recommendations and only a few conservation recommendations arise. She believed that his was particularly true for small cetaceans, where there have been differences throughout the years. In this sense, the practice of the Scientific Committee should be reviewed and when there is concern over the status of any cetacean species or threats are identified, there should also be a focus on providing conservation recommendations.

Given the limited time available at this meeting, the Committee **agrees** that this matter should be placed on the agenda for discussion at next year's meeting.

25. ELECTION OF OFFICERS

This is the third and last year in the terms of the Committee's Chair (Palka - USA) and Vice-Chair (Kitakado - Japan). Kitakado has agreed to assume the position of Chair of the Scientific Committee at the end of the 2012 Annual Meeting. To fill the vacant Vice-Chair position, the Heads of Delegations were happy to unanimously nominate Caterina Fortuna (Italy). Fortuna accepted the Vice-Chair position. The Committee stood in acclaim to thank Palka for her great contribution to the Committee's work during the past three years and congratulated Kitakado and Fortuna on their new positions.

26. PUBLICATIONS

This had been a difficult year for the *Journal* with staff limited by maternity leave, reduced hours, illness and a change in staff. Despite that the department produced:

(1) the 520 page *Supplement*;
(2) 3 issues of the *Journal* (two are at the printers) with one more almost complete; and
(3) the Special Issue on Southern Hemisphere humpback whales.

Illness to Donovan resulted in less progress than anticipated on the Special Issue devoted to the RMP but the timetable for its publication has been finalised and it should be available in early 2013. Most of the chapters written by Hammond and Donovan are nearing completion and will be ready for formal review in autumn 2012. These include: (1) an introductory guide to the RMP; (2) a history of the scientific approach to whale management within the IWC prior to the RMP development; (3) a history of the RMP development process including the development of various Requirement and Guidelines; (4) a history of the *Implementation* (and *Implementation Review)* process summarising the cases for western North Pacific common minke whales, western North Pacific Bryde's whales, North Atlantic common minke whales, and North Atlantic fin whales; and (5) a concluding overview. In addition, the volume will include the papers from all of the original developers summarising their work in the format determined by Kirkwood. Allison is preparing the appropriate graphs and tables in the new format, including the results of the cross validation trials developed after the *CLA* was adopted.

The special volume commemorating the IDCR/SOWER cruises will be undertaken under an Editorial Board under Bannister as reported elsewhere.

The testing and trial process for the online submission, review and finalisation process has been recently completed and has recently become operational – thanks are due to those members of the Committee who kindly acted as 'guinea pigs' and have helped shape the site and develop the online instructions.

All of the *Journal* volumes are now available as pdf files and the *Journal* will become available in that format either directly via the new IWC website or through an existing company; we are in the process of examining the practical and financial implications of this and will report back to the Committee next year, after consultation via a questionnaire by email. This issue has become particularly important given the difficulties with printers that have occurred over the past two years and the recent news that the Cambridge University Press printing division is likely to be taken over by another company.

The Committee thanked Donovan and his team for the excellent work on publications. It **reiterates the importance** of these to its work as well as providing outside scientists the opportunity to benefit from the Committee's work and to encourage co-operation.

27. OTHER BUSINESS

No other business was discussed.

28. ADOPTION OF REPORT

The report was adopted at 17:00 on 23 June 2012. As is usual final editing was carried out by the Convenors after the meeting. In closing the meeting the Chair thanked the Secretariat for carrying out its duties in its customary friendly and efficient manner, as well as once again thanked the Government of Panama and other Panamanian contributors for their hosting of the meeting and for providing snacks and lunches for us, which greatly enhanced productivity and mental health.

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Annex E

Report of the Standing Working Group on the Aboriginal Whaling Management Procedure (AWMP)

Members: Donovan (Convenor), Allison, Baulch, Bell, Betancourt, Bickham, Brandão, Brandon, Brownell, Butterworth, Castro, Chilvers, Cipriano, de Moor, Deimer-Schüette, Double, Dupont, Elvarsson, Feindt-Herr, Gallego, George, Givens, Gunnlaugsson, Hiruma, Ilyashenko, Iñíguez, Jackson, Jaramillo-Legorreta, Jérémie, Katsuyama, Kelly, Kim, Kitakado, Lang, Lauriano, Leslie, Mate, Moore, New, Palacios, Palka, Palsbøll, Panigada, Punt, Quakenbush, Reeves, Ritter, Robbins, Rodríguez-Fonseca, Roel, Rose, Sakamoto, Scheidat, Scordino, Simmonds, Skaug, Stimmelmayr, Suydam, Tajima, Thomas, Tiedemann, Wade, Walløe, Weller, Witting, Yamada, Yasokawa, Zeh.

1. INTRODUCTORY ITEMS

1.1 Convenor's opening remarks
Donovan welcomed the participants to Panama. He noted that the SWG had a considerable amount of work to do this year, including the completion of two *Implementation Reviews.*

1.2 Election of Chair
Donovan was elected Chair.

1.3 Appointment of rapporteurs
Butterworth, Givens and Punt acted as rapporteurs, with assistance from the Chair.

1.4 Adoption of agenda
The adopted agenda is given in Appendix 1.

1.5 Documents available
The new primary documents available to the SWG were SC/64/AWMP1-15, SC/64/BRG1, SC/64/BRG3, SC/64/BRG9 and SC/64/Rep3.

2. *IMPLEMENTATION REVIEW* OF GRAY WHALES WITH EMPHASIS ON THE PCFG

2.1 Summary of intersessional Workshop
Donovan briefly summarised the key conclusions of the intersessional Workshop held from 19-23 March 2012, kindly hosted by the Southwest Fisheries Science Center in La Jolla, California (SC/64/Rep3). With respect to gray whales, the Workshop focus was to build upon the work of the 2011 Annual Meeting to facilitate the completion of the *Implementation Review* with emphasis on the Pacific Coast Feeding Group (PCFG) at the 2012 Annual Meeting.

The Workshop was pleased to note that the code implementing the control programme and that producing summary statistics had been validated and it thanked Brandão and Punt for their hard work in this regard. A final set of *SLA* variants to be considered in the trials was agreed and these can be found in Appendix 2 of the present report. Considerable effort was put in after the 2011 Annual Meeting and at the Workshop to finalise the trial specifications and complete conditioning of the trials.

The Workshop undertook a thorough review of abundance estimates (Calambokidis *et al.*, 2012) and it agreed a final set of estimates based on the modified Jolly-Seber estimator developed at the 2011 Intersessional Workshop. These are given in Table 1 below. It was agreed that the 1998 estimate which was negatively biased to an appreciable extent for likely values of the detection probability for animals available to the surveys for the first time should be excluded. The Workshop also agreed that the operating model would be fitted to the abundance estimates for the NCA-NBC area (~41-52°N) while the *SLA*s would be based on the abundance estimates for the smaller OR-SVI area (Oregon to SVI ~42-49°N).

Table 1

JS1 abundance estimates (N) and standard errors in OR-SVI and NCA-NBC after exclusion of known calves from the year in which they were identified as calves.

Year	N	SE(N)
Region: OR-SVI		
1998	63	4.1
1999	78	8.4
2000	89	11.9
2001	117	8.9
2002	133	15
2003	151	13.7
2004	157	15.5
2005	162	15.7
2006	154	15.3
2007	152	14.5
2008	150	12.5
2009	146	14.9
2010	143	16.8
Region: NCA-NBC		
1998	101	6.2
1999	135	12
2000	141	13.2
2001	172	12.6
2002	189	9.2
2003	200	16.4
2004	206	14.9
2005	206	22.6
2006	190	18.8
2007	183	23.1
2008	191	16.1
2009	185	23.2
2010	186	18.7

The Workshop also welcomed the results of a simulation-based assessment of plausible levels of external recruitment into the PCFG stock (Lang and Martien, 2012). The generation of simulated datasets followed the steps outlined in TOSSM (IWC, 2007a). A number of suggestions were made for additional work and a revised paper for the 2012 Annual Meeting is discussed under Item 2.2 below. In addition, the Workshop strongly supported continued collection of genetic samples, particularly throughout the range of the northern stock.

In reviewing the intersessional results, a number of agreements were reached for modifications including:

(1) adult survival should be constrained to be <0.99 in future trials;
(2) the upper limit on maximum pregnancy rate of 0.6 should be retained;
(3) correction of an error in the previous trial specifications;
(4) incorporation of emigration as well as immigration in the trials; and
(5) incorporation of a revised value (0.3) of the proportion of whales classified as PCFG whales in the November-May period.

The Workshop also reviewed the requirements for graphical and tabular summaries to review results. These are not repeated here, but the agreed list can be seen in Appendix 2. The Workshop finalised the list of factors to be considered in the trials and these are given in Table 2.

The final set of *Evaluation* and *Robustness Trials* proposed by the Workshop can be found as Tables 3 and 4.

The Workshop agreed to a work plan for tasks to be undertaken prior to the 2012 Annual Meeting. The results of that work are detailed below.

In discussion, the SWG thanked the participants at the Workshop for their hard work and **endorsed** the report and its recommendations.

2.2 New information

2.2.1 Abundance

SC/64/AWMP10 provides an analysis of 13 years (1998-2010) of photo-id data for PCFG gray whales which were defined to be those whales present from 1 June to 30 November between 41°N to 52°N (northern California and northern British Columbia). Both closed and open population models were explored for abundance estimation. Closed models failed to accommodate transient behaviour of whales that were only seen in one year. Simulation showed that the standard Lincoln-Petersen (LP) estimator was biased high and even the trend was incorrect due to the transiency pattern. Instead of using LP, a limited LP estimator which removed transient whales by only using observations of whales in consecutive years that were also seen either before or after the consecutive years was used to construct the estimate. Various open Jolly-Seber type models were also fitted to the data. Those analyses demonstrated a relationship between minimum tenure (days between first and last sighting) and resighting probability in subsequent year and first-year apparent survival which includes permanent emigration. Post-first-year survival (excludes transients) for whales present in 1998 was 0.968 (SE=0.0093), but was only 0.881 (SE=0.0217) for whales first seen in 1999 or later which suggested some level of permanent emigration of whales that entered the PCFG during the 1999-2000 stranding event. The transients and minimum tenure preclude use of the standard Jolly-Seber abundance estimator. SC/64/AWMP10 considered two estimators (JS1 and JS2) that excluded the transients. JS1 assumed that all new whales in each year were seen and estimated the number of previously seen, and whales still in the population using the estimated resighting probability for each whale that was sighted. Simulation showed that it will underestimate the initial population size because all whales in the first year are 'new' but with the parameter values for these data, it provides the best current abundance estimate. The JS2 estimator was based on the resighting data after removing whales that were seen in only one year and is a parallel to the limited LP estimator. As expected, simulation showed that JS2 provides a better initial estimate of abundance but is biased low for the current abundance because any newly seen whales in the last year are excluded.

The SWG noted that bias identified in SC/64/AWMP10 is largest for 1998 and that this was a reason for excluding the estimate of abundance for 1998 when conditioning the trials.

2.2.2 Stock structure

SC/64/AWMP2 tested the assumption that individuals of the southern feeding group mate with the rest of population, and therefore that the eastern North Pacific gray whale represents one interbreeding population because this assumption is key to making appropriate management decisions given there is an interest by native groups in Washington and British Columbia to resume their traditional hunts. Such hunts could disproportionally affect whales of the PCFG, and

Table 2

Details of factors considered in trials.

Factors	Levels (reference levels shown bold and underlined)
$MSYR_{1+}$ (north)	**2%**, **4.5%**
$MSYR_{1+}$ (PCFG)	**1%**, **2%**, **4.5%**
Immigration rate (annual)	**0, 1, 2**, 4, 6
Pulse immigration (1999/2000)	**0**, 10, **20**, 30
Proportion of PCFG whales in PCFG area, ϕ_{fut}	0, **0.3**, 0.6, 1
Struck and lost rate (PCFG area)	0, **50%**, 75%
Northern need in final year (linear change from 150 in 2010)	**340**, 530
Historic survey bias	**None/Appendix 2, Table 6**, increasing between 1967 to 2002 from 0.5→1 (north only) 50% (PCFG only)
Future episodic events[1]	**None**, 3 events occur between yrs 1-75 (with at least 2 in yrs 1-50) in which 20% of the animals die. Events occur every 5 years in which 10% of the animals die[2]
Time dependence in K	**Constant**, halve linearly over 100yr; double linearly over 100yr
Time dependence in natural mortality, M *	**Constant**, double linearly over 100yr
Parameter correlations	Yes, **No**
Probability of mismatching north whales, p_2	0, **0.01**, 0.01-0.05
Probability of mismatching PCFG whales, p_1	**0**, 0.5
Frequency of PCFG surveys	**Annual**, 6-year
Incidental catch	**Reference**, double reference, half reference
Future sex ratio	**0.5:0.5**, 0.2:0.8 (M:F)
Episodic events with future pulse events[1]	**None**, 3 events occur between yrs 1-75 (with at least 2 in yrs 1-50) in which 20% of the north stock die and a pulse of 20 animals is added to the PCFG stock.

[1]The average value for adult survival needs to be adjusted to ensure the population is stable for these trials. [2]Selected to mimic the implications of stochasticity in the population dynamics.

Table 3

The *Evaluation Trials*. Values given in bold type show differences from the base case trial. The final three columns indicate which trials apply to which 'broad' hypotheses. For 'broad' hypotheses B and I, the number given is the plus in 1999/2000. Unless specified otherwise ϕ_{PCFG}=0.3, the struck and lost rate is 0.5, and there are no stochastic dynamics or episodic events.

Trial	Cond-ition	Description	$MSYR_{1+}$ North	$MSYR_{1+}$ PCFG	Final Need	Annual immigration	Survey freq.	Survey bias (north)	Hypothesis P	B	I
1A	Y	$MSYR_{1+}$=4.5%/4.5%	4.5%	4.5%	340/7	2	10/1	1	20	Y	10
1B	Y	$MSYR_{1+}$=4.5%/2%	4.5%	2%	340/7	2	10/1	1	20	Y	10
1C	Y	$MSYR_{1+}$=4.5%/1%	**4.5%**	**1%**	340/7	2	10/1	1	20	Y	10
1D	Y	$MSYR_{1+}$=2%/2%	**2%**	**2%**	340/7	2	10/1	**0.5→1**	20	Y	10
2A	Y	Immigration=0	4.5%	4.5%	340/7	**0**	10/1	1	20	Y	10
2B	Y	Immigration=0	4.5%	2%	340/7	**0**	10/1	1	20	Y	10
2C	Y	Immigration=0	**4.5%**	**1%**	340/7	**0**	10/1	1	20	Y	10
2D	Y	Immigration=0	**2%**	**2%**	340/7	**0**	10/1	**0.5→1**	20	Y	10
3A	Y	Immigration=1	4.5%	4.5%	340/7	**1**	10/1	1	20	Y	10
3B	Y	Immigration=1	4.5%	2%	340/7	**1**	10/1	1	20	Y	10
4A	Y	Immigration=4	4.5%	4.5%	340/7	**4**	10/1	1	20	Y	10
4B	Y	Immigration=4	4.5%	2%	340/7	**4**	10/1	1	20	Y	10
5A	Y	Immigration=6	4.5%	4.5%	340/7	**6**	10/1	1	20	Y	10
5B	Y	Immigration=6	4.5%	2%	340/7	**6**	10/1	1	20	Y	10
6A		High northern need	4.5%	4.5%	**530/7**	2	10/1	1	20	Y	
6B		High northern need	4.5%	2%	**530/7**	2	10/1	1	20	Y	
7A		3 episodic events	4.5%	4.5%	340/7	2	10/1	1	20	Y	
7B		3 episodic events	4.5%	2%	340/7	2	10/1	1	20	Y	
8A		Stochastic events 10% every 5 years	4.5%	4.5%	340/7	2	10/1	1	20	Y	
8B		Stochastic events 10% every 5 years	4.5%	2%	340/7	2	10/1	1	20	Y	
9A		Episodic events with future pulse events	4.5%	4.5%	340/7	2	10/1	1	20	Y	
9B		Episodic events with future pulse events	4.5%	2%	340/7	2	10/1	1	20	Y	
10A		Relative probability of harvesting a PCFG whale, ϕ_{PCFG}=0.6	4.5%	4.5%	340/7	2	10/1	1	20	Y	
10B		Relative probability of harvesting a PCFG whale, ϕ_{PCFG}=0.6	4.5%	2%	340/7	2	10/1	1	20	Y	
11A		Struck and lost (25%)	4.5%	4.5%	340/7	2	10/1	1	20	Y	
11B		Struck and lost (25%)	4.5%	2%	340/7	2	10/1	1	20	Y	
12A		Struck and lost (75%)	4.5%	4.5%	340/7	2	10/1	1	20	Y	
12B		Struck and lost (75%)	4.5%	2%	340/7	2	10/1	1	20	Y	
13A	Y	Higher 1999-2000 pulse	4.5%	4.5%	340/7	2	10/1	1	**30**		
13B	Y	Higher 1999-2000 pulse	4.5%	2%	340/7	2	10/1	1	**30**		
13C	Y	Higher 1999-2000 pulse	**4.5%**	**1%**	340/7	2	10/1	1	**30**		
14A	Y	Lower 1999-2000 pulse	4.5%	4.5%	340/7	2	10/1	1	**10**		
14B	Y	Lower 1999-2000 pulse	4.5%	2%	340/7	2	10/1	1	**10**		

Table 4

The *Robustness Trials*.

Trial	Condition	Description	$MSYR_{1+}$ north	$MSYR_{1+}$ PCFG	Survey freq.	Hypothesis P	B
1A		6 year surveys	4.5%	4.5%	10/6	20	Y
1B		6 year surveys	4.5%	2%	10/6	20	Y
2A		Linear decrease in K^{1+} [K halves over years 0-99]	4.5%	4.5%	10/1	20	Y
2B		Linear decrease in K^{1+} [K halves over years 0-99]	4.5%	2%	10/1	20	Y
3A		Linear decrease in PCFG K^{1+} [K halves over years 0-99]	4.5%	4.5%	10/1	20	Y
3B		Linear decrease in PCFG K^{1+} [K halves over years 0-99]	4.5%	2%	10/1	20	Y
4A		Linear increase in M [M halves over years 0-99]	4.5%	4.5%	10/1	20	Y
4B		Linear increase in M [M halves over years 0-99]	4.5%	2%	10/1	20	Y
5A		Linear increase in PCFG M [M halves over years 0-99]	4.5%	4.5%	10/1	20	Y
5B		Linear increase in PCFG M [M halves over years 0-99]	4.5%	2%	10/1	20	Y
6A		Perfect detection; p_1 =0; p_2=0.01-0.05	4.5%	4.5%	10/1	20	Y
6B		Perfect detection; p_1 =0; p_2=0.01-0.05	4.5%	2%	10/1	20	Y
7A		p_1 = 0.5	4.5%	4.5%	10/1	20	Y
7B		p_1 = 0.5	4.5%	2%	10/1	20	Y
8B	Y	Survey bias PCFG + p_1 = 0.5	4.5%	2%	10/1	20	Y
9B	Y	Correlation (draw for N; same quantile in the range for PCFG)	4.5%	2%	10/1	20	Y
10B	Y	Double incidental catches	4.5%	2%	10/1	20	Y
11B	Y	Halve incidental catches	4.5%	2%	10/1	20	Y
12A		Sex ratio = 0.2: 0.8	4.5%	4.5%	10/1	20	Y
12B		Sex ratio = 0.2: 0.8	4.5%	2%	10/1	20	Y
13A		Relative probability of harvesting a PCFG whale, ϕ_{PCFG} =1	4.5%	4.5%	10/1	20	Y
13B		Relative probability of harvesting a PCFG whale, ϕ_{PCFG} =1	4.5%	2%	10/1	20	Y

understanding how these whales are related to the rest of the population is necessary for properly managing such hunts. SC/64/AWMP2 analysed 15 nuclear microsatellite loci in 82 samples representing the PCFG and 51 samples from one of the calving lagoons – considered to be representative of the larger population – to test the hypothesis that the eastern North Pacific gray whale represents one interbreeding population. There was no indication of population substructuring based on the nuclear loci, suggesting that all sampled whales do indeed represent one interbreeding population. Combined with the results presented in Frasier *et al.* (2011), the mitochondrial and nuclear markers suggest one interbreeding population that is seasonally subdivided based on maternally-directed site fidelity to different feeding areas.

In discussion, the SWG questioned whether defining the larger population using samples from San Ignacio Bay, Mexico was appropriate because previous analyses had found differences between the Mexican lagoons using microsatellites (Alter *et al.*, 2009) and between animals inside lagoons and those sampled while feeding or migrating using mtDNA (Goerlitz *et al.*, 2003). It also noted that the sample sizes representing the larger eastern North Pacific population were very small, and the SWG was concerned about the reliability of genotyping given that gender could only be determined for 93 of the 133 samples. Finally, although the value for F_{ST} was low (0.0010), the uncertainty associated with this estimate may be large, implying that a wide range of migration rates may be comparable with the data. The SWG **recommended** that all estimates of F_{ST} be accompanied by confidence intervals.

Previous comparisons of the PCFG with whales feeding north of the Aleutians have revealed small but significant levels of mtDNA differentiation, which suggest that matrilineal fidelity is important in creating structure among feeding grounds. The relatively high levels of genetic diversity in the PCFG, however, suggest that some immigration into the group could also be occurring. In SC/64/AWMP4, a simulation-based approach was used to evaluate the plausible range of immigration into the PCFG. This work represents an update to the results presented in Lang and Martien (2012) and reflects modifications made in response to some of the recommendations from the intersessional Workshop (SC/64/Rep3, item 2.4.2.2). An individual-based population model was used to create simulated datasets that incorporate a post-whaling split of the PCFG from the larger ENP population. The scenarios simulated incorporated annual immigration ranging from 0 to 0.0008 (corresponding to between 0 and 16 immigrants/year when the larger ENP population reaches carrying capacity) both with and without additional pulse immigration. Comparison of mtDNA summary statistics (haplotype diversity, number of haplotypes, F_{ST} , and χ^2/df) generated from sampling of the simulated populations with those from empirical data suggest that immigration of less than two and more than eight animals per year (once the simulated larger ENP population has reached carrying capacity) are inconsistent with the empirical data, and that immigration of ~4 animals per year led to results that were most consistent with the empirical data. SC/64/AWMP4 also explored whether changes to the specifications of the model could result in a finding that no annual immigration into the PCFG is consistent with the empirical data. Most simulations were based on the PCFG splitting from the larger ENP in 1930 and on carrying capacity for the PCFG (K_{PCFG}) being set to 200 in accordance with recent abundance estimates. Additional simulations were performed that involved the PCFG splitting from the larger ENP population between 1940 and 1990. Results suggested that if the PCFG was colonised after 1950, and most plausibly between 1960 and 1980, a scenario with no annual immigration could lead to results similar to those found in the empirical data. In addition, simulations incorporating K_{PCFG} ranging from 500 to 5,000 were run; these simulations suggested that K_{PCFG} would need to be >500 and more plausibly between 2,000-3,000 animals for the simulations with no annual immigration to produce summary statistics consistent with those derived from the empirical data.

The SWG thanked Lang and Martien for providing this analysis which responded to several of the recommendations from the intersessional Workshop. Some discussion followed regarding how the mtDNA diversity in the simulated ENP population compared to measures based on the empirical data. As recommended at the intersessional Workshop, the mtDNA mutation rate parameter was tuned to produce simulated diversity values that more closely matched the observed data for the larger ENP population. After tuning, the median values of haplotype diversity and number of haplotypes were similar between the simulated and empirical data, but simulated values of nucleotide diversity were markedly higher than that found in the empirical data. The simulated datasets in SC/64/AWMP4 for the ENP stock yielded consistently higher nucleotide diversity estimates than observed. An alternative explanation could be that the simulated population size of the ENP stock is too high, as diversity scales with population size (at equilibrium). Tiedemann also noted that a higher-than-observed diversity in the simulated dataset will introduce a bias into the migration estimates towards a systematic underestimation.

Notwithstanding the difficulties, the SWG was pleased to see that the TOSSM framework was being used to address this complex issue. It **recommended** that future analyses consider a broader range of parameter choices to explore the robustness of the conclusions to uncertainty regarding these parameters.

Overall, SC/64/AWMP4 suggested that migration rates of greater than one or less than ten were most comparable with the genetics data. However, the SWG noted that fixing several parameters meant that the uncertainty associated with estimates of migration rates is higher than suggested by SC/64/AWMP4, and also that the population size trajectories for the PCFG in SC/64/AWMP4 are not comparable with the mark-recapture estimates of abundance for migration rates of roughly two and higher, and best for a zero migration rate. The *Implementation Trials* developed during the March 2012 intersessional Workshop cover migration rates from zero to six per year when the northern stock equals 20,000 animals. Given the assessment performed in SC/64/AWMP4, and the photo-identification work summarised by Calambokidis *et al.* (2012), Scordino considered that zero immigration should be allocated very low plausibility. The SWG **agreed** that the trials cover a plausible range of migration rates and that the information in SC/64/AWMP4 does not lead to a need to modify this range.

2.3 Progress with intersessional tasks

The SWG was pleased to note that the tasks identified in the work plan from the March 2012 intersessional Workshop had been completed and thanked those undertaking the work.

(1) The need to revise the scenarios regarding incidental catches was discussed by Punt, Scordino and Weller. However, these scenarios were not changed given that the magnitude of change with the updated incidental

take estimates was a fraction of a whale and not thought large enough to warrants changes to the structure of the operating models.

(2) All of the trials were reconditioned and provided to the Steering Group.
(3) Brandon, Punt and Scordino reviewed the results of the conditioning, and identified several trials for which the conditioning appears to have problems (see SC/64/AWMP11).
(4) Laake conducted further simulation analyses related to the plausibility of trials in which bias is varying (see Item 2.2).
(5) Lang and Martien conducted further TOSSM-based simulations to explore the plausibility of different levels of immigration into the PCFG (see Item 2.2).

Punt noted that all of the trials (see Tables 3 and 4 for a summary) had been run for the eleven *SLA*s (see Table 5 of Appendix 2). Software has been developed which produced the plots and tables identified by the March 2012 intersessional Workshop.

2.4 Finalise the specifications for the trials and presentation of results

The SWG **endorsed** the trial specifications, including the choice of *Evaluation* and *Robustness Trials*. The SWG selected a graphical format to summarise the results of the conditioning as well as those of projections based on different *SLA* variants, in addition to tables of the mandatory statistics (see Section F of Annex F of SC/64/Rep3 for details). The graphical summaries are based on those used previously to select the *Gray Whale SLA*, but with a focus on the PCFG. The full set of graphs and tables are available to members of the Scientific Committee through the Secretariat.

SC/64/AWMP11 presented an update on progress towards identifying a final set of trials for the ENP gray whale *Implementation Review*. Following the March 2012 intersessional Workshop, the proposed set of trials was conditioned and the authors of SC/64/AWMP11 evaluated the adequacy of this process for each trial. The primary factor assessed was the extent to which each trial was able to mimic the observed patterns in the time series of PCFG abundance estimates (all of the trials were able to mimic the abundance estimates for the northern stock). Only five of the 55 trials conditioned were identified as needing further scrutiny before being retained or dropped from the final set of trials. These trials (denoted by a first letter for the hypothesis, then the trial number and finally a last letter for the specifications for $MSYR_{1+}$ for each stock) were: B02C; IO2C; P05A; P14B, and P58B (robustness trial P08B).

Past practice in the SWG is only to drop trials from consideration if there is consensus to do so. Some members noted that trials P14B and P58B were sufficiently similar to the data to continue to be used for evaluating *SLA* variants. Consequently, only trials B02C, I02C, and P05A were dropped for further consideration given problems with conditioning.

2.5 Review results of trials

The SWG noted that its evaluation of *SLA*s was based on the objectives accepted by the Commission (IWC, 1983; 1995) which are to:

(a) ensure that the risks of extinction to individual stocks are not seriously increased by subsistence whaling;
(b) enable aboriginal people to harvest whales in perpetuity at levels appropriate to their cultural and nutritional requirements, subject to the other objectives; and
(c) maintain the status of stocks at or above the level giving the highest net recruitment and to ensure that stocks below that level are moved towards it, so far as the environment permits.

Highest priority is accorded to the objective of ensuring that the risk of extinction to individual stocks is not seriously increased by subsistence whaling.

2.5.1 Evaluation Trials

There were 75 *Evaluation Trials*, three of which were not considered further owing to problems conditioning them (see Item 2.4). The SWG adopted the following criteria (related to conservation performance) for identifying trials to examine in detail.

(1) The lower 5%ile of the final depletion distribution is lower than 0.6 (the MSYL level) and the lower 5%ile of the rescaled final depletion is lower than 0.6.
(2) The trial involved episodic events.
(3) The lower 5%ile of the trend in 1+ population size indicated a decline in population size of 5% or larger over the final 20 years of the 100-year projection period.

These criteria identified 16 trials (see Table 5). The SWG considered these trials in detail by reviewing the Zeh plots, the time-trajectories of 1+ population size for each *SLA* variant along with the median time-trajectory of 1+ population when there are no future catches and when there are only incidental catches (i.e. no aboriginal catches), and the median time-trajectories of 1+ population size for all *SLA* variants (see Appendix 3 for an example). Based on this review, the SWG identified the following features of the results.

- *SLA* variants 3, 6, 9, and 11 did not meet conservation objectives on trials with $MSYR_{1+}$ less than 4.5% and were not considered further.
- *SLA* variants 7 and 10 are most likely to lead to a declining trend in the lower 5%ile of 1+ population size.
- Most of the trials selected involve $MSYR_{1+}$=1% (trials P01C, B01C, I101C, P02C, P13C), episodic events, or no immigration from the north stock into the PCFG (trials P02B, B02B, I02B).
- All *SLA* variants lead to a declining trend in the lower 5%ile of 1+ population size for the trials based on $MSYR_{1+}$ = 1% when there is no immigration into the PCFG stock (trial P02C – this trial is the most challenging from a conservation viewpoint).
- *SLA* variant 5 leads to the best performance for the difficult trials. For example, only *SLA* variant 5 did not lead to a declining trend in the lower 5%ile of 1+ population size for trials B10B and P10B. However, this *SLA* variant also leads to the lowest landings and is hence 'inefficient' (lower landings without a correspondingly large increase in population size compared to some other *SLA* variants).
- The episodic events trials (e.g. P08B, P08B) show that episodic events can have a large impact on performance. The value for survival was adjusted for these trials so that the population persists, but this means that $MSYR_{1+}$ is effectively lower than 2% for these trials.
- The lower 5%ile of population size can drop below the initial levels in the trials with occasional large (20%) drops in abundance even though the overall trend in the lower 5%ile of 1+ population size is positive (e.g. B07B).

Table 5

Evaluation Trials which were considered in detail (see text).

Hypothesis		
P	B	I
01C	01C	01C
02B	02B	02B
02C	-	-
08B	08B	-
09B	09B	-
10A	10A	-
10B	10B	-
13C	-	-

2.5.2 Robustness Trials

The SWG applied the criteria used for the *Evaluation Trials* to select the following *Robustness Trials* for further consideration: P03A, P04A, P05A, P12A, P12B, P13A, P13B, B03A, B04B, B05B, B12B. Note that none of the *Robustness Trials* included episodic events. Based on the review of these trials, the SWG identified the following features of the results.

- Only *SLA* variants 1-3 reduce the strike limit for the trials in which abundance declines (e.g. *Robustness Trials* 05A and 05B).
- *SLA* variants 7 and 10 perform very poorly in terms of conservation performance for robustness test 13B compared to their performance for the other trials.
- The *SLA* variants perform adequately for the trials in which the sex ratio of future catches is female-biased (e.g. P12A). However, the sex ratio of the hunt should be monitored and considered in future *Implementation Reviews*.

The SWG thanked the small group which assembled the outputs (Brandon, Givens, Scordino); it would have been impossible to review the larger number of the trials without the ability to reduce the number of trials to a manageable number for full SWG review.

2.5.3 General comments and selection of SLAs

SC/64/Rep3, Annex D describes the hunting management plan proposed by the Makah Tribe. In order to minimise the risk of taking PCFG whales, the plan restricts the hunt both temporally (to the migratory season for gray whales, i.e. 1 December-31 May) and geographically (to the Pacific Ocean region). Some PCFG whales are present during the migratory season and thus the plan proposes an allowable PCFG limit (APL) during hunts that are targeting eastern North Pacific migrating whales, with the aim of ensuring that accidental takes of PCFG whales do not deplete the PCFG. The APL formula is provided in Appendix 2. The Tribe also recognises that whales struck in May might have a higher probability of being PCFG whales since they feed in this area in June. It thus proposes an additional requirement that all animals struck-and-lost in May are assumed to be PCFG whales (i.e. count against the APL), whereas whales struck between December and April are not.

Weather conditions and availability of whales makes it likely that most hunting will occur in May. However, there are insufficient data to assess the number of strikes by month. Consequently, it is not possible to reliably estimate the proportion of struck-and-lost whales that would count towards the APL. Given this uncertainty about how the plan would respond to failing to take into account struck-and-lost PCFG whales, the Tribe had proposed two *SLA* variants (1 and 2) that spanned the options as to when the hunt might occur.

SLA variant 1 proposes that struck-and-lost whales do not count towards the APL, i.e. there is no management response to PCFG whales struck but not landed. *SLA* variant 2 proposes that all struck-and-lost whales count towards the APL irrespective of hunting month, i.e. the number of whales counted towards the APL may exceed the actual number of PCFG whales struck. A number of other *SLA* variants were proposed by the Tribe to explore additional management options. However, none of the variants precisely mimicked the management plan proposed to the IWC.

The purpose of the trials is to provide information on those *SLA* variants that meet the Commission's objectives, with primary attention given to conservation performance.

After the initial examination of the trial results for each of the 11 *SLA* variants, the SWG **agreed**:

(1) *SLA* variants 1 and 2 were potentially satisfactory and performed well in nearly all 72 *Evaluation Trials* (see Appendix 4); and
(2) *SLA* variants 1 and 2 performed acceptably for all *Robustness Trials*.

Given this, the SWG focused on those few trials for which conservation performance required further consideration. It noted that the trials with 1% $MSYR_{1+}$ are the most challenging and that the conservation performance for some of these trials for both variants was not satisfactory (see Table 6). However, the SWG noted that given the available information for the eastern North Pacific population as a whole (the observed recovery rate from severe historical depletion, as well as the current recovery rate from the 1999/2000 mortality event), the most recent assessment (Punt and Wade, 2012) resulted in an estimated MSYR rate of 4.6% [90% posterior interval 2.2%, 6.4%]. Therefore, the $MSYR_{1+}$=1% trials were considered to be at the lower bounds of plausibility and that the conservation performance in these trials alone was not reason to preclude the conclusion that both variants have overall satisfactory conservation performance.

The SWG then focused on certain trials within the 2% $MSYR_{1+}$ set for which conservation performance might be considered questionable. Trial 08B (pulse and bias) involved 10% declines in abundance every five years as a proxy for random biological, environmental or anthropogenic events (e.g. disease or contamination). As noted above, these trials are in effect trials with lower $MSYR_{1+}$ than the nominal 2% of the trial. Given this, the SWG **agreed** that both variants 1 and 2 could be considered to have acceptable performance for these two trials.

Trial 10B (pulse and bias) involves an assumption that the relative probability of harvesting PCFG whales in the Makah U&A is double the observed ratio of PCFG whales to migrating whales observed in the available photo-identification studies. The conservation performance of *SLA* variant 2 was considered acceptable for this trial but that for variant 1 was considered marginal (Table 6). In discussing the results of this trial, the SWG noted that the ratio of PCFG whales to migrating whales could be monitored directly from data collected during the hunting period allowing this assumption to be evaluated.

In conclusion, the SWG **agreed**:

(1) *SLA* variant 2 performed acceptably and met the Commission's conservation objectives for conservation while allowing limited hunting; and
(2) *SLA* variant 1 performed acceptably for nearly all the trials and could be considered to meet the Commission's conservation objectives provided that it is accompanied

Table 6

Final depletion and rescaled final depletion statistics for *SLA*s 1 and 2 for the trials with $MSYR_{1+}$=1% and the trials with $MSYR_{1+}$=2% for which conservation performance might be considered to be questionable.

	SLA variant 1				*SLA* variant 2			
	Final depletion		Rescaled final depletion		Final depletion		Rescaled final depletion	
Trial	Low 5%	Median	Low 5%	Median	Low 5%	Median	Low 5%	Median
$MSYR_{1+}$=1%								
GB01C	0.259	0.343	0.314	0.383	0.290	0.365	0.352	0.414
GP01C	0.382	0.461	0.400	0.472	0.438	0.515	0.460	0.528
GP02C	0.231	0.272	0.255	0.295	0.299	0.347	0.334	0.372
GI01C	0.378	0.446	0.399	0.459	0.434	0.497	0.457	0.513
$MSYR_{1+}$=2%								
GB08B	0.357	0.458	0.505	0.594	0.396	0.504	0.560	0.656
GB10B	0.492	0.556	0.492	0.557	0.575	0.633	0.576	0.635
GP08B	0.330	0.442	0.475	0.578	0.364	0.482	0.528	0.635
GP10B	0.475	0.536	0.476	0.538	0.556	0.619	0.557	0.621

by a photo-identification programme to monitor the relative probability of harvesting PCFG whales in the Makah U&A which is undertaken each year and the results presented to the Scientific Committee for evaluation.

The SWG **agreed** that the *Implementation Review* was completed.

Finally, the SWG noted that the *SLA* variants tested did not correspond exactly to the management plan proposed by the Makah to the US government. The SWG **agreed** to test such a variant intersessionally and present the results to the next Annual Meeting.

2.6 Other business

Spatial mixing between eastern and western North Pacific gray whale stocks along the Pacific coast of North America outside of the feeding season has been recently documented (IWC, 2012a). This raises issues about the population structure within the Sakhalin feeding area; see SC/64/BRG10 and IWC (2012a). The broad issue of stock structure of North Pacific gray whales is being addressed in the BRG sub-committee (Annex F) and through a basinwide research programme (IWC, 2012a). However, as noted last year, this finding raises concern about the possibility of whales feeding in the western North Pacific being subject to the proposed Makah Tribe hunt in northern Washington.

Last year (IWC, 2012a, p.15) the Committee had agreed that formally there was no need to modify the existing trials structure which had been designed to evaluate the *SLA*s for the northern and PCFG areas in the context of eastern gray whales. However, it had also noted that this structure does not incorporate conservation implications for western gray whales and the Committee had stressed three points.

(1) The new information on movements of gray whales highlighted the importance of further clarification of the stock structure of North Pacific gray whales. In particular, the matches of western gray whales with animals seen in the PCFG area and other areas along the west coast emphasised the need for efforts to estimate the probability of a western gray whale being taken in aboriginal hunts for Pacific gray whales (noting that this did not require incorporation of western gray whales into the *Implementation Review*).

(2) It had strongly endorsed the basinwide research programme, noting that the results of the research may require further trials for future *SLA* testing, but that this would certainly be a matter for consideration at the next *Implementation Review* if not before.

(3) The Committee will continue to monitor the situation and was willing to respond to any guidance or requests for further information from the Commission.

SC/64/BRG9 addressed point (1) above. It provided estimates for the probability of taking ≥1 western North Pacific whale during the hunt using five models from three model classes which vary depending on the type of data being used for estimation. Model set 1 makes use of abundance estimates for the western and eastern North Pacific populations. Model set 2 makes use of these abundance estimates, as well as sightings data from the proposed hunt area. Model set 3 makes use of the sightings data only. Within model sets 1 and 2, two models (A and B) differ depending on whether migrating eastern and western North Pacific whales are assumed to be equally available to the hunt per capita (A) or whether this assumption is relaxed somewhat (B). All models make the precautionary assumption that all western North Pacific whales migrate to the North American coast and are thus potentially available. The authors of SC/64/BRG9 considered Model 2B the most plausible because it made use of both available types of information and used a less restrictive assumption about the per capita strike probability on western relative to eastern North Pacific whales. Based on this model, the probability of taking one or more western gray whales in a single season ranged from 0.014 to 0.050, depending on whether the median or upper 97.5th percentile estimate was used and whether five or seven whales would be struck in a year (corresponding to two different types of strike limits in the Makah proposal; see SC/64/Rep3, Annex D). The probability of taking one or more western North Pacific whales once over five seasons, based on base case limits in the Makah plan (20 or 35), ranged from 0.056 to 0.225 across these same variables for Model 2B.

Moore stated that the estimates for the probability of taking one or more western gray whales based on the alternative scenario that total strikes *of non-PCFG whales* would equal three or four in a single year, and 15 or 20 over a 5-year period. The estimate of 3 non-PCFG strikes was informed by taking the average across all *Evaluation Trials* for *SLA* variant 1 (conditional on the bias hypothesis (B)), given the median estimated annual number of total strikes less the median estimated number of PCFG strikes; the estimate of four non-PCFG whales was calculated under the same scenarios, but taken as the average over the difference between the upper 95%ile of estimated annual total strikes and the lower 5%ile of such for PCFG strikes. The justification for considering these scenarios was that, given other management measures within the Makah Tribe's plan – most importantly the provision to cease the annual hunt if a certain number of PCFG whales are struck – it may be unlikely that the maximum strike limits of five or seven annually would be achieved. The additional estimates did not change the assessment presented in SC/64/BRG9, since, for the models considered most credible, the estimated parameters related to western gray whale strikes over the course of five years fell within the range of estimates presented in SC/64/BRG9.

The SWG welcomed this work. However, it **agreed** that the description of the methods was insufficient for a full review. It also noted that there are several categories of uncertainties that might need to be considered but that SC/64/BRG9 does not explain the choice of uncertainties addressed. The question was also raised that some of the results (such as the probability of encountering a western gray whale given a catch of five whales reported in the abstract) did not seem consistent with other information presented in SC/64/BRG9. The SWG also noted that additional sensitivity tests (e.g. to choices of priors) should be conducted, more information on convergence of the MCMC algorithm should be provided, and posteriors for model outputs should be presented.

The SWG **recommended** that a revised document be developed for further review at next year's meeting, noting its potential importance for the provision of management advice. It established an Advisory Group (Brandon, Givens, Punt, Scordino) to provide guidance to Moore and Weller.

3. *IMPLEMENTATION REVIEW* FOR BERING-CHUKCHI-BEAUFORT SEAS BOWHEAD WHALES

Donovan recalled the procedure and purpose of *Implementation Reviews* for aboriginal whaling *SLA*s, as summarised under Items 2.1 and 7. The SWG should assess whether there is any new information that would suggest that the range of trials used to evaluate the *Bowhead SLA* is no longer sufficient to ensure that it meets the Commission's conservation and user objectives.

3.1 Consideration of new information with a focus on whether this implies a need for new trials

SC/64/AWMP6 reviewed publications and information relevant to the Scientific Committee's 2012 *Implementation Review* of Bering-Chukchi-Beaufort Sea (B-C-B) bowhead whales and data that was provided under the Scientific Committee's Data Availability Agreement (DAA). Since the last *Implementation Review* in 2007, major studies ranging from molecular biology to broad-scale distribution/relative abundance have been conducted on B-C-B bowhead whales by the local, state, and federal government and the oil and gas industry in Alaska. Of particular relevance to the 2012 *Implementation Review* is the following: (i) the last abundance estimate accepted by the Scientific Committee is 12,631 with CV 0.2442 for the year 2004 (Koski *et al.*, 2010); (ii) subsistence harvest totals from recent years for US communities; and (iii) recent stock structure investigations. Also reviewed were selected publications relevant to the status of B-C-B bowhead whales (e.g. satellite telemetry, oil and gas, health status, etc.). The review did not identify any new information suggesting a concern with the current management scheme.

3.1.1 Stock structure

SC/64/BRG1 reported on a satellite telemetry study of 57 B-C-B bowhead whales tagged during 2006-11. The results elucidated the seasonal movements of bowheads in this stock throughout the entire annual cycle of migration. The paper was also considered by the Sub-Committee on Bowhead, Right and Gray Whales (Annex F) and so the presentation to the SWG focused on those results relevant to stock structure within the B-C-B stock. All tagged bowhead whales used the western Bering Sea during winter; the time period when mating occurs. All but one tagged whale migrated past Point Barrow in spring and went to Amundsen Gulf. The one exception migrated west along the Chukotka coast and summered in the Chukchi Sea. This whale was tagged near Barrow the previous August, but had not returned to Barrow before the tag stopped transmitting in August the following year. The movements of this whale indicate that individuals may not return to the same summer area in consecutive years. While most tagged whales summered within the Canadian Beaufort Sea, extensive summer movements included travel far to the north and northeast to overlap with at least one tagged bowhead whale from the eastern Canada stock. The two whales overlapped in space, but not in time, and each returned to its area of origin in the autumn. Other summer movements included complete transits from the Canadian Beaufort Sea to an area offshore of Barrow and back to the Canadian Beaufort Sea; and one whale travelled to the coast of Chukotka, Russia in July and spent the rest of the summer there. The autumn migration route across the Chukchi Sea was variable within and between years. The authors concluded that the movements and behaviour observed during this study support the hypothesis of a single stock of bowhead whales in the western Arctic. Further, they noted that satellite telemetry has proven to be a powerful new tool for determining the spatial and temporal distribution of B-C-B bowhead whales.

During discussion of these findings, it was noted that when conception occurs (usually March), all the tagged animals are consolidated in the northern Bering Sea. This is further evidence that B-C-B bowhead whales constitute one breeding population.

The SWG commended the authors of SC/64/BRG1 for providing useful and relevant data on bowhead migration patterns, and recognised the cooperation of native hunters who were closely involved in all aspects of this study, and deployed most of the tags. It **agreed** that the tracking information provided no evidence to suggest that the trials evaluated during the previous *Implementation Review* (IWC, 2008b) did not adequately address stock structure concerns. The SWG **recommended** that such tagging and telemetry efforts continue.

SC/64/AWMP3 compared the use of SNPs and microsatellites for studying population structure, assignment and demographic analyses of bowhead whale populations in the Sea of Okhotsk, Bering-Chukchi-Beaufort Seas, and eastern Canada. The authors found that datasets of 42 linked and unlinked SNPs and 22 microsatellites provided similar power to detect low levels of population differentiation, but neither marker performed well for Bayesian analysis of population structure when the level of population differentiation was low. Microsatellites provided greater precision than this set of SNPs for estimating N_e and applying assignment tests. Using the microsatellites, SC/64/AWMP3 found small differences between B-C-B individuals estimated to have been born before 1949 and those born after 1979. However all analyses indicated that the B-C-B stock of bowhead whales represents a single population. The SWG noted that this paper was discussed primarily in the Stock Definition sub-committee (Annex I) since it evaluated of merits of studying different genetic markers.

The SWG concurred with SC/64/AWMP3 that the SNPs results were consistent with previous results from microsatellite analysis, and also noted that the use of SNPs has the advantage that the SNPs can be reproduced between labs and can be obtained from non-optimal tissues. With respect to conclusions about stock structure, the SWG **agreed** that the results provided no evidence to suggest that the trials evaluated during the previous *Implementation Review* (IWC, 2008b) did not adequately address stock structure concerns.

SC/64/AWMP9 presented sequences from three mtDNA genes from 350 bowhead whales from the B-C-B, eastern Canadian Arctic and the Sea of Okhotsk stocks, and discussed methods to calculate gene and site specific mutation rates. SC/64/AWMP9 used the data to demonstrate the improved resolution in phylogenetic analysis provided by increasing amounts of DNA sequence and in resolving recurrent substitutions. The mutation rate for the control region for bowhead whales was estimated as 2.8% per million years which is about half as fast as gray, humpback and minke whales reported in the literature and the time to most recent common ancestor of the mtDNA was estimated as 1.16 million years. Estimates of F_{ST} among the three bowhead stocks showed the Sea of Okhotsk stock to be significantly different from both B-C-B and Canada but Canada and the B-C-B do not differ significantly. The F_{ST} estimated between the Okhotsk and B-C-B stocks based upon the three gene mtDNA dataset was greater than a previous estimate in the literature calculated from control region alone. Tests of neutrality differed in their results for the control region compared to the two protein coding genes, with the latter both showing evidence for a population expansion that was not recovered from the control region sequence.

The SWG **agreed** that the results in SC/64/AWMP9 did not support the need for any additional trials for the *Bowhead SLA*. Consideration of the methodological issues raised in this paper were discussed by the Stock Definition Sub-Committee (see Annex I).

SC/64/AWMP1 investigated the demographic history the B-C-B population of bowhead whales using a variety of analytical methods, including approximate Bayesian computation and extended Bayesian skyline analysis, in addition to many classical bottleneck and demographic tests. The results support a pre-depletion ancestral population size of 10,000 to 20,000 individuals. However, uncertainty over mutation rate limited the precision of these estimations. This is the first genetic-based estimate of the pre-whaling population size of bowhead whales. In addition, the signal for a historical population expansion having begun approximately 75,000 years before present was supported by multiple analyses. A subsequent, non-anthropogenically driven, population reduction, that ensued about 15,000 years ago, was also detected. No genetic signature for the recent population depletion caused by commercial whaling was recovered through any analysis incorporating realistic mutation assumptions. The authors concluded that while bowhead whales have a dynamic demographic history, the reduction in population size caused by commercial whaling was of insufficient magnitude to contribute to this genetic history. From a biological perspective the bottleneck was of short duration in relation to the long generation time of the bowhead whale, which served as a buffer to minimise erosion of variability through genetic drift.

The SWG **agreed** that the new information presented provided no evidence to suggest that the trials evaluated during the previous *Implementation Review* (IWC, 2008b) did not adequately address stock structure concerns.

3.1.2 Abundance and rate of increase

A new agreed abundance estimate is not required for completion of the B-C-B bowhead whale *Implementation Review*. When a new estimate becomes available it can be incorporated into the *Bowhead SLA* calculations to provide management advice.

In SC/64/AWMP5, it was noted that George *et al.* (2004) fitted an exponential growth model to the 1978-2001 ice-based survey data of Zeh and Punt (2005) via generalised least squares, obtaining an estimated annual rate of increase (ROI) for B-C-B bowhead whales of 3.4% with a 95% confidence interval (CI) of 1.7% to 5%. SC/64/AWMP5 adds the 1985 and 2004 abundance estimates obtained from aerial photography survey data by Koski *et al.* (2010) to the ice-based survey data to obtain an updated ROI for 1978-2004. The resulting ROI value is 3.5% with 95% CI 2.2% to 4.8% (Fig. 1). Thus, the point estimate is almost identical, but the two added estimates improved precision. Photographic surveys can be carried out even in years when ice-based surveys are unsuccessful because of weather and/or ice conditions. When large numbers of photos are obtained, as in 1984-86, the resulting photographic survey estimate can be more precise than many of the ice-based survey estimates.

The SWG **recommends** that the Committee adopt this estimate (3.5% with 95% CI 2.2%, 4.8%) as the best available estimate of annual rate of increase for the B-C-B bowhead population. It also **agreed** that the best estimate of current abundance is 12,631 (95% bootstrap percentile CI 7,900 -19,700; 5% lower limit 8,400) for 2004 (Koski *et al.*, 2010).

The SWG was pleased to receive information from recent ice-based surveys that count whales migrating past Barrow, Alaska (SC/64/AWMP7). Full discussion of these surveys will occur in conjunction with the presentation of new abundance estimates within the next two years.

The 2009 visual survey was nearly a complete failure due to closed leads through the latter half of the season and was not discussed further. In 2010 and 2011, a primary perch and a second independent observer (IO) perch were used. The 2010 survey began with an unusually early (31 March)

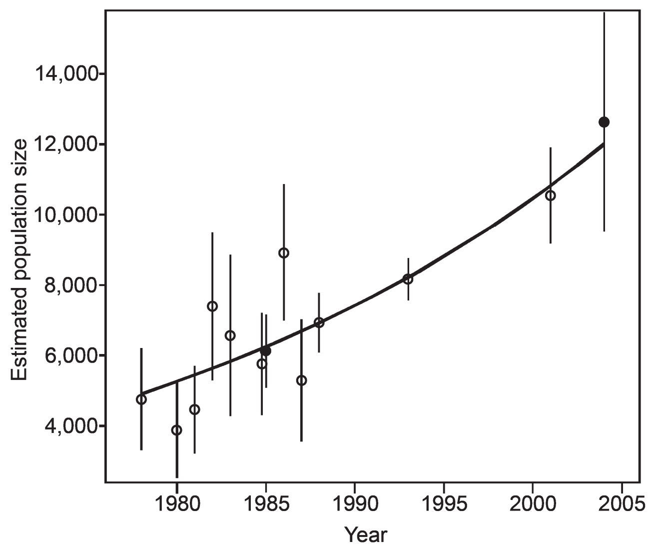

Fig.1. Estimated rate of increase for the B-C-B bowhead whales for the period 1978 to 2004 (from SC/64/AWMP5). The black dots indicate estimates based on photo mark-recapture techniques, the open dots are ice-based estimates.

pulse of bowheads that has not previously been documented (1978-present surveys). Field protocols were devised for operating the IO perches, and methods were developed for real-time and *post hoc* matching of whale sightings between perches. In 2010, a substantial portion (roughly 1/3) of the bowhead migration occurred during times when sightings were impossible due to closed near-shore leads while ice conditions rendered the acoustic data useless. Therefore, no abundance estimate was attempted for 2010, although the survey yielded a large amount of IO data from which estimates of detection probabilities were calculated.

By contrast, the 2011 survey conducted from 4 April to 5 June was extremely successful. Bowheads again arrived earlier than usual, with the first sightings on 9 April and a major pulse on 16 April; earlier sightings were made by whalers. Seven acoustic recorders were deployed of which six provided useful data. The survey resulted in one of the highest raw number of new whales seen. The same IO methods used in 2010 were applied in 2011, with the exception of the real-time matching. Total IO effort was about 180 hours in 2011. An aerial survey was conducted in spring 2011 near Point Barrow concurrent with the ice-based census. Some 4,594 photographs containing 6,801 bowhead whale images were obtained (not accounting for resightings). Thus, the 2011 season was exemplary in that full visual, acoustic and aerial photographic surveys were conducted in the same season. As a final note, first sighting data from 1978 to 2011 surveys were compiled which indicated an earlier arrival of bowheads at Barrow in recent years. This finding is consistent with observations of Barrow whale hunters who have independently reported earlier arrival of bowhead whales at Barrow.

In discussion, the earlier timing of the migration was emphasised and it was noted that there is age-structure within the northbound migration (Koski *et al.*, 2006). However, until the photographs have been analysed it is not known whether large whales were present in the 'early' animals. Rugh *et al.* (2004) found that the arrival times of well-marked whales varied among years, with some large whales (without calves) arriving early in the migration.

SC/64/BRG4 presented estimates of visual detection probabilities from the spring 2011 ice-based survey of bowhead whales migrating near Barrow, Alaska. The same methods will also be applied to similar data from the 2010 survey. These estimates are highly relevant to the AWMP SWG since they constitute one foundation upon which a future population abundance estimate will be calculated from the 2011 survey counts. This abundance estimate will then be used as input to the *Bowhead SLA*. The data for these analyses were produced by observer teams from two nearby ice perches who recorded sightings of whale groups independently, along with a wide variety of covariates. Then, the data were scrutinised *post hoc* to identify possible matches, i.e. whale groups seen from both perches. Whale groups seen from both perches constitute recaptures in the context of a capture-recapture analysis. However, standard capture-recapture model fitting methods are not directly applicable to the 2011 survey dataset for several reasons. First, a single perch may make multiple sightings of the same whale group, but these re-identifications and the links between them are uncertain. Second, the between-perch matches declared *post hoc* are also uncertain, and the analysts performing the matching task must rate each declared match with a confidence rating. Third, the group sizes recorded for multiple sightings both within and between perches are not always consistent, so it is necessary to estimate when or if extra group members belong to a partially unseen recaptured group or an independent individual that is not recaptured. Thus, bias correction methods are essential to produce accurate detection probability estimates. After developing and incorporating these corrections, the authors applied the general framework of Huggins (1989) and reported that detection probabilities depend on group size and the distance of the sighting from the perches. Specifically, group sizes of only one whale and increasing distance from the perch are associated with lower detection probabilities. For example, the detection probability estimates for a single whale at 3,000m and a group of whales at 1,000m are 0.377 and 0.645, respectively. The sample-weighted mean estimated detection probability is 0.495; most standard errors are less than 0.03. Thus, about half the bowheads migrating within the range of potential visual detection are not sighted by observers at the primary perch.

In discussion, the SWG noted that the independent observer (IO) method used in the 2010 and 2011 surveys is entirely different than the removal method protocol used in 1985 and previously to estimate detection probabilities (Zeh and Punt, 2005). Thus, the detection probability estimates from the two methodologies are not exchangeable. The authors of SC/64/BRG4 indicated their intent to estimate 2011 abundance using detection probability estimates based only on the new IO data, abandoning the irrelevant, older estimates. The SWG **endorsed** this approach, while also recognising that any possible implications of the shift to the superior IO method might merit future consideration. However, it was also noted that abundance estimates based on photo-identification have been added to the time series of abundance estimates (SC/64/AWMP5), and an abundance estimate from the new IO study would be another important contribution. The SWG and other Committee members interested in abundance estimation are **encouraged** to contact the authors of SC/64/BRG4 intersessionally with comments and suggestions so that the future abundance estimate for use in the *Bowhead SLA* could be based on an approved estimate of detection probabilities.

SC/64/BRG3 described an aerial photographic survey for B-C-B bowhead whales conducted from 19 April to 6 June 2011. The field season was very successful, both in terms of total flight days and the very large number of whale images (approximately 6,800) obtained during this time. These photographs are a significant contribution to the bowhead whale photographic catalogue. The SWG recognised the importance of this work as potentially providing an estimate of population abundance for use with the *Bowhead SLA*. This estimate would be entirely independent of the ice-based survey estimate described in SC/64/BRG4. Analyses of the photo-id data may also provide better precision in estimates of bowhead whale life-history parameters such as adult survival rate. A detailed discussion of this paper is provided in the BRG sub-committee report (Annex F).

3.1.2 Other

SC/64/AWMP8 provides a preliminary summary of the subsistence harvest of bowhead whales in Alaska from 1974 to 2011. Bowhead whales fill an important nutritional and cultural need for villages in northern and western Alaska. In total, 1,149 whales have been landed by 12 villages from 1974-2011, primarily during migration. The implementation of a quota in 1978 led to an abrupt drop in the number of whales harvested, but as more information became available about bowhead whales, the quota and the number of animals landed increased. The efficiency (no. landed/no. struck) of the hunt has also increased over this period. The average efficiency has reached a plateau at approximately 75% to 80%. In the past 5-10 years, not all strikes have been used. This is due in part to deteriorating ice conditions in the spring, which has made it very difficult for some villages to hunt and land whales. The total strike allocation has never exceeded what was allowed within a block quota based on the *Bowhead SLA*.

The SWG welcomed this information and noted that strikes have remained within the need envelope tested during development of the *Bowhead SLA*. It therefore **agreed** that no additional trials were warranted in this regard.

3.2 Discussion of new trials

In consideration of the evidence described in Item 3.1, the SWG **agreed** that there was no need for new trials or simulation testing of the *Bowhead SLA*.

3.3 Conclusions and recommendations

The SWG thanked the US scientists, the North Slope Borough, Alaska, and the native communities for continuing to provide a considerable body of high-quality scientific work which facilitated the SWG's *Implementation Review* process. The SWG **agreed** that the *Bowhead SLA* continues to be the most appropriate way for the Committee to provide management advice for the B-C-B population of bowhead whales. This completes the *Implementation Review* for the B-C-B bowhead whales.

4. CONSIDERATION OF WORK REQUIRED TO DEVELOP *SLA*S FOR ALL GREENLAND HUNTS

This topic had been advanced at the intersessional Workshop held in La Jolla in March 2012. Donovan summarised the discussions which had taken place at the Workshop (SC/64/Rep3), commenting on the different nature of the requirements for each of the four species (common minke whale, fin whale, humpback whale and bowhead whale) to be considered. He explained that separate *SLA*s would be considered for each species despite Greenlands request for a multi-species approach, as that would be too complex an exercise to undertake at this stage of the process.

The SWG referred to the benefits in previous *CLA* and *SLA* developments in the Committee of a co-operative competition amongst more than one *SLA* developer, and the Chair asked which groups might be interested in participating in such an exercise for the development of Greenland hunt *SLA*s: Witting, Butterworth and Givens (for the bowhead whale only) responded positively to this enquiry. He also drew attention to previous discussions within the SWG on the development of long-term *SLA*s. In particular, he noted the multi-species nature of the Greenland hunts and Greenland's desire for flexibility amongst species in meeting its subsistence needs. The SWG **reiterated** that its approach will first be to develop *SLA*s for individual species before considering whether and how to address multispecies considerations (IWC, 2010; 2011; 2012b).

4.1 Common minke whales

SC/64/AWMP15 had been submitted in response to a recommendation from the March intersessional Workshop in relation to common minke whales. This document dealt with stock structure issues, abundance estimates and aspects of simulation trial structure. The SWG thanked Witting for responding to this request. A summary of the information provided by Witting for each of the Greenland species is given as Appendix 5.

Donovan advised of a planned Workshop on the stock structure of this species in the North Atlantic, which is planned to inform the RMP *Implementation Review* process for common minke whales in the North Atlantic scheduled for 2014. The operating models developed in this process should (perhaps with minor adjustment to take account of focus on different populations) also serve for the *SLA* development process, which would accordingly be informed by expertise in RMP development for this species.

The SWG noted the need for a co-ordinated approach to the issue of stock structure and it **endorsed** the collaborative proposal given in Annex D, Appendix 6 that would culminate in a joint AWMP/RMP Workshop on stock structure in spring 2014.

4.2 Fin whales

SC/64/AWMP12 had been submitted in response to a recommendation from the March 2012 intersessional Workshop in relation to fin whales. This document dealt with stock structure and assessment issues, abundance data and aspects of simulation trial structure. The SWG thanked Witting for responding to this request.

The sub-committee noted that a pre-meeting for a North Atlantic fin whale RMP *Implementation Review* is scheduled before the 2013 Scientific Committee meeting. The stock structure discussions at this meeting would provide useful input to the fin whale *SLA* development process.

4.3 Humpbacks whales

SC/64/AWMP13 had been submitted in response to a recommendation from the March 2012 intersessional Workshop in relation to humpback whales. This document dealt with need envelopes, *SLA* development, stock structure and assessment issues, abundance data and aspects of simulation trial structure. The SWG thanked Witting for responding to this request.

Witting suggested that the ENP gray whale trial structure offered a framework around which trials for the single humpback stock involved could be developed. Punt supported this, commenting that this offered a process which should prove straightforward to implement.

4.4 Bowhead whales

SC/64/AWMP14 had been submitted in response to a recommendation from the March 2012 intersessional Workshop in relation to bowhead whales. This document dealt with stock structure, assessment and simulation trial issues. Here the earlier B-C-B bowhead trial structure may provide a helpful basis around which to design trials. The SWG thanked Witting for responding to this request.

4.5 Conclusions

The SWG **re-emphasised** the importance of developing long-term *SLA*s for the Greenlandic hunts as soon as possible and certainly before 2018. It **agreed** that it should be possible to develop appropriate trial structures and operating models for the humpback and bowhead whale hunts before the next Annual Meeting to enable potential *SLA*s to be evaluated in the future. It **endorsed** the proposal outlined in Appendix 6 to support this work.

It also **emphasised** the importance of developers beginning to consider the development of *SLA*s for fin whales and common minke whales in the context of the work being undertaken on stock structure with the RMP sub-committee especially the joint AWMP/RMP proposal for work on the stock structure of North Atlantic common minke whales (see

Annex D, Appendix 6). It noted that the development of an AWMP/RMP-lite program as outlined in Appendix 6 would also assist developers in beginning to investigate potential *SLA*s for common minke whales and fin whales.

In order to progress this essential *SLA* development work, the SWG **agreed** that an intersessional Workshop (to be held in winter 2012, probably in Copenhagen, at a cost of £8,000) was essential to maintain progress. As in previous years, maintenance of the AWMP Developer's Fund was also supported.

5. IMPLICATIONS OF NEW INFORMATION ON BROAD GRAY WHALE STOCK STRUCTURE (WITH BRG)

5.1 Summary of relevant BRG discussions

The SWG was informed that the sub-committee on BRG had received a number of interesting papers (see Annex F, item 4.1), but that at present its work on the basinwide review of gray whale stock structure was incomplete.

5.2 Conclusions with respect to *Implementation Review*

The SWG **agreed** that it was premature at this stage to consider whether the new information about western gray whales may warrant an *Implementation Review* (although see the discussion under Item 2).

6. ANNUAL REVIEW OF MANAGEMENT ADVICE

6.1 Common minke whales off West Greenland

6.1.1 New information

In the 2011 season, 174 minke whales were landed in West Greenland and six were struck and lost (SC/64/ProgRep Denmark). Of the landed whales, there were 133 females, 39 males, and two whales of unreported sex. Genetic samples were obtained from 90 of these whales. The SWG **re-emphasised** the importance of collecting genetic samples from these whales, particularly in the light of the proposed joint AWMP/RMP Workshop (see Item 4.1).

Witting noted that the next large whale survey off West Greenland is planned for 2015. The SWG agreed that next year it would review its best estimate of abundance in light of a slightly revised estimate provided in Heide-Jørgensen *et al.* (2010).

6.1.2 Management advice

In 2007, the Commission agreed that the number of common minke whales struck from this stock shall not exceed 200 in each of the years 2008-12, except that up to 15 strikes can be carried forward. In 2009, the Committee was for the first time ever able provide management advice for this stock based on a negatively biased estimate of abundance of 17,307 (95% CI 7,628-39,270) and the method for providing interim management advice which was confirmed by the Commission. Such advice can be used for up to two five year blocks whilst *SLA*s are being developed (IWC, 2009, p.16). Based on the application of the agreed approach, and the lower 5th percentile for the 2007 estimate of abundance, the SWG **repeats** its advice of last year that an annual strike limit of 178 will not harm the stock.

Table 7

Most recent abundance estimates for minke whales in the Central North Atlantic.

Small Area(s)	Year(s)	Abundance and CV
CM	2005	26,739 (CV=0.39)
CIC	2007	10,680 (CV=0.29)
CG	2007	1,048 (CV=0.60)
CIP	2007	1,350 (CV=0.38)

6.2 Common minke whales off East Greenland

6.2.1 New information

Nine common minke whales were struck (and landed) off East Greenland in 2011, and one was struck and lost (SC/64/ProgRepDenmark). All landed whales were females. The SWG noted that catches of minke whales off East Greenland are believed to come from the large Central stock of minke whales. No genetic samples were obtained from minke whales caught in East Greenland. The SWG **re-emphasised** the importance of collecting genetic samples from these whales, particularly in the light of the proposed joint AWMP/RMP Workshop (see Item 4.1).

6.2.2 Management advice

In 2007, the Commission agreed to an annual quota of 12 minke whales from the stock off East Greenland for 2008-12, which the Committee stated was acceptable in 2007. The present strike limit represents a very small proportion of the Central stock (and see Item 4.1). The SWG **repeats** its advice of last year that the present strike limit would not harm the stock.

6.3 Fin whales off West Greenland

6.3.1 New information

A total of five fin whales (all females) were landed, and none were struck and lost, in West Greenland during 2011 (SC/64/ProgRepDenmark). No genetic samples were obtained from caught fin whales in 2011. The SWG **re-emphasised** the importance of collecting genetic samples from these whales, particularly in the light of the proposed work to develop a long-term *SLA* for this stock (see Item 4.2).

6.3.2 Management advice

In 2007, the Commission agreed to a quota (for the years 2008-12) of 19 fin whales struck off West Greenland. The Committee agreed an approach for providing interim management advice in 2008 and this was confirmed by the Commission. It had agreed that such advice could be used for up to two blocks whilst *SLA*s were being developed (IWC, 2009). Based on the agreed estimate of abundance for fin whales (4,539 95%CI 1,897-10,114), and using this approach, the SWG **repeats** its advice that an annual strike limit of 19 whales will not harm the stock.

6.4 Humpback whales off West Greenland

6.4.1 New information

A total of eight (three males; five females) humpback whales were landed (none were struck and lost) in West Greenland during 2011 (SC/64/ProgRepDenmark). Genetic samples were obtained from three of these whales. The SWG **re-emphasised** the importance of collecting genetic samples from these whales, particularly with respect to the YoNAH and MoNAH initiatives (Clapham, 2003; EC YoNAH, 2001).

6.4.2 Management advice

In 2007, the Committee agreed an approach for providing interim management advice and this was confirmed by the Commission. It had agreed that such advice could be used for up to two five year blocks whilst *SLA*s were being developed (IWC, 2009, p.16). Based on the agreed estimate of abundance for humpback whales (3,039, CV 0.45, annual rate of increase 0.0917 SE 0.0124) and using this approach, the SWG **agreed** that an annual strike limit of 10 whales will not harm the stock.

6.5 Humpback whales off St Vincent and The Grenadines

6.5.1 New information

Last year the SWG noted that it had received no catch data from St Vincent and The Grenadines for 2010-11. This year the Secretariat received information that a 35-foot whale was taken on 18 April 2011. It was reported that its girth was 18.6 feet, its flukes 9.7 feet and its 'tail length' was 17.9 feet. It also received information on a 33.75 foot female taken on 14 April 2012. Its girth was 18.25 feet. Genetic samples and photographs were taken.

Brownell reported that the USA and St Vincent and The Grenadines are discussing the transfer of tissue samples from this whale for analysis and storage at SWFSC (the IWC archive where *inter alia* SOWER samples are stored).

The SWG **welcomed** this information.

It also repeats its previous strong **recommendations** that St Vincent and The Grenadines:

(1) provide catch data, including the length of harvested animals, to the Scientific Committee; and
(2) that genetic samples be obtained for any harvested animals as well as fluke photographs, and that this information be submitted to appropriate catalogues and collections.

6.5.2 Management advice

The Committee has agreed that the animals found off St Vincent and The Grenadines are part of the large West Indies breeding population (11,570 95% CI 10,290-13,390). The Commission adopted a total block catch limit of 20 for the period 2008-12.

The SWG **repeats** its advice of last year that this block catch limit will not harm the stock.

6.6 Implications of possible move to biennial meetings with respect to length of block quotas

The Commission is considering a change from annual to biennial meetings. This has raised the issue within two Commission working groups as to whether there are any scientific implications for the Commission moving to setting block quotas for an even number of years rather than the present five-year intervals. This issue was addressed at the intersessional Workshop (see SC/64/Rep3).

The Workshop had recalled that trials for the B-C-B bowhead and Eastern North Pacific gray whale *SLA*s had shown satisfactory performance for surveys at intervals of 10 years (and even for some *Robustness Trials* for 15 years). The Workshop agreed that there are no scientific reasons for the Commission not to set catch limits for blocks of even numbers of years up to eight years for these stocks. However, it drew attention to its discussions of the AWS where it noted that despite the trial results it would not be appropriate for catches to be left unchanged if new abundance estimates were not available after 10 years (IWC, 2004 and see Item 7.2).

The Workshop had noted that this would not mean that the Committee would need to change its regular process of *Implementation Reviews* approximately every five years (with the provision for 'special' reviews should circumstances arise) or an annual examination of new information and provision of advice.

The Workshop had also noted that the interim safe *SLA* for the Greenland hunts (see Items 6.1-6.4 above) had also been tested for surveys at 10-year intervals and shown satisfactory performance and had been adopted by the Committee and the Commission in 2008. However, as noted at the time those tests had been for a restricted number of scenarios than the wider range of hypotheses customarily considered for such trials. It had thus been agreed that this *SLA* was appropriate for the provision of advice for up to two blocks (i.e. approximately 10 years) or to approximately 2018. The Workshop agreed that there were no scientific reasons why the next quota block for the Greenland hunts could not be for a six-year period, noting that the long-term *SLA*s will be available for implementation for the following block quota.

The SWG **endorsed** the views of the Workshop.

7. ABORIGINAL WHALING MANAGEMENT SCHEME

7.1 Draft guidelines for *Implementation Reviews*

An integral part of the AWMP process is the undertaking of regular or 'special' *Implementation Reviews*, as noted for example during the development process of the *Bowhead Whale SLA* (IWC, 2003b).

The first Bering-Chukchi-Beaufort Seas stock bowhead whale *Implementation Review* took place over two years and was completed in 2007 with most focus being on the issue of stock structure (IWC, 2007b; 2008a; 2008b; 2008c; 2008d). No changes needed to be made to the *Bowhead SLA* after the review. The first *Implementation Review* for gray whales was completed in 2010 and the *Gray Whale SLA* was not changed with respect to providing advice on the Russian hunt off Chukotka (IWC, 2011). However, as discussed above, during that review, information was received that led to the need to call for an immediate *Implementation Review* before providing advice for a potential hunt of gray whales by the Makah Tribe on the west coast of the USA.

The SWG had agreed that it would be useful to develop guidelines for *Implementation Reviews*, given the experience gained thus far. The adopted guidelines, which cover the issues outlined below, are provided in Appendix 7.

(1) Objectives.
(2) Timing of regular and special *Implementation Reviews.*
(3) Outcomes.
(4) Data availability.
(5) Computer programs.

The SWG **commends** these guidelines to the Committee.

7.2 Scientific aspects of an Aboriginal Whaling Scheme (AWS)

In 2002, the Committee strongly recommended that the Commission adopt the Aboriginal Subsistence Whaling Scheme (IWC, 2003a, pp.22-23). This covers a number of practical issues such as survey intervals, carryover, and guidelines for surveys. The Committee has stated in the past that the AWS provisions constitute an important and necessary component of safe management under AWMP *SLA*s and it **reaffirms** this view. It noted that discussions within the Commission of some aspects such as the 'grace period' are not yet complete.

8. PROGRESS ON FOLLOW-UP WORK ON CONVERSION FACTORS FOR THE GREENLANDIC HUNT

In 2009, the Commission appointed a small working group (comprising several Committee members) to visit Greenland and compile a report on the conversion factors used by species to translate the Greenlandic need request which is provided in tonnes of edible products to numbers of animals (Donovan *et al.*, 2010). At that time the group provided conversion factors based upon the best available data, noting that given the low sample sizes, the values for species other than common minke whales should be considered provisional. The group also recommended that a focused attempt to collect new data on edible products taken from species other than common minke whales be undertaken, to allow a review of the interim factors; and that data on both 'curved' and 'standard' measurements are obtained during the coming season for all species taken.

Last year the Committee had welcomed an initial report, recognising the logistical difficulty of collecting this kind of data. However, it had noted that considerably more detail is needed and requested that a detailed report be presented for consideration at the next meeting.

In particular, it had requested that the report should provide:

(1) a description of the field protocols and sampling strategy, including effort and likely sample sizes;
(2) a description of analysis methods and models; and
(3) presentation from results thus far, including from preliminary analyses with the available data.

It had noted that such information will assist the SWG in addressing issues such as appropriate sample size.

This year, the SWG received further information on the data collected thus far from the Greenlandic authorities which can be summarised as follows.

(1) Humpback whales (*n*=4). The average in kg ± SE:
- meat: 4,823 ± 3,020;
- mattak: 3,140 ± 1,282;
- ventral grooves: 2,670 ± 454; and
- total weight: 10,633 ± 4,217.

(2) Fin whales (*n*=2). The average in kg ± SE:
- meat: 3,075 ± 955;
- mattak: 1,998 ± 1,241;
- ventral grooves: 1,238 ± 902; and
- total weight: 6,311 ± 2,390.

(3) Bowhead whales (*n*=5). The average in kg ± SE:
- total weight: 8,673 ± 2,127.

The SWG welcomed this information and the provision of data. It noted that a comparison of these values and the Recommended Conversion Factors Per Animal (RCPFA) from Donovan *et al.* (2010) showed reasonable agreement for humpback and bowhead whales (within 1 SD), but the yield for fin whales was lower than expected. It was not possible to examine this difference *inter alia* because no lengths of the animals included in the analysis were provided.

Although welcoming this information, the SWG expressed a number of concerns over the insufficient level of detail provided, the efficiency of the sampling regime (relatively poor sample sizes) and the extrapolation procedure in which only one meat tote or box is weighed.

In response to the concern over the lack of samples, Witting informed the SWG that the Greenland Institute of Natural Resources (GINR) has been asked to investigate this and is working with the hunters and authorities to improve the sample size in the future. The SWG greatly **encourages** this and looks forward to a report on progress made. It also encourages the GINR to develop improved protocols including weighing as many of the meat, mattak, and qiporaq bins as possible (i.e. not just 1 bin). Providing a breakdown of products from bowhead whales would be valuable both for conversion factors and biological information.

Given these concerns, the SWG **recommends**:

(1) the provision of a full scientific paper to the next Annual Meeting that details *inter alia* a full description of the field protocols and sampling strategy, analytical methods; and a presentation of the results thus far, including information on the sex and length of each of the animals for which weight data are available; and
(2) the collection and provision of data on Recommendation No. 2 of Donovan *et al.* (2010) comparing standard *vs.* curvilinear whale lengths. This should be done for all three species on as many whales as possible. Guidelines and protocols are suggested in Donovan *et al.* (2010).

9. WORK PLAN

The SWG draws attention to the following work identified in the report for completion intersessionally or at the 2013 Annual Meeting (note that item (7) was raised during review of report).

(1) Item 2.5.3. Present *Evaluation* and *Robustness Trial* results to the SWG of an *SLA* variant that corresponds exactly to the management plan proposed by the Makah Tribe to the US Government (co-ordinator: Brandon).
(2) Item 2.6. Present a revised document on the probability of a gray whale that regularly feeds in the western North Pacific being taken in a Makah hunt (Moore and Weller, with assistance from an advisory group comprising Brandon, Givens, Punt and Scordino).
(3) Item 4. Develop trial structures and operating models for the Greenland hunts of bowhead and humpback whales to be presented initially at an intersessional workshop (Punt – see Appendix 6).
(4) Item 4. Develop an AWMP/RMP-lite program to assist developers of *SLA*s for the Greenland hunts of fin and common minke whales (Punt – see Appendix 6).
(5) Item 4. Hold an intersessional Workshop to progress work on the development of *SLA*s for the Greenland hunts (estimated cost £8,000).
(6) Item 8. Present a full scientific paper on the work in Greenland related to the collection of information on conversion factors (co-ordinator: Witting; paper: Greenlandic authorities).
(7) Present a document that provides advice on the development of *SLA*s and their evaluation (co-ordinators: Donovan, Punt and Scordino).

10. ADOPTION OF REPORT

The Report was adopted at 18:00 on 19 June apart from Item 2.5.3 and Item 8 that were adopted by email at 09:15 on 20 June 2012. The Chair thanked the participants for their extremely hard work in completing a very full agenda, and especially Punt, Brandon, Butterworth, Givens and Scordino for their rapporteuring work and initial examination of trial results.

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Appendix 1

AGENDA

1. Introductory items
   1.1 Convenor's opening remarks
   1.2 Election of Chair
   1.3 Appointment of rapporteurs
   1.4 Adoption of agenda
   1.5 Documents available
2. *Implementation Review* of gray whales with emphasis on the PCFG
   2.1 Summary of intersessional Workshop
   2.2 New information
   2.3 Progress with intersessional tasks
   2.4 Finalise the specifications for the trials and presentation of results
   2.5 Review results of trials
      2.5.1 *Evaluation Trials*
      2.5.2 *Robustness Trials*
   2.6 Other business
3. *Implementation Review* for B-C-B bowhead whales
   3.1 Consideration of new information with a focus on whether this implies a need for new trials
      3.1.1 Stock structure
      3.1.2 Abundance and rate of increase
      3.1.2 Other
   3.2 Discussion of new trials
   3.3 Conclusions and recommendations
4. Consideration of work required to develop *SLA*s for all Greenland hunts before the end of the interim period
   4.1 Common minke whales
   4.2 Fin whales
   4.3 Humpback whales
   4.4 Bowhead whales
5. Implications of new information on broad gray whale stock structure (with BRG)
   5.1 Summary of relevant BRG discussions
   5.2 Conclusions with respect to *Implementation Review*
6. Annual review of management advice
   6.1 Common minke whales off West Greenland
      6.1.1 New information
      6.1.2 Management advice
   6.2 Common minke whales off East Greenland
      6.2.1 New information
      6.2.2 Management advice
   6.3 Fin whales off West Greenland
      6.3.1 New information
      6.3.2 Management advice
   6.4 Humpback whales off West Greenland
      6.4.1 New information
      6.4.2 Management advice
   6.5 Humpback whales off St Vincent and The Grenadines
      6.5.1 New information
      6.5.2 Management advice
   6.6 Implications of possible move to biennial meetings with respect to length of block quotas
7. Aboriginal Whaling Management Scheme
   7.1 Draft guidelines for *Implementation Reviews*
   7.2 Scientific aspects of an Aboriginal Whaling Scheme
8. Progress on follow-up work on conversion factors for the Greenlandic hunt
9. Work plan
10. Adoption of report

Appendix 2

TRIALS SPECIFICATIONS

This document outlines a set of trials to evaluate the performance of *SLA*s for hunting in the Pacific Northwest, with a primary focus on the PCFG (Pacific Coast Feeding Group). The operating model assumes the two groups (the 'north' group and the PCFG) are separate stocks, but with possible immigration of 'north' group animals into the PCFG group. The operating model considers four strata (north of 52°N, south of 41°N, PCFG December-May, and PCFG June-November) because the relative vulnerability of the two stocks to whaling and incidental mortality differs among these strata.

A. The population dynamics model

The underlying population dynamics model is deterministic, age- and sex-structured, and based on a two-stock version of the Baleen II model (Punt, 1999).

A.1 Basic dynamics

Equation A1.1 provides the underlying 1+ dynamics.

$$\begin{aligned} R^{s,m/f}_{t+1,a+1} &= (R^{s,m/f}_{t,a} + I^{s,m/f}_{t,a} - C^{s,m/f}_{t,a})\, \tilde{S}^s_t\, S^s_a + U^{s,m/f}_{t,a}\, \tilde{S}^s_t\, S^s_a\, \delta_{a+1} & 0 \le a \le x-2 \\ R^{s,m/f}_{t+1,x} &= (R^{s,m/f}_{t,x} + I^{s,m/f}_{t,x} - C^{s,m/f}_{t,x})\, \tilde{S}^s_t\, S^s_x + (R^{s,m/f}_{t,x-1} + I^{s,m/f}_{t,x-1} - C^{s,m/f}_{t,x-1})\, \tilde{S}^s_t\, S^s_{x-1} & \\ U^{s,m/f}_{t+1,a+1} &= U^{s,m/f}_{t,a}\, \tilde{S}^s_t\, S^s_a\, (1-\delta_{a+1}) & 0 \le a \le x-2 \end{aligned} \quad \text{(A1.1)}$$

$R^{s,m/f}_{t,a}$ is the number of recruited males/females of age a in stock s at the start of year t;

$U^{s,m/f}_{t,a}$ is the number of unrecruited males/females of age a in stock s at the start of year t;

$C^{s,m/f}_{t,a}$ is the catch of males/females of age a from stock s during year t (whaling is assumed to take place in a pulse at the start of each year);

δ_a is the fraction of unrecruited animals of age a-1 which recruit at age a (assumed to be independent of sex, time, and stock);

S^s_a is the annual survival rate of animals of stock s and age a in the absence of catastrophic mortality events (assumed to be the same for males and females):

$$S^s_a = \begin{cases} S^s_0 & \text{if } a = 0 \\ S^s_{1+} & \text{if } 1 < a \end{cases} \quad \text{(A1.2)}$$

S^s_0 is the calf survival rate for animals of stock s;

S^s_{1+} is the survival rate for animals aged 1 and older for animals of stock s;

$\tilde{S}^s_t$ is the amount of catastrophic mortality (represented in the form of a survival rate) for stock s during year t (catastrophic events are assumed to occur at the start of the year before mortality due to whaling and natural causes; in general $\tilde{S}^s_t$=1, i.e. there is no catastrophic mortality);

$I^{s,m/f}_{t,a}$ is the net migration of female/male animals of age a into stock s during year t; and

x is the maximum (lumped) age-class (all animals in this and the x-1 class are assumed to be recruited and to have reached the age of first parturition). x is taken to be 15 for these trials.

Catastrophic mortality is assumed to be zero (i.e., $\tilde{S}^s_t$=1) except for the north stock for 1999 and 2000 when it is assumed to be equal to the parameter $\tilde{S}$. This assumption reflects the large number of dead ENP gray whales observed stranded along the coasts of Oregon and Washington during 1999 and 2000 relative to annual numbers stranding there historically (Brownell *et al.*, 2007; Gulland *et al.*, 2005). The mortality event is assumed to have only impacted the north stock because the abundance estimates for the PCFG stock increased when the mortality event occurred, in contrast to those for the north stock which declined substantially.

Immigration only occurs from the north stock to the PCFG stock and only animals aged 1+ immigrate. The annual number of animals immigrating is either $\bar{I}_t = I\ N_t^{\text{north},1+}/20{,}000$ where $\bar{I}$ is the hypothesized recent average number of individuals recruiting into the PCFG from the north stock (i.e., 2, 4 or 6) or a fixed level (0, 10, 20 or 30). The annual number of immigrants by age and sex is given by:

$$I^{s,m/f}_{t,a} = I_t \frac{(R^{\text{north},m/f}_{t,a} + U^{\text{north},m/f}_{t,a})}{N_t^{\text{north},1+}} \quad \text{(A1.3)}$$

Emigration from the PCFG stock is modelled by implementing an extra survival rate, S after 1930 (immigration or emigration are ignored when carrying capacity and the parameters which determine the productivity of the population are calculated). Owing to the different sizes of the two stocks, emigrants from the PCFG stock are assumed to die rather than join the north stock. The value of $\tilde{\tilde{S}}$ is set so that at carrying capacity immigration and emigration are balanced, i.e.:

$$\bar{I}\, K_{1+}^{\text{north}} = K_{0+}^{\text{PCFG}} (1-\tilde{\tilde{S}}) \quad \text{(A1.4)}$$

A.2 Births

The number of births to stock s at the start of year t+1, B^s_{t+1}, is given by:

$$B_{t+1}^{s} = b_{t+1}^{s} N_{t+1}^{s,f} \quad \text{(A2.1)}$$

$N_t^{s,f}$ is the number of mature females in stock s at the start of year t:

$$N_t^{s,f} = \sum_{a=a_m}^{x} (R_{t,a}^{s,f} + U_{t,a}^{s,f}) \quad \text{(A2.2)}$$

a_m is the age-at-maturity (the convention of referring to the mature population is used here, although this actually refers to animals that have reached the age of first parturition);

b_{t+1}^s is the probability of birth/calf survival for mature females:

$$b_{t+1}^{s} = b_{-\infty}^{s} \{1 + A^s (1 - (D_{t+1}^s / D_{-\infty}^s)^{z^s})\} \quad \text{(A2.3)}$$

$b_{-\infty}^s$ is the average number of live births per year per mature female in the pristine (pre-exploitation) population for stock s;

A^s is the resilience parameter for stock s;

z^s is the degree of compensation for stock s;

D_t^s is the size of the component of stock s in year t upon which the density-dependence is assumed to act; and

$D_{-\infty}^s$ is the pristine size of the component of stock s upon which the density-dependence is assumed to act.

The number of female births, $B_t^{s,f}$, is computed from the total number of the births during year t according to the equation:

$$B_t^{s,f} = 0.5\, B_t^s \quad \text{(A2.4)}$$

The numbers of recruited/unrecruited calves is given by:

$$\begin{aligned} R_t^{s,f} &= \pi_0\, B_t^{s,f} & R_t^{s,m} &= \pi_0\, (B_t^s - B_t^{s,f}) \\ U_t^{s,f} &= (1-\pi_0)\, B_t^{s,f} & U_t^{s,m} &= (1-\pi_0)(B_t^s - B_t^{s,f}) \end{aligned} \quad \text{(A2.5)}$$

π_0 is the proportion of animals of age 0 which are recruited (0 for these trials).

For the trials $D_t^s = N_t^{s,1+}$ and $D^s_{-\infty} = K^s_{1+}$ because density-dependence is assumed to act on the 1+ component of the population and affects fecundity and infant survival. $N_t^{s,1+}$ and K^s_{1+} are defined according to the equations:

$$N_t^{s,1+} = \sum_{a=1}^{x} (R_{t,a}^{s,\text{f}} + U_{t,a}^{s,\text{f}} + R_{t,a}^{s,\text{m}} + U_{t,a}^{s,\text{m}}) \qquad K_{1+}^{s} = \sum_{a=1}^{x} (R_{-\infty,a}^{s,\text{f}} + U_{-\infty,a}^{s,\text{f}} + R_{-\infty,a}^{s,\text{m}} + U_{-\infty,a}^{s,\text{m}}) \quad \text{(A2.6)}$$

A.3 Catches

The historical (t<2010) catches by stratum (north, south, PCFG December-May, and PCFG June-November) are taken to be equal to the reported catches (Table 1). The historical catches are allocated to stocks in fixed proportions as follows:

- North area catches: all north animals;
- PCFG area catches in December-May: PCFG animals with probability ϕ_{PCFG} - base-case value 0.3, as determined by the photo-ID data (Calambokidis *et al.*, 2012);
- PCFG area catches in June-November: all PCFG animals; and
- South area catches: PCFG animals with probability ϕ_{south} (base-case value 0.01, as determined by relative abundance).

Table 1

Historical catches of eastern north Pacific gray whales.

	South			PCFG Jun.-Nov.			PCFG Dec.-May			North			Total		
Year	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total
1930	0	0	0	0	0	0	0	0	0	23	24	47	23	24	47
1931	0	0	0	0	0	0	0	0	0	5	5	10	5	5	10
1932	5	5	10	0	0	0	0	0	0	5	5	10	10	10	20
1933	30	30	60	0	0	0	0	0	0	8	7	15	38	37	75
1934	30	30	60	0	0	0	0	0	0	36	30	66	66	60	126
1935	55	55	110	0	0	0	0	0	0	16	28	44	71	83	154
1936	43	43	86	0	0	0	0	0	0	50	62	112	93	105	198
1937	0	0	0	0	0	0	0	0	0	12	12	24	12	12	24
1938	0	0	0	0	0	0	0	0	0	32	32	64	32	32	64
1939	0	0	0	0	0	0	0	0	0	19	20	39	19	20	39
1940	0	0	0	0	0	0	0	0	0	56	69	125	56	69	125
1941	0	0	0	0	0	0	0	0	0	38	39	77	38	39	77
1942	0	0	0	0	0	0	0	0	0	60	61	121	60	61	121
1943	0	0	0	0	0	0	0	0	0	59	60	119	59	60	119
1944	0	0	0	0	0	0	0	0	0	3	3	6	3	3	6
1945	0	0	0	0	0	0	0	0	0	25	33	58	25	33	58
1946	0	0	0	0	0	0	0	0	0	14	16	30	14	16	30
1947	0	0	0	0	0	0	0	0	0	11	20	31	11	20	31
1948	0	0	0	0	0	0	0	0	0	7	12	19	7	12	19
1949	0	0	0	0	0	0	0	0	0	10	16	26	10	16	26
1950	0	0	0	0	0	0	0	0	0	4	7	11	4	7	11
1951	0	0	0	0	0	0	1	0	1	5	8	13	6	8	14
1952	0	0	0	0	0	0	0	0	0	17	27	44	17	27	44
1953	0	0	0	0	0	0	6	4	10	15	23	38	21	27	48
1954	0	0	0	0	0	0	0	0	0	14	25	39	14	25	39
1955	0	0	0	0	0	0	0	0	0	22	37	59	22	37	59
1956	0	0	0	0	0	0	0	0	0	45	77	122	45	77	122
1957	0	0	0	0	0	0	0	0	0	36	60	96	36	60	96
1958	0	0	0	0	0	0	0	0	0	55	93	148	55	93	148
1959	1	1	2	0	0	0	0	0	0	73	121	194	74	122	196
1960	0	0	0	0	0	0	0	0	0	58	98	156	58	98	156
1961	0	0	0	0	0	0	0	0	0	77	131	208	77	131	208
1962	4	0	4	0	0	0	0	0	0	55	92	147	59	92	151
1963	0	0	0	0	0	0	0	0	0	68	112	180	68	112	180
1964	15	5	20	0	0	0	0	0	0	75	124	199	90	129	219
1965	0	0	0	0	0	0	0	0	0	71	110	181	71	110	181
1966	15	11	26	0	0	0	0	0	0	80	114	194	95	125	220
1967	52	73	125	0	0	0	0	0	0	109	140	249	161	213	374
1968	41	25	66	0	0	0	0	0	0	48	87	135	89	112	201
1969	39	35	74	0	0	0	0	0	0	50	90	140	89	125	214
1970	0	0	0	0	0	0	0	0	0	71	80	151	71	80	151
1971	0	0	0	0	0	0	0	0	0	57	96	153	57	96	153
1972	0	0	0	0	0	0	0	0	0	61	121	182	61	121	182
1973	0	0	0	0	0	0	0	0	0	97	81	178	97	81	178
1974	0	0	0	0	0	0	0	0	0	94	90	184	94	90	184
1975	0	0	0	0	0	0	0	0	0	58	113	171	58	113	171
1976	0	0	0	0	0	0	0	0	0	69	96	165	69	96	165
1977	0	0	0	0	0	0	0	0	0	87	100	187	87	100	187
1978	0	0	0	0	0	0	0	0	0	94	90	184	94	90	184
1979	0	0	0	0	0	0	0	0	0	58	125	183	58	125	183
1980	0	0	0	0	0	0	0	0	0	53	129	182	53	129	182
1981	0	0	0	0	0	0	0	0	0	36	100	136	36	100	136
1982	0	0	0	0	0	0	0	0	0	57	111	168	57	111	168
1983	0	0	0	0	0	0	0	0	0	46	125	171	46	125	171
1984	0	0	0	0	0	0	0	0	0	59	110	169	59	110	169
1985	0	0	0	0	0	0	0	0	0	54	116	170	54	116	170
1986	0	0	0	0	0	0	0	0	0	46	125	171	46	125	171
1987	0	0	0	0	0	0	0	0	0	48	111	159	48	111	159
1988	0	0	0	0	0	0	0	0	0	43	108	151	43	108	151
1989	0	0	0	0	0	0	0	0	0	61	119	180	61	119	180
1990	0	0	0	0	0	0	0	0	0	67	95	162	67	95	162
1991	0	0	0	0	0	0	0	0	0	67	102	169	67	102	169
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	21	23	44	21	23	44
1995	0	0	0	0	0	0	0	0	0	48	44	92	48	44	92
1998	0	0	0	0	0	0	0	0	0	64	61	125	64	61	125
1999	0	0	0	0	0	0	0	1	1	69	54	123	69	55	124
2000	0	0	0	0	0	0	0	0	0	63	52	115	63	52	115

Cont.

	South			PCFG Jun.-Nov.			PCFG Dec.-May			North			Total		
Year	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total
Table 1 cont.															
1996	0	0	0	0	0	0	0	0	0	18	25	43	18	25	43
1997	0	0	0	0	0	0	0	0	0	48	31	79	48	31	79
2001	0	0	0	0	0	0	0	0	0	62	50	112	62	50	112
2002	0	0	0	0	0	0	0	0	0	80	51	131	80	51	131
2003	0	0	0	0	0	0	0	0	0	71	57	128	71	57	128
2004	0	0	0	0	0	0	0	0	0	43	68	111	43	68	111
2005	0	0	0	0	0	0	0	0	0	49	75	124	49	75	124
2006	0	0	0	0	0	0	0	0	0	57	77	134	57	77	134
2007	0	0	0	0	1	1	0	0	0	50	81	131	50	82	132
2008	0	0	0	0	0	0	0	0	0	64	66	130	64	66	130
2009	0	0	0	0	0	0	0	0	0	59	57	116	59	57	116
2010	0	0	0	0	0	0	0	0	0	57	61	118	57	61	118

The future catches by stratum are incidental catches and the catches arising from application of the *SLA*s. Subsistence catches are only assumed to occur in the north and the PCFG area from December-May. The sex-ratio of future catches is assumed to be 50:50 except for a sub-set of the robustness trials. The catches are allocated to stock as outlined above, except that the subsistence catches from the PCFG area in June-November are modelled individually. Thus, the catch from the PCFG area is allocated to the PCFG stock based on Bernoulli trials with probability:

$$\frac{\sum_{\text{m/f}}\sum_{a'} R_{y,a'}^{\text{PCFG,m/f}}}{\delta\sum_{\text{m/f}}\sum_{a"} R_{y,a"}^{\text{north,m/f}} + \sum_{\text{m/f}}\sum_{a"} R_{y,a"}^{\text{PCFG,m/f}}} \tag{A3.1}$$

where δ is the relative probability of harvesting a PCFG versus a north animal had the sizes of the two populations been the same. δ is calculated from ϕ under the assumption that the number of PCFG animals is 200 and north animals is 20,000, i.e.:

$$\delta=(200 / \phi) - 200 / 20{,}000 \tag{A3.2}$$

The incidental catches by stratum for the historical period are computed using the equation:

$$C_y^{\text{I}/s} = 0.5\begin{cases}\left\{1-\frac{0.5}{69}[1999-y]\right\}\bar{C}^I & \text{if } y \le 1999 \\ \bar{C}^I N_y^{1+} / \bar{N}^{1+} & \text{otherwise}\end{cases} \tag{A3.3}$$

$C_y^{\text{I}/s}$ is the incidental catch of animals of sex *s* during year *y*;
$\bar{C}^I$ is the mean catch in the stratum (see Table 2); and
$\bar{N}^{1+}$ is the mean 1+ abundance (in the stratum concerned from 2000-09).

The catches from the PCFG and north stocks are then allocated to age and size using the formula:

$$C_{t,a}^{s,m} = C_t^{s,m} R_{y,a}^{s,m} / \sum_{a"} R_{y,a"}^{s,m}; \quad C_{t,a}^{s,\text{f}} = C_t^{s,\text{f}} R_{y,a}^{s,\text{f}} / \sum_{a"} R_{y,a"}^{s,\text{f}}; \tag{A3.4}$$

The probability of not identifying a PCFG whale as such, is p_2, (base-case value 0) while the probability of incorrectly identifying a north whale as a PCFG whale is p_1 (base-case 0.01). If the survey frequency for the PCFG area is not annual, p_2 is defined as:

$$p_{2,t} = 1 - \frac{\sum_{a\ge SF}(R_{t,a}^{\text{north,m}} + R_{t,a}^{\text{north,f}} + U_{t,a}^{\text{north,m}} + U_{t,a}^{\text{north,f}})}{\sum_{a\ge 1}(R_{t,a}^{\text{north,m}} + R_{t,a}^{\text{north,f}} + U_{t,a}^{\text{north,m}} + U_{t,a}^{\text{north,f}})} \tag{A3.5}$$

where *SF* is the survey frequency for the PCFG area.

Stratum	Average incidental catch
North	0[1]
PCFG [Dec.-May]	2
PCFG [Jun.-Nov.]	1.4[2]
South	3.4

[1]Obviously not actually zero, but will be small relative to population size.
[2]Includes southern whales during June-November as these whales are almost certainly PCFG animals.

A.4 Recruitment
The proportion of animals of age *a* that would be recruited if the population was pristine is a knife-edged function of age at age 0, i.e.:

$$\pi_a = \begin{cases} 0 & \text{if } \quad a = 0 \\ 1 & \text{otherwise} \end{cases} \tag{A4.1}$$

The (expected) number of unrecruited animals of age *a* that survive to age *a*+1 is $U_{t,a}^{s,m/f}\ S_a$. The fraction of these that then recruit is:

$$\delta_{a+1} = \begin{cases} [\pi_{a+1} - \pi_a]/[1-\pi_a] & \text{if } 0 \le \pi_a < 1 \\ 1 & \text{otherwise} \end{cases} \tag{A4.2}$$

A.5 Maturity
Maturity is assumed to be a knife-edged function of age at age a_m.

A.6 Initialising the population vector
The numbers at age in the pristine population are given by:

$$\begin{aligned} R_{-\infty,a}^{s,\mathrm{m/f}} &= 0.5 \quad N_{-\infty,0}^{s} \quad \pi_a \prod_{a'=0}^{a-1} S_{a'}^{s} & \text{if} \quad 0 \le a < x \\ U_{-\infty,a}^{s,\mathrm{m/f}} &= 0.5 \quad N_{-\infty,0}^{s} \quad (1-\pi_a) \prod_{a'=0}^{a-1} S_{a'}^{s} & \text{if} \quad 0 \le a < x \\ R_{-\infty,x}^{s,\mathrm{m/f}} &= 0.5 \quad N_{-\infty,0}^{s} \prod_{a'=0}^{x-1} \frac{S_{a'}^{s}}{(1-S_x)} & \text{if} \quad a = x \end{aligned} \tag{A6.1}$$

$R_{-\infty,a}^{s,\mathrm{m/f}}$ is the number of animals of stock *s* of age *a* that would be recruited in the pristine population;
$U_{-\infty,a}^{s,\mathrm{m/f}}$ is the number of animals of stock *s* of age *a* that would be unrecruited in the pristine population; and
$N_{-\infty,0}^{s}$ is the total number of animals of stock *s* of age 0 in the pristine population.

The value for $N_{-\infty,0}^{s}$ is determined from the value for the pre-exploitation size of the 1+ component of the population using the equation:

$$N_{-\infty,0}^{s} = K_{1+}^{s} / \left(\sum_{a'=1}^{x-1} \prod_{a'=1}^{a-1} S_a^s + \frac{1}{1-S_x} \prod_{a'=0}^{x-1} S_{a'}^{s} \right) \tag{A6.2}$$

It is well-known that it is not possible to make a simple density-dependent population dynamics model consistent with the abundance estimates for the eastern north Pacific stock of gray whales (Butterworth *et al.*, 2002; Cooke, 1986; Lankester and Beddington, 1986; Reilly, 1981; 1984). This is why recent assessments of this stock (Punt and Wade, 2012) have been based on starting population projections from a more recent year (denoted as τ) than that in which the first recorded catch occurred. The trials are therefore based on the assumption that the age-structure at the start of τ=1930 is stable rather than that the population was at its pre-exploitation equilibrium size at the start of 1600, the first year for which catch estimates are available. The choice of 1930 for the first year of the simulation is motivated by the fact that the key assessment results are not sensitive to a choice for this year from 1930-68 (Punt and Butterworth, 2002; Punt and Wade, 2012). Note that even though the operating model ignores the catch data for 1600-1929, these catches are nevertheless provided to the *SLA* for the north area.

The determination of the age-structure at the start of 1930 involves specifying the effective 'rate of increase', γ, that applies to each age-class. There are two components contributing to γ, one relating to the overall population rate of increase (γ^+) and the other to the exploitation rate. Under the assumption of knife-edge recruitment to the fishery at age 1, only the γ^+ component (assumed to be zero following Punt and Butterworth, 2002) applies to ages a of age 0. The number of animals of age a at the start of τ=1930 relative to the number of calves at that time, $N^{s,*}_{\tau,a}$, is therefore given by the equation:

$$N^{s,*}_{\tau,a} = \begin{cases} 1 & \text{if } a=0 \\ N^{s,*}_{\tau,0}\, S^s_0 & \text{if } a \le 1 \\ N^{s,*}_{\tau,a-1}\, S^s_{a-1}\,(1-\gamma^+) & \text{if } 1<a<x \\ N^{s,*}_{\tau,x-1}\, S^s_{x-1}(1-\gamma^+)/(1-S^s_x(1-\gamma^+)) & \text{if } a=x \end{cases} \tag{A6.3}$$

B^s_τ is the number of calves in year τ (=1930) and is derived directly from equations A2.1 and A2.3 (for further details see Punt, 1999):

$$B^s_\tau = \left(1-\left[1/(N^{s,f}_\tau b^s_{-\infty})-1\right]/A^s\right)^{1/z^s} \frac{D^s_{-\infty}}{D^{s,*}_\tau} \tag{A6.4}$$

$D^{s,*}_\tau$ is the number of animals in the density-dependent component of the population relative to the number of births at that time (see equation A2.6).

The effective rate of increase, γ^s, is selected so that if the population dynamics model is projected from 1930 to 1968, the size of the 1+ component of the population (both stocks) in 1968 equals a pre-specified value, P^s_{1968} .

A.7 z and A

A^s, z^s and S^s_0 , are obtained by solving the system of equations that relate $MSYL^s_{1+}$, $MSYR^s_{1+}$, S^s_0 , S_{1+}, $f_{\max}$ a_m, A^s and z^s, where $f_{\max}$ is the maximum theoretical pregnancy rate (Punt, 1999).

A.8 Conditioning

The method for conditioning the trials (i.e. selecting the 100 sets of values for the parameters a_m, S^s_0 , S_{1+}, S, K^{north}_{1+}, K^{PCFG}_{1+}, A^{north}, A^{PCFG}, z^{north}, and z^{PCFG}) is based on a Bayesian assessment of the eastern North Pacific stock of gray whales (Punt and Butterworth, 2002; Punt and Wade, 2012; Wade, 2002). The algorithm for conducting the Bayesian assessment is as follows:

Draw values for the parameters S_{1+}, $f_{\max}$, a_m, K^{north}_{1+}, K^{PCFG}_{1+}, P^{north}_{1968}, P^{PCFG}_{1968}, $\tilde{S}$, CV^{north}_{add} (the additional variance for the estimates of 1+ abundance at Carmel, California in 1968), CV^{PCFG}_{add} (the additional variance for the estimates of 1+ abundance from northern California to southeast Alaska in 1968, had such a survey taken place) from the priors in Table 3. It is not necessary to draw values for $MSYL^s_{1+}$ and $MSYR^s_{1+}$ because the values for these quantities are pre-specified rather than being determined during the conditioning process.

Solve the system of equations that relate $MSYL^s_{1+}$, $MSYR^s_{1+}$, S^s_0 , S_{1+}, $f_{\max}$, a_m, A^s and z^s to find values for S^s_0 , A^s and z^s.

Calculate the likelihood of the projection for each area, given by[1]:

$$-\ell nL = 0.5\ell n\,|\mathbf{V}+\Omega| + 0.5\sum_i\sum_j(\ell n N^{\text{obs}}_i - \ell n\hat{P}^{1+}_i)[(\mathbf{V}+\Omega)^{-1}]_{i,j}(\ell n N^{\text{obs}}_j - \ell n\hat{P}^{1+}_j) \tag{A8.1}$$

N^{obs}_i is the i^{th} estimate of abundance[2] (Tables 4a, 4b),

$\hat{P}^{1+}_i$ is the model-estimate corresponding to N^{obs}_i ,

$\mathbf{V}$ is the variance-covariance matrix for the abundance estimates, and

Ω is a diagonal matrix with elements given by $E(CV^2_{add,t})$:

$$E(CV^2_{add,t}) = CV^2_{add}\frac{0.1+0.013P^*/\hat{P}_t}{0.1+0.013P^*/\hat{P}_{1968}} \tag{A8.2}$$

Steps (a)-(c) are repeated a large number (typically 1,000,000) of times.

[1]This formulation assumes that the observed data relate to the medians of sampling distributions for the data. Alternative assumptions (such as that the observed data relate to the means of the sampling distribution) will be inconsequential given the extent of uncertainty associated with the estimates of abundance.

[2]The shore-based abundance estimate for year y/y+1 is assumed to pertain to abundance at the start of year y+1.

100 sets of parameters vectors are selected randomly from those generated using steps (a)-(c), assigning a probability of selecting a particular vector proportional to its likelihood. The number of times steps (a)-(c) are repeated is chosen to ensure that each of the 100 parameter vectors are unique.

The expected value for the estimate of abundance of the north area is taken to the total 1+ abundance (PCFG and north stocks combined) while the abundance estimates for the PCFG area are assumed to pertain to the PCFG stock only.

Table 3

The prior distributions for the eastern north Pacific stock of gray whales.

Parameter	Prior distribution
Non-calf survival rate, S_{1+}	U[0.95, 0.99]
Age-at-maturity, a_m	U[6, 12]
K_{1+}^{north}	U[16,000, 70,000]
K_{1+}^{PCFG}	U[100, 500]
Maximum pregnancy rate, f_{max}	U[0.3, 0.6]
Additional variation (population estimates) CV_{add}, in 1968	U[0, 0.35]
1968 abundance, P_{1968}^{north}	U[8,000, 16,000]
1968 abundance, P_{1968}^{PCFG}	U[50, 300]
Catastrophic mortality, $\tilde{S}$	U[0.5,1.0]

B. Data generation

B.1 Absolute abundance estimates

The historic (t<2011) abundance estimates (and their CVs) are provided to the *SLA*s and are taken to be those in Tables 4a, 4c. Future estimates of absolute abundance (and their estimated CVs) are generated and provided to the *SLA* once every F years during the management period (starting in year 2011 where the default values for F are 10 for the northern area and F=1 for the PCFG area). The CV of the abundance estimate (CV_{true}) may differ from the CV provided to the *SLA* (further details are provided below).

The survey estimate, $\hat{S}$, may be written as:

$$\hat{S} = B_A PY\, w / \mu = B_A\, P^*\, \beta^2\, Y\, w \quad \text{(B1.1)}$$

B_A is the bias (the bias for the bulk of the simulations for the north area is 1 while the bias for PCFG area is generated from $\ell n B_A \sim N(-0.305, 0.108)$ – this bias reflects the difference between the abundance estimates on which the ABL is based [which pertain to Oregon to Southern Vancouver Island] and the abundance of the entire stock];

P is the current total 1+ population size ($= N_t^{1+}$); (B1.2)

Y is a lognormal random variable: $Y = e^{\phi}$ where: $\phi \sim N[0; \sigma_\phi^2]$ and $\sigma_\phi^2 = \ell n(1+\alpha^2)$ (B1.3)

w is a Poisson random variable, independent of Y, with $E(w) = \text{var}(w) = \mu = (P / P^*) / \beta^2$; and (B1.4)

P^* is the reference population level (the pristine 1+ population, $= K^{1+}$).

The steps used in the program to generate the abundance estimates and their CVs are given below[3].

The *SLA* is provided with estimates of CV_{est} (the estimation error associated with factors considered historically) for each future sightings estimate. The estimate of $CV_{est,t}$ is given by:

$$\hat{C}V_{est,t} = \sqrt{\sigma_t^2 \, (\chi_n^2 / n)} \qquad \sigma_t^2 = \ell n(1 + E(CV_{est,t}^2)) \quad \text{(B1.5)}$$

$E(CV_{est,t}^2)$ is the sum of the squares of the actual CVs due to estimation error:

$$E(CV_{est,t}^2) = \theta^2 (a^2 + b^2 / w\beta^2) \quad \text{(B1.6)}$$

[3]The steps used to generate estimates of abundance and their CVs are as follows (steps (i)-(iii) are part of the conditioning process).

(i) Read in CV_{est}. Generate values of CV^2_{add} for 1968.

(ii) Set η using equation B1.6b and the value of CV_{add} generated in step (i).

(iii) Set θ^2 using equation B1.7a and the values for CV_{est} from step (i) and $w\beta^2 = P/P^* = P_{1968} / P^*$. Set α^2 and β^2 using equation B1.8.

(iv) Generate w (Poisson random variable – see equation B1.4) and ϕ (lognormal random variable – see equation B1.3).

(v) Set abundance estimate $\hat{S}$ using equation B1.1.

(vi) Set E($CV^2_{est,t}$) using eqn B1.6a.

(vii) Generate $CV_{est,t}$ from χ^2_n distribution using equation B1.5.

χ^2_n is a random number from a χ^2 distribution with n (=19; the value assumed for the single stock trials for the RMP) degrees of freedom;

a^2, b^2 are constants and equal to 0.02 and 0.012 respectively;

The relationship between CV_{est} and CV_{true} is given by:

$$\eta = [E(CV^2_{true}) - E(CV^2_{est})] / (0.1 + 0.013P^* / P) \quad \text{(B1.7a)}$$

where η is a constant known as the additional variance factor. The value of η is based on the population size and CVs for 1968 (for consistency with the way the CV for P_{1968} is generated in Table 3):

$$\eta = CV^2_{add} / (0.1 + 0.013P^* / P_{1968}) \quad \text{(B1.7b)}$$

The values of α and β are then computed as:

$$\alpha^2 = \theta^2 a^2 + \eta 0.1 , \qquad \beta^2 = \theta^2 b^2 + \eta 0.013 \quad \text{(B1.8)}$$

Table 4a

Estimates of absolute abundance (with associated standard errors) for the eastern north Pacific stock of gray whales based on shore counts (source: table 9 in Laake *et al.*, 2012).

Year	Estimate	CV	Year	Estimate	CV
1967/68	13,426	0.094	1979/80	19,763	0.083
1968/69	14,548	0.080	1984/85	23,499	0.089
1969/70	14,553	0.083	1985/86	22,921	0.081
1970/71	12,771	0.081	1987/88	26,916	0.058
1971/72	11,079	0.092	1992/93	15,762	0.067
1972/73	17,365	0.079	1993/94	20,103	0.055
1973/74	17,375	0.082	1995/96	20,944	0.061
1974/75	15,290	0.084	1997/98	21,135	0.068
1975/76	17,564	0.086	2000/01	16,369	0.061
1976/77	18,377	0.080	2001/02	16,033	0.069
1977/78	19,538	0.088	2006/07	19,126	0.071
1978/79	15,384	0.080			

Table 4b

Estimates of absolute abundance (with associated CVs) for 41°-52°N (source: J. Laake, pers. commn).

Year	Estimate	CV	Year	Estimate	CV
1998	101	0.062	2005	206	0.109
1999	135	0.089	2006	190	0.099
2000	141	0.093	2007	183	0.126
2001	172	0.073	2008	191	0.084
2002	189	0.048	2009	185	0.125
2003	200	0.082	2010	186	0.100
2004	206	0.072			

Table 4c

Estimates of absolute abundance (with associated CVs) for the Oregon to Southern Vancouver Island (source: J. Laake, pers. commn).

Year	Estimate	CV	Year	Estimate	CV
1998	63	0.066	2005	162	0.097
1999	78	0.107	2006	154	0.099
2000	89	0.133	2007	152	0.095
2001	117	0.076	2008	150	0.083
2002	133	0.113	2009	146	0.102
2003	151	0.090	2010	143	0.116
2004	157	0.098			

C. Need

The level of need in each year, Q_t, will be supplied to the *SLA*s. The need is given by $Q_t = Q_{2011} + \frac{t - 2011}{100} (Q_{2111} - Q_{2011})$ where Q_{2011} (=150 for the north area and =7 for the PCFG area) is the need at the start of the first year in which the AWMP is applied and Q_{2111} is the value 100 years later.

D. Implementing the Makah harvest regime

The overall application of the Makah management regime is as follows:

- compute the ABL (Allowable Bycatch Limit of PCFG whales);
- strike an animal;
- if the animal is struck and lost in December-April[4]:
  - if the total number of struck and lost animals is 3, stop the hunt;
  - if the total number of struck animals equals the need of 7 stop the hunt;

If the animal is struck-and lost in May:

- add one to the number of whales counted towards the ABL;
- if the ABL is reached; stop the hunt;
- if the total number of struck and lost animals is 3, stop the hunt;
- if the total number of struck animals equals the need of 7; stop the hunt;

If the animal is landed and is matched against the catalogue[5]:

- add one to the number of whales counted towards the ABL;
- if the ABL is reached; stop the hunt;
- if the total number of landed whales equals 5; stop the hunt;
- if the total number of struck animals equals the need of 7; stop the hunt;
- if the number of landed whales for the current five-year block equals 20; stop the hunt;

If the animal is landed and does not match any whale in the catalogue:

- if the total number of landed whales equals 5; stop the hunt;
- if the total number of struck animals equals the need of 7; stop the hunt;
- if the number of landed whales for the current five-year block equals 20; stop the hunt;

The base-case and the 10 alternative variants are listed in Table 5.

Table 5

The Makah Tribe's proposed hunt and suggested Variants for evaluation noting which management measure is altered as compared to the Makah Tribe's proposed management plan.

Variant number	Bycatch limit	Modelled time period of hunt	Availability of PCFG
Makah proposal	ABL formula	December to April	Trial specified
2	ABL formula	May only	Trial specified
3	ABL formula	May only	PCFG=100%
4	1	December to April	Trial specified
5	1	May only	Trial specified
6	1	May only	PCFG=100%
7	2	December to April	Trial specified
8	2	May only	Trial specified
9	2	May only	PCFG=100%
10	No limit	December to May	Trial specified
11	No limit	May only	PCFG=100%

E. Trials

There three 'broad' hypotheses to capture possible reasons for the trend in the abundance data for the PCFG area:

- The 1998 abundance estimate is biased due to 'discovery', and 20 whales immigrated into the PCFG stock from the northern stock in each of 1999 and 2000 (hypothesis 'P').
- There has been no pulse immigration into the PCFG stock; rather the abundance estimates are subject to time-varying bias (Table 6) (hypothesis 'B').
- Ten whales immigrated into the PCFG stock from the northern stock in each of 1999 and 2000 and the abundance estimates are subject to time-varying bias (but not the extent as for hypothesis P; Table 6) (hypothesis 'I').

Table 6

Bias for the 'B' and 'I' hypotheses.

Year	Hypothesis B	Hypothesis I
1998	0.513	0.7565
1999	0.631	0.8155
2000	0.750	0.8750
2001	0.869	0.9345
2002	0.988	0.9940
2003+	1.000	1.0000

[4]Whether a whale is struck and lost is determined from a Bernoulli trial with probability 0.5 (base-case).

[5]PCFG whales are mismatched as north stock whales with probability p_2 while north stock whales are matched to the catalogue with probability p_1.

Table 7 lists all of the factors considered in the trials. Table 8 summarises the trials. Note that some trials do not apply to some of the 'broad' hypotheses. Table 8 also indicates which trials need to be conditioned.

Table 7

Details of factors considered in trials.

Factors	Levels (reference levels shown bold and underlined)
$MSYR_{1+}$ (north)	**2%**, **4.5%**
$MSYR_{1+}$ (PCFG)	**1%**, **2%**, **4.5%**
Immigration rate (annual)	**0, 1, 2**, 4, 6
Pulse immigration (1999/2000)	**0**, 10, **20**, 30
Proportion of PCFG whales in PCFG area, ϕ_{fut}	0, **0.3**, 0.6, 1
Struck and lost rate (PCFG area)	0, **50%**, 75%
Northern need in final year (linear change from 150 in 2010)	**340**, 530
Historic survey bias	**None/Appendix 2, Table 6**, increasing between 1967 to 2002 from 0.5→1 (north only) 50% (PCFG only)
Future episodic events[1]	**None**, 3 events occur between yrs 1-75 (with at least 2 in yrs 1-50) in which 20% of the animals die. Events occur every 5 years in which 10% of the animals die[2]
Time dependence in K	**Constant**, halve linearly over 100yr; double linearly over 100yr
Time dependence in natural mortality, M *	**Constant**, double linearly over 100yr
Parameter correlations	Yes, **No**
Probability of mismatching north whales, p_2	0, **0.01**, 0.01-0.05
Probability of mismatching PCFG whales, p_1	**0**, 0.5
Frequency of PCFG surveys	**Annual**, 6-year
Incidental catch	**Reference**, double reference, half reference
Future sex ratio	**0.5:0.5**, 0.2:0.8 (M:F)
Episodic events with future pulse events[1]	**None**, 3 events occur between yrs 1-75 (with at least 2 in yrs 1-50) in which 20% of the north stock die and a pulse of 20 animals is added to the PCFG stock.

[1]The average value for adult survival needs to be adjusted to ensure the population is stable for these trials. [2]Selected to mimic the implications of stochasticity in the population dynamics.

Table 8a

The *Evaluation Trials*. Values given in bold type show differences from the base case trial. The final three columns indicate which trials apply to which 'broad' hypotheses. For 'broad' hypotheses B and I, the number given is the plus in 1999/2000. Unless specified otherwise ϕ_{PCFG}=0.3, the struck and lost rate is 0.5, and there are no stochastic dynamics or episodic events.

Trial	Cond-ition	Description	$MSYR_{1+}$ North	$MSYR_{1+}$ PCFG	Final Need	Annual immigration	Survey freq.	Survey bias (north)	Hypothesis P	B	I
1A	Y	$MSYR_{1+}$=4.5%/4.5%	4.5%	4.5%	340/7	2	10/1	1	20	Y	10
1B	Y	$MSYR_{1+}$=4.5%/2%	4.5%	2%	340/7	2	10/1	1	20	Y	10
1C	Y	$MSYR_{1+}$=4.5%/1%	**4.5%**	**1%**	340/7	2	10/1	1	20	Y	10
1D	Y	$MSYR_{1+}$=2%/2%	**2%**	**2%**	340/7	2	10/1	**0.5→1**	20	Y	10
2A	Y	Immigration=0	4.5%	4.5%	340/7	**0**	10/1	1	20	Y	10
2B	Y	Immigration=0	4.5%	2%	340/7	**0**	10/1	1	20	Y	10
2C	Y	Immigration=0	**4.5%**	**1%**	340/7	**0**	10/1	1	20	Y	10
2D	Y	Immigration=0	**2%**	**2%**	340/7	**0**	10/1	**0.5→1**	20	Y	10
3A	Y	Immigration=1	4.5%	4.5%	340/7	**1**	10/1	1	20	Y	10
3B	Y	Immigration=1	4.5%	2%	340/7	**1**	10/1	1	20	Y	10
4A	Y	Immigration=4	4.5%	4.5%	340/7	**4**	10/1	1	20	Y	10
4B	Y	Immigration=4	4.5%	2%	340/7	**4**	10/1	1	20	Y	10
5A	Y	Immigration=6	4.5%	4.5%	340/7	**6**	10/1	1	20	Y	10
5B	Y	Immigration=6	4.5%	2%	340/7	**6**	10/1	1	20	Y	10
6A		High northern need	4.5%	4.5%	**530/7**	2	10/1	1	20	Y	
6B		High northern need	4.5%	2%	**530/7**	2	10/1	1	20	Y	
7A		3 episodic events	4.5%	4.5%	340/7	2	10/1	1	20	Y	
7B		3 episodic events	4.5%	2%	340/7	2	10/1	1	20	Y	
8A		Stochastic events 10% every 5 years	4.5%	4.5%	340/7	2	10/1	1	20	Y	
8B		Stochastic events 10% every 5 years	4.5%	2%	340/7	2	10/1	1	20	Y	
9A		Episodic events with future pulse events	4.5%	4.5%	340/7	2	10/1	1	20	Y	
9B		Episodic events with future pulse events	4.5%	2%	340/7	2	10/1	1	20	Y	
10A		Relative probability of harvesting a PCFG whale, ϕ_{PCFG}=0.6	4.5%	4.5%	340/7	2	10/1	1	20	Y	
10B		Relative probability of harvesting a PCFG whale, ϕ_{PCFG}=0.6	4.5%	2%	340/7	2	10/1	1	20	Y	
11A		Struck and lost (25%)	4.5%	4.5%	340/7	2	10/1	1	20	Y	
11B		Struck and lost (25%)	4.5%	2%	340/7	2	10/1	1	20	Y	
12A		Struck and lost (75%)	4.5%	4.5%	340/7	2	10/1	1	20	Y	
12B		Struck and lost (75%)	4.5%	2%	340/7	2	10/1	1	20	Y	
13A	Y	Higher 1999-2000 pulse	4.5%	4.5%	340/7	2	10/1	1	**30**		
13B	Y	Higher 1999-2000 pulse	4.5%	2%	340/7	2	10/1	1	**30**		
13C	Y	Higher 1999-2000 pulse	**4.5%**	**1%**	340/7	2	10/1	1	**30**		
14A	Y	Lower 1999-2000 pulse	4.5%	4.5%	340/7	2	10/1	1	**10**		
14B	Y	Lower 1999-2000 pulse	4.5%	2%	340/7	2	10/1	1	**10**		

Table 8b

The *Robustness Trials*.

Trial	Condition	Description	$MSYR_{1+}$ north	$MSYR_{1+}$ PCFG	Survey freq.	Hypothesis P	Hypothesis B
1A		6 year surveys	4.5%	4.5%	10/6	20	Y
1B		6 year surveys	4.5%	2%	10/6	20	Y
2A		Linear decrease in K^{1+} [K halves over years 0-99]	4.5%	4.5%	10/1	20	Y
2B		Linear decrease in K^{1+} [K halves over years 0-99]	4.5%	2%	10/1	20	Y
3A		Linear decrease in PCFG K^{1+} [K halves over years 0-99]	4.5%	4.5%	10/1	20	Y
3B		Linear decrease in PCFG K^{1+} [K halves over years 0-99]	4.5%	2%	10/1	20	Y
4A		Linear increase in M [M halves over years 0-99]	4.5%	4.5%	10/1	20	Y
4B		Linear increase in M [M halves over years 0-99]	4.5%	2%	10/1	20	Y
5A		Linear increase in PCFG M [M halves over years 0-99]	4.5%	4.5%	10/1	20	Y
5B		Linear increase in PCFG M [M halves over years 0-99]	4.5%	2%	10/1	20	Y
6A		Perfect detection; p_1 =0; p_2=0.01-0.05	4.5%	4.5%	10/1	20	Y
6B		Perfect detection; p_1 =0; p_2=0.01-0.05	4.5%	2%	10/1	20	Y
7A		$p_1 = 0.5$	4.5%	4.5%	10/1	20	Y
7B		$p_1 = 0.5$	4.5%	2%	10/1	20	Y
8B	Y	Survey bias PCFG + $p_1 = 0.5$	4.5%	2%	10/1	20	Y
9B	Y	Correlation (draw for N; same quantile in the range for PCFG)	4.5%	2%	10/1	20	Y
10B	Y	Double incidental catches	4.5%	2%	10/1	20	Y
11B	Y	Halve incidental catches	4.5%	2%	10/1	20	Y
12A		Sex ratio = 0.2: 0.8	4.5%	4.5%	10/1	20	Y
12B		Sex ratio = 0.2: 0.8	4.5%	2%	10/1	20	Y
13A		Relative probability of harvesting a PCFG whale, ϕ_{PCFG} =1	4.5%	4.5%	10/1	20	Y
13B		Relative probability of harvesting a PCFG whale, ϕ_{PCFG} =1	4.5%	2%	10/1	20	Y

F. Statistics

The risk- and recovery-related performance statistics are computed for the mature female and for the total (1+) population sizes (i.e. P_t is either the size of the mature female component of the population, N_t^f, or the size of the total (1+) population, N_t^{1+}). P_t^* is the population size in year t under a scenario of zero strikes in the northern and PCFG area (but allowing for incidental catches) over the years $t \geq 2011$ (defined as t=0 below), P_t^{**} is the population size in year t under a scenario of zero strikes in the PCFG area (but allowing for incidental catches and strikes in the north area) over the years $t \geq 2011$ (defined as t=0 below), and K_t^* is the population size in year t if there had never been any harvest.

The trials are based on a 100-year time horizon, but a final decision regarding the time horizon will depend *inter alia* on interactions between the Committee and the Commission regarding need envelopes and on the period over which recovery might occur. To allow for this, results are calculated for T=20 and 100 (T^* denotes the number of blocks for a given T; for the PCFG area T^* is 19 and 99 respectively for T=20 and T=100 while for the north area T^* is 3 and 19 respectively for T=20 and T=100).

Statistics marked in bold face have previously been considered the more important. Note that the statistic identification numbers have not been altered for reasons of consistency. Hence, there are gaps in the numbers where some statistics have been deleted.

E.1 Risk

D1. Final depletion: P_T/K. In trials with varying K this statistic is defined as P_T/K_t^*.

D2. Lowest depletion: $\min(P_t/K)$:t=0,1,…,T. In trials with varying K this statistic is defined as $\min(P_t/K_t^*)$:t=0,1,…,T.

D6. Plots for simulations 1-100 of $\{P_t : t = 0,1,..,T\}$, $\{P_t^* : t = 0,1,..,T\}$, $\{P_t^{**} : t = 0,1,..,T\}$.

D7. Plots of $\{P_{t[x]} : t = 0,1,...,T\}\{P^*_{t[x]} : t = 0,1,...,T\}$ and $\{P^{**}_{t[x]} : t = 0,1,..,T\}$ where $P_{t[x]}$ is the xth percentile of the distribution of P_t. Results are presented for x = 5 and x = 50.

D8. Rescaled final population: P_T / P_T^* and P_T / P_T^{**}.

D9. Minimum population level in terms of mature females, $\min(P_t)$: t = 0,1,…,T.

D10. Relative increase P_T/P_0.

E.2 Need

N1. Total need satisfaction: $\sum_{t=0}^{T-1} C_t / \sum_{t=0}^{T-1} Q_t$

N2. Length of shortfall = (negative of the greatest number of consecutive blocks in which $C_t < Q_t$) / T^*

N4. Fraction of blocks in which $C_t = Q_t$

N7. Plot of $\{V_{t[x]}$: $t = 0,1,T^* -1\}$ where $V_{t[x]}$ is the xth percentile of the distribution of $V_t = C_t/Q_t$ [catch for the PCFG area].

N8. Plots of V_t for simulations 1-100.

N9. Average need satisfaction: $\frac{1}{T}\sum_{t=0}^{T-1}\frac{C_t}{Q_t}$

N10. AAV (Average Annual Variation): $\sum_{b=0}^{T^*-1} \left| C_{b+1} - C_b \right| / \sum_{t=0}^{T^*-1} C_b$ where C_b is the catch in block *b*.

N11. Anti-curvature: $\frac{1}{T^*-1} \sum_{b=0}^{T^*-2} \left| \frac{C_b - M_b}{\max(10, M_b)} \right|$ where $M_b = \left(C_{b+1} + C_{b-1} \right) / 2$.

N12. Mean downstep (or modified AAV): $\sum_{t=-1}^{T^*-1} \left| \min\left(C_{b+1} - C_b, 0 \right) \right| / \sum_{t=-1}^{T^*-2} C_b$.

N13. Average annual number of animals landed.

N14. Average annual number of animals struck and lost.

The following key plots are to be produced for each trial:

Time-trajectories of 1+ population size (northern and PCFG stock) in absolute terms and relative to carrying capacity, along with the fits to the abundance estimates. This plot allows an evaluation of whether conditioning has been achieved satisfactorily.

Histograms of the 100 parameter vectors for each trial. This plot allows an evaluation of whether and how conditioning has impacted the priors for these parameters.

Individual time-trajectories of 1+ population size for the northern and PCFG stocks, individual time-trajectories of strikes for the northern and PCFG area, a summary (median and 95% intervals) for the depletion of the PCFG stock, and a summary (median and 95% intervals) for the time-trajectories of 1+ population size when: (a) there are no future catches; (b) there are only incidental catches; and (c) there are incidental catches and catches due to hunts in the PCFG and northern area.

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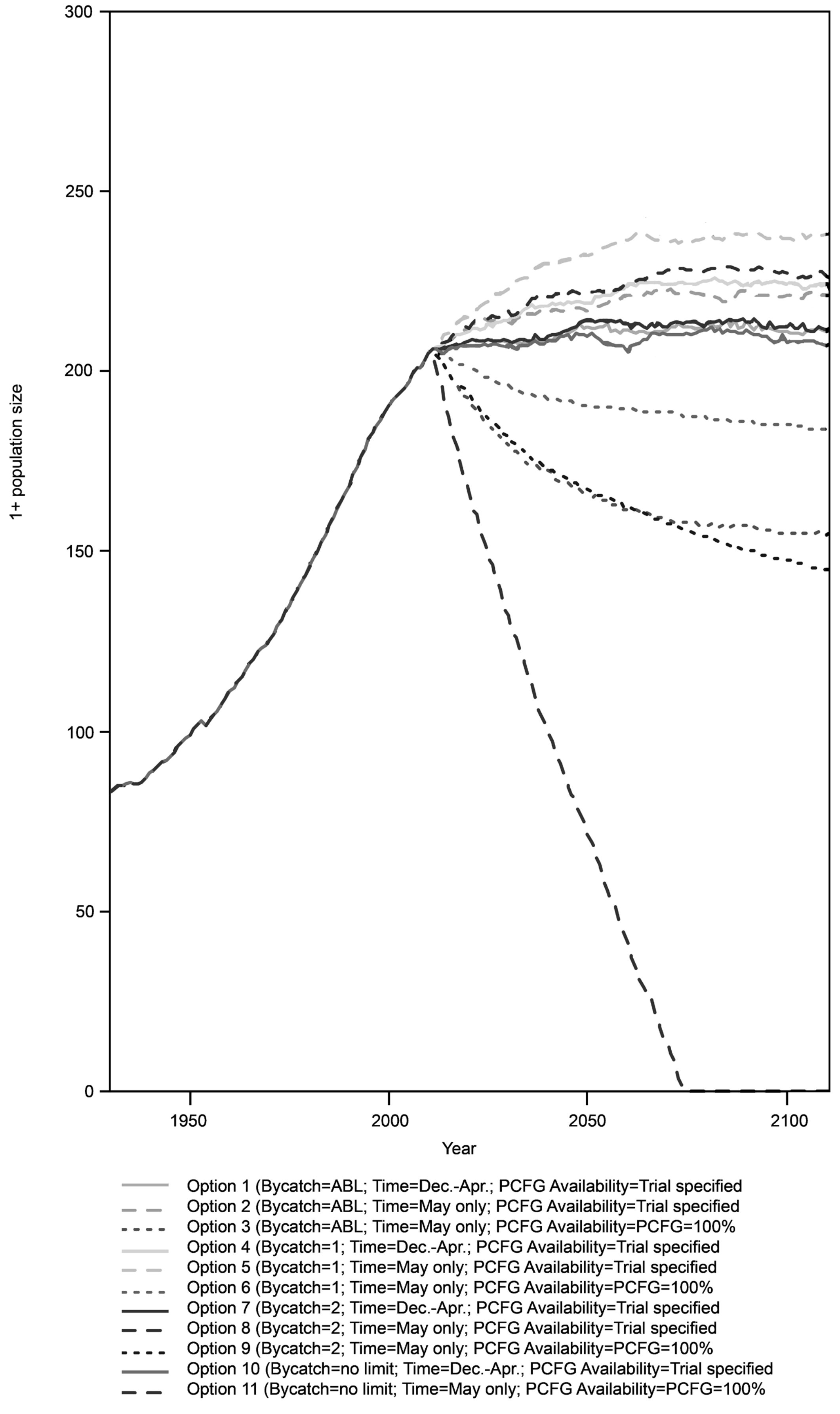
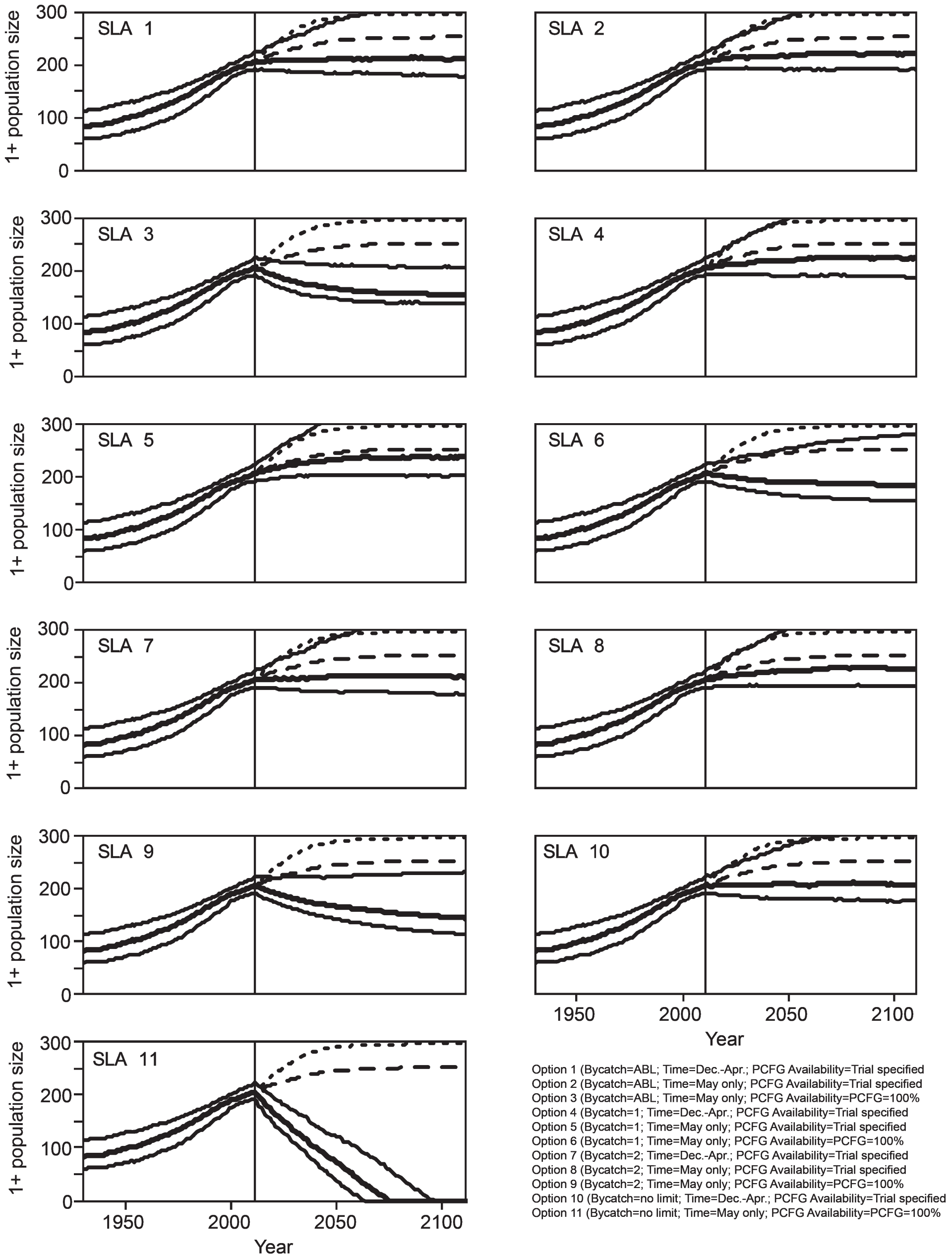
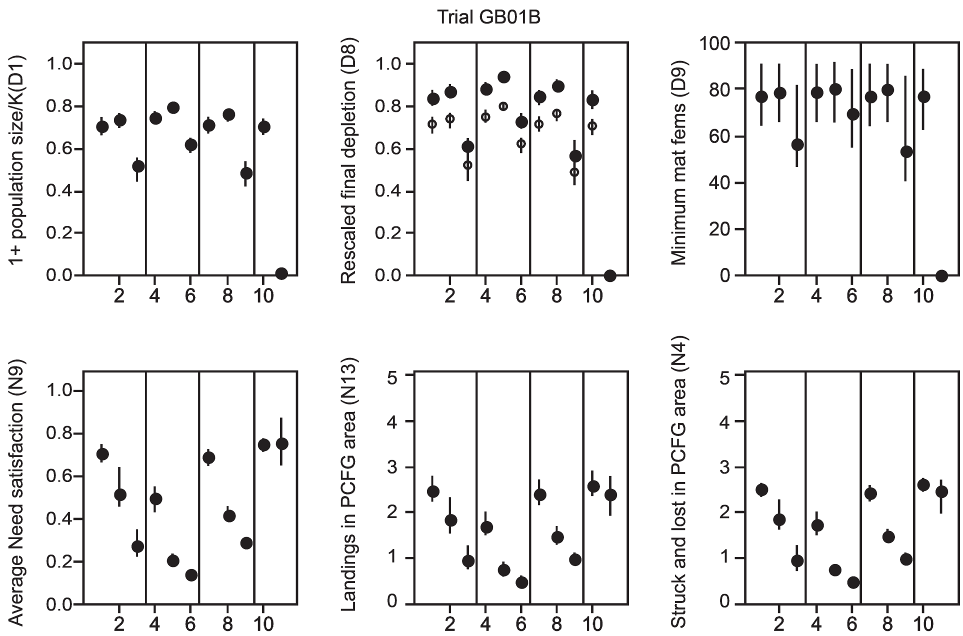
Appendix 3

EXAMPLE PLOTS USED WHEN REVIEWING THE RESULTS OF THE *EVALUATION TRIALS*




SLA 1
SLA 2
SLA 3
SLA 4
SLA 5
SLA 6
SLA 7
SLA 8
SLA 9
SLA 10
SLA 11
1+ population size
Year
Option 1 (Bycatch=ABL; Time=Dec.-Apr.; PCFG Availability=Trial specified
Option 2 (Bycatch=ABL; Time=May only; PCFG Availability=Trial specified
Option 3 (Bycatch=ABL; Time=May only; PCFG Availability=PCFG=100%
Option 4 (Bycatch=1; Time=Dec.-Apr.; PCFG Availability=Trial specified
Option 5 (Bycatch=1; Time=May only; PCFG Availability=Trial specified
Option 6 (Bycatch=1; Time=May only; PCFG Availability=PCFG=100%
Option 7 (Bycatch=2; Time=Dec.-Apr.; PCFG Availability=Trial specified
Option 8 (Bycatch=2; Time=May only; PCFG Availability=Trial specified
Option 9 (Bycatch=2; Time=May only; PCFG Availability=PCFG=100%
Option 10 (Bycatch=no limit; Time=Dec.-Apr.; PCFG Availability=Trial specified
Option 11 (Bycatch=no limit; Time=May only; PCFG Availability=PCFG=100%


Trial GB01B
1+ population size/K(D1)
Rescaled final depletion (D8)
Minimum mat fems (D9)
Average Need satisfaction (N9)
Landings in PCFG area (N13)
Struck and lost in PCFG area (N4)

Appendix 4

SUMMARY OF CONSERVATION PERFORMANCE AND LANDINGS FOR *SLA* VARIANTS 1 AND 2 FOR THE *EVALUATION TRIALS*

Table 1

Trials indicated with an asterisk selected for detailed examination.
Underlined trials fail to leave either final depletion or rescaled final depletion at 0.6 or above.

	SLA 1					*SLA* 2				
	Final depletion		Rescaled final depletion		Annual landings	Final depletion		Rescaled final depletion		Annual landings
Trial	Low 5%	Median	Low 5%	Median	Median	Low 5%	Median	Low 5%	Median	Median
GB01A	0.856	0.880	0.857	0.881	2.42	0.881	0.893	0.884	0.895	1.63
GB01B	0.669	0.711	0.671	0.713	2.47	0.700	0.743	0.702	0.745	1.84
GB01C*	0.259	0.343	0.314	0.383	2.47	0.290	0.365	0.352	0.414	1.98
GB01D	0.685	0.722	0.685	0.724	2.48	0.705	0.747	0.707	0.749	1.80
GB02A	0.856	0.881	0.856	0.881	2.41	0.884	0.896	0.884	0.896	1.62
GB02B*	0.623	0.666	0.623	0.666	2.47	0.662	0.704	0.662	0.705	1.90
GB02D	0.651	0.683	0.651	0.684	2.49	0.681	0.715	0.681	0.715	1.96
GB03A	0.859	0.879	0.859	0.879	2.42	0.879	0.897	0.879	0.898	1.63
GB03B	0.660	0.693	0.660	0.693	2.47	0.695	0.728	0.696	0.728	1.85
GB04A	0.857	0.880	0.861	0.882	2.43	0.878	0.893	0.881	0.896	1.69
GB04B	0.710	0.746	0.713	0.750	2.49	0.729	0.765	0.731	0.770	1.85
GB05A	0.855	0.874	0.858	0.879	2.43	0.873	0.888	0.879	0.894	1.68
GB05B	0.731	0.763	0.736	0.770	2.47	0.754	0.779	0.759	0.786	1.85
GB06A	0.849	0.871	0.849	0.871	2.41	0.872	0.887	0.874	0.888	1.61
GB06B	0.657	0.696	0.659	0.697	2.46	0.692	0.728	0.694	0.729	1.83
GB07A	0.982	1.000	0.686	0.907	2.45	0.991	1.009	0.696	0.916	1.73
GB07B	0.886	0.954	0.728	0.812	2.48	0.910	0.969	0.761	0.821	2.00
GB08A*	0.741	0.769	0.830	0.854	2.38	0.769	0.788	0.859	0.874	1.53
GB08B*	0.357	0.458	0.505	0.594	2.28	0.396	0.504	0.560	0.656	1.49
GB09A*	0.927	0.952	0.698	0.895	2.43	0.942	0.961	0.705	0.907	1.78
GB09B*	0.807	0.852	0.730	0.780	2.52	0.818	0.868	0.743	0.793	2.14
GB10A*	0.792	0.812	0.793	0.813	2.04	0.837	0.849	0.837	0.850	1.32
GB10B*	0.492	0.556	0.492	0.557	2.06	0.575	0.633	0.576	0.635	1.38
GB11A	0.857	0.879	0.859	0.879	3.76	0.873	0.887	0.873	0.888	2.93
GB11B	0.670	0.711	0.672	0.711	3.79	0.693	0.728	0.696	0.730	3.23
GB12A	0.873	0.890	0.876	0.892	0.97	0.885	0.902	0.885	0.902	0.66
GB12B	0.705	0.739	0.707	0.741	0.98	0.726	0.759	0.727	0.759	0.77
GP01A	0.859	0.877	0.859	0.879	2.43	0.877	0.893	0.878	0.894	1.75
GP01B	0.663	0.702	0.663	0.703	2.48	0.684	0.732	0.685	0.734	1.88
GP01C*	0.382	0.461	0.400	0.472	2.34	0.438	0.515	0.460	0.528	1.57
GP01D	0.669	0.709	0.671	0.712	2.49	0.683	0.732	0.686	0.734	1.95
GP02A	0.858	0.876	0.860	0.876	2.40	0.880	0.893	0.880	0.894	1.61
GP02B*	0.592	0.642	0.593	0.643	2.46	0.635	0.684	0.635	0.684	1.90
GP02C	0.231	0.272	0.255	0.295	2.17	0.299	0.347	0.334	0.372	1.31
GP02D	0.631	0.678	0.633	0.678	2.46	0.661	0.711	0.663	0.711	1.83
GP03A	0.857	0.876	0.860	0.876	2.43	0.878	0.892	0.879	0.892	1.69
GP03B	0.635	0.682	0.635	0.682	2.47	0.664	0.710	0.666	0.710	1.90
GP04A	0.853	0.873	0.857	0.877	2.39	0.874	0.888	0.878	0.892	1.57
GP04B	0.696	0.731	0.699	0.735	2.49	0.719	0.749	0.720	0.753	2.07
GP05B	0.712	0.747	0.716	0.753	2.49	0.738	0.764	0.744	0.771	1.95
GP06A	0.848	0.867	0.848	0.869	2.43	0.870	0.885	0.872	0.886	1.74
GP06B	0.643	0.684	0.645	0.685	2.46	0.670	0.718	0.671	0.719	1.88
GP07A	0.974	0.996	0.756	0.908	2.47	0.978	1.005	0.765	0.916	1.84
GP07B	0.876	0.941	0.750	0.798	2.49	0.885	0.955	0.752	0.810	2.00
GP08A*	0.728	0.762	0.824	0.847	2.42	0.750	0.782	0.844	0.870	1.61
GP08B*	0.330	0.442	0.475	0.578	2.28	0.364	0.482	0.528	0.635	1.49
GP09A*	0.925	0.946	0.739	0.893	2.46	0.932	0.955	0.735	0.904	1.90
GP09B*	0.786	0.845	0.720	0.770	2.52	0.790	0.854	0.741	0.784	2.13
GP10A*	0.781	0.806	0.781	0.809	2.10	0.825	0.841	0.827	0.843	1.38
GP10B*	0.475	0.536	0.476	0.538	2.02	0.556	0.619	0.557	0.621	1.42
GP11A	0.858	0.875	0.859	0.877	3.77	0.870	0.884	0.870	0.885	3.05
GP11B	0.663	0.699	0.665	0.701	3.78	0.678	0.716	0.679	0.718	3.24
GP12A	0.866	0.887	0.869	0.890	0.98	0.880	0.899	0.881	0.900	0.71
GP12B	0.697	0.729	0.699	0.731	0.97	0.705	0.747	0.706	0.749	0.77
GP13A	0.856	0.876	0.856	0.876	2.43	0.877	0.892	0.879	0.893	1.62
GP13B	0.675	0.709	0.677	0.710	2.44	0.699	0.741	0.699	0.744	1.78
GP13C*	0.392	0.464	0.409	0.476	2.36	0.442	0.520	0.464	0.533	1.59
GP14A	0.860	0.877	0.861	0.877	2.48	0.875	0.888	0.876	0.889	1.82
GP14B	0.666	0.699	0.667	0.700	2.49	0.678	0.720	0.679	0.722	1.97
GI01A	0.860	0.877	0.861	0.877	2.48	0.875	0.888	0.876	0.889	1.82
GI01B	0.666	0.699	0.667	0.700	2.49	0.678	0.720	0.679	0.722	1.97
GI01C*	0.378	0.446	0.399	0.459	2.38	0.434	0.497	0.457	0.513	1.64
GI01D	0.669	0.708	0.671	0.710	2.49	0.691	0.725	0.693	0.728	2.07
GI02A	0.853	0.876	0.853	0.876	2.46	0.873	0.891	0.873	0.892	1.78
GI02B*	0.606	0.643	0.607	0.644	2.46	0.631	0.685	0.632	0.686	1.89
GI02D	0.614	0.671	0.615	0.673	2.46	0.652	0.702	0.653	0.702	1.98
GI03A	0.853	0.876	0.853	0.876	2.48	0.872	0.890	0.872	0.890	1.77
GI03B	0.639	0.680	0.639	0.681	2.47	0.663	0.706	0.664	0.706	1.95
GI04A	0.852	0.875	0.856	0.876	2.42	0.873	0.886	0.875	0.890	1.65
GI04B	0.692	0.727	0.694	0.730	2.49	0.709	0.741	0.710	0.744	2.09
GI05A	0.851	0.870	0.859	0.877	2.38	0.870	0.885	0.877	0.892	1.60
GI05B	0.720	0.749	0.725	0.753	2.49	0.733	0.764	0.736	0.770	2.06

Appendix 5

BIOLOGICAL INFORMATION RELATING TO *SLA* DEVELOPMENT FOR THE LARGE WHALE HUNTS IN WEST GREENLAND

Lars Witting

Humpback whale

Agreed abundance estimates for West Greenland humpback whales are listed in Table 1. Other information include a 2007 estimate of 4,365 (CV:0.20) humpback whales in Canadian waters (NAMMCO, 2010; 2011).

The latest assessment paper is Witting (2011) that use an age- and sex-structured population model to examine if the long-term dynamics of West Greenland humpback whales is best described by density regulated growth or by selection-delayed dynamics (earlier referred to as inertia dynamics). Discussion of the results of this exercise and implications for the operating model(s) for *SLA* development will form part of the development process.

There is no estimate of the age of the first reproductive event (a_m) for humpback whales in West Greenland. There are, however, several estimates from other areas (Clapham, 1992; Gabriele *et al.*, 2007; Ramp, 2008; Robbins, 2007). For North Atlantic humpback whales, Ramp (2008) estimated a_m to exceed 12 years in the Gulf of St. Lawrence, Clapham (1992) estimated it to a range from five to seven years for humpback whales in the Gulf of Maine, and a later estimate from this area obtained an average estimate of seven years, ranging from five to 13 (Robbins, 2007).

There is no estimate of the birth rate for humpback females in West Greenland, but estimates exist for other areas. Gabriele *et al.* (2007) found that adult females in Alaska typically give birth every second to third year, with a documented range from one to six, and a mode every second year. Robbins (2007) found a comparable range for humpback whales in the Gulf of Maine, with a mean estimated annual birth rate of 0.57 and a process variance of 0.042 for 201 adult in the south-west of the area. The assessment model (Witting, 2011) used the latter estimate as an informative beta prior on the birth rate (a=2.741, b=2.111). As for a_m, for density-regulated growth and selection-delayed dynamics, the prior on the birth rate should reflect the expected range for the average birth rate among the individuals in a population that increases at its maximum growth rate. As West Greenland humpbacks are estimated to increase at a rate faster than humpbacks in the Gulf of Maine (Clapham *et al.*, 2003; Heide-Jørgensen *et al.*, 2008c), the applied prior may be in the lower range of the true value.

Larsen and Hammond (2004) estimated an annual survival rate (p) of 0.957 (SE=0.028) for humpback whales off West Greenland. This is similar to estimates of 0.951 (SE=0.010) and 0.960 (SE=0.008) for the Gulf of Maine feeding aggregation of humpbacks (Barlow and Clapham, 1997; Buckland, 1990), and an estimate of 0.963 (95% CI:0.944-0.978) for humpbacks in the central North Pacific (Mizroch *et al.*, 2004). In the Gulf of Maine, calf survival was estimated at 0.664 (95% CI:0.517-0.784), and yearly adult survival at 0.991 (95% CI:0.919-0.999) when excluding animals younger than five years of age (Robbins, 2007). From age zero to five, yearly survival was found to increase by an approximate straight line.

Table 1

Abundance estimates for West Greenland humpback whales with CV in parenthesis (given in %). I_a is an index series from aerial surveys. I_b is an index series of mark-recapture estimates, and N a fully corrected line transect survey from 2007. Data from Larsen and Hammond (2004), Heide-Jørgensen *et al.* (2008c).

Year	I_a	I_b	N
1984	138 (54)	-	-
1988	231 (70)	357 (16)	-
1989	-	355 (12)	-
1991	-	376 (19)	-
1992	-	348 (12)	-
1993	873 (53)	-	-
2005	1,218 (38)	-	-
2007	-	-	3,270 (50)

Bowhead whale

Abundance estimates for EA-WG bowhead whales are listed in Table 2. Abundance estimates that relate to the two stock hypothesis are 6,340 (CV: 0.38) for Baffin Bay-Davis Strait in 2002 and 1,350 (CV: 0.78) for Foxe Basin-Hudson Bay in 2003 (Givens *et al.*, 2009; IWC, 2009).

Table 2

Abundance estimates for bowhead whale N_{bd} is an agree estimate from 2002 for Baffin Bay and Davis Strait (1+ component), with CV in % in parenthesis. N_{wg} is (†) a fully corrected line-transect and (‡) a mark-recapture estimate from West Greenland (mainly mature animals), with CV in parenthesis. I_{wg} is sighting rates (number/km) from aerial surveys in West Greenland (mature animals), with the total number of sightings given in parenthesis. Data from Heide-Jørgensen *et al.* (2007; 2008b), Givens *et al.* (2009), IWC (2009) and Wiig *et al.* (2011).

Year	N_{bd}	N_{wg}	I_{wg}
1981	-	-	0.0011 (1)
1982	-	-	0.0004 (1)
1990	-	-	0.0017 (1)
1991	-	-	0.0028 (3)
1993	-	-	0.0000 (0)
1994	-	-	0.0000 (0)
1998	-	-	0.0042 (5)
1999	-	-	0.0000 (0)
2002	6,340 (38)	-	-
2006	-	1,229† (47)	0.0109 (18)
2010	-	1,410‡ (23)	-

Under the two stock hypothesis there appears to be no stock structure uncertainty associated with the allocation of the West Greenland catches, which in this case will be allocated to the Baffin Bay-Davis Strait stock. While the assumed Foxe Basin-Hudson Bay and the Baffin Bay-Davis Strait stocks may mix on the wintering ground at the northern Labrador coast and the entrance to Hudson Strait, in spring, Foxe Basin-Hudson Bay animals would have to migrate in the opposite direction of the Baffin Bay-Davis Strait animals that migrate to West Greenland (Heide-Jørgensen *et al.*, 2006; Heide-Jørgensen *et al.*, 2010a).

Fin whale

Agreed abundance estimates for West Greenland fin whales are listed in Table 3. Other abundance information includes a 2007 estimate of 1,716 (CV:0.40) fin whales in Canadian waters (NAMMCO, 2010; 2011).

To examine annual growth rates and life-histories in North Atlantic fin whales, an age- and sex-structured

Table 3

Abundance estimates for North Atlantic fin whales with CV in parenthesis (given in %). WG estimates from IWC (1992), Heide-Jørgensen *et al.* (2008a) and pro-rated estimates for EG, WI and EI from IWC (2010).

Year	N_{WG}	N_{EG}	N_{WI}	N_{EI}
1987	-	-	-	5,260 (28)
1988	1,100 (35)	5,270 (22)	4,240 (23)	-
1995	-	10,200 (29)	7,360 (22)	7,170 (29)
2001	-	14,200 (19)	7,430 (19)	9,550 (26)
2005	3,230 (44)	-	-	-
2007	4,360 (45)	15,800 (20)	8,900 (26)	-

Table 4

Abundance estimates for West Greenland minke whales with CV in parenthesis (given in %). *N* absolute estimates; 1987/88, 1993 and 2005 cue count estimates; 2007: fully corrected line-transect estimate. *I* time series of relative abundance. Data from Larsen (1995), Heide-Jørgensen and Laidre (2008), Heide-Jørgensen *et al.* (2008a; 2010b).

Year	*N*	*I*
1984	-	446 (36)
1985	-	198 (38)
1987	-	297 (31)
1988	-	1,841 (37)
1987/8	3,266 (31)	-
1989	-	636 (37)
1993	8,371 (43)	1,055 (86)
2005	10,792 (59)	663 (33)
2007	16,610 (43)	1,365 (25)

population model with exponential growth was fitted to recent abundance estimates (Table 3) for the West Greenland (WG), East Greenland (EG), West Iceland (WI) and East Iceland/Faroese (EI) summer aggregations of North Atlantic fin whales. Discussion of the results of this exercise and implications for the operating model(s) for *SLA* development will form part of the development process.

Minke whale

Abundance estimates for West Greenland minke whales are listed in Table 4. Other abundance information include a 2007 estimate of 5,675 (CV:0.24) minke whales in Canadian waters (NAMMCO, 2010; 2011).

SC/64/AWMP15 also presented a model for sex and density dependent dispersal between summer aggregations of minke whales. Discussion of the results of this exercise and implications for the operating model(s) for *SLA* development will form part of the development process.

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Appendix 6

DEVELOPMENT OF AN OPERATING MODEL FOR WEST GREENLAND HUMPBACK AND BOWHEAD WHALES

1. Relevant Agenda item (no. and title)
Annex E, Item 4

2. Brief description of project and why it is necessary to your sub-committee
The Committee developed interim *Strike Limit Algorithms* (*SLA*s) for the minke, fin, humpback and bowhead whales off West Greenland. These *SLA*s need to be reviewed and perhaps revised, ideally by the 2017 Annual Meeting. Development of *SLA*s for the hunts of minke and fin whales can be co-ordinated with the *Implementation Reviews* for these whales which are being conducted by the RMP sub-committee. In contrast, the situations for humpback and bowhead whales are relatively straightforward (essentially single-stock situations), but without a fully-specified and coded operating model progress on these cases will be limited. The first step in the process of developing *SLA*s is constructing an operating model and associated trials, and this project aims to make sufficient progress that an AWMP Workshop (in late 2012) could finalise trials and initiate testing.

The key activities covered by the proposal are as follows.

(1) Extend the single-stock gray whale trials so that trials can be conducted for humpback and bowhead whales.
(2) Outline a set of *Evaluation* and *Robustness Trials* which could form the basis for the evaluation of *SLA*s for these two groups of whales.
(3) Present the trial specifications and results for: (a) the interim *SLA*s; and (b) an alternative *SLA* at an intersessional AWMP Workshop.
(4) Develop an AWMP/RMP-lite to assist developers of *SLA*s for the cases of fin whales and common minke whales.

3. Timetable
(1) Obtain the latest version of the gray whale trials from the Secretariat (July-August 2012).
(2) Update the trials as needed: (a) update the catch streams; (b) add the ability to condition to existing data for West Greenland; and (c) add the ability to test user-specified *SLA*s (before the AWMP Workshop).
(3) Draft full technical specifications for the proposed trials (before the AWMP Workshop).

4. Researchers name
André Punt (University of Washington).

5. Estimated total cost with breakdown as needed
Total budget: £5,000.

Appendix 7

DRAFT GUIDELINES FOR AWMP *IMPLEMENTATION REVIEWS*

1. Objectives of *Implementation Reviews*
The primary objectives of an *Implementation Review* are to:

(1) review the available information (including biological data, abundance estimates and data relevant to stock structure issues) to ascertain whether the present situation is as expected (i.e. within the space tested during the development of a *Strike Limit Algorithm* (*SLA*)) and determine whether new simulation trials are required to ensure that the *SLA* still meets the Commission's objectives; and
(2) to review information required for the *SLA*, i.e. catch data and, when available at the time of the *Review*, new abundance estimates (note that this can also occur outside an *Implementation Review* at an Annual Meeting).

2. Timing of *Implementation Reviews*
Regular Implementation Reviews
Implementation Reviews are undertaken regularly, normally every five years. This does not have to coincide with the renewal of catch/strike limits in the Commission. For logistical and resource reasons, only one major *Implementation Review* shall be undertaken at a time. The Committee shall begin planning for the *Review* at the Annual Meeting at least two years before the Annual Meeting at which the *Review* is expected to be finished. This is to enable the Committee to schedule additional work or Workshops if it believes that new information or analyses are likely to be presented that will necessitate the development of new simulation trials. Early planning will enhance the likelihood that the Committee will complete an *Implementation Review* on schedule. It is not expected that every *Implementation Review* will entail a large amount of work.

Special Implementation Reviews
In addition to regular *Implementation Reviews*, under exceptional circumstances the Committee may decide to call for special *Implementation Reviews,* should information be presented to suggest that this is necessary and especially if there is a possibility that the Commission's conservation objectives may not be met.

Calling such a *Review* does not necessarily mean revising the Committee's advice to the Commission, although it may do so. The Committee has not tried to compile a formal comprehensive list of what factors might 'trigger' such an early review, which implies unexpected/unpredictable factors. However, the following list is provided to give examples of some possible factors.

(1) Major mortality events (e.g. suggested by large numbers of stranded animals).
(2) Major changes in whale habitat (e.g. the occurrence of natural or anthropogenic disasters or changes, an oil spill, dramatic change in sea-ice, development of a major oil/gas field, etc.).
(3) Major ecological changes resulting in major long-term changes in habitat or biological parameters.
(4) A dramatically lower abundance estimate (although the *SLA* has been tested and found to be robust to large sudden drops in abundance, the Committee would review the potential causes of unexpected very low estimates).
(5) Information from the harvest and hunters (this might include very poor harvest results, reports of low abundance despite good conditions, reports of large numbers of unhealthy animals).
(6) Changes in biological parameters that may result in changes to management advice (e.g. reproduction, survivorship).
(7) If there are cases when need is not being satisfied, strong information that might narrow the plausibility range and allow an increase in block limits.
(8) A new harvest regime (e.g. the potential hunt of gray whales by the Makah Tribe on the west coast of the USA).

3. Outcomes of *Implementation Reviews*

There are a number of possible conclusions of *Implementation Reviews:*

(1) there is no need to run additional trials and that the existing *SLA* is acceptable;
(2) the results from the additional trials developed and run reveal that the existing *SLA* is acceptable;
(3) there is no need for any immediate additional trials or changes to management advice but work is identified that is required for consideration at the next *Implementation Review*; or
(4) the results of the additional trials require the development of a new (or modified and then retested) *SLA* in which case management advice will have to be reconsidered until that work is complete.

4. Data availability

Implementation Reviews fall under the Committee's Data Availability Agreement Procedure A (IWC, 2004). By the time of the Annual Meeting prior to that at which the *Implementation Review* is expected to be completed, the scientists from the country or countries undertaking the hunts, or others intending to submit relevant analyses, shall develop a document or documents that explains the data that will/could be used for the *Implementation Review*. Such a document will:

(a) outline the data that will be available, including by broad data type (e.g. sighting data, catch data, biological data): the years for which the data are available; the fields within the database; and the sample sizes.
(b) provide references to data collection and validation protocols[1] and any associated information needed to understand the datasets or to explain gaps or limitations; and
(c) where available, provide references to documents and publications of previous analyses undertaken of data.

The data themselves shall be available in electronic format one month after the close of that Annual Meeting.

In the case of complex *Implementation Reviews* that may last more than one year and involve one or more workshops, new data can be submitted, provided that the data are described and made available at least nine months before the Annual Meeting at which the *Implementation Review* is expected to be completed.

5. Computer programs

All non-standard programs used in analyses submitted to the *Implementation Review* shall be lodged with the Secretariat at least at the same time (in accordance with the time schedule provided in DAA Procedure A) as the submission of the papers to which they pertain. The Committee may decide that the programmes need independent validation.

All final trial runs shall be undertaken by the Secretariat using validated programmes.

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[1]Genetic data must follow the quality control guidelines developed by the Scientific Committee in 2008 (IWC, 2009).

Report of the Scientific Committee

The meeting was held at the Shilla Jeju Hotel, Republic of Korea from 3-15 June 2013 and was chaired by Toshihide Kitakado. This meeting is SC/65a. The next meeting of the Scientific Committee in May or June 2014 will be SC/65b, and the next meeting of the Commission (IWC/65) will take place during September or October 2014. A list of participants is given as Annex A.

1. INTRODUCTORY ITEMS

1.1 Chair's welcome and opening remarks

Kitakado, the Committee Chair for the first time, welcomed the participants to the 2013 Annual Scientific Committee meeting. He thanked the Government of Korea for hosting the meeting and for providing the excellent facilities and an opening reception. He also expressed his thanks to the IWC Commissioner for Korea, Mr Bok-Chul Chung, for his assistance. The Committee then paused for a moment of silence, with great sorrow, for those who had passed away since the last meeting.

Graham Chittleborough died in October 2012. He gained an international reputation for his work on humpback whales based on the commercial catches off Australia and in the Antarctic following World War II. Graham contributed his knowledge of humpback whales to the work of the 'Committee of Three Scientists on the Special Scientific Investigation of the Antarctic Whale Stocks', attending meetings to review its progress and findings in Rome (1961) and Seattle (1963). He was also the first scientist to recognise the extent of illegal hunting of humpback whales taking place in the Antarctic in the late 1950s-early 1960s.

Malcolm Clarke died in May 2013. He was recognised internationally for his work on oceanic squid, and was well known to and respected by many members of the Scientific Committee for his investigations of squid as the food of sperm whales, in particular his *Discovery Report* based on stomach contents of sperm whales in Southern Hemisphere catches. He also undertook ground-breaking research on sperm whale anatomy, including the use of the spermaceti organ in diving.

Rebecca Leaper died unexpectedly just before the meeting, well before her time. She was a dedicated and passionate marine conservation scientist and spent two years on the Australian delegation as an ecosystem modeller. She had been a key member of science teams at the Australian Antarctic Division, the Tasmanian Aquaculture and Fisheries Institute, CSIRO and most recently at the University of Tasmania's Institute of Marine and Antarctic Science, working on issues ranging from the role of whales in their marine ecosystems through to conservation mechanisms for marine biodiversity. Her passion for her work was matched only by her generosity of spirit.

Captain Leif Petersen, who died in March 2013, never attended the Scientific Committee. However, his dedication, skill and courage as a pilot for pioneering aerial surveys beginning in Greenland and Iceland in the 1980s and eventually for many parts of northern Europe including the more recent SCANS and NASS programmes meant that he contributed as much to conservation and management as any of the scientists who participated. It is important that scientists never underestimate the contribution of pilots, skippers and crews to their work. Leif became an indispensable colleague and lasting friend to many scientists attending the Scientific Committee meeting; several of us are still alive because of him.

Vyacheslav Alekseevich Zemsky died at the age of 93 after a distinguished career in the Soviet Union and the Russian Federation. In the 1970s, he was very active in IWC related issues and the new Russia-US marine mammal working group. Between 1993-2000, Zemsky, with a number of members of the Soviet whaling expeditions, collated all the materials and documents preserved in departmental archives to create a corrected catch history of the whales hunted in the Southern Hemisphere.

1.2 Appointment of rapporteurs

Donovan was appointed rapporteur with assistance from various members of the Committee as appropriate. Chairs of sub-committees and Working Groups appointed rapporteurs for their individual meetings.

1.3 Meeting procedures and time schedule

The Committee agreed to the meeting procedures and time schedule outlined by the Chair.

1.4 Establishment of sub-committees and working groups

As agreed last year (IWC, 2013c, p.59) and included in the draft agenda, a pre-meeting of the sub-committee on the Revised Management Procedure (RMP) met in Jeju on 1-2 June 2013 to begin the *Implementation Review* for North Atlantic fin whales. The report of the pre-meeting is given as Annex D, Appendix 2.

A number of sub-committees and Working Groups were established. Their reports were either made Annexes to this report (see below) or subsumed into the main text of this report.

Annex D – Sub-Committee on the Revised Management Procedure;
Annex D1 – Working Group on the *Implementation Review* for Western North Pacific Common Minke Whales;
Annex E – Standing Working Group on Aboriginal Subsistence Whaling Management Procedures;
Annex F – Sub-Committee on Bowhead, Right and Gray Whales;
Annex G – Sub-Committee on In-Depth Assessments;
Annex H – Sub-Committee on Other Southern Hemisphere Whale Stocks;
Annex I – Working Group on Stock Definition;
Annex J – Working Group on Non-deliberate Human-Induced Mortality of Large Whales;
Annex K – Standing Working Group on Environmental Concerns;
Annex K1– Working Group to Address Multi-species and Ecosystem Modelling Approaches;
Annex L – Sub-Committee on Small Cetaceans;
Annex M – Sub-Committee on Whalewatching;
Annex N – Working Group on DNA;
Annex O – *Ad hoc* Working Group on National Progress Reports;
Annex P – Working Group on Special Permits; and
Annex Q – *Ad hoc* Working Group on Abundance Estimates.

Table 1
List of data received by the IWC Secretariat since the 2012 meeting.

Date	From	IWC ref.	Details
Catch data from the previous season:			
25/04/13	Norway: N. Øien	E108 Cat2012	Individual minke records from the Norwegian 2012 commercial catch.
01/06/13	Japan: T. Sakamoto	E108 Cat2012	Individual data for Japan special permit catch 2012 North Pacific (JARPN II) and 2012/13 Antarctic (JARPA II).
02/06/13	Russia: V. Ilyashenko	E108 Cat2012	Individual catch records from the aboriginal harvest in the Russian Federation in 2012.
03/06/13	Iceland: G. Víkingsson	E108 Cat2012	Individual catch records from the Icelandic 2012 commercial catch.
Sightings data:			
17/04/13	Japan: K. Matsuoka	E106	POWER North Pacific cruise sightings data 2012.
17/04/13	Japan: K. Matsuoka	E107	Data from dedicated sightings surveys in 2012 in the North Pacific under JARPN II.

1.5 Computing arrangements
Allison outlined the computing and printing facilities available for delegate use**.**

2. ADOPTION OF AGENDA
The adopted agenda is given as Annex B.

3. REVIEW OF AVAILABLE DATA, DOCUMENTS AND REPORTS

3.1 Documents submitted
The documents available are listed in Annex C. As agreed last year, for the first time, primary papers were only available at the meeting in electronic format (IWC, 2013c, pp.78-9).

3.2 National Progress Reports on research
As agreed last year, all National Progress Report information usually submitted in paper form was submitted electronically through the IWC National Progress Reports data portal (IWC, 2013c, p.1). Developing such a portal and then expanding it to allow multiple data entry users for each country (the latter had not originally been envisaged two years ago when the portal was agreed) was a major undertaking. The Committee thanked Miller of the Secretariat for the considerable amount of work he had undertaken during the year to make this possible. Inevitably, a number of issues to be addressed and potential improvements to be made arose during the year as the portal began to be used. These were referred to an *ad hoc* Working Group and the Committee **endorses** the report of that Group (Annex O) and its recommendations. It again **recommends** that all member states submit National Progress Reports through the IWC portal (*http://portal.iwc.int*).

3.3 Data collection, storage and manipulation
3.1.1 Catch data and other statistical material
Table 1 lists data received by the Secretariat since the 2012 meeting.

3.1.2 Progress of data coding projects and computing tasks
Allison reported that Version 5.5 of the catch databases was released in February 2013. Work has continued on the entry of catch data into both the IWC individual and summary catch databases, including data received from the 2011 season and some additional information for records from Durban in the 1960s and 1970s. Sightings data from the 2011 POWER cruise (see Annex G, Appendix 2) are being validated.

Programming work during the past year has focused on completing the North Pacific common minke whale *Implementation* trials including amending the control program and conditioning and running trials. Further details are given under Item 6.1.

4. COOPERATION WITH OTHER ORGANISATIONS
The Committee noted the great value of co-operation with other international organisations to its work. The observers' reports below briefly summarise relevant meetings of other organisations. The contributions of several collaborative efforts are dealt with in the relevant sub-committees.

4.1 Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR)
The report of the IWC observer at the 31st Meeting of the CCAMLR Scientific Committee (CCAMLR-SC), held in Hobart, Australia from 22-26 October 2012 is given as IWC/65/4(2013)A. The main items considered at the CCAMLR meeting of relevance to the IWC included: (1) fishery status and trends of Antarctic fish stocks, krill, squid and stone crabs; (2) incidental mortality of seabirds and marine mammals in fisheries in the CCAMLR Convention Area; (3) harvested species; (4) ecosystem monitoring and management; (5) management under conditions of uncertainty about stock size and sustainable yield; (6) scientific research exemption; (7) CCAMLR Scheme of International Scientific Observation; (8) new and exploratory fisheries; and (9) joint CCAMLR-IWC Workshop with respect to ecosystem modelling in the Southern Ocean.

Reports of the Scientific Committee (SC-CCAMLR) and its Working Groups on Ecosystem Monitoring and Management (WG-EMM) and Fish Stock Assessment (WG-FSA) and their various subgroups are available through the CCAMLR secretariat and on the CCAMLR website[1].

The CCAMLR Working Group on Incidental Mortality in Fisheries (WG-IMAF) did not meet in 2012 and no new information on cetacean-fisheries interactions in the Southern Ocean became available to CCAMLR. The next meeting of the Working Group is likely to take place prior to the annual meeting of CCAMLR in 2013.

The Committee thanked Kock for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next CCAMLR-SC meeting.

4.2 Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)[2]
The Committee did not receive a report from an observer at the 2013 meeting of the Conference of the Parties (3-14 March 2013).

4.3 Convention on the Conservation of Migratory Species (CMS)[3]
4.3.1 Scientific Council
There was no meeting of the Scientific Council during the intersessional period.

[1] *http://www.ccamlr.org/.*
[2] *http://www.cites.org.*
[3] *http://www.cms.int.*

4.3.2 Conference of Parties (COP)
There was no Meeting of the Parties during the intersessional period.

4.3.3 Agreement on Small Cetaceans of the Baltic and North Seas (ASCOBANS)[4]
The report of the IWC observer at the 7th Meeting of the Parties (MoP) to ASCOBANS, held in Brighton, UK from 22-24 October 2012 is given as IWC/65/4(2013)G. The main results from the meeting are summarised below.

(1) The Conservation Plan for the Harbour Porpoise Population in the Western Baltic, the Inner Danish Waters and the Kattegat was adopted. The main aim of the plan is to intensify research and conservation efforts for harbour porpoises in this area.
(2) Work on the Baltic Sea Recovery Plan (Jastarnia Plan) and the North Sea Conservation Plan were reviewed. The implementation of these will continue to be of importance over the next three years.
(3) Bycatch and underwater noise were identified as future priorities. The impact of marine debris on cetaceans will also be considered.
(4) A better understanding of how new and often lesser-studied contaminants affect individuals and populations is needed. Limiting the introduction of chemical substances into the marine environment should be considered.
(5) The western part of the ASCOBANS area has a large diversity of whale and dolphin species, but knowledge of their abundance and distribution as well as the magnitude of different threats remains scarce. Collaboration for research and conservation action in this area is needed.
(6) In general, cooperation and interaction with the European Commission, other international organisations, fishery and other economic sectors, NGOs and non-Party Range States should be strengthened.
(7) The 4th ASCOBANS Outreach and Education Award 2012 was given to Mats Amundin of Kolmården Djurpark in Sweden for his work in promoting the conservation of harbour porpoises.

No observer for the IWC attended the 20th meeting of the Advisory Committee to ASCOBANS.

The Committee thanked Scheidat for her report and **agrees** that she should represent the Committee as an observer at the next ASCOBANS Meeting of Parties and Advisory Committee meeting.

4.3.4 Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS)[5]
Donovan attended the 2012 meeting of the ACCOBAMS Scientific Committee (ASC) held in Monaco from 13-15 November 2012 and his report is given as IWC/65/4(2013) L. The full report of the meeting can be found on the ACCOBAMS website.

A number of recommendations were made. The first concerned the long-standing (nine-year) recommendation, also endorsed by the IWC Scientific Committee, for an ACCOBAMS Survey Initiative. The ASC strongly endorsed an updated basinwide survey plan, agreed on the need for synergies with other efforts in the North Atlantic and on the need to hire a co-ordinator. It noted news of a survey funded by DG-Mare that will cover about 25% of the Black Sea in summer 2013. However, it strongly recommended that the whole of the Black Sea be covered synoptically and urged ACCOBAMS to do all it could to ensure this and not miss a unique opportunity.

A second recommendation addressed the continued live removals of bottlenose dolphins in the Black Sea. The ACCOBAMS Secretariat was asked to send a letter of concern to the Georgian and Ukrainian governments (copied to the Bern Convention Secretariat, the Black Sea Commission and the CITES Secretariat) recalling the illegality of live removals of cetaceans from the Black Sea and asking them to carry out an inventory and thorough assessment of individual identity of all bottlenose dolphins kept in captivity by means of genetic, morphological and photo-id methods and to provide appropriate administrative measures in order to prevent substitution of dolphins that die in captivity by animals taken from the wild. The ASC noted that the IWC Scientific Committee has guidelines on the practical aspects of the use of DNA registers for cetaceans.

The ASC also agreed to work towards a Conservation Plan for fin whales of the Mediterranean. It noted: (1) the importance of continuing work to elucidate the stock structure and movements of fin whales in the ACCOBAMS area; (2) the importance of the ACCOBAMS Survey initiative to provide a summer snapshot of distribution throughout the whole region as well as a reliable estimate of total abundance; (3) that all of the groups working in the area be asked to update available information on fin whales, including those related to potential threats (e.g. see the work of Fossi on micro-plastics, Fossi *et al.*, 2012) and to consult on priorities for future work with a focus on conservation; and (4) that an outline draft Conservation Plan be developed for consideration at the next ASC, with a view to reviewing whether the time is ripe to engage with stakeholders to develop a full plan.

The ASC also developed a statement of concern over the ongoing seismic survey work in the area of the Hellenic Trench. In particular, it requested all involved in the planned surveys to provide information to the ASC and take urgent precautionary action to protect the local cetaceans. The ASC offered to provide advice and drew attention to the ACCOBAMS guidelines for seismic surveys, and urged that: duplicate surveys should be avoided across the same area, alternative approaches to seismic airgun survey should be sought and deployed and efforts should be made to avoid ensonifying adjacent areas simultaneously.

ACCOBAMS and the IWC have been working together on ship strikes for some time. ACCOBAMS agreed that the work should continue, welcomed the appointment of the ship strikes co-ordinators (one of whom is the Chair of the ASC ship strikes working group) and reiterated its support for the global database and existing monitoring and mitigation efforts. The ASC ship strikes working group will continue to work on these issues and foster collaboration with IWC, ASCOBANS, CMS and IMO and develop priority actions and studies, including the consideration of a project to develop a standard training module.

Finally, the ASC developed a recommendation on scientific aspects of whalewatching. It noted that an 'ACCOBAMS certificate of accreditation for whale watching' will be developed and agreed that this should take into account the ACCOBAMS Whale Watching Guidelines. It also supported the continuation and expansion of national or regional training courses (based on the PELAGOS expertise) for operators covering the biology of animals,

[4]*http://www.ascobans.org.*
[5]*http://www.accobams.org.*

risks, boat behaviour around the animals, how to achieve ACCOBAMS accreditation, involvement in scientific research, etc. The ASC will continue to consider potential adverse effects on cetaceans and means to mitigate these. It also urged monitoring the activity of whale-watching operators in each country in order to obtain information on growth and development to try to identify potential problems before they become too difficult to manage. Finally it agreed to assist in the development of methods to better inform the general public about responsible boat behaviour around cetaceans. The ASC noted the importance of continued co-operation with IWC and others on this issue.

The Committee thanked Donovan for his report and **agrees** that he should represent the IWC at the next ACCOBAMS meeting.

4.4 Food and Agriculture Organisation of the United Nations (FAO)

No observer for the IWC attended the 2012 meeting of FAO.

4.5 Inter-American Tropical Tuna Commission (IATTC)

The reports of the IWC observer at the 83rd and 84th meetings of the IATTC held in La Jolla, USA 25-29 June 2012 and 24 October 2012 respectively are given as IWC/65/4(2013) E. The Antigua Convention came into force on 27 August 2010 and under this the IATTC is expected to give greater consideration to non-target and associated species, including cetaceans, in taking management decisions. A summary was given of ongoing work describing what is known about the direct impact of the fisheries on other species in the ecosystem and the environment. This ongoing work will shape future directions of AIDCP (see Item 4.6) and IATTC measures aimed at managing fisheries and conserving dolphins.

The Committee thanked Rusin for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next AIDCP meeting.

4.6 Agreement on the International Dolphin Conservation Program (AIDCP)

The report of the IWC observer at the 25th and 26th Meetings of the Parties to the AIDCP held in La Jolla, USA on 19 June 2012 and 23 October 2012 respectively is given as IWC/65/4(2013)F. The AIDCP mandates 100% coverage by observers of fishing trips by purse seiners of carrying capacity greater than 363t in the agreement area and in 2012 all trips (746) by such vessels were sampled by independent observers.

The overall dolphin mortality limit (DML) for the international fleet in 2012 was 5,000 animals and the unreserved portion of 4,900 was allocated to 84 qualified vessels that requested DMLs. In 2012, no vessel exceeded its DML. The number of sets on dolphin associated schools of tuna made by vessels over 363t has been increasing in recent years, from 9,246 in 2008 to 10,910 in 2009 to 11,645 in 2010, however fewer were made in 2011 (9,604) and 2012 (9,220). While fewer dolphin sets were made in 2011 and 2012, this remains a frequent practice and the predominant method for catching yellowfin tuna by purse-seine in the ETP. There have been insufficient resources to conduct dolphin and ecosystem assessment surveys since 2006 so it is unclear when updated abundance estimates for cetaceans in the ETP will be available.

In 2011 and 2012, the AIDCP focused significant discussion on consideration of reducing observer coverage and developing an 'Ecosystem Friendly' certification scheme for tuna caught in association with dolphins. Due to the increasing sentiment among some Parties that the dolphin problem has been solved and that dolphin-fishing methods are better economically and environmentally than dolphin-safe methods, in 2013 the AIDCP Parties are expected to continue consideration of these proposals and others that have the potential to increase fishing effort on dolphins and the magnitude of associated direct and indirect effects of this practice.

The Committee thanked Rusin for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next AIDCP meeting.

4.7 International Committee on Marine Protected Areas (ICMMPA) and IUCN Marine Mammal Protected Areas Task Force

The International Committee for Marine Mammal Protected Areas was formed as an international committee of experts in 2006 to address common issues and challenges faced by scientists and managers using spatial management tools to manage and conserve important cetacean habitats or populations. In 2008, the IWC endorsed and supported a proposal by ICMMPA to host the first international conference on marine mammal protected areas, in 2009. Since that time, the ICMMPA has undertaken several initiatives and has co-hosted, with France, a second conference in Martinique, in 2011[6]. In October 2012 the ICMMPA met in La Rochelle, France, hosted by l'Université de La Rochelle. The primary agenda for the meeting was to develop the mission statement, terms of reference and structural organisation of the newly approved IUCN arm of ICMMPA. This partner organisation is a Task Force on Marine Mammal Protected Areas. These documents were developed and will be available from the new Task Force co-chairs Erich Hoyt and Giuseppe Notarbartolo di Sciara, once the Task Force is officially announced. The IUCN MMPA Task Force membership includes all of the ICMMPA members, with several IUCN member additions. The ICMMPA remains a non-governmental partner for the Task Force and, amongst other tasks, will convene conferences and other initiatives that may not fit the IUCN Task Force terms of reference. The IUCN MMPA Task Force will be officially announced at IMPAC3 in October 2013.

ICMMPA is currently working with the Government of Australia, who will host the third International Conference on Marine Mammal Protected Areas, at a venue in Adelaide in November 2014.

4.8 International Council for the Exploration of the Sea (ICES)[7]

The report of the IWC observer documenting the 2012 activities of ICES is given as IWC/65/4(2013)B. The ICES Working Group on Marine Mammal Ecology (WGMME) met 5-8 March 2012.

The WGMME built on the work of the ASCOBANS/HELCOM small cetacean population structure workshop to determine Management Units (MUs) for the more common species as such information is relevant to the development of biodiversity indicators. Based on the available information, there were single MUs in the European North Atlantic for common dolphins, white-beaked dolphins, white-sided dolphins and common minke whale. For bottlenose dolphins there are ten separate units closely associated with the mainly

[6] *http://second.icmmpa.org.*
[7] *http://www.ices.dk.*

resident inshore populations in the European North Atlantic and a separate MU for the wider ranging mainly offshore animals. For harbour porpoises, MUs are proposed for the Iberian Peninsula, Bay of Biscay, Celtic Sea and northwest Ireland/west Scotland and the North Sea. The MUs for harbour porpoises will need to be revisited as indicators for the Marine Strategy Framework Directive (MSFD) become better defined.

The WGMME considered biodiversity indicators and bycatch was the only indicator suggested that had a clear link with a particular human activity. The indicator metric proposed by ICG-COBAM was very clearly linked to OSPAR's EcoQO on harbour porpoise bycatch in the North Sea. With pressure for the rapid development of biodiversity indicators for good environmental status through the Marine Strategy Framework Directive (MSFD), it is essential that they are based on sound science and take a pragmatic approach to the incorporation of fisheries data. As such, it was proposed that a management framework approach is adopted (rather than the EcoQO approach) and further developed in 2013 for relevant species.

WGMME conducted a review of the effects of wave energy converters on marine mammals and provided recommendations on research, monitoring and mitigation schemes. These are at a relatively early stage of development when compared to other renewable energy technologies and this is reflected in the lack of knowledge of their effects on the marine environment. It is essential that full advantage is taken of test deployments and early arrays to gather information on the actual interactions between devices and wildlife. A review of such work is being undertaken during 2013.

The ICES Working Group on Bycatch of Protected Species (WGBYC) met on 7-10 February 2012. It reviewed the status of information on recent bycatch estimates and assessed the extent of the implementation of bycatch mitigation measures. Reports from 17 member states indicated extrapolated estimates of bycatch for 2010 of about 870 cetaceans. The species involved were striped dolphins, common dolphins, harbour porpoises and bottlenose dolphins. Estimates are patchy and monitoring obligations not being met by several member states. Implementation of bycatch mitigation measures was also found to be poor, with few countries able to confirm that obligations for pinger deployment were being met.

The 2012 ICES Annual Science Conference (ASC) was held in Bergen, Norway 17-21 September 2011. Some sessions were designed with marine mammals included as an integral part. A number of sessions were of relevance to the Committee, including those describing:

(1) bycatch and discards;
(2) consequences of improved survey performance on assessments and management advice; and
(3) how does renewable energy production affect aquatic life?

The Committee thanked Haug for the report and **agrees** that he should represent the Committee as an observer at the next ICES meeting.

4.9 International Maritime Organization (IMO)[8]

The report of the IWC observer to the IMO is given as IWC/65/4(2013)J. The IWC has contributed to IMO discussions on addressing ship strikes and the impacts of underwater noise from shipping. In December 2012, IMO adopted changes to the shipping lanes in the Santa Barbara Channel, and off San Francisco, California, USA in order to reduce ship strike risk to blue whales (COLREG.2/Circ.64).

The IMO has been developing non-mandatory technical guidelines to minimise underwater noise from commercial ships. These include available options for ship-quieting technologies and operational practices. In April 2013, the IMO correspondence group working on the issue (including participation by the IWC Secretariat) presented draft guidelines to the IMO sub-committee on ship design and equipment (DE57/17). The guidelines help establish a consistent approach to assist designers, ship owners and ship operators in evaluating how much noise reduction is possible for new and existing ships when compared to existing ships of similar type, size and propulsion system. The IMO Marine Environment Protection Committee (MEPC) is expected to approve the guidelines in early 2014 and make them available as an MEPC circular.

The IMO also continued to develop a mandatory Polar Code. This is intended to augment existing measures to reduce the environmental impacts of shipping in polar waters, taking into account their greater environmental sensitivity. This work will continue through 2013.

The Committee thanked Leaper for his report and **agrees** that he (or the Secretariat) should represent the Committee at the next IMO meeting.

4.10 International Union for the Conservation of Nature (IUCN)[9]

Cooke and Reeves, the IWC observers, reported on the considerable cooperation with IUCN that had occurred during the past year and this is given as IWC/65/4(2013)I.

World Conservation Congress

The World Conservation Congress was held on Jeju Island, Korea in September 2012. There were three cetacean-related events at the Congress: a workshop on lessons learned from the IUCN western gray whale conservation initiative; a poster presentation on the local population of Indo-Pacific bottlenose dolphins found around Jeju; and a workshop on cetacean conservation and whalewatching in Africa. IUCN issued a number of statements on Korean environmental issues, including on the possible resumption of whaling in Korean waters.

Western gray whales

Two further meetings of the IUCN Western Gray Whale Advisory Panel have been held in the past year, in November 2012 in Korea and in May 2013 in Japan. At the time of writing, the report of the May meeting is not yet available but a summary of results can be found in Annex F, Appendix 5. An updated population assessment was received by the Panel but the data from the two independently collected series of photo-id data yielded apparently discrepant results, one indicating an increasing population and the other indicating a stable or declining population. An assessment based on one of these data sets is available as SC/65a/BRG27.

Red List updates

Updates since the last Annual Meeting include listing of the Mediterranean 'subpopulations' of the following species: sperm whale (Endangered), fin whale (Vulnerable), striped dolphin (Vulnerable), common bottlenose dolphin (Vulnerable), Cuvier's beaked whale (Data Deficient), long-finned pilot whale (Data Deficient) and Risso's dolphin (also Data Deficient).

[8]*http://www.imo.org.*

[9]*http://www.iucn.org/.*

A current list of all cetacean species and populations that have been assessed for the Red List, and their current Red List classification, is maintained on the Cetacean Specialist Group site[10] with links to the assessments which are held on the Red List website[11].

Cetacean Specialist Group
IUCN Cetacean Specialist Group members have continued to actively assist with cetacean conservation and research projects around the world. Of particular current interest is the ongoing project on study of the status and management options for the Critically Endangered Mekong river population of Irrawaddy dolphins run by WWF Cambodia in co-operation with relevant public authorities. The website of the IUCN Cetacean Specialist Group[12] contains regular updates on IUCN's cetacean-related activities and other work in which group members are involved.

The Committee thanked Cooke and Reeves for their report and **agrees** that Cooke should continue to act as observer to IUCN for the IWC.

4.11 North Atlantic Marine Mammal Commission (NAMMCO)[13]

4.11.1 Scientific Committee
The report of the IWC observer at the 19th meeting of the NAMMCO Scientific Committee (NAMMCO SC) held in Tasiilaq, East Greenland from 19-22 April 2012 is given as IWC/65/4(2013)K.

A joint Norwegian-Russian Ecosystem Survey examined habitat use and prey associations of white-beaked dolphins in late summer. Dolphins used the southern Atlantic waters and the Polar Front area farther north, with a general overlap with most prey species and positive association with blue whiting in the southern habitat.

Catch and bycatch data from 2006-08 from a monitored segment of the Norwegian fleet of coastal gillnetters were used to estimate bycatch rates of harbour porpoises in Norway. Landings statistics were used to extrapolate to the entire fishery, estimating a total annual bycatch of 6,900 porpoises by the two fisheries. The bycatch numbers of harbour porpoises could also be high in Iceland, based on preliminary information presented to the NAMMCO-ICES workshop in 2010. The NAMMCO-SC recommended that total bycatch estimates be attempted and that assessments of sustainability proceed through the relevant Working Groups.

NARWHALS-WEST GREENLAND/CANADA
The NAMMCO-SC agreed on the metapopulation structure for narwhals in Baffin Bay, Hudson Bay and adjacent waters as a useful approach for identifying summer aggregations as management units in narwhals. Satellite tracking of whales that return to summering grounds the following year suggest interannual site fidelity, with summer aggregations to some extent being demographically-independent sub-populations with minimal or no exchange of animals. Narwhals in Canada constitute five separate stocks with some limited exchange between three of the stocks.

There had been an overall increase in West Greenland narwhal catches during the 20th century which was especially pronounced after 1950. However since 1993, a significant decline in overall catches has been observed. Aerial surveys conducted in the North Water in May resulted in fully corrected abundance estimates of 10,677 (95% CI: 6,120-18,620) narwhals in 2009 and 4,775 (95% CI: 2,417-9,430) in 2010.

Age estimation by racemization was used to estimate biological parameters of narwhals, including a maximal lifespan expectancy of ~100 years of age.

NARWHALS IN EAST GREENLAND
Satellite tracking showed that narwhals in East Greenland have a yearly migration where they leave the fjords and move off the coast in winter. Whales from the Scoresby Sound area seem to belong to a stock separate from other narwhal aggregations in East Greenland. Age-structure data from Ittoqqortormiit was applied to assessments of both East Greenland areas, and the harvest was found to select for older animals. The current annual growth rate in the absence of harvest was estimated between 1.2% (95% CI:0-3.5) and 3.7% (95% CI:1.6-5.9), depending upon model and area.

It was noted that there is little information on the predicted response of marine mammals to changing Arctic conditions including changes in sea ice, climate and prey species as well as increased human development activity such as seismic, shipping, and drilling. The NAMMCO-SC recommended holding an international symposium on the effect of seismic and other development activities on Arctic marine mammals with a focus on white whales and narwhals.

WHITE WHALES
Aerial surveys conducted in the North Water in May resulted in fully corrected abundance estimates of 2,008 (95% CI 1,050-3,850) white whales in 2009 and 2,482 (95% CI 1,439-4,282) in 2010.

The assessment of West Greenland white whales was updated with age-structured data, recent abundance estimates and catches. Results from different scenarios provided annual growth rate estimates from 3.2% to 5%, in the absence of harvest. The depletion ratio for 2012 was estimated as 44% (95% CI: 16%-88%), with a yearly replacement of 510 (95% CI:170-780) individuals. The NAMMCO-SC agreed that the revised assessment confirmed that the current removals based on the 2009 advice are sustainable. Based on a 70% probability of population increase, it concluded that a total annual removal of 310 white whales in West Greenland is sustainable (excluding Qaanaaq).

No specific advice was given on the North Water (Qaanaaq), since the current removals remain at a low level relative to the population size. No advice was given for the harvest in Canada.

AGE DETERMINATION WORKSHOPS
Recognising that there are a number of problems with age determination for white whales and narwhals, three age determination workshops were organised. The first in Tampa (FL, USA) examined the state of the art of general ageing techniques; the second in Beaufort (NC, USA) focused on age estimation of belugas using teeth; and the third in Copenhagen (Denmark) focused on the use of tusks for age estimation in narwhals.

The NAMMCO-SC agreed that an annual deposition rate of tooth GLG was to be the accepted standard in white whales, and it recommends that aspartic acid racemisation is applied to white whales, including fore known history/age animals in the analyses in order to calibrate the technique and provide an alternative ageing method.

PILOT WHALES
The NAMMCO-SC agreed that it was unlikely that a full pilot whale assessment could be attempted in the near future.

[10]*http://www.iucn-csg.org/index.php/status-of-the-worlds-cetaceans.*
[11]*http://www.redlist.org.*
[12]*http://www.iucn-csg.org/.*
[13]*http://www.nammco.no/.*

It was noted that both an adapted 'AWMP' procedure as well as the PBR approach could be used for an inverse advice calculation of the minimum abundance required to sustain the average take by the Faroese.

With the average annual catch by the Faroese since 1997 being 678, and the CV of the latest abundance estimate being 0.27, the AWMP procedure estimates that an abundance estimate around 50,000 pilot whales and a similar precision is required to sustain the catch. In comparison, the PBR approach calculates an abundance estimate around 80,000 whales. These calculations reflect precautionary estimates of the minimum abundance estimates required to sustain the Faroese hunt. However, the geographical range of the stock(s) that supply the Faroese hunt is unknown, and it is unresolved how the calculated estimates compare with the accepted estimate of 128,000 (95% CI: 75,700-217,000) pilot whales from the Icelandic and Faroe Islands area of T-NASS.

The average annual catch of long-finned pilot whales in West Greenland during 1993-2007 was 126 whales and an aerial survey estimated 7,440 (95% CI 3,014-18,367) animals in 2007. Applying a PBR approach, the sustainable harvest level of pilot whales would be around 50 whales per year. An estimate based on the AWMP procedure suggests that an annual take of 70 whales is sustainable. However, the survey did not cover the entire range of pilot whales in West Greenland and the summer aggregation cannot be considered an isolated stock. Instead, it is likely connected to pilot whales along Labrador and at Newfoundland.

The NAMMCO-SC noted that humpback whales are present in previously unsurveyed areas off East Greenland, in agreement with information provided by observers on seismic surveys.

The average annual catch of white-beaked dolphins in West Greenland during 1993-2007 was 30 dolphins. An aerial survey estimated 11,801 (95% CI 7,562-18,416) animals in 2007. Applying a PBR approach suggests that the sustainable harvest level would be around 125 whales per year.

A bowhead whale male tagged in Disko Bay in May 2010 moved into the Northwest Passage where it spent about two weeks in September 2010 in close proximity to a bowhead whale tagged in Alaska in spring the same year. Both returned to their normal seasonal range, but the excursions suggest that bowhead whales from the Pacific and the Atlantic occasionally may be connected in years with little sea ice in the Northwest Passage.

Based on an increase in sightings, the NAMMCO-SC recommended monitoring of trends and abundance of the Spitsbergen population of bowhead whales. Norway will continue passive acoustic monitoring with two extra devices in the northern Fram Strait and north of Svalbard.

SURVEY PLANNING

A new large-scale T-NASS survey of cetaceans in the North Atlantic is desirable within the near future, and the NAMMCO-SC discussed how best to approach such a large-scale survey effort. The most optimal year for a large scale coordinated survey is 2015. The survey plans for the different countries are generally similar to those of the last T-NASS survey.

4.11.2 Council

The report of the IWC observer at the 21st Annual Council Meeting of NAMMCO held in Svolvær, Norway from 11-13 September 2012 is given as IWC/65/4(2013)C. In 2010, the Council approved the go-ahead for a manual on hunting. It will be the first comprehensive manual for hunters that details weaponry and ballistics information with a focus on safety.

An international expert group on killing methods for small cetaceans met in November 2011. Significant reductions in killing times have been recorded in recent years in the Faroe Islands, Greenland, Japan and Nunavut Canada, due to development of new equipment and practices. Several recommendations were made regarding further improvement in killing methods, safety and training of hunters.

The Council has concluded that an abundance of pilot whales in the range of 50,000-80,000 animals will sustain the annual Faroese drive hunt. The most recent abundance estimate for the pilot whale stock is 128,000 in the Iceland-Faroese survey area. This means that the annual Faroese catch of pilot whales is well within sustainable limits.

Based on a NAMMCO initiative, a project has been designed to test different modelling approaches of interactions between marine mammals and fisheries. The project, which includes scientists both from NAMMCO and other relevant countries, will start as soon as funding is obtained.

The Committee thanked Sakamoto for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next NAMMCO Council Meeting.

4.12 North Pacific Marine Science Organisation (PICES)[14]

The report of the IWC observer at the 21st annual meeting of PICES held from 12-21 October 2012 in Hiroshima, Japan is given as IWC/65/(2013)H. The Marine Birds and Mammals Advisory Group (AP-MBM) requested that a seabird observer be included in the IWC-POWER cruise and it also revised its terms of reference as follows:

(1) provide information and scientific expertise to BIO and the FUTURE Program, and, when necessary, to other scientific and technical committees with regard to the biology and ecological roles of marine mammals and seabirds in the PICES region;
(2) identify important problems, scientific questions, and knowledge gaps for understanding the impacts of climate change and anthropogenic factors on MBMs in ecosystems of the PICES region through Workshops, Theme Sessions and Science Reports;
(3) assemble information on the status and key demographic parameters of marine mammals and seabirds and contribute to the Status Reports; and
(4) improve collaborative, interdisciplinary research with marine mammal and seabird researchers and the PICES scientific community.

Two sessions at the 2012 AP-MBM workshop were of relevance to the IWC, these were:

(1) the feasibility of updating prey consumption by marine birds, marine mammals, and large predatory fish in PICES regions; and
(2) environmental contaminants in marine ecosystems: seabirds and marine mammals as sentinels of ecosystem health.

The Committee thanked Kato for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next PICES meeting.

[14]*http://www.pices.int/.*

4.13 Protocol on Specially Protected Areas and Wildlife of the Cartagena Convention for the Wider Caribbean (SPAW)[15]

The report of the IWC observer to SPAW is given as IWC/65/4(2013)D. At its 5th meeting of the Scientific and Technical Advisory Committee, held 22nd October 2012, SPAW recommended that collaboration with the IWC should be strengthened through the possible conclusion of a Memorandum of Cooperation.

The three-year Spain-UNEP LifeWeb Project comes to an end in December 2013. Under this, a number of activities have been completed including:

(1) broad-scale regional mapping of migration routes, critical habitats and human threats after compilation of available information and datasets; and
(2) a regional workshop on integration, mapping, GIS analysis of marine mammal migration routes, critical habitats and human threats in the wider Caribbean Region (WCR) held in Miami, Florida, 9-11 May 2011.

As a result of this work, regional maps and factsheets have been produced on the following issues:

(1) distribution of the 25 marine mammals species that occur regularly in the WCR (24 cetaceans and the West Indies manatee);
(2) species' richness;
(3) main threats and human impacts faced by marine mammals: pollutions, interactions with fisheries, maritime traffic, etc.; and
(4) existing policies, marine protected areas and governance for the conservation of marine mammals.

SPAW has developed a management plan for the Marine Mammal Sanctuary of the Dominican Republic and a learning exchange on the economic benefits of whalewatching was organised in March 2013 in Samaná, Dominican Republic.

A workshop on broadscale marine spatial planning and transboundary marine mammal management was held in Panama in May 2012. Participants were trained in marine spatial planning applied to marine mammals. As a result of this workshop, two sub-regional areas have been approved for the future scenario work in the WCR, due to their importance as habitats for marine mammals and to existing work and ongoing cooperation dynamics on marine mammals. The first sub-region proposed ranges from the Dominican Republic down to Trinidad and Tobago through the Lesser Antilles, with a focus on strengthening the links between existing or projected marine mammal sanctuaries and on developing other cooperation activities with the neighbouring islands.

The second sub-region encompasses the continental coast of Latin America from Venezuela to the border between Brazil and French Guiana, together with the Dutch Caribbean islands of Aruba, Bonaire and Curacão being included in the area. The scenario work in this second area will foster support to the already started cooperation between these countries and territories, particularly through a technical workshop held in Suriname in March 2013.

The IWC and Caribbean Environmental Programme (CEP) Secretariats have partnered in order to convene three workshops on the topics of entanglement and ship strike for the wider Caribbean countries. It was recognised that the IWC has the international technical expertise in understanding and responding to these human impacts and as such can provide the countries of the WCR access to this expertise through capacity building training and workshops. The first of two capacity building trainings on determining human impact and entanglement response training was conducted in English and Spanish in Mexico in November 2012.

The Committee thanked Carlson for attending on its behalf and **agrees** that she should represent the Committee as an observer at the next SPAW meeting.

4.14 Commission of the South Pacific (CPPS, Comisión Permanente del Pacífico Sur)

The report of the observers at the Meeting of the Parties to CPPS, held in Guayaquil, Ecuador from 10-12 April 2013 is given as IWC/65/4(2013)F. Mattila presented an overview of the global scope of the large whale entanglement issue and described the training currently offered through the IWC by the technical adviser and other members of the IWC expert advisory panel on this topic. Subsequently, the national representatives of the CPPS countries consulted with the Government of Ecuador, which had made an earlier formal request of the IWC Secretariat for National training for Ecuador. As a result of these consultations, Ecuador has agreed to host an IWC entanglement response training that will include participation by up to three participants from the other CPPS countries. Ecuador, CPPS and NGOs will provide the logistical and financial support for the training, and the IWC will provide the trainers and curriculum. The training will be held in Salinas, Ecuador, 27-28 June 2013.

It is anticipated that this training may stimulate requests for full national training from some other CPPS member countries. It may also represent a model or mechanism by which the two Conventions can conduct cooperative work in order to advance common goals to reduce human impact to cetaceans.

The Committee thanked Mattila and Félix for their joint report and also Mattila for attending on its behalf and **agrees** that he should represent the Committee at the next CPPS meeting.

5. REVISED MANAGEMENT PROCEDURE (RMP) – GENERAL ISSUES

5.1 Complete the MSY rates review

Since 2007, the Committee has been discussing maximum sustainable yield rates (MSYR) in the context of a general reconsideration of the plausible range to be used in population models used for testing the *Catch Limit Algorithm* (*CLA*) of the RMP (IWC, 2008b; 2009a; 2009c; 2010b; 2010c; 2010e; 2011d; 2011g; 2012b). The current range is 1% to 7%, in terms of the mature component of the population. Last year, the Committee agreed that no more than one further year should be allowed to complete the review, and that if it could not be completed this year, the current range (MSYR 1-7% in terms of the mature component of the population) would be retained.

5.1.1 Report of the intersessional Workshop

As part of the work plan agreed last year to complete the review, an intersessional Workshop was held in La Jolla, USA in March 2013 and a detailed summary and review of its report (SC/65a/Rep5) is given in Annex D, item 2.1.1. While the Workshop made considerable progress, it was not able to develop recommendations on the appropriate range of MSYR rates. Rather, it identified four areas of work that would assist discussions at this meeting. It also identified three main issues requiring discussion at the Annual Meeting:

[15]*http://www.cep.unep.org/cartagena-convention*.

(1) limitations of the modelling approach itself;
(2) limitations within the approach (e.g. paucity of data); and
(3) interpretation of the results in the context of the RMP.

The Committee thanked Donovan for chairing the intersessional Workshop and the participants for their work during it and subsequently, without which it would not have been possible to conclude the MSYR review at this meeting (see below).

5.1.2 Discussion including work completed since the Workshop

SC/65a/RMP09 presented results from an energetic model presented to the MSYR Workshop. The model was used to predict variability in the realised rate of increase (r_0) in a generic depleted whale population given estimates of the variability and autocorrelation in birth-rates. The Committee thanked de la Mare for conducting the analyses. The individual-based population dynamics model was reviewed by the EM group (see Annex K1).

None of the model runs conducted in SC/65a/RMP09 led to estimates of MSYL that were 0.6 or larger. In addition, Cooke (2007) had shown that MSYL was closer to 0.5 than to 0.6 based on simulations in the context of a model with environmental effects for a wide range of parameter values. The Workshop had identified two scenarios for consideration with respect to the relationship between $MSYR_{1+}$ and r_0: $MSYR_{1+}=r_0/2$ and $MSYR_{1+}=r_0/1.619$. The latter scenario corresponds to $MSYL_{1+}=0.6$. Given the results in SC/65a/RMP09 and in Cooke (2007), the Committee **agrees** that $MSYR_{1+}=r_0/2$ was more appropriate for drawing inferences regarding the range of MSY rates for use in trials.

A key component of the work over the period of the review had been directed at a meta-analysis of observed rates of increase at low population size. SC/65a/RMP08 provided the results of a final sensitivity test for the Bayesian hierarchical meta-analysis using the data for rates of increase for the 13 baleen whale stocks selected in SC/65a/Rep05. The extent of environmental variation in r_0 as a function of r_0/r_{max} in SC/65a/RMP08 was determined from Equation 2 in SC/65a/RMP09. The lower 5% and 10% points of the posterior predictive distribution for r_0/r_{max} for an unknown stock for this sensitivity test were 0.419 and 0.512 respectively. SC/65a/RMP02 constructed a posterior predictive distribution for an unknown stock for r_0 rather than r_0/r_{max}. The lower 5% and 10% points of this posterior predictive distribution were 0.029 and 0.037 respectively. The Committee thanked Punt for his work in undertaking these analyses.

The Committee recognised the considerable additional work that had been undertaken since the current range for (1% to 7% in terms of the mature component of the population) was selected in 1993 (IWC, 1994c, p.57). In particular, since 2007, the Committee had *inter alia:*

(1) assembled and evaluated information on rates of increase for stocks at low population size;
(2) explored some of the impacts of environmental effects on r_0 relative to r_{max} and the shape of the yield curve for exploited baleen whales; and
(3) developed a meta-analysis framework to integrate this information, along with information on demographics, to derive a probability distribution for r_0 and r_0/r_{max}.

Given the available information and knowledge, the Workshop had explored the sensitivity of the distribution for r_0/r_{max} to a number of factors, including choices of stocks from amongst those for which suitable data were available and to the potential effects of environmental variation on rates of increase (see Annex D, table 4). The Committee recognised that while the meta-analysis was an important advance, it was inevitably limited for a number of unavoidable reasons including uncertainty over a number of factors, as described in Annex D, item 2.1.3.

In conclusion, despite these uncertainties, the Committee **agrees** that it has a better basis to select the range for MSYR for use in trials than when the 1% to 7% choice had been made in 1993. In completing the review this year it recognised that this did not mean that additional work should not continue and be periodically reviewed by the Committee, both in a general sense and as part of *Implementations* and *Implementation Reviews.*

Given its importance in terms of meeting conservation objectives, discussion focused on the lower bound for MSYR for use in trials, based on the assumption MSYR $\sim r_0/2$. A number of options were considered when examining the results of the meta-analysis relating to choice of percentile (5% or 10%), the value for r_{max}, and whether the meta-analysis should be based on r_0 or r_0/r_{max}. A broad consideration of the full set of sensitivity tests in SC/65a/Rep05, SC/65a/RMP02 and SC/65a/RMP08, suggests a range of 1% to 2.5% for the lower bound for MSY rate expressed in terms of the age 1+ component of the population (during the RMP development process and to date, MSYR has been expressed in terms of the mature component of the population; the AWMP development process by contrast expresses MSYR in terms of the 1+ component).

Recognising the uncertainties in the meta-analysis and the need for precaution, the Committee **recommends** that $MSYR_{1+}=1\%$ be adopted as a pragmatic and precautionary lower bound for use in trials. The value corresponds to the lower of the two percentiles in table 5 of SC/65a/Rep05, and the lowest of the r_{max} values; all of the point estimates of r_0 used in the meta-analysis correspond to $MSYR_{1+}$ values larger than 1% under $MSYR_{1+}\sim r_0/2$. In essence, $MSYR_{1+}=1\%$ is roughly the equivalent of 1.5% $MSYR_{mat}$. The Committee also **recommends** that the current upper bound of $MSYR_{mat}=7\%$ be changed to the roughly equivalent $MSYR_{1+}=4\%$. These recommendations have the additional practical advantage of unifying the MSYR 'currencies' of the RMP and AWMP processes.

In making this practical recommendation, the Committee **recognises** that much remains to be learnt regarding MSYR for baleen whales and that the issue of the appropriate range for MSYR should continue to be reviewed as new information becomes available. In particular, should data become available for more species and populations, the meta-analysis should be revisited with a view to making it more representative. The Committee **emphasises** in particular the need for information relating to stocks of species of interest for the RMP, including fin, sei, Bryde's and minke whales (although of course information on MSYR is important in assessing the status of all species within the Committee's work). Work should also continue to better understand the impact of environmental variation on MSYR and the biological and ecological processes leading to density-dependence, together with the shape of yield curves and hence the relationship between r_0 and $MSYR_{1+}$. As is already the case, consideration of MSYR for particular species and stocks should also occur during *Implementations* and *Implementation Reviews,* particularly where other information for the stock or species concerned suggests alternative plausible values to those discussed above.

The Committee also **recommends** that the '*Requirements and Guidelines for Implementations under the RMP*' (IWC, 2012h) be updated as given in Annex D, item 2.1.3.

The Committee thanked Brandon, Butterworth, Cooke, de la Mare, Donovan, Kitakado and Punt, as well as the other participants of the many intersessional meetings without whom it would not have been possible to complete the MSYR review. Above all, it acknowledged the contribution and dedication of the field researchers, whose data, particularly on bowhead, blue, right and humpback whales, collected over periods of up to 40 years, formed the backbone of the meta-analysis and the MSYR review.

5.2 Finalise the approach for evaluating proposed amendments to the *CLA*

In 2006, the Committee agreed that two steps needed to be completed in order to finalise the approach for evaluating proposed amendments to the *CLA*: the review of MSY rates, completed this year (see Item 5.1 above), and specification of additional trials for testing the *CLA* and amendments to it. Last year, the Committee re-established a working group under Allison to develop and run such trials for consideration at this year's meeting. However, Allison reported that there had been insufficient time during the intersessional period to conduct the work.

The Committee noted that the Working Group on Ecosystem Modelling had identified a set of possible issues to be addressed using individual-based simulation and other models (see Annex K1, item 3). These issues could form the basis for additional trials to further explore the behaviour of the RMP. The Committee **agrees** to re-establish the working group under Allison (see Annex R) to formulate and run trials related to environmental degradation, taking account of the discussions in Annex K1, and to report the results to the next Annual Meeting.

5.3 Evaluate the Norwegian proposal for amending the *CLA*

In 2004, Norway had indicated that it might submit a proposal for the revision of the *CLA* and the base-case and *Robustness Trials* (IWC, 2006a, pp.79-80). In 2007, the Committee received a paper (Aldrin and Huseby, 2007) documenting the results for all single stock trials for a proposed alternative *CLA*, as required for consideration of a proposed revision of this nature (IWC, 2007a, p.89).

The Committee noted in the past that evaluation of this proposal required: (a) completion of the MSYR review, (b) review of the trials conducted in Aldrin and Huseby (2007); and (c) review of additional trials which explore the performance of the RMP given environmental degradation. This year, the Committee has completed the MSYR review (see Item 5.1), but it was not able to complete the trial specifications related to environmental degradation (see Item 5.2) and it did not have time to review Aldrin and Huseby (2007).

The Committee **agrees** that: (a) Aldrin and Huseby (2007) should be a primary document for SC/65b; and (b) it would not be necessary to have all of the trials related to environmental degradation completed before a decision on amending the *CLA* could be made, given the time required to parameterise trials based on individual-based models. It also **agrees** that the *Implementation Review* for the North Atlantic common minke whales could take place even though a decision had yet to be made regarding the Norwegian proposal to amend the *CLA*.

5.4 Modify the 'Catch Limit' program to allow variance-covariance matrices

Last year, it was noted that the Norwegian 'CatchLimit' code for the current *CLA* allows variance-covariance matrices for the abundance estimates to be specified, and Allison was tasked to work intersessionally with the Norwegian Computing Center to develop a final version of the program. She reported that the Norwegian version of the current *CLA* version was used in the trials for western North Pacific minke whales, although some coding issues remain. The Committee **recommends** that Allison contact the Norwegian Computing Center to resolve any final coding issues.

5.5 Update the 'Requirements and Guidelines for Conducting Surveys'

Last year, the Committee recommended that a review covering model-based abundance estimation in theory and practice, and its relation to the design-based approach, be conducted. The review was to provide draft text for inclusion in the 'Requirements and Guidelines for Conducting Surveys' (IWC, 2012g). Hedley was contracted to conduct the review, but was unable to complete it on time. The Committee looks forward to receiving the review at the 2014 Annual Meeting.

5.6 Update the list of accepted abundance estimates to include western North Pacific common minke whales

The Committee noted that last year it had developed a list of accepted abundance estimates related to RMP stocks (IWC, 2013d, p.105). It **agrees** that the list of accepted abundance estimates for the RMP be updated using the values provided by the Working Group on western North Pacific minke whale (see Annex D1, item 9). The broader question of accepted abundance estimates is addressed under Item 22.

5.7 Other business

A number of issues arose during the 'second' western North Pacific common minke whale *Implementation Review* Workshop (SC/65a/Rep04) that were of general relevance to the RMP process and required the Committee's attention. The issues, and the rationale for the sub-committee's recommendations, are given in Annex D, item 2.7. The recommendations arising are as follows.

(1) Imbalanced sex ratio in incidental catches: the Committee **agrees** to consider this matter at the 2014 Annual Meeting and encourages papers on this topic.
(2) Review of abundance estimates in an RMP context: the Committee **endorses** the recommendation that the specified set of associated information be provided along with abundance estimates in its 'Requirements and Guidelines for *Implementations* and *Implementation Reviews*'.
(3) Changing survey coverage in time-series of abundance estimates: the Committee **agrees** to consider the matter at the 2014 Annual Meeting and encourages papers on the topic. It will at that time re-examine the set of core robustness trials which relate to this issue.
(4) Use of surveys carried out in different months in both the *Implementation* process and in actual implementation of the RMP: the Committee **agrees** to consider the matter at the 2014 Annual Meeting and encourages papers on the topic.

5.8 Work plan

The Committee's views on the work plan developed by the RMP sub-committee are given in Item 24, and the financial implications in Item 26.

6. RMP – *IMPLEMENTATION*-RELATED MATTERS

6.1 North Pacific common minke whales

Since 2010, the Committee has been following the process of an *Implementation Review* for western North Pacific common minke whales according to its 'Requirements and Guidelines for *Implementations* under the RMP' (IWC, 2012b). The scheduled period for an *Implementation* or *Implementation Review* is normally two years but, given the complexities of this particular *Implementation Review*, it has not been possible to keep to this schedule. This year's Annual Meeting was thus the third of the *Implementation Review*, but its objectives were those of the 'Second Annual Meeting' as described in the Requirements and Guidelines for *Implementations*, which are to complete the *Implementation Review* by examining the results of the final *Implementation Simulation Trials* and agreeing recommendations for implementation of the RMP.

6.1.1 Review report of intersessional Workshop

The Committee reviewed the report of the intersessional Workshop held in La Jolla, California in March 2013 and chaired by Donovan (SC/65a/Rep04). The Workshop is referred to as the '2nd Intersessional Workshop', although it is actually the third such Workshop because of the extended schedule of this *Implementation Review*.

The Workshop was primarily a technical Workshop, the objectives of which were to review the results of work agreed at the 2012 Annual Meeting of the Scientific Committee (IWC, 2013c) and to consider the results of the final trials using the agreed approach that forms part of the *Implementation* process (IWC, 2012h). The ultimate objectives were to develop recommendations for consideration by the Committee on: management areas; RMP variants (e.g. catch-cascading, catch-capping); suggestions for future research to narrow the range of plausible hypotheses or eliminate some hypotheses; and 'less conservative' variants(s) with their associated required research programmes and duration.

A detailed summary of the Workshop report is given in Annex D1, item 2. A map defining the sub-areas used for the *Implementation Review* is given as Fig. 1.

The Workshop made considerable progress but it had not been possible to consider final trial results because decisions necessary for finalising the trials were only able to be taken at the Workshop. However, some preliminary results for some trials were available and review of these led to refinement and reduction of the total number of management variants (see Item 6.1.3.1) to be considered at this Annual Meeting.

The Workshop had developed a work plan for the remainder of the intersessional period aimed at completing the final trials and providing results well in advance of this Annual Meeting. Considerable progress was made but because of the complexities of this *Implementation Review* it had not been possible to complete this work prior to the Annual Meeting. The Workshop had also identified a number of generic issues related to conducting trials which were referred to the RMP sub-committee (see Annex D, item 2.7).

The Committee **endorses** the conclusions and recommendations from the Workshop report (SC/65a/Rep04) and expressed its thanks to Donovan and all participants for their hard work and progress.

6.1.2 Progress since intersessional Workshop

6.1.2.1 UPDATE TO TRIAL SPECIFICATIONS

Changes to the trial specifications and the code implementing these specifications since the 2nd Intersessional Workshop are described in Annex D1, item 3.1. The Committee **endorses** these changes to the trial specifications; the final trial specifications are given in Annex D1, Appendix 2.

6.1.2.2 REVIEW OF FINAL CONDITIONING RESULTS

Regarding conditioning the *Implementation Simulation Trials*, the Committee had reviewed the fit diagnostics for the base-case trials and those for many of the sensitivity tests implemented in other trials at the 2012 Annual Meeting (IWC, 2013c). Work on conditioning trials continued during the intersessional period and the conditioning diagnostics for all trials conducted during this period had been reviewed by Punt. The Committee had agreed that the *ad hoc* Working Group established under the Working Group on the *Implementation Review* for Western North Pacific common minke whales to review trial results should check the conditioning of any trials that may be influential in the final decisions regarding the selection of RMP variants. The

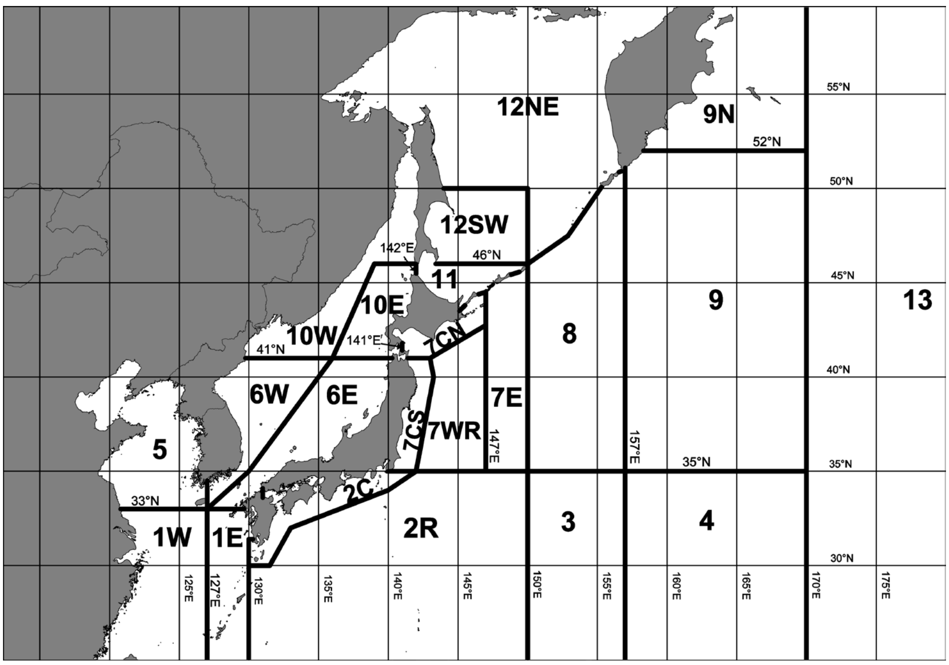

Fig.1. The 22 sub-areas used for the *Implementation Simulation Trials* for North Pacific minke whales.

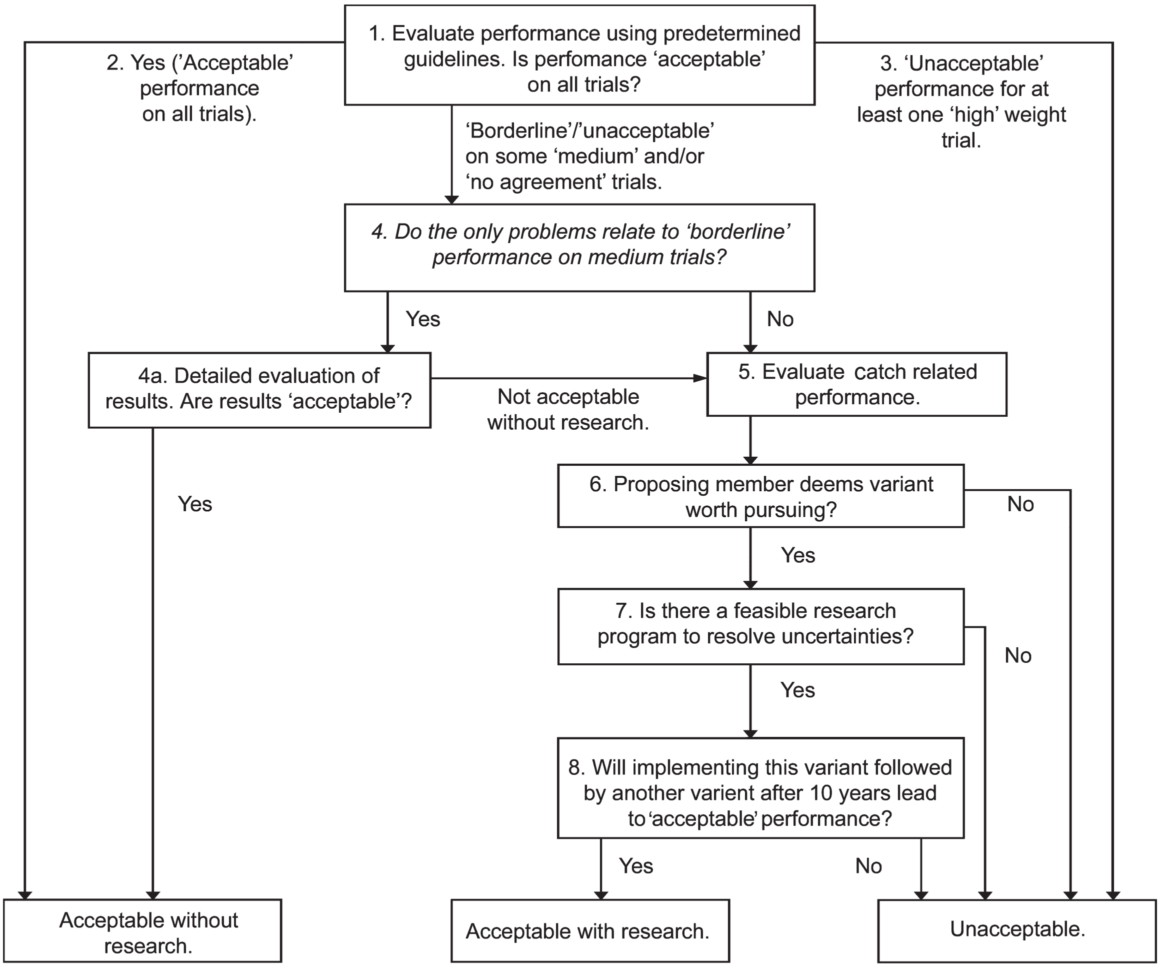

Fig.2. Flowchart summarising the procedure for review of *IST*s (from IWC, 2005a, pp.91-92).

Committee confirms that conditioning had been successfully achieved for all influential trials (Annex D1, item 3.2).

6.1.3 Complete Implementation Review

According to the Requirements and Guidelines for *Implementations,* completing the *Implementation Review* involves reviewing the results of the final *Implementation Simulation Trials* and making recommendations on: Management Areas; RMP variants; and inputs to the *CLA* for use in actual applications of the RMP.

6.1.3.1 REVIEW RESULTS OF FINAL *IMPLEMENTATION SIMULATION TRIALS*

The procedure for reviewing results of the final trials is given in the Committee's Requirements and Guidelines for *Implementations* (IWC, 2012h). A very brief summary is given below.

Fig. 2 shows a flow chart of the decision process to be followed.

The procedure first involves consideration of specified diagnostics to evaluate conservation performance generated from trial results, and determining from them whether the performance of each trial is 'acceptable', 'borderline' or 'unacceptable' under each of the defined RMP variants (see Annex D1, item 4.1). The style in which these results should be presented is detailed in Annex D1, item 4.2. RMP variants are defined by the *Management Areas* to be used (*Small Areas*, etc.) and how any catches are to be taken from them (see Annex D1, item 5). This part of the procedure is a technical exercise that follows directly from the results and requires no judgement.

The second stage is to evaluate each RMP variant by considering the results of all trials together in order to decide whether each variant is 'acceptable without research', 'acceptable with research' or 'unacceptable' (see Annex D1, item 5). This part of the procedure does require judgement because consideration is needed of the overall balance of the trials and the characteristics of any specific trials for which performance is questionable. The process for evaluating each variant can be summarised as follows:

(1) if the performance is close to 'acceptable' for a small number of 'borderline' trials then the Committee may agree that the variant is 'acceptable without research';
(2) if the performance is close to 'unacceptable' or is 'unacceptable' for a number of trials based on a specific hypothesis, then the Committee may agree that this is a candidate for the 'acceptable with research'; and
(3) if the performance is close to 'unacceptable' or is 'unacceptable' for a number of trials under several hypotheses, then the Committee may agree that the variant is 'unacceptable' and thus eliminated from further consideration.

Ten RMP variants to be evaluated had arisen from the 2nd Intersessional Workshop.

(1) *Small Areas* equal sub-areas. For this option, the *Small Areas* for which catch limits are set are 5, 6W, 7CS, 7CN, 7WR, 7E, 8, 9*, and 11.
(2) Sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* and catches are taken from sub-areas 5, 6W, 7CN, 9 and 11.
(3) Sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* and catches are taken from sub-areas 5, 6W, 7CS, 9 and 11.

(4) Sub-areas 5, 6W, 7CS, 7CN, 7WR+7E+8, 9* and 11 are *Small Areas* and catches are taken from sub-areas 5, 6W, 7CS, 7CN, 7WR, 9 and 11.
(5) Sub-areas 5 and 6W are *Small Areas* and catches are taken from sub-areas 5 and 6W. Sub-areas 7+8+9*+11+12 form a combination area and catches are cascaded to the sub-areas within the combination area. The catch limits for sub-areas 12SW and 12NE are not taken.
(6) Sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* except that the catches from the 7+8 *Small Area* are taken from sub-areas 7CS and 7CN using the same method as for catch cascading to allocate the catch across the two sub-areas.
(7) Sub-areas 5+6W+6E+10W+10E and 7+8+9*+11 are *Small Areas*; catches from the 5+6W+6E+10W+10E *Small Area* are taken from subareas 5 and 6W using the same method as for catch cascading to allocate the catch across those five sub-areas, and catches from the 7+8+9+11 *Small Area* are taken in sub-area 7CN.
(8) Sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* and catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 8 and 9 using the same method as for catch cascading to allocate the catch across the two sub-areas.
(9) Sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* and catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 using the same method as for catch cascading to allocate the catch across these sub-areas.
(10) Sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* and catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8, 9 and 11 using the same method as for catch cascading to allocate the catch across these sub-areas. Catches from sub-area 11 occur in May and June only.

After reviewing the initial results at the meeting, Japan requested that an 11th variant be evaluated.

(11) Sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* and catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 using the same method as for catch cascading to allocate the catch across these sub-areas, except the catches from sub-areas 7CS, 7CN, 7WR and 7E are reduced by 50% after first subtracting the bycatches in these sub-areas.

The Committee's Requirements and Guidelines for *Implementations* allow for additional variants to be proposed for evaluation during the 2nd Intersessional Workshop as part of the *Implementation* process. However, due to the complexities of this *Implementation Review*, the results of only a few trials had been available during the 2nd Intersessional Workshop rather than the complete set as envisioned in the Requirements and Guidelines. Recognising these exceptional circumstances, the Committee **decided** to evaluate this additional variant noting that it was in accord with the RMP in that catches from all *Small Areas* cannot exceed the RMP catch limit (except when the bycatch exceeds the RMP catch limit when the commercial catch is set to zero).

In doing so, the Committee **reiterates** that, under normal circumstances, proposal and evaluation of additional variants should not take place at the 2nd Annual Meeting.

Annex D1, table 2 lists the factors considered in the trials and the plausibility assigned to each. Some of the factors were assigned 'medium' plausibility because the Committee had not been able to reach agreement on whether they should be 'low', 'medium' or 'high' (IWC, 2013c, p.11). A list of all the trials is given in Annex D1, table 1. In all there were 66 trials of which none were given 'high' weight. More details are given in Annex D1, item 5.

Annex D1, tables 3 and 4 summarise the application of the procedure for evaluating conservation performance. Results are shown in Annex D1, table 3 by stock-structure hypothesis and in Annex D1, table 4 by RMP variant. Annex D1, table 5 lists the average catches by sub-area for each RMP variant for the six base-case trials, reported for years 1-10 and for the entire 100-year projection period. The results in this table are illustrative only; the actual catches will depend on the application of the *CLA* to the abundance estimates and catches selected by the Committee (see Items 6.1.4.2 and 6.1.4.3).

The full set of trial results is available from the Secretariat upon request. Results for each variant are given in Annex D1, item 5 and are summarised below.

Variants 1, 2, 3, 4 and 6
These variants did not have 'unacceptable' performance for any trials, but had 'borderline' performance for one trial (B04) as shown in Annex D1, fig. 3. Given that the 'borderline' performance was close to 'acceptable', and that 'borderline' performance occurred only once out of 66 trials, these variants can be considered as candidates which are 'acceptable without research' (step 4a in Fig. 2).

Variant 5
Variant 5 had 'unacceptable' performance for trial B04 (Annex D1, fig. 3). It had 'borderline' performance for trials A04 (Annex D1, fig. 4), B03 (Annex D1, fig. 5), C03 (Annex D1, fig. 6), and C04 (Annex D1, fig. 7). Given that this variant fails for only one trial (B04) and is 'borderline' on four trials in which it is close to 'acceptable' for trial A04, this variant can be considered 'acceptable with research' because it fails only for stock structure hypothesis B (step 4a in Fig. 2).

Variant 7
Variant 7 performed 'unacceptably' on 22 out of 27 trials for stock-structure hypothesis C and 'borderline' on two (C14, C17). It also had 'borderline' performance for two trials based on stock-structure hypotheses A and B (A04, B04). This variant was close to 'acceptable' for these two trials (Annex D1, figs 3 and 4). This variant can thus be considered as a candidate for 'acceptable with research' because it was 'borderline' for only two out of 39 trials for hypotheses A and B, while its performance was 'unacceptable' for hypothesis C; that is, this variant fails for only one stock structure hypothesis (step 4a in Fig. 2).

Variant 8
Variant 8 was acceptable for all 'medium' weight trials. Therefore this variant can be considered to be 'acceptable without research' (steps 1 and 2 in Fig. 2).

Variant 9
Variant 9 performed 'unacceptably' on 20 out of 27 trials for stock-structure hypothesis C, and had 'borderline' performance for four trials (C11, C14, C17 and C30). It had 'borderline' performance on only two out of 39 trials based on stock-structure hypotheses A and B (A04, B04). This variant can thus be considered as a candidate for 'acceptable with research' because it fails only for stock structure hypothesis C (step 4a in Fig. 2).

Variant 10

Variant 10 performed 'unacceptably' on 23 out of 27 trials for stock-structure hypothesis C and had 'borderline' performance for two trials (C17 and C27). It also performed 'unacceptably' for one trial for stock structure hypothesis B (B04) and 'borderline' for 8 trials (B03, B05, B06, B09, B18, B20, B22, B28). 'Borderline' performance was also observed for three trials for stock structure hypothesis A (A03, A04, A28). This variant is therefore 'unacceptable'.

Variant 11

Variant 11 performed 'unacceptably' on three out of 27 trials for stock-structure hypothesis C (C13, C20, C23) and had 'borderline' performance for 16 stock structure hypothesis C trials. The conservation performance of this variant is between that of variants 5 and 9, which were both considered to be candidates for variants with research. Therefore, this variant can be considered as a candidate for 'acceptable with research'.

Variants with research

With respect to variants that are candidates for 'acceptable with research', it is the responsibility of relevant government(s) to inform the Committee whether it wishes additional trials to be run to determine the conservation performance of proposed 'hybrid variants'. A 'hybrid variant' is one for which catches for the first 12 years are set using the candidate 'acceptable with research' variant followed by a 6-year phase down/phase out period and then catches set by an 'acceptable without research' variant. The conservation performance of the 'hybrid variant' must be 'acceptable' under the criteria described above.

If the 'hybrid variant' performs acceptably then, before it can be recommended, the Committee must agree a research programme that it believes has a realistic chance of determining whether the trial(s) for which this variant performed poorly should be accorded low weight. The Committee will review progress with the research programme annually and may recommend early reversion to the 'acceptable' variant if progress is not sufficient.

The Committee noted that any research proposal submitted would be reviewed at next years' meeting.

6.1.4 Recommendations

6.1.4.1 RMP VARIANTS

Under the management options recommended (see below), the *Management Area* designations for each RMP variant are as follows.

(1) Variant 1: sub-areas 5, 6W, 7CS, 7CN, 7WR, 7E, 8, 9* and 11 are *Small Areas*.
(2) Variant 2: sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* (all of the catch from the 7+8 *Small Area* is taken from sub-area 7CN).
(3) Variant 3: sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* (all of the catch from the 7+8 *Small Area* is taken from sub-area 7CS).
(4) Variant 4: sub-areas 5, 6W, 7CS, 7CN, 7WR+7E+8, 9* and 11 are *Small Areas* (all of the catch from the 7WR+7E+8 *Small Area* is taken from sub-area 7WR).
(5) If Variant 5 proves to be acceptable with research: sub-areas 5 and 6W are *Small Areas* and catches are taken from sub-areas 5 and 6W. Sub-areas 7+8+9*+11+12 form a Combination Area (catch limits for sub-areas 12SW and 12NE are not taken).
(6) Variant 6: sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* (catches from the 7+8 *Small Area* are taken from sub-areas 7CS and 7CN using the same method as for catch cascading).
(7) If Variant 7 proves to be acceptable with research: sub-areas 5+6W+6E+10W+10E and 7+8+9*+11 are *Small Areas*; (catches from the 5+6W+6E+10W+10E *Small Area* are taken from sub-areas 5 and 6W using the same method as for catch cascading; catches from the 7+8+9+11 *Small Area* are taken in sub-area 7CN).
(8) Variant 8: sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* (catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 8 and 9 using the same method as for catch cascading).
(9) If Variant 9 proves to be acceptable with research: sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* (catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 using the same method as for catch cascading).
(10) If Variant 11 proves to be acceptable with research: sub-areas 5, 6W, and 7+8+9*+11+12 are *Small Areas* (catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 using the same method as for catch cascading).

The Committee **agrees** that, according to the Committee's Requirements and Guidelines for *Implementations* (IWC, 2012h):

(1) variants 1, 2, 3, 4, 6 and 8 are 'acceptable without research';
(2) variants 5, 7, 9 and 11 are candidates for 'acceptable with research'; and
(3) variant 10 is 'unacceptable'.

Some members stated that with only two exceptions, all of the 'unacceptable' trials were under stock structure hypothesis C. Under the Committee's current Requirements and Guidelines for *Implementations* under the RMP, when there is no agreement on plausibility of the hypotheses, the plausibility is automatically assigned as 'medium'. In the case of stock structure hypothesis C, there was no agreement and therefore the plausibility became 'medium' as for the other stock structure hypotheses. However these members reiterated their view that the plausibility of stock structure hypothesis C is 'low' (IWC, 2011c, p.138). Whilst agreeing that the review of trials had appropriately followed the Committee's current Requirements and Guidelines for *Implementations*, under these circumstances they could not accept the recommendations on management based on the conservation performance of the *Implementation Simulation Trials* using hypothesis C reviewed at this meeting. They pointed out that the problem of assigning plausibility has been an ongoing problem and suggested that it is necessary to review the method of determining plausibility.

6.1.4.2 ESTIMATES OF ABUNDANCE

The Committee did not have sufficient time to finalise the estimates of abundance for use in actual applications of the RMP. Annex D1, table 6 summarises the current status of abundance estimates for use in the trials and in actual applications of the RMP. Work to determine whether the abundance estimates that need further consideration can be accepted for use in actual applications of the RMP is included in the work plan. Final decisions regarding which abundance estimates can be used in actual applications of the RMP will be made at next year's meeting, taking into account any revision to the Requirements and Guidelines for Conducting Surveys (see Item 5.5, Annex D, item 2.5).

6.1.4.3 HISTORICAL AND FUTURE REMOVALS

The Committee has previously agreed that the best estimates of the direct catches and the average predicted bycatch from the six baseline trials would be used in actual applications of the RMP (IWC, 2013c). The calculated average predicted bycatch from the six baseline trials are given in Annex D1, Appendix 2.

6.1.4.4 CONSIDERATION OF DATA/ANALYSES TO REDUCE HYPOTHESES IN FUTURE

The Committee did not have sufficient time to discuss this item fully. It **encourages** those Contracting Governments which are contemplating application of the RMP to review previous discussions on this matter in the Committee.

The Committee highlighted that the *Implementation Simulation Trials* structure provided a way to identify the value of information to resolve uncertainties. In particular, analyses could be undertaken to assess where data on mixing proportions and abundance would be most informative in terms of resolving the plausibility of various hypotheses. The Committee recognised that becoming familiar with how to use the *Implementation Simulation Trials* structure to evaluate the value of information could be complicated, and **encourages** members of the Committee to work with the Secretariat to develop the ability to condition and run trials.

6.1.5 Surveys and estimates of abundance

6.1.5.1 RESULTS FROM RECENT SURVEYS

SC/65a/NPM01 presented the results of satellite tracking of common minke whales in the Sea of Japan in autumn 2012. Little information on migration behaviour was obtained because of the short transmission duration (14 days). More details are given in Annex D1, item 8.1. The Committee welcomes this information and **recommends** that researchers conducting tagging studies on North Pacific minke whales work together with those conducting similar work in other areas, particularly in relation to tag technology and deployment.

SC/65a/NPM04 provided a cruise report on a sighting survey in the East Sea in spring 2012. More details are given in Annex D1, item 8.1.

6.1.5.2 PLANS FOR FUTURE SURVEYS

SC/65a/NPM02 presented the research plan for a sighting survey for common minke whales in the Sea of Okhotsk, including the Russian EEZ, in summer 2014. The primary objective of the survey is to obtain a new estimate of abundance for sub-areas 11 and 12. The secondary objective of the survey will be biopsy sampling and satellite tagging for common minke whales, if permission is obtained from the Government of the Russian Federation. This latter objective is important given the need to obtain information on the mixing rate of J- and O-stocks, and the distribution of J-stock in the Okhotsk Sea. Further details are given in Annex D1, item 8.2.

SC/65a/NPM05 reported that a sighting survey for common minke whale will be conducted in the Yellow Sea in spring 2014. This survey is part of a four-year programme to survey the waters of sub-areas 5 and 6W and increase survey coverage from 13% to 35%. Further details are given in Annex D1, item 8.2.

The Committee welcomes these plans and noted that there have been no surveys in sub-area 12 in recent years. It appointed Miyashita and An to provide oversight of these surveys on behalf of the Committee. The Committee **strongly recommends** that the Government of the Russian Federation give permission for the survey to take place in its EEZ in the Sea of Okhotsk throughout sub-area 12, given the importance of abundance estimates for sub-area 12 to the understanding of the status of common minke whales in the western North Pacific.

6.1.5.3 UPDATED LIST OF ACCEPTED ABUNDANCE ESTIMATES

Annex D1, Appendices 3 and 4 summarise information on primary effort, primary sighting position, survey blocks, sub-areas and area definitions for surveys for western North Pacific minke whales. The Committee thanked Miyashita, Hakamada and An for providing this information, which had been requested by the 2nd Intersessional Workshop.

Annex D1, table 7 lists these estimates of abundance in a format consistent for collation with estimates from other species and areas.

6.1.6 Conclusions

The Committee re-established the Intersessional Steering Group (see Annex D1, item 11 for membership) to co-ordinate intersessional work and prepare for the 2014 Annual Meeting.

The Committee recognised that this *Implementation Review* had been the most complicated to date and thanked all those who had contributed over the last three years to its completion, especially Hammond and Donovan who chaired the Working Group and intersessional Workshops, respectively. In particular, the Committee expressed its appreciation for the large amount of work done by Allison and De Moor without which it would not have been possible to complete the *Implementation Review*. The Committee noted that the need to take three years to complete this complicated *Implementation Review* may have implications for conducting other *Implementations* and *Implementation Reviews.* The Committee **agrees** to review its Requirements and Guidelines for *Implementations* under the RMP in this context at next year's meeting.

6.2 North Atlantic fin whales

6.2.1 Implementation Review

The Committee reviewed the report of the pre-meeting to initiate the *Implementation Review* (see Annex D, Appendix 2) and **endorses** its conclusions, recommendations and work plan. It established an intersessional group (see Annex R) under Elvarsson to develop revised specifications for the trials. It **recommends** that a two-day Workshop is held back-to-back with an AWMP intersessional Workshop in early 2014 to reduce travel costs.

6.3 North Atlantic common minke whales

6.3.1 Review new information

The Committee received five papers which had either been presented to the Special Permit Review Workshop held in Iceland (SC/65a/Rep03), or were revised versions of papers presented then. Details are given in Annex D, item 3.2.1.

The Committee **welcomes** the information in SC/F13/SP17 and SC/F13/SP20rev. It should be useful for the upcoming *Implementation Review,* and, in particular, the work of the joint AWMP/RMP Working Group on stock structure.

The Committee recognised the value of the satellite tracking of minke whales, reported in SC/F13/SP18, for the development of *Implementation Simulation Trials*. It **reiterates** the recommendations of the Special Permit Review that such tagging should continue, as much information as possible should be collected from each tagged individual, and that the results from the various stock definition approaches should be integrated.

The Committee **agrees** that data from satellite tracking could be used in *Implementation Simulation Trials* both qualitatively and quantitatively. There would be benefits in identifying the analysis methods to apply to data from satellite-tagged animals to determine the minimum number of animals needed for meaningful quantitative estimates and the point at which tagging additional animals leads to minimal additional information. If such analysis methods are developed, they should be reviewed by the Working Group on Stock Definition.

The Committee noted that SC/F13/SP06 stated the main objective of the aerial survey component of the research programme is to obtain a seasonal profile of relative abundance in coastal Icelandic waters in the off-season. This is discussed in Annex D, item 3.2.1.

6.3.1.1 NEW SURVEYS

SC/65a/RMP10 presented Norway's plans to conduct a new series of annual partial surveys over the period 2014-19 to collect data for a new estimate of minke whale abundance in the Northeast Atlantic in accordance with the requirements of the RMP. The survey and analytical methods will follow the procedures used in the previous survey cycles.

The Committee noted that the upcoming *Implementation Review* could lead to changes to the definitions of the *Small Areas*. It recognised that there are some advantages in agreement between survey and *Small Area* boundaries, but **agrees** that an approach has been developed which can address changes in *Small Area* boundaries.

6.3.2 Prepare for 2014 Implementation Review

The Committee was informed that the joint AWMP/RMP group is coordinating discussions and analyses on using genetics to examine stock structure for North Atlantic minke whales. It reviewed the report of the group (Annex D, Appendix 3) and **endorses** its recommendations. It **reiterates** its recommendation from last year that the work plan for the group (IWC, 2013d) be completed, and **recommends** the holding of a joint AWMP/RMP intersessional Workshop to consider stock structure hypotheses for common North Atlantic minke whales. It **recommends** a research proposal to conduct simulation analyses to support the deliberations of the intersessional Workshop (Annex D, Appendix 4) and future considerations of stock structure for other populations (see Item 26).

6.3.3 Recommendations

The Committee **recommends** that a Steering Group under Walløe be established to co-ordinate planning for the 2014 *Implementation Review* (see Annex R). It **recommends** that a three day pre-meeting be held prior to the 2014 Annual Meeting to ensure that sufficient progress is made on the *Implementation Review*, noting that this *Implementation Review* could be more complicated than previous ones because the original *Implementation* was not conducted under the current Requirements and Guidelines for *Implementation.*

6.4 North Atlantic sei whales

Last year, the Committee established an intersessional group to review the available data for North Atlantic sei whales in the context of a possible *pre-Implementation assessment* and provide a report to the 2013 Annual Meeting. Unfortunately, insufficient progress was made during the intersessional period to warrant starting the *pre-Implementation assessment* at this year's meeting. The Committee therefore **recommends** that the intersessional group be re-established and progress evaluated at the 2014 Annual Meeting. The decision whether to initiate an *Implementation* after a *pre-Implementation assessment* is made by the Commission. The Committee noted that this procedure might lead to delays now that the Commission will meet biennially; it may consider possible recommendations to the Commission at next year's meeting.

6.5 Western North Pacific Bryde's whales

6.5.1 Prepare for 2016 Implementation Review

The Committee received an update on progress and plans for the 2016 *Implementation Review* (Annex D, item 3.4). A sighting survey will be conducted in western North Pacific minke whales sub-areas 7 and 8 in 2013. IWC-POWER cruises will also take place in 2013 and 2014. Sightings data will be collected and attempts will be made to biopsy Bryde's whales. Bryde's whale genetic samples were collected during JARPN II cruises in 2012 and additional samples will be collected during the 2013 JARPN II cruises.

6.6 Work plan

The Committee's views on the work plan for the sub-committee on the RMP are given in Item 24, and the financial implications in Item 26.

7. NON-DELIBERATE HUMAN-INDUCED MORTALITY OF LARGE WHALES

The report of the Working Group on Non-deliberate Human-induced Mortality of Large Whales is given as Annex J.

7.1 Criteria for determining cause of death

The objective of this Item is to assist the Committee in its general attempts to assess human caused mortality and in particular to agree to specific criteria by which the Ship Strike Data Review Group can assess ship strikes reported to the ship strike database. If standardised criteria became internationally accepted, this will also assist countries as they report ship strikes through their National Progress Reports.

Moore reported via videolink on a workshop held in the USA (1-2 February 2012) that defined criteria for degrees of confidence in the diagnosis of sharp or blunt vessel trauma, and peracute or chronic fishery trauma in cetaceans. The amount of data needed to make an adequate diagnosis depends on the scenario as is discussed in Moore *et al.* (2013b) and summarised in Annex J, item 6. Their criteria are for 'Confirmed', 'Probable' and 'Suspect' outcomes and this approach had been used to examine large whale mortalities in the northwest Atlantic in the context of management strategies designed to mitigate these impacts (Van der Hoop *et al.*, 2012). They found that trends in numbers (and location) of reports of vessel strikes and entanglements did not differ significantly before or after 2003, when a number of management mitigation initiatives were begun along the Atlantic coast of the USA.

A handbook was presented for recognising, evaluating and documenting human interactions in stranded cetaceans and pinnipeds was presented (Moore and Barco, 2013). The Committee **recognises** the value of standardising approaches to enable more consistent data collection which in turn can assist in obtaining information on the likely extent of causes of death and necessary priorities for mitigation. Details are provided in Annex J, item 6.

The above two papers describe complementary actions and criteria and represent important tools for stranding networks globally. While a full forensic necropsy is often very difficult this should nevertheless be the goal to aim for. The two papers provided a progression of data collection options, and the visual options in the handbook should be feasible almost anywhere. Data collected using these protocols are being archived with the ultimate intent of making some images available for consultations and training. The Committee **encourages** this work and broader use of the handbook.

One hundred and eight ship strike reports from Alaskan waters between 1978-2011 are described in Neilson *et al.* (2012). In order to assess the reliability of these reports, which ranged from well documented reports with full necropsies to secondhand reports with sparse documentation, the authors developed 'confidence criteria' for categorising the reports. The Committee **welcomes** this summary and noted that this information will provide valuable input into the IWC's ship strikes database.

The criteria developed in these papers have been used to develop the criteria and definitions in Annex J, Appendix 2. The Committee **recommends** that these be adopted for the IWC ship strike database.

7.2 Reporting to National Progress Reports

This matter is discussed under Item 3.2.

7.3 Entanglement of large whales

7.3.1 Estimation of rates of entanglement, risks of entanglement and mortality

SC/65a/HIM02 describes a recent incidental catch of a baleen whale in a long-line fishery off the Brazilian coast. The incident demonstrates the need for more investigation of such interactions in the southwest Atlantic Ocean. A large long-line fleet operates out of ports along Brazil's southern coast in the path of migratory whales. The fleets are not monitored and they are unlikely to report whales entangled in their gear since, while it is forbidden to entangle a whale and there are regulations requiring that they are reported, these measures are not effective. In September 2012, just south of this area, a meeting was held to develop an action plan to mitigate bycatch and entanglement in similar Argentine fisheries. It is hoped that a report of the action plan developed will be available at next year's meeting. The Committee looks forward to receiving a report of the plan.

7.3.2 Methods to estimate time-series of bycatch

This item was not discussed by the Working Group this year but will be considered next year in light of discussions in e.g. Annexes D1 and E.

7.3.3 Collaboration with FAO and FIRMS

The IWC is currently an observer to the FIRMS partnership (Fisheries Resources Management System). It had been hoped that FIRMS may hold data on fishing effort that could be useful in estimating bycatch but FIRMS appears to have changed its focus somewhat since initial discussions with the IWC. Leaper will follow up on any new developments intersessionally to see if there is progress to discuss next year.

7.3.4 Collaboration with Commission initiatives on entanglement, including consideration of mitigation measures

Much of the work of the Secretariat's technical advisor, Mattila (generously seconded by the USA since 2012) has been devoted to capacity building on the issue of large whale entanglement. The strategy has provided an overview for over 500 scientists and government managers from 20 countries, followed by detailed training and assistance with setting up entanglement response networks. Over the remainder of 2013, training is scheduled for Ecuador (with participants from the Permanent Commission for the South Pacific (CPPS) countries), Panama, and a joint IWC-UNEP-SPAW session for the French and English Caribbean. The Committee **commends** this work, noting that besides assisting countries to establish relatively safe entanglement response capabilities which have already released a number of individual whales, it has stimulated other local and national initiatives on the issue of entanglement, including actions intended to both understand and mitigate them. The Committee **reiterates** that prevention rather than disentanglement is the ultimate solution. It **encourages** members to submit information and papers on prevention studies to next year's meeting.

7.4 Ship strikes

7.4.1 Progress on the global database

Last year, in response to a Committee recommendation (IWC, 2013h), Ritter and Panigada had been contracted jointly as co-ordinators for the ship strikes database. The primary objective was to raise awareness about the ship strike database and to stimulate its use. Outreach activities have resulted in a large number of new data entries compared to previous years. Data from around 100 incidents have been entered in the last year and the data from around a further 200 incidents are expected to be incorporated during the rest of 2013. These data cover some areas not previously covered including the Gulf of St Lawrence (Canada) and Alaskan waters. Contact was also made with researchers and authorities in Sri Lanka. A total of 111 entries of collisions between sailing vessels and cetaceans are expected to be entered by the end of 2013. A new edition of the multi-lingual IWC ship strike leaflet, supported by Belgium, has been distributed to a range of stakeholders. A self-standing banner display has been developed and two copies were produced; one was displayed at the recent European Cetacean Society conference in Portugal.

The Committee **commends** this work, noting that a modest financial investment by the IWC has produced good results. It noted the value of the leaflet to highlight the issue and create an ongoing dialog on whale avoidance in the maritime industry; for example, Neilson *et al.* (2012) had recommended its wide distribution. The Committee **recommends** that this work continues and is funded (see Item 26). The Committee also **agrees** that the co-ordinators should give priority to populations identified for CMPs for proactive data gathering outreach efforts.

The Committee noted that Australia and the USA have ship strike databases and have worked to ensure that these are compatible with the IWC database, and that data fields can be accurately mapped between them to facilitate data exchange. The Committee **reiterates** previous recommendations that member nations should submit data to the IWC's global database as soon as possible.

7.4.2 Estimating rates of ship strikes, risk of ship strikes and mortality

SC/65a/HIM01 provided information from the Canary Islands. A large fleet of commercial ferries operates on a year-round basis in the area and ship strikes are a known problem. Different ferry types exhibit distinct noise spectra. Based on certain assumptions, especially on hearing thresholds, the authors concluded that whales may be capable of hearing approaching vessels at distances that should enable them to react fast enough to avoid a collision. However, numerous factors need to be considered in evaluating the actual collision risk. Jet-driven ferries travelling at high speed, combined with comparably low intensity bow-radiated noise, result in an especially high risk of collision. These results confirm the role of vessel speed and the need to reduce vessel speed so as to minimise the risk of collision.

SC/65a/HIM03 reported that two pygmy blue whales were struck and killed in Sri Lankan waters in early 2012. The southern coast of Sri Lanka is one of the busiest shipping routes in the world and overlaps with an area of high whale sightings. The reported deaths can only be considered minimum values. These deaths and the unknown population size highlight an urgent need for long-term monitoring of the blue whale population in Sri Lankan waters and elsewhere in the northern Indian Ocean.

Vaes and Druon (2013) presented a novel approach to considering the seasonal ship strike risk to fin whales in the western Mediterranean Sea using satellite-derived data (surface temperature and chlorophyll-a content) as a proxy for fin whale habitat in addition to using AIS data for vessel traffic. The Committee agreed that further comparisons using this approach with contemporary whale sighting data are required to assess its value.

Neilson *et al.* (2012) reported data on collisions in Alaska between 1978 and 2011; these have been made available to the IWC database as noted above. There were 108 reports classified as definite, probable or possible ship strikes, mostly from collisions witnessed at sea. It was noted that even in this relatively large data set there were only a few cases in which the circumstances of the collision and outcome could be related to the size, speed and type of the vessel involved. This highlights the need for a central global database, which will increase the likelihood of obtaining a sample size sufficiently robust for meaningful analyses of factors related to risk.

7.4.3 Collaboration with the Commission's ship strikes working group including consideration of mitigation measures

An IWC-endorsed Ship Strike Mitigation Workshop was held in Tenerife in October 2012 (Tejedor *et al.*, 2013). This was primarily aimed at management and mitigation. There was broad recognition and acceptance that currently the best way to avoid collisions with whales is to avoid areas of high density, but if this is not possible then ships should maintain a vigilant watch and slow down as appropriate. Several participants from the industry agreed that they would prefer to know of a whale 'hot spot' well in advance, and be able to plan their routes accordingly, rather than getting a message upon arrival in an area that they need to re-route.

The apparent willingness of key stakeholders at this Workshop to investigate the feasibility and utility of voyage planning to avoid high density areas represents an opportunity for the Committee to play an important role in this effort. The Committee **agrees** that this is a productive way forward on this issue and **recommends** that the topic of defining and identifying critical whale 'hot spots' and engaging the shipping industry in the process should be an agenda item for the Commission's next Ship Strike Workshop. The Committee recognised that the Tenerife Workshop was primarily concerned with management and mitigation, and as such, **recommends** that the Commission's next Ship Strike Workshop reviews the report in full, and considers endorsing it and seeking partnerships with stakeholders to carry out appropriate recommended actions.

Bryde's whales in the Hauraki Gulf, New Zealand were also discussed. The population is believed to be less than 200 individuals and there have been 16 confirmed ship strike mortalities between 1996 and 2013. A proposal for funding an aerial survey to provide an abundance estimate for Bryde's whales throughout their primary range in New Zealand and to use this and data on distribution to inform mitigation measures to reduce ship-strike mortality was received (also see Item 26).

7.5 Marine debris

7.5.1 Report of the intersessional Workshop

A summary of the first IWC Marine Debris Workshop (SC/65a/Rep06), held from 13-17 May 2013 at Woods Hole Oceanographic Institution, was presented. The original objectives are outlined in IWC (2013j, pp.261-62).

Thirty-eight participants representing eight countries attended the Workshop. The first day of the Workshop included a public seminar consisting of keynote presentations which illustrated the ways in which debris and cetaceans interact, including the long lingering deaths that can result from entanglement, and a growing realisation that ingestion of plastics, including microplastics, may be a significant problem. In 2012, 280 million tonnes of plastic were produced globally, less than half of which was consigned to landfill or recycled. If current rates of consumption continue, the planet will hold another 33 billion tonnes of plastic by 2050 (Rochman, 2013). The keynote presentations also highlighted the need for improved international cooperation.

The participants recognised the potential significant impact that marine debris has on both cetacean habitat and cetaceans through both macrodebris (such as fishing gear, plastic bags and sheeting) entanglement and ingestion and through microplastics and their associated chemical exposures through ingestion or inhalation. The Workshop encouraged debris sampling when conducting observational cetacean research at sea (i.e. water sampling and visual observations during cetacean sightings surveys) and recommended that industry partners be involved in marine debris prevention, research and response to ensure success in reducing marine debris impacts on cetaceans.

Finally, the Workshop agreed that ingestion and inhalation of marine debris may sometimes be lethal, that sub-lethal impacts may also occur with long term negative consequences and that intake of debris is a problem, both as an individual welfare concern and potentially for some populations and species. More research was encouraged. The Workshop recommended that the IWC Scientific Committee should evaluate the risks of ingestion and inhalation based upon: (1) the spatial distribution of microplastics and macro debris; and (2) the feeding strategies and location of feeding areas of cetaceans. It also recommended that the Scientific Committee prioritise studies of those cetaceans that are likely at greatest risk of ingesting or inhaling macro- and micro-debris and associated pollutants (e.g. see Fossi *et al.*, 2012). The Workshop thus recommended that the initial focus of research be on three species of baleen whale: the North Atlantic right whale, the fin whale in the Mediterranean Sea and the gray whale in the eastern North Pacific. The Workshop noted that none of its recommendations required the lethal collection of cetaceans.

7.5.2 Committee discussion

A full discussion of the Workshop report can be found in Annex K, item 11.2. For a full list of scientific recommendations see SC/65a/Rep06. Information was also presented on marine debris found in the stomach contents of common minke whales, sei whales, Bryde's whales and sperm whales sampled by JARPN II (SC/65a/O03, SC/65a/O06, SC/65a/O07). No marine debris was observed in the stomachs of Antarctic minke whales (SC/65a/O09). After review of the Workshop report and other papers, the Committee **endorses** the recommendations of the Workshop (see SC65a/Rep06 for full details), including its recommended pathology protocol and **agrees** that:

(1) legacy and contemporary marine debris have the potential to be persistent, bioaccumulative and lethal to cetaceans and represent a global management challenge; and
(2) entanglement in and intake of active and derelict fishing gear and other marine debris have lethal and sub-lethal effects on cetaceans.

Therefore the Committee **strongly agrees** that marine debris and its contribution to entanglement, exposures including ingestion or inhalation, and associated impacts, including toxicity, are welfare and conservation issues for cetaceans on a global scale and a growing concern. The Committee **recommends** that the Commission and the Secretariat take prompt action to help better understand and address this growing problem, including:

(1) providing data on rates of marine debris interactions with cetaceans into the national progress reports and supporting the second marine debris Workshop (which will have mitigation and management as its focus);
(2) strengthening capacity building in the IWC entanglement response curriculum and adding information on marine debris;
(3) building international partnerships with other relevant organisations and stakeholders including an effective transfer of information about on-going research and debris-reduction and removal programmes and the international and national marine debris communities;
(4) developing programmes to remove derelict gear and schemes to reduce the introduction of new debris; and
(5) incorporating consideration of marine debris into IWC conservation management plans where appropriate and to consider making it the focus of a plan in its own right.

The Committee thanked the Workshop Convenor, the Woods Hole Oceanographic Institution for hosting the Workshop and the tremendous work done by the Workshop organisers and participants. The Committee also appreciates the funds provided by the various organisations in support of this Workshop.

The Committee **agrees** to establish an intersessional correspondence group (see Annex R) to review and prioritise the research-related recommendations from the Workshop. It was noted that this review should give consideration to: (1) the evaluation of the efficacy of fishing practices that pose a lower risk of entanglement or loss of gear, given that active and derelict fishing gear are a major cause of injury and mortality in cetaceans; and (2) further investigations into microplastics, their associated chemical pollutants and microbes, and macrodebris ingestion. Further work on microplastics has been taken up by the POLLUTION 2020 work plan (see Annex K, Appendix 2). The intersessional correspondence group will also liaise with the steering group for the second Marine Debris Workshop.

7.6 Work plan

The Committee's views on the work plan developed by the Working Group are given in Item 24, and the financial implications in Item 26.

8. ABORIGINAL SUBSISTENCE WHALING MANAGEMENT PROCEDURE (AWMP)

This item continues to be discussed as a result of Resolution 1994-4 of the Commission (IWC, 1995a). The report of the SWG on the development of an Aboriginal Whaling Management Procedure (AWMP) is given as Annex E. The Committee's deliberations, as reported below, are largely a summary of that Annex, and the interested reader is referred to it for a more detailed discussion. The primary issues at this year's meeting comprised: (1) finalising work on the PCFG (the Pacific Coast Feeding Group) of gray whales; (2) developing *SLAs* and providing management advice for Greenlandic hunts; and (3) reviewing management advice for the humpback whale fishery of St Vincent and The Grenadines. Considerable progress on items (1) and (2) was made as a result of an intersessional Workshop (see SC/65a/Rep02).

8.1 Matters arising out of the *Implementation Review* for eastern North Pacific gray whales

8.1.1 SLAs for the potential Makah hunt

In 2010, the Committee agreed that PCFG (Pacific Coast Feeding Group) whales should be treated as a separate management unit. The Makah Tribe would like to take gray whales in the Makah Usual and Accustomed fishing grounds (U&A) in the future and the objective of the *SLA*s tested during the *Implementation Review* process was to minimise the risk to the PCFG whales and meet the Commission's conservation objectives.

Last year, the Committee had agreed that two *SLA* variants met the conservation objectives of the Commission (IWC, 2013e):

(1) *SLA* variant 1: struck-and-lost whales do not count towards the APL (the 'allowable PCFG limit' – a protection level) i.e. there is no management response to PCFG whales struck but not landed; and
(2) *SLA* variant 2: all struck-and-lost whales count towards the APL irrespective of hunting month i.e. the number of whales counted towards the APL may exceed the actual number of PCFG whales struck.

SLA variant 2 was only acceptable if it was accompanied by a research programme (i.e. a photo-id programme to monitor the relative probability of harvesting PCFG whales, the results of which are presented to the Scientific Committee for evaluation each year).

However, the Committee also noted that the two variants did not exactly mimic the proposed hunt and expressed concern that the actual conservation outcome of the proposed hunt had not been fully tested. The reason for this relates to how strikes in May are treated in *SLA* calculations. No hunting is allowed after May since that is when the proportion of PCFG whales to migrating whales is highest (PCFG whales are defined as those photographed in multiple years from 1 June to 30 November within the PCFG area).

After discussions at the intersessional Workshop (SC/65a/Rep02), results were received for six new variants to cover the full range of possible strikes occurring in May or prior to May, i.e. variants allowing x strikes prior to May where $x = 1,\ldots,6$ (SC/65a/AWMP06). In summary, the performance of all the new variants was no worse than for Variant 1 and no better than for Variant 2.

In conclusion, the Committee **agrees** that the conservation performance of the proposed Makah whaling management plan has now been fully examined within the *SLA* evaluation framework. It **confirms** that the proposed management plan meets the conservation objectives of the Commission provided that if struck and lost animals are not proposed to be counted toward the APL, then a photo-identification research programme to monitor the relative probability of harvesting PCFG whales in the Makah U&A is undertaken each year and the results presented to the Scientific Committee for evaluation. In other words, only Variant 2 above meets the Commission's conservation objectives without the research requirement.

The Committee noted that the intersessional Workshop (SC/65a/Rep02) had recommended that the photo-id catalogue for the eastern North Pacific gray whales that will be used to assess whether landed whales are from the PCFG be made publicly available as it is a key component of the management approach. Weller reported that NOAA still has funds available to digitise the catalogue of PCFG whales. Scordino noted that work is underway to compile photographs from a few key contributors for a photo catalogue of PCFG whales to be held at NOAA's National Marine Mammal Laboratory; this catalogue, at least initially, will not be publicly available.

SC/65a/AWMP03 presented an update on the availability of PCFG whales in the Makah U&A based on photo-identification surveys. The results: (1) supported the proposed prohibition of hunting in the Strait of Juan de Fuca; and (2) confirmed that the availability of PCFG gray whales in Pacific Ocean waters of the Makah U&A was not appreciably different to the 30% availability used in the 2012 *Implementation Review*. An updated paper next year will also include an examination of possible trends.

8.1.2 Potential for western gray whales to be taken during aboriginal hunts

Given ongoing concern about the status of the gray whales that summer in the Western North Pacific (WNP), in 2011 the Scientific Committee emphasised the need to estimate the probability of a western gray whale being killed during aboriginal gray whale hunts (IWC, 2012a). The Committee noted that the work described in SC/65a/AWMP3 above can assist in this. This year, Moore and Weller (2013) updated the analysis of mortality risk to WNP whales from the proposed Makah hunt by incorporating Committee feedback last year (IWC, 2013c, p.20). Based on their preferred model, depending on assumptions, the probability of striking at least one WNP gray whale during a five-year period ranges from 0.036 to 0.170. The authors concluded that this represents a conservative initial step in assessing the potential risk.

The Committee welcomed this paper, recognising that it represents an initial approach. As detailed under Annex F, item 2.2.2, it also received information on an ongoing telemetry study of PCFG whales and considered the report of a US scientific task force that assessed gray whale stock structure in the light of US domestic legislation.

The Committee **agrees** that all of this information will make a valuable contribution to the recommended rangewide Workshop (Annex F, Appendix 2) described under Item 26.

Finally, in regard to questions on whether it should consider conducting an *Implementation Review* to evaluate the potential impacts of the Makah hunt on whales identified in the western North Pacific, the Committee **agrees** that ideally before an *Implementation Review* is conducted, the recommended rangewide Workshop be held (see Item 26).

8.2 Guidelines for *SLA* development and evaluation

Considerable effort was put into general consideration of the development of *SLA*s at the beginning of the AWMP process (IWC, 2000b; 2001b; 2001c; 2002b). This year, the Committee briefly outlined some guiding principles for *SLA*s to assist developers of candidate *SLA*s for the Greenland hunts. These are summarised below.

(1) The primary objective of any *SLA* is to meet the objectives set by the Commission with respect to need satisfaction and conservation performance, with priority given to the latter.
(2) *SLA*s must incorporate a feedback mechanism.
(3) Once need has been met for the 'high' need envelope while giving acceptable conservation performance, then there is no need to try to improve the performance of an SLA further.
(4) Simple *SLA*s are to be preferred, providing this simplicity does not compromise achieving the Commission's objectives.
(5) With respect to (4), empirical procedures may prove preferable to population model based procedures because: (a) they are more easily understood by stakeholders; and (b) there is little chance for significant updating of population model parameters (e.g. MSYR) over time as the extent of additional data will probably be limited for populations subject to aboriginal whaling only. Nevertheless, the choice of the form for any candidate *SLA* lies entirely in the hands of its developer, with selection amongst candidates to be based on performance in trials.
(6) If in developing *SLA*s, a situation arises where relatively simple *SLA*s fail on one or a few trials where the circumstances which might lead to the failure occur only many years in the future, rather than attempt to develop more complex *SLA*s to overcome this problem, a simpler *SLA* could be proposed despite this failure, and the difficulties dealt with by means of an *Implementation Review* should there be indications in the future that the circumstances concerned are arising. This principle applies only to:
    (a) circumstances in a scenario that are external and independent of the hunting/quota feedback loop, such as very high values of the future need envelope; and
    (b) are judged to be very unlikely to occur in the next few decades.

    Failure of an *SLA* to perform acceptably in some circumstances is not in itself a reason to apply this principle.

The Committee also reviewed and discussed the performance statistics, tables and plots that are required to evaluate conditioning and trial results. This discussion can be found under item 3.2.3 of Annex E. The Committee **endorses** this approach.

8.3 Progress on *SLA* development for the Greenlandic hunts

In Greenland, a multispecies hunt occurs and the expressed need for Greenland is for 670 tonnes of edible products from large whales for West Greenland; this involves catches of common minke, fin, humpback and bowhead whales. The flexibility among species is important to the hunters and satisfying subsistence need to the extent possible is an important component of management. For a number of reasons, primarily related to stock structure issues, development of *SLA*s for some Greenland aboriginal hunts (especially for common minke and fin whales) is more complex than previous *Implementations* for stocks subject to aboriginal subsistence whaling. The Committee has endorsed an interim safe approach to setting catch limits for the Greenland hunts in 2008 (IWC, 2009b), noting that this should be considered valid for two blocks, i.e. the target will be for agreed and validated *SLA*s, at least by species, for the 2018 Annual Meeting.

8.3.1 Common minke whales and fin whales off West Greenland

The Committee's discussions were informed by the work of the intersessional Workshop (SC/65a/Rep02) as well as those in Annex E. There is potential overlap between RMP and AWMP management with respect to common minke whales and fin whales in the North Atlantic. The process of developing *SLAs* and RMP *Implementations* for stocks in regions where both commercial and aboriginal catches occur should include the following steps: (a) development of a common trials structure which adequately captures uncertainties (regarding stock structure, mixing, MSYR, etc.); (b) identification of an *SLA* which performs as adequately as possible if there are no commercial catches; and (c) evaluation of the performance of RMP variants given the *SLA* selected at step (b).

With respect to common minke whales, the Workshop **reiterates its support** for a joint AWMP/RMP stock structure Workshop which will be essential to the *SLA* development process and the simulation framework (see Annex D, Appendix 2).

With respect to fin whales, in addition to working closely with intersessional work being undertaken within an RMP context (see Annex D), the Committee also noted that it may be possible to base the *SLA* for fin whales off West Greenland on operating models which considered West Greenland only. This will be investigated further (including at the intersessional RMP Workshop on fin whales) as it requires careful evaluation as to whether there may be more than one stock mixing off West Greenland.

In order to progress development work, the Committee last year funded a new computer program called RMP/AWMP-lite. It uses an age-aggregated rather than an age-structured model to considerably speed up calculations; this will allow developers to explore more easily the properties of candidate *SLA*s before they are submitted to rigorous full testing. It allows for multiple stocks of whales being exploited by a combination of commercial and aboriginal whaling operations. This was first reviewed at the intersessional Workshop (SC/65a/Rep02) and SC/65a/RMP05 implements the improvements suggested there.

The current approach to evaluating *SLA*s for the Greenlandic hunts treats each species independently even though need is expressed as a total amount of edible products over multiple species. The Committee **reiterates** that work on single-species *SLA*s should be completed before multi-species considerations are examined.

8.3.2 Humpback whales

The Committee's discussions were informed by the work of the intersessional Workshop (SC/65a/Rep02) as well as those in Annex E. Development of an *SLA* for humpback whales had been identified as one of the priorities for the Workshop and considerable progress was made.

8.3.2.1 STOCK STRUCTURE AND MOVEMENTS

The Committee has already agreed that the West Greenland feeding aggregation was the appropriate management unit to consider when formulating management advice. Whales from this aggregation mix with individuals from other similar feeding aggregations on the breeding grounds in the West Indies (IWC, 2008a, p.21).

In order to investigate whether West Greenland humpback whales are subject to mortality in other parts of the range then it is important to examine the available information from telemetry and photo-identification data. Considerable telemetry work has been undertaken off West Greenland (Heide-Jørgensen, 2012) and similarly there has been extensive photo-identification work. This has been used to inform how ship strike and bycatch data will be incorporated into the trials. This work is ongoing and Greenlandic scientists will work with the College of the Atlantic to present a review of the photo-identification data in time for an intersessional Workshop (see Item 26).

8.3.2.2 ABUNDANCE

The Committee has relative abundance data available from aerial surveys (see SC/65a/Rep02 and Annex E). It **agrees** to use the estimates of relative abundance from aerial surveys to condition the trials. The mark-recapture studies cover a shorter period and are heavily correlated so they will only be used in a *Robustness Trial*. However, given that mark-recapture abundance estimates may become common in the future for both humpback and bowhead whales, the Committee **agrees** that efforts should be made to develop ways to better integrate them into the operating models for the *SLA* trials.

With respect to absolute abundance, SC/65a/AWMP01 used information from 31 satellite-linked time-depth recorders to address the question of availability bias for the 2007 aerial survey. Fully corrected abundance estimates of 4,090 (CV=0.50) for mark-recapture distance sampling analysis and 2,704 (CV=0.34) for a strip census abundance estimate were developed. The estimated annual rate of increase is 9.4% per year (SE 0.01), unchanged from Heide-Jørgensen *et al.* (2012).

The Committee noted that the methods behind the new estimates had been discussed fully at previous meetings when considering the 2007 survey. The revised estimate was based on updated and improved information on the diving behaviour of whales from additional satellite tag data. It therefore **accepts** the new strip census abundance estimate as the best estimate. This information is also included in the trial specifications (see Annex E, Appendix 2).

8.3.2.3 REMOVALS

The Committee **agrees** that given past difficulties in modelling the full western North Atlantic (including allocation of past catches) and the decision to treat the feeding aggregation as the appropriate management unit, trials will begin in 1960 under an assumption that the age-structure in that year is steady. The direct catch series for this period is known. However, given possible migration routes (e.g. from telemetry data), it was noted that known direct catches occurred from whaling stations off the east coast of Canada after 1960 that may have included some 'West Greenland' animals. An approach to account for this has been developed. The Committee **agrees** that this will be incorporated into the catch series in the revised trial specifications, but that no future direct catches off Canada will be simulated.

In addition to direct catches, the question of bycatch in both West Greenland and of West Greenland animals elsewhere in their range needs investigation. For West Greenland, noting that the crab fishery which was primarily responsible for bycatch has now peaked, a conservative (from a conservation perspective) method for generating future bycatch has been developed. A similar method for accounting for bycatch outside West Greenland has been developed for bycatch and ship strikes. The Secretariat will work with Canadian scientists and others to investigate the available information on bycatch and ship strikes and develop a final removals table for consideration.

8.3.2.4 BIOLOGICAL PARAMETERS

Prior distributions need to be specified for three biological parameters: (a) non-calf survival rate; (b) age-at-maturity; and (c) maximum pregnancy rate. The values for these parameters used in the actual trials will encompass a narrower range than these priors because the priors will be updated by the data on abundance and trends in abundance during the conditioning process. Considerable discussion of this took place at the intersessional Workshop based on the range of estimates in the literature. The Committee **endorses** the priors shown in Annex E, Appendix 2. Recognising the considerable uncertainty, *Robustness Trials* have been developed to investigate the sensitivity to these priors.

8.3.2.5 NEED

Need envelopes are an important component of developing a trial structure and are the responsibility of the relevant Governments. They are used to allow for advice to be provided in the future on any increased need requests without having to conduct major *Implementation Reviews* or new *SLA* development. The need 'envelope' usually includes maintenance of the current limit, is bounded by a 'high need' case and then includes a middle option. A need envelope for humpback whales was submitted to the intersessional Workshop by Greenland (SC/D12/AWMP4) and these reflected the Greenlandic preference for humpback whales over fin whales and Greenland's desire for flexibility and a 'backup' to account for any unforeseen decline in the common minke whale strike limits. The need envelope is summarised in Annex E.

8.3.2.6 *SLA*S TO BE CONSIDERED

All trials will be conducted for a bounding case and for two 'reference *SLA*s', in addition to any other *SLA*s which might be proposed by developers:

(1) the *Strike Limit* is set to the need;
(2) the *Strike Limit* is based on the interim *SLA* (IWC, 2009b); and
(3) the *Strike Limit* is based on a variant of the interim *SLA* which makes use of all of the estimates of abundance, but downweights them based on how recent they are.

Guiding principles for *SLA*s are discussed under Item 8.2 above.

Developers are provided with the following information: total need for the next block; catches by sex; mortalities due to bycatch in fisheries and ship strikes; and estimates of absolute abundance and their associated CVs.

8.3.2.7 TRIAL STRUCTURE

After considering the report of the intersessional Workshop and the new information available at this meeting, the Committee agrees to the detailed trial specifications given in Annex E, Appendix 2. Some further discussion and parameterisation of one of the trials (that on asymmetric environmental stochasticity) is required and an intersessional steering group has been established to oversee this (Annex R).

The factors considered in the trials are summarised in Table 2 while the trials themselves are given in Annex E, Appendix 2, tables 5 and 6. The Committee **endorses** the trial specifications.

As noted under Item 8.2, the Committee also **endorses** the performance statistics, tables and plots proposed.

Table 2

Factors tested in the trials.

Factors	Levels (reference levels shown underlined)	
	Humpback whales	Bowhead whales
$MSYR_{1+}$	1%, 3%, 5%, 7%	1%, 2.5%, 4%
$MSYL_{1+}$	0.6	0.6, 0.8
Time dependence in K*	Constant, Halve linearly over 100 years	
Time dependence in natural mortality, M*	Constant, Double linearly over 100 years	
Episodic events*	None, 3 events occur between years 1-75 (with at least 2 in years 1-50) in which 20% of the animals die, events occur every 5 years in which 5% of the animals die	
Need envelope	A: 10, 15, 20; 20 thereafter B: 10, 15, 20; 20->40 over years 18-100 C: 10, 15, 20; 20->60 over years 18-100 D: 20, 25, 30; 30->50 over years 18-100	A: 2, 3, 5; 5 thereafter B: 2, 3, 5; 5 -> 10 over years 18-100 C: 2, 3, 5; 5 -> 15 over years 18-100
Future Canadian catches	N/A	A: 5 constant over 100 years B: 5-> 10 over 100 years C: 5-> 15 over 100 years D: 2.5 constant over 100 years?
Survey frequency	5 years, 10 years, 15 years	
Historic survey bias	0.8, 1.0, 1.2	0.5, 1.0
First year of projection, τ	1960	1940
Alternative priors	S_{1+} ~ U[0.9, 0.99]; f_{max} ~ U[0.4, 0.6]; a_m ~ U[5, 12]	N/A
Strategic surveys	Extra survey if a survey estimate is half of the previous survey estimate	
Asymmetric environmental stochasticity parameters	To be finalised by an intersessional group	

*Effects of these factors begin in year 2013 (i.e. at start of management). The adult survival rate is adjusted so that in catches were zero, then average population sizes in 250-500 years equals the carrying capacity. Note: for some biological parameters and levels of episodic events, it may not be possible to find an adult survival rate which satisfies this requirement.

8.3.3 Bowhead whales

8.3.3.1 STOCK STRUCTURE

The current working hypothesis in the Scientific Committee is a single Baffin Bay-Davis Strait stock of bowhead whales (see Annex E, fig. 2). However, pending the availability of some genetic analyses, the Scientific Committee had agreed that the possibility that there are in fact two different stocks present in the overall area, with the second located in the Foxe Basin-Hudson Strait region, cannot be ruled out (e.g. see IWC, 2009b).

Given that the objective is to develop an *SLA* for the Greenland hunt of bowhead whales, the Committee **agrees** to proceed first on a conservative basis that assumes that the absolute abundance of bowhead whales on the West Greenland wintering area is informed by abundance estimates from data for that region only (see below). Only if such an *SLA* proved unable to meet need would abundance estimate information and stock structure considerations from the wider area be taken into account.

8.3.3.2 ABUNDANCE

The absolute abundance estimates can be found in Annex E, table 3. It is not possible to combine the Foxe Basin-Hudson Bay 2003 survey with the 2002 Prince Regent Inlet survey to obtain an estimate for the entire Davis Strait-Baffin Bay-Foxe Basin area. The Committee therefore **agrees** to condition the operating model using data for Davis Strait-Baffin Bay stock only.

It is not known whether the 2002 survey in Prince Regent Inlet will be regularly conducted, although a new survey is anticipated, whereas it is known that regular surveys will be conducted off West Greenland. The Committee therefore **agrees** to conduct trials: (a) in which the estimate for Prince Regent Inlet is treated as an estimate of absolute abundance; and (b) in which the estimates from West Greenland are treated as estimates of absolute abundance.

With respect to relative estimates of abundance, the Committee **agrees** that they should be considered in a similar manner to those for humpback whales. Details can be found in Annex E, item 3.3.1.2. These estimates are also included in the trial specifications (see Annex E, Appendix 2).

While the sex ratio of animals in West Greenland is ~80:20 in favour of females (Heide-Jørgensen *et al.*, 2010), it is expected that the sex ratio for the total population is 50:50 (based on historic catches over the whole region and present Canadian catches). The trials will assume that the proportion of males available to the surveys will be the observed average male/female ratio in the biopsy samples.

The Workshop **agrees** that the information provided to the *SLA* will be the results of surveys off West Greenland (relative indices if the operating model is conditioned to the estimate of abundance for Prince Regent Inlet and absolute if the operating model is conditioned to the estimate of abundance for West Greenland).

8.3.3.3 REMOVALS

For reasons similar to those agreed for humpback whales above, the Committee **agrees** that population projections should begin from a recent year (1940). This is earlier than for humpback whales because of the extended age-structure of the population. All post-1940 direct catches of bowhead whales by Canada and Denmark (Greenland) are at present assumed known and thus that there may be no need to consider an alternative catch series. The Secretariat will consult with Reeves on post-1940 Canadian catches.

The Secretariat is consulting with Canada with respect to the agreed allowance for the hunters, to determine whether it applies to landed whales only or includes strikes.

The Workshop agreed that four scenarios regarding future Canadian catches should be considered as detailed in Annex E, item 3.3.1.3 and included in the trial specifications. The sex-ratio for the West Greenland catches will be set to the sex ratio observed in the biopsy samples taken off West Greenland over the 2002-11 period while that for the Canadian catches will be set to the observed sex-ratio which is being confirmed by the Secretariat.

Known bycatch of bowhead whales in this stock's range and further information on bycatch or ship strikes that can be found by the Secretariat in consultation with Canadian scientists will be included in the revised trials specification. The Committee noted that if the number of ship strikes increases as the Northwest Passage opens up, this could trigger an *Implementation Review*.

8.3.3.4 BIOLOGICAL PARAMETERS

In the absence of information for this region, the Workshop agreed to use the priors for f_{max}, S_{1+}, and a_m used for the *Implementation* for the Bering-Chukchi-Beaufort Seas bowhead whales, noting that these incorporate considerable uncertainty for all three parameters.

8.3.3.5 NEED

SC/D12/AWMP4 presented by Greenland had proposed three scenarios, each of which involves an increase to the need from 2 to 5 at the start of the projection period followed by either: (1) no increase of need; (2) a doubling; and (3) a tripling of need in a linear fashion over the total time period. This is shown in Annex E.

8.3.3.6 TRIALS

After considering the report of the intersessional Workshop and the new information available at this meeting, the Committee **agrees** to the detailed trial specifications given in Annex E, Appendix 2. As for the humpback whale case, some further discussion and parameterisation of one of the trials (that on asymmetric environmental stochasticity) is required and an intersessional steering group has been established to oversee this (see Annex R). The factors considered in the trials are summarised in Table 2 while the trials themselves are given in Annex E, Appendix 2, tables 5 and 6. The Committee **endorses** the trial specifications.

As noted under Item 8.2, the Committee also **endorses** the performance statistics, tables and plots proposed.

A number of the preliminary results considered under Item 8.3.4 illustrated that it would be difficult to meet conservation objectives satisfactorily when the need level was high, especially if Canadian catches (which are taken by a non-IWC member country) increase. The SWG discussed whether it would be advisable to reconsider how strike quotas and incidental removals (i.e. by Canadian hunters) are accounted for in the *SLA* computations. However, the Committee **agrees** to continue with the current framework but also **agrees** that this topic should be further considered at the next intersessional Workshop.

8.3.4 Results of initial work on SLA*s*

The Committee welcomed papers SC/65a/AWMP02, SC/65a/AWMP04 and SC/65a/AWMP05 that produced initial exploratory results by two sets of developers based on the draft trial specifications developed at the intersessional Workshop. It was noted that at this stage, each set of developers had developed their own approaches to choose amongst the *SLA* candidates which they had tested. The Committee noted that this was an acceptable approach for developers to take when investigating the performance of their initial *SLA*s before deciding to put 'official' candidates forward, but re-iterated that final choices would need to be based on the full set of performance statistics agreed for the trials.

8.4 Scientific aspects of an Aboriginal Whaling Scheme

In 2002, the Committee **strongly recommended** that the Commission adopt the Aboriginal Subsistence Whaling Scheme (IWC, 2003). This covers a number of practical issues such as survey intervals, carryover, and guidelines for surveys. The Committee has stated in the past that the AWS provisions constitute an important and necessary component of safe management under AWMP *SLA*s and it **reaffirms** this view as it has for the previous 11 years.

8.5 Greenland conversion factors

In 2009, the Commission appointed a small scientific working group (comprising several Committee members) to visit Greenland and compile a report on the conversion factors used by species to translate the Greenlandic need request which is provided in tonnes of edible products, to numbers of animals (Donovan *et al.*, 2010). At that time, the group provided conversion factors based upon the best available data, noting that given the low sample sizes, the values for species other than common minke whales should be considered provisional. The group also recommended that a focused attempt to collect new data on edible products taken from species other than common minke whales be undertaken, to allow a review of the interim factors; and that data on both 'curved' and 'standard' measurements are obtained during the coming season for all species taken. The group's report was **endorsed** by the Committee (IWC, 2011b, p.21).

Since then, the Committee has received progress reports but has commented that more detail and information is required. Last year, the Committee reiterated its recommendations from 2010 and 2011 (IWC, 2013c, p.22):

(1) the provision of a full scientific paper to the next Annual Meeting [i.e. IWC/65] that details *inter alia* at least a full description of the field protocols and sampling strategy (taking into account previous suggestions by the Committee), analytical methods, and a presentation of the results thus far, including information on the sex and length of each of the animals for which weight data are available; and

(2) the collection and provision of data on Recommendation No. 2 of Donovan *et al.* (2010) comparing standard versus curvilinear whale lengths, this should be done for all three species on as many whales as possible.

8.5.1 New information

SC/65a/AWMP07 reported on the collection of weights and length measures from fin, humpback and bowhead whales caught in West Greenland. To improve the data collection process, information meetings involving biologists, hunters, wildlife officers and hunting license coordinators were held in the larger towns in 2012, and an information folder was produced and distributed to the hunters. The data collection process was also combined with an existing research project on hunting samples in order to get a stronger involvement of biologists. When researchers participate in hunts they train the hunters in measuring the lengths (curved and standard) and they make sure that the meat is weighed.

Until now the reporting rate has been lower than expected, with the data obtained in 2012 being from only one fin whale and one humpback whale, and the total number of reports since 2009 being from six bowhead whales, six humpback whales and three fin whales. These data provide preliminary yield estimates for all edible products of 9,014kg (SE: 846) per humpback whale, of 6,967kg (SE: 2.468) per fin whale, and of 8,443kg (SE: 406) per bowhead whale. These numbers are all somewhat lower than the suggested yield in Donovan *et al.* (2010), and this is especially pronounced for fin whales. Nevertheless, the obtained estimates for fin whales fall within the range of previous yield weight estimates for fin whales in West Greenland.

A major reason for the low reporting rate has been the almost complete absence of weighing equipment where the whalers could weigh the different products. To increase the reporting rate, the Greenland Institute of Natural Resources has now purchased and distributed weighing equipment that can be fitted to cranes in major towns for the hunters to use for weighing when landing a catch. It was also realised that the 'bin system' described in previous reports (e.g. IWC/64/ASW10) is more complicated than first anticipated because there is a large variation in the size of the bins used within the same hunt and between hunters. It is therefore now recommended that hunters weigh all edible products with the crane weight when they land the meat. This approach will be investigated further in 2013 and discussed with the hunters. Owing to the logistical difficulties involved with whale hunts in Greenland (which are widespread along the huge coastline and occur at unpredictable times during a long season) and the required change in the reporting system and subsequent need for training, it is likely that it will take several years to collect sufficient data on edible products.

8.5.2 Discussion

In response to questions, a number of clarifications were made. The original intention of weighing ten boxes had been so that an average weight per box could be developed to be multiplied by the total number of boxes to obtain an estimated total weight. However, with the efficient crane weights that are now in place in three cities, and with the finding that hunters may use different sized boxes even for the same whale, it has now been decided to weigh all boxes.

There were only five cases when scientists were able to be present at a humpback catch, and this low number illustrates the logistical difficulties in having scientists present at hunts. Witting did not have the precise details of this work or of the number of wildlife officers who may be able to assist in the work but will consult in Greenland. Efficient reporting requires not only training of hunters, but also the distribution of weighing equipment, so that hunters can report on their own.

In conclusion, the Committee **agrees** that the report was an advance on those previously received (and provided the first information on curvilinear lengths). However, it also **agrees** that it still did not provide sufficient information to fulfil the recommendations of last year. While aware of the logistical difficulties involved in obtaining these data, it **repeats its recommendations** of last year given in the second paragraph of this section. It **encourages** Witting to assist in the writing of such a report to ensure that it better meets the request of the SWG next year.

9. ABORIGINAL SUBSISTENCE WHALING MANAGEMENT ADVICE

9.1 Eastern Canada and West Greenland bowhead whales

9.1.1 New information

No new information was presented.

9.1.2 New catch information
No bowhead whales were taken off West Greenland in 2012. Official catch data have not yet been received from the Canadian Government for 2012. The Secretariat reported that it is in contact with the Canadian authorities who have acknowledged the request but not yet sent the catch data. The Committee also **encourages** the Government of Canada to continue research on Eastern Canadian bowheads.

9.1.3 Management advice
Using the interim safe approach (IWC, 2009b, p.16) as endorsed by the Commission, the Committee **agrees** that the current annual limit of two strikes for Greenland will not harm the stock. It was also aware that catches from the same stock have been taken by a non-member nation, Canada. Should Canadian catches continue at a similar level as in recent years, this would not change the Committee's advice with respect to the strike limits agreed for West Greenland.

9.2 Eastern North Pacific gray whales
9.2.1 New information
SC/65a/BRG02 presented new estimates of abundance for eastern North Pacific gray whales. Shore-based counts of southbound migrating whales off California have formed the basis of abundance estimation since 1967. A new observation approach has been used and evaluated in four recently monitored migrations (2006/07, 2007/08, 2009/10 and 2010/11). The summed estimates of migration abundance ranged from 17,820 (95% Highest Posterior Density Intervals [HPDI]=16,150-19,920) in 2007/08 to 21,210 (95% HPDI=19,420-23,230) in 2009/10, consistent with previous estimates and indicative of a stable population size.

The Committee welcomes and **accepts** the new population estimates.

SC/65a/BRG05 reported on photographic identification research in Laguna San Ignacio, Laguna Ojo de Liebre and Bahia Magdalena, Mexico, during the 2012 and 2013 winters. These results demonstrate a greater amount of movement between different breeding and calving lagoons for female-calf pairs than for single adult whales.

SC/65a/BRG05 summarised the results of a standard boat census of gray whales in Laguna San Ignacio and Laguna Ojo de Liebre during the winters from 2007 to 2013. In Laguna San Ignacio, counts of female-calf pairs increased during January and February to their highest numbers in March and April. During the 2011 to 2013 winters the average number of pairs was 108 and numbers remained high in the lagoon in April; by contrast, this number was only 40 pairs during the 2007 to 2010 winters and there were no pairs in April. In Laguna Ojo de Liebre in 2013 numbers of adults increased from January to February and declined to mid-April. Single animals only use the lagoon for 3-5 days. Females with calves use lagoons for up to 18 days. In one season with the highest counts, there was an estimated total of approximately 2,500 whales that used Laguna San Ignacio.

The Committee thanked Urbán and his colleagues for the interesting results from the studies in the breeding lagoons and **encourages** the continuation of those studies that will contribute greatly to the proposed intersessional rangewide gray whale Workshop (see Items 23 and 26).

SC/65a/BRG21 presented information on the body condition of gray whales in northwestern Washington, USA, from 2004-10 to examine whether this can provide insights into the variability of gray whale fidelity to the region. Of particular interest was a comparison with similar studies for the animals feeding off Sakhalin Island (Bradford *et al.*, 2012) that suggested that body condition in northwestern Washington is generally not as good as at Sakhalin. The reasons for this are not clear.

SC/65a/BRG12 presented information on harvested gray whales in 2012. In June and September 2012, scientists examined 23 gray whales caught near Mechigmensky Bay. Females averaged about 10m in length. Animals between 7.7m and 9.5m were sub-adults. Yearlings had the highest body condition index (blubber thickness/body length) and immature animals had the lowest; some 67% of the examined animals had full or half-full stomachs. There were no 'stinky' gray whales in Mechigmensky Bay. An immature, 7.7m female had traces of milk in an almost empty stomach. The hunters did not see a large whale escorting this small one and believed it was feeding independently. In discussion it was noted that milk might remain in the stomach for several hours or a little more.

SC/65a/BRG13 reported on the stomach contents of 82 gray whales taken in Mechigmensky Bay (63 from Lorino) from 2007-09; amphipods and polychaetes predominated by biomass and frequency of occurrence. Information was also presented on coastal counts.

The Committee thanked the authors for this interesting and important work examining harvested gray whales. It encouraged the work on photo-identification of harvested whales which is now beginning.

9.2.2 Catch information
SC/65a/BRG24 and SC/65a/BRG25 presented catch data for gray and bowhead whales in Russia. The quota is expressed in terms of landed animals not strikes and the 2007-12 block quota was for 620 gray whales (maximum 140 in any one year). A total of 143 gray whales were struck in 2012 of which 139 were landed (50 males and 89 females); eight were inedible ('stinky' whales). Body length and weight data were presented. In general some 10% of the whales are stinky. While stinky whales can sometimes be detected at sea and avoided, sometimes the whale has to be butchered before it is found to be stinky. For the period 2008-12, 638 gray whales were struck, 11 were lost and 627 whales were landed of which 24 were inedible, i.e. 603 edible whales were landed. Ilyashenko stated that stinky whales were not counted against the quota by the Russian authorities, since they do not meet the food needs of the indigenous people.

The Committee noted that the total number of gray whales struck during the 2008-12 period was 638 animals of which 24 of the 627 whales landed were inedible ('stinky') whales. The Commission expressed its limits for the 2008-12 period in terms of whales taken (620). While matters related to struck, landed and 'stinky' whales are matters for the Commission, the Committee noted that from an *SLA* perspective, all struck whales are considered removals.

9.2.3 Management advice
As was the case last year, the Committee **agrees** that the *Gray Whale SLA* remains the appropriate tool to provide management advice for eastern North Pacific gray whales taken off Chukotka; the question of the Makah hunt and whales from the Pacific Coast Feeding Group (PCFG) is considered under Item 8.1. The Commission adopted catch limits for a six-year block in 2012, i.e. 2013-18. The total number of gray whales taken shall not exceed 744 with a maximum in any one year of 140. The Committee **agrees** that these limits will not harm the stock.

9.3 Bering-Chukchi-Beaufort (B-C-B) Seas bowhead whales

9.3.1 New information

Three papers (SC/65/BRG01, SC/65a/BRG09 and SC/65a/BRG11) presented the improvements in field methods, the details of the acoustic and visual field observations and the new estimation method that underlie a new abundance estimate of this bowhead stock for 2011. The 2011 survey was among the most successful. The details are discussed fully in Annex F, item 2.1 and only a short summary is provided here.

SC/65a/BRG11 presented an overview of the spring 2011 bowhead whale abundance survey conducted near Point Barrow, Alaska. The 2011 survey was unique in that it included multiple simultaneous data collection efforts, these included: ice-based visual observations, an independent observer (IO) survey (to estimate detection probabilities), acoustic surveillance and an aerial photo identification survey. A total of 3,379 new whales was seen from the primary perch. This is close to the record (3,383 in 1993); however in that year it was estimated that 93% of the whales passed within view of the perch in contrast to 58% in 2011. Information was also provided on extensive photo-identification effort (aerial) and acoustic work.

SC/65a/BRG09 reported much higher levels of bowhead acoustic activity in comparison to recording efforts in past seasons that included high rates of singing and call sequences. The mean rate of acoustically located events in 2011 (calls/hr) was some 5.7 times higher than in 1993. Viewing conditions were similar to past surveys including substantial periods of watch missed due to poor visibility and closed leads. Telemetry and acoustic data suggest several hundred whales passed without the possibility of being seen.

SC/65a/BRG01 presented a new estimate of the total abundance for this population. The estimate is based on two large datasets: visual sightings and acoustic locations from spring 2011. A Horvitz-Thompson type estimator was used, based on the numbers of whales counted at ice-based visual observation stations. It divided sightings counts by three correction factors: (1) for detectability (and see Givens *et al.*, 2012, discussed by the Committee last year); (2) for whale availability using the acoustic location data (SC/65a/BRG09); and (3) for missed visual watch effort. The mean correction factors are estimated to be 0.501 (detection), 0.619 (availability) and 0.520 (effort). The resulting 2011 abundance estimate is 16,892 (95% CI; 15,704, 18,928). The annual increase rate is estimated to be 3.7% (95% CI; 2.8%, 4.7%). These abundance and trend estimates are consistent with previous findings.

The Committee thanked the authors, recognising the substantial field and analytical work that underlies the new abundance estimate. Discussion of the analytical approach can be found in Annex G, item 2.1. In conclusion, the Committee **accepts** this estimate and **endorses** it for use with the *Bowhead Whale SLA*. It further notes that under the guidelines outlined in the proposed Aboriginal Whaling Management Scheme (see Item 8.4), which has not been agreed by the Commission, a new survey would be required by 2021.

In discussion, it was noted that ice-based surveys depend very much on the availability of suitable ice conditions. The ice conditions may change within and between years and may become more difficult in the light of the climate changes observed in the Arctic. Aerial photographic surveys, which also were conducted during 2011, can form the basis of an independent mark recapture estimate of abundance (Koski *et al.*, 2010) although their precision is less than ice-based surveys.

SC/65a/BRG22 presented a study of DNA sequence variation for X- and Y-chromosome linked genes (USP9X and USP9Y) in bowhead whales using two methods to discover variable sites. The authors noted that with the PCR and sequencing primers reported, the X and Y chromosomes could be used to assess population variation in bowheads and other great whales to provide new perspectives on genetic issues such as stock structure, male reproductive success, gene flow and evolution. In discussion it was noted that bowhead whales have a relatively low level of variation in the Y chromosome due to skewness in male reproductive success. Population studies are underway.

9.3.2 New catch information

SC/65a/BRG19 provided harvest data for the Alaska hunt. In 2012, 69 bowhead whales were struck resulting in 55 animals landed. Total landed in 2012 was higher than the past 10 years (2002-11: mean of landed=38.9; SD=7.1) but similar for efficiency (no. landed/no. struck; mean of efficiency=77%; SD=0.07). Of the landed whales, 29 were females, 24 were males, and sex was not determined for two animals. Based on total length, six of the 29 females were presumed mature (>13.4m in length). All five of the mature females that were examined were pregnant.

SC/65a/BRG25 reported the results of the Russian aboriginal whaling in the Chukota region for the period of 2008-12: four bowhead whales were struck and landed out of a possible quota of 25 animals for that period. No bowhead whales were reported as struck and lost.

9.3.3 Management advice

The Committee **endorses** the abundance estimate of 16,892 (95% CI: 15,704-18,928) for spring 2011. It was noted that the next survey should be completed by 2021 based on the provisional guidelines in the Aboriginal Whaling Scheme (see Item 8.4).

The Committee **agrees** that the *Bowhead Whale SLA* continues to be the most appropriate way for the Committee to provide management advice for this population of bowhead whales. The Commission adopted catch limits for a six-year block in 2012, i.e. 2013-18. The total number of strikes shall not exceed 336 with a maximum of 67 in any one year (with a carryover provision). The Committee **agrees** that these limits will not harm the stock.

9.4 Common minke whale stocks off Greenland

The Committee noted that the Commission had not reached agreement on strike limits for Greenland at the 2012 Annual Meeting (see IWC, 2013a). It based its management advice on the same limits considered last year. In providing this advice it noted that the Commission has endorsed the interim safe approach (based on the lower 5th percentile for the most recent estimate of abundance) for providing advice for the Greenland hunts developed by the Committee in 2008 (IWC, 2009b, p.16); it was agreed that that this should be considered valid for two blocks, i.e. up to the 2018 Annual Meeting. This applies to all of the Greenland hunts below (i.e. Items 9.4-9.6).

9.4.1 West Greenland

NEW INFORMATION

In the 2012 season, 144 minke whales were landed in West Greenland and 4 were struck and lost. Of the landed whales, there were 109 females, 33 males and 2 of unknown sex. Genetic samples were obtained from 112 of these whales. Last year, the Committee re-emphasised the importance of collecting genetic samples from these whales, particularly in the light of the proposed joint AWMP/RMP Workshop (see

Table 3
Most recent estimates of abundance for the Central stock of common minke whales.

Small Area(s)	Year(s)	Abundance and CV
CM	2005	26,739 (CV=0.39)
CIC	2007	10,680 (CV=0.29)
CG	2007	1,048 (CV=0.60)
CIP	2007	1,350 (CV=0.38)

Annex D). The Committee **welcomes** the fact that nearly 80% of the catch had been sampled in 2012 and **encourages** continued sample collection.

This year, the Committee adopted a revised estimate of abundance for the 2007 survey. The revised published estimate (16,100, CV=0.43) was slightly lower than that first agreed in 2009. The Committee noted that this estimate is an underestimate of the total population by an unknown amount.

MANAGEMENT ADVICE
In 2009, the Committee was for the first time able to provide management advice for this stock. This year, using the agreed interim approach and the revised estimate of abundance given above, the Committee **advises** that an annual strike limit of 164 will not harm the stock. It **draws attention** to the fact that this is 14 whales fewer than its advice of last year due to the revised 2007 abundance estimate.

9.4.2 East Greenland
NEW INFORMATION (INCLUDING CATCH DATA AND AGREED ABUNDANCE ESTIMATES)
Four common minke whales were struck (and landed) off East Greenland in 2012. Two were females and the sex of the other two was unknown. The Committee was **pleased** to note that genetic samples were obtained from all of minke whales caught in East Greenland (these could be used *inter alia* to determine the sex of the unknown animals). The Committee **again emphasises** the importance of collecting genetic samples from these whales, particularly in light of the proposed joint AWMP/RMP Workshop (see Annex D).

MANAGEMENT ADVICE
Catches of minke whales off East Greenland are believed to come from the large Central Stock of minke whales. The most recent strike limit of 12 represents a very small proportion of the Central Stock (see Table 3). The Committee **repeats** its advice of last year that a strike limit of 12 will not harm the stock.

9.5 Fin whales off West Greenland (AWMP)
9.5.1 New information
A total of four fin whales (all females) were landed, and one was struck and lost, off West Greenland during 2012. The Committee was **pleased** to note that genetic samples were obtained from three whales. It **re-emphasises** the importance of collecting genetic samples from these whales, particularly in the light of the proposed work to develop a long-term *SLA* for this stock.

9.5.2 Management advice
Based on the agreed 2007 estimate of abundance for fin whales (4,500; 95%CI 1,900-10,100), and using the agreed interim approach, the Committee **repeats** its advice that an annual strike limit of 19 whales will not harm the stock.

9.6 Humpback whales off West Greenland
9.6.1 New information
A total of seven (two males; four females; one unknown sex) humpback whales were landed (three more were struck and lost) in West Greenland during 2012. The Committee was **pleased** to learn that genetic samples were obtained from all of these whales and that Greenland was contributing fluke photographs to the North Atlantic catalogue – four have been submitted from whales taken since 2010. The Committee again **emphasises** the importance of collecting genetic samples and photographs of the flukes from these whales, particularly with respect to the MoNAH and YoNAH initiatives (Clapham, 2003; YoNAH, 2001).

This year, the Committee **accepts** the revised fully corrected abundance estimate for West Greenland from the 2007 survey of 2,704 (CV=0.34) for the strip census abundance estimate (see Item 8.3.2.2 above). The agreed annual rate of increase of 0.0917 (SE 0.0124) remains unchanged.

9.6.2 Management advice
Based on the revised agreed estimate of abundance for humpback whales given above and using the agreed interim approach, the Committee **agrees** that an annual strike limit of 10 whales will not harm the stock.

9.7 Humpback whales off St Vincent and The Grenadines
9.7.1 New information
No new information or catch data were provided in time for consideration by the Scientific Committee although information has been requested by the Secretariat. There is one sample collected from a humpback whale taken on 11 April 2012 in the SWFSC tissue archive. The Committee **welcomes** this information.

Iñíguez reported information obtained from local newspapers on hunts in St Vincent and The Grenadines: a 35ft male (8 March 2013); a 41ft female and a 35ft male (both 18 March 2013); and another whale with no length or sex information (12 April 2013).

Regarding the same stock, he referred to reports that residents of Petite Martinique, Grenada, spent hours attempting to drive a mature whale onto a beach using five inflatable boats, two large trader boats and a speedboat on 22 November 2012. The whale finally escaped but was harpooned four times. He has no further information on the fate of this whale.

9.7.2 Management advice
The Committee repeated its previous strong recommendations that St Vincent and The Grenadines:

(1) provide catch data, including the length of harvested animals, to the Scientific Committee; and
(2) that genetic samples be obtained for any harvested animals as well as fluke photographs, and that this information be submitted to appropriate catalogues and collections.

The Committee has agreed that the animals found off St Vincent and The Grenadines are part of the large West Indies breeding population (abundance estimate 11,570; 95%CI 10,290-13,390). The Commission adopted a total block catch limit of 24 for the period 2013-18 for Bequians of St Vincent and The Grenadines. The Committee **repeats** its advice that this block catch limit will not harm the stock.

The Committee **draws the Commission's attention** to the unofficial reports of attempts to land a humpback whale in Grenada; the Schedule specifies that the quota applies only to Bequians of St Vincent and The Grenadines. It requests that the Secretariat contacts the Government of Grenada to obtain official information on this incident.

10. WHALE STOCKS

10.1 Antarctic minke whales
The Committee is undertaking an in-depth assessment of the Antarctic minke whale. Details of the discussions summarised below can be found in Annex G. The primary abundance data are those collected from the 1978/79 to 2003/04 IWC-IDCR/SOWER cruises (e.g. Matsuoka *et al.*, 2003) that had been divided into three circumpolar series (CPI, CPII and CPIII). Two methods for estimating abundance from CPII and CPIII have been developed in recent years. Last year, the Committee formally agreed abundance estimates (IWC, 2013c, p.27). These were developed by basing the estimates on one method (the OK model, Okamura and Kitakado, 2012) and applying adjustment factors based on analyses from the other method (the SPLINTR model, e.g. Bravington and Hedley, 2012).

While the agreed estimates were suggestive of a decline in abundance between CPII and CPIII, the decline was not statistically significant either at a circumpolar level or at a *Management Area* level, given the inferred amount of annual variability in distribution (see Item 10.1.2). The Committee has been working for some time on explaining variability in abundance of Antarctic minke whales, both by the development of population dynamics models (Item 10.1.3) and by examining possible changes in environmental conditions during the period of the CPII and CPIII surveys (Item 10.1.2). Regarding the latter, the Committee has been investigating possible ways to estimate abundance of Antarctic minke whales within the unsurveyed pack ice region (since the IWC-IDCR/SOWER cruises were only able to survey in open water), and to discover the extent to which changes in sea ice concentration and many other environmental processes may have been affecting the open water abundance estimates.

10.1.1 Consideration of technical aspects of the agreed abundance estimates for CPII and CPIII
No further developments were presented to the Committee this year, although the items identified last year (IWC, 2013c, p.28) remain pertinent. The model refinements required will be assisted by the recent work described in SC/65a/IA15, in which a new IWC simulated data scenario is developed based on empirical data from Antarctic minke whale video dive time experiments conducted on the 2004/05 IWC SOWER cruise.

The Committee welcomed the new datasets, recognising that it was unlikely that improved methods would be available next year, but that further progress was expected by the meeting after. The results of this exercise (improved simulated datasets and estimation methods) should be of value not only to this species but also to many abundance estimation tasks faced by the Committee.

The estimates agreed last year were presented as two sets of numbers with two sets of CVs; Annex G, item 2.2.2, clarifies the reasons why the estimates were presented this way, and what the limitations are when interpreting these numbers.

In summary and also to provide clarity on what can be said at this stage in relation to trends, the Committee noted the following issues.

(1) At the scale of the circumpolar surveys, there is no statistically significant difference between the two population estimates. This of course does not mean that the number of Antarctic minke whales did not change at all. Rather, the uncertainty around the two estimates is sufficiently large that it is not possible to conclude with confidence whether the abundance increased, decreased, or remained about the same.

(2) The same is true at the scale of the six IWC Management Areas; there are no statistically significant trends detected.

(3) Nevertheless, the point estimate of change at a circumpolar level is quite large, and the same is true for some of the Management Areas. While not significant statistically, the differences are suggestive that some real changes in abundance may have occurred, particularly in areas near the large embayments of the Ross and Weddell Seas. The Committee is continuing to investigate issues of habitat utilisation and movement patterns of Antarctic minke whales which may further inform its understanding and ability to interpret these survey results (see Item 10.1.2).

10.1.2 Continue to examine reasons for the difference between abundance estimates from CPII and CPIII

10.1.2.1 AERIAL SURVEYS
The Committee has for some years been working towards explaining a putative decline in Antarctic minke whale abundance between CPII and CPIII. Aside from the statistical catch-at-age modelling work described in Item 10.1.3, a particular focus has been on investigating possible changes in the relative proportions of whales within the pack ice, since such regions were inaccessible to the IDCR/SOWER vessels. Papers describing Australian surveys using fixed-wing aircraft (Kelly *et al.*, 2011; 2012) and German surveys from a vessel-based helicopter (Williams *et al.*, 2011) have been considered by the Committee at previous meetings, and although no new work on these surveys was presented at SC/65a, further analyses are expected to be received next year.

10.1.2.2 NEW MODELLING WORK
Without further information from direct observations, the Committee is restricted to analyses based on extrapolations of sightings in open water areas to within-ice regions for investigating the relative proportions of whales that may have been within the ice regions during the CPII and CPIII period. SC/65a/IA11 presented one such approach for doing so, using models which assumed a relationship between whale abundance and ice concentration. It also examined causal relationships between Antarctic minke and humpback whale distribution; the Committee considered that this approach was more promising for open water areas than within pack ice regions where humpback whales do not enter.

10.1.2.3 NEW INFORMATION
SC/65a/IA12 described a study of Antarctic minke whales in their sea ice habitat during the austral summer of 2012-13, in two regions of the Antarctic: the Ross Sea and the western Antarctic Peninsula. In less than a month of fieldwork (of which only a portion was dedicated to Antarctic minke whale research), the researchers deployed 16 satellite-linked data recorders and two short-term archival data recorders; they also collected biopsy samples and took a large number of photo-identification images of well-marked individuals.

In discussion of SC/65a/IA12, the Committee congratulated the authors on their achievement: this is the first time that reliable tag deployment has been achieved on this species. For investigation of differences in abundance estimates between CPII and CPIII, the Committee noted that the diving data collected from one type of tag deployed is also directly relevant to the interpretation of aerial survey estimates of abundance in different sea-ice conditions. The Committee **recommends** that this work should continue (and see Item 26).

There was considerable discussion (see Annex G, item 2.3) about *inter alia*: the particular conditions, location and group size and behaviour needed for successful tag deployment or biopsy sampling; the utility of photo-identification for abundance estimation; the feeding behaviour inferred from the telemetry result; and the relative merits and demerits of lethal and non-lethal sampling for in-depth assessment of Antarctic minke whales.

10.1.2.4 DID MINKE WHALE ABUNDANCE DIFFER BETWEEN CPII AND CPIII?

The Committee noted the apparent contradiction in retaining this item on its agenda when the difference in point estimates of abundance are not statistically significant at the usual 5% level (Item 10.1.1; see also Annex G, item 2.4). There is some evidence of differences (for example as seen consistently from the integrated statistical catch-at-age (SCAA) modelling – see Item 10.1.3 below), but the wide uncertainty around the estimates cannot exclude the possibility that overall abundance has not changed between CPII and CPIII. The Committee **agrees** to rename this item as: 'What are the factors that drive minke whale distribution and abundance?'

10.1.3 Apply statistical catch-at-age models

Population dynamics modelling provides a way to explore possible changes in abundance and demographic parameters within Areas IIIE-VW, where appropriate data are available. The inputs are catch, length, age, and sex data from the commercial harvests and both JARPA and JARPA II programmes, as well as abundance estimates from IDCR/SOWER. For over a decade, the Committee has been developing population dynamics models of Antarctic minke whales, and following early attempts using an ADAPT-VPA approach (e.g. Butterworth *et al.*, 2002), the Committee concluded that SCAA modelling was the most appropriate framework, since *inter alia,* the latter approach is able to incorporate variability in age-reading (and consequent errors in age-at-length). Following the abundance estimates agreed from IDCR/SOWER last year, this year it has been possible for the first time to study the performance of the models using a fairly complete set of agreed inputs.

SC/65a/IA04 presented an updated statistical method for quantifying age-reading error, i.e. the extent of bias and inter-reader variability among age-readers. The method was applied to data for Antarctic minke whales taken during Japanese commercial (1971/72-1986/87) and scientific (1987/88-2004/05) whaling.

The methodology and conclusions of SC/65a/IA04 were based on a careful experimental study to compare readers (see Annex G, item 2.1). To estimate the bias and variance, the method needs to assume that at least one of the readers produces age estimates which are either unbiased or have a known degree of bias, and that ageing errors between readers but on the same earplug are independent. These assumptions are unavoidable for any analysis of ageing error where no absolute ground-truth is available, and the Committee **agrees** that the approach and results of SC/65a/IA04 provide useable input data for the SCAA analysis in SC/65a/IA01.

SC/65a/IA01 reported on the most recent application of SCAA to data for Antarctic minke whales, thus incorporating the agreed IDCR/SOWER abundance estimates and the age-at-length data for recent years of JARPA II, neither of which had been available when results from these models have been presented previously to the Committee. This work has been directed by the Committee and funded through the Committee's budget. The SCAA approach allows for multiple breeding stocks, which can be allowed to mix across several spatial strata on the summer feeding grounds where catches are taken. It also allows carrying capacity and the annual deviations in juvenile survival to vary over time. Most analyses indicated that Antarctic minke whale abundance in Antarctic Areas III-E to VI-W increased from 1930 until the mid-1970s and declined thereafter, with the extent of the decline greater for minke whales in Antarctic Areas III-E to V-W than for those further eastward.

In discussion of SC/65a/IA01, the Committee noted that the modifications to the SCAA model suggested last year plus the addition of the new data had now produced largely acceptable fits (see also table 1 of Annex G). The SCAA has received extensive scrutiny and improvement over the years of its development (far more than is usual for similar fishery assessment models used in management), and appears to have stood up well. Nonetheless, some issues do remain; detailed technical suggestions to investigate these are given in Annex G, item 8. The Committee considered the interpretation of the current results in SC/65a/IA01 (plus additional runs of the model made during the meeting), bearing in mind also the numerous sensitivity analyses and alternative formulations explored in previous years. Overall, some conclusions appear to be quite robustly supported, while others are more sensitive to details of model formulation or data selection. Resolution of the issues identified will allow more confident interpretation of the results next year.

10.1.4 Work plan

The work plan for the in-depth assessment of Antarctic minke whales is described in Annex G, item 8 and will be furthered by two intersessional Working Groups – one on SCAA issues for further investigation, and one on remaining IDCR/SOWER data management. The Committee's views on the work plan for the sub-committee on In-depth Assessments is given under Item 24.

10.2 Southern Hemisphere humpback whales

The report of the IWC Scientific Committee on the assessment of Southern Hemisphere humpback whales is given in Annex H. The Committee currently recognises seven humpback whale breeding stocks (BS) in the Southern Hemisphere, labelled A to G; (IWC, 1998b), which are connected to feeding grounds in the Antarctic. An additional population that does not migrate to high latitudes is found in the Arabian Sea. Assessments of BSA (western South Atlantic), BSD (eastern Indian Ocean) and BSG (eastern South Pacific) were completed in 2006 (IWC, 2007b), although it was concluded that BSD might need to be re-assessed with BSE and BSF in light of mixing on the feeding grounds. An assessment for BSC (western Indian Ocean) was completed in 2009 (IWC, 2010d) and for BSB in 2011 (IWC, 2012c).

10.2.1 Assessment of Breeding Stocks D, E and F

In 2011, the Committee initiated the re-assessment of BSD, and the assessment of BSE and BSF. As shown in Fig. 3, these stocks correspond, respectively, to humpback whales wintering off Western Australia (BSD), Eastern Australia (sub-stock BSE1) and the western Pacific Islands in Oceania including New Caledonia (sub-stock BSE2), Tonga (sub-stock BSE3) and French Polynesia (sub-stock BSF2). For simplicity, the combination of BSE2, BSE3 and BSF2 will be referred to as Oceania.

10.2.1.1 NEW INFORMATION

SC/65a/SH13 presented the results of an updated analysis recommended last year by the Committee (IWC, 2013g p. 217). It analysed mixing proportions of humpback whale breeding stocks BSD, BSE and BSF in Antarctic Areas IIIE to VI. The analysis was based on 575 samples obtained in the Antarctic during JARPA/JARPA II and IDCR/SOWER and 1,057 samples from low latitudes of the South Pacific and eastern Indian Ocean. Analysis of approximately the first half of the mtDNA control region yielded 137 haplotypes, and mixing proportions and Fst were analysed under two stock structure hypotheses. Under the most general hypothesis of six breeding stocks, BSD predominated in Areas IIIE, IV-W and IV-E. BSE1 predominated in Area V-W, BSE2 dominated in Area V-E and BSE3 dominated in Area VI. BSF sub-stocks did not predominate in any Antarctic area, although BSF1 was partially represented in Area VI.

The Committee thanked the authors for completing the work in time for on-going assessment modelling. Technical aspects of the paper were discussed by the Working Group on Stock Definition (see Annex I) and mixing proportions for alternate Antarctic area boundaries were calculated for the assessment models (see Item 10.2.1.2).

SC/65a/SH08 described the first photo-id and biopsy sampling surveys for humpback whales and small cetaceans around nine islands in eastern French Polynesia's Tuamotu and Gambier Islands (BSF2). The Committee welcomed this information on BSF2 and **recommends** additional sampling in this remote area of the South Pacific from which few data are available.

Rankin *et al.* (2013) estimated calving intervals of humpback whales at Hervey Bay, East Australia based on a long-term photo-id catalogue of 2,973 individuals. Two methods of calculation (multi-event mark-recapture modelling and truncation) led to similar estimates of calving intervals: 2.98 years (95% CI: 2.27-3.51) and 2.78 years (95% CI: 2.23-3.68) respectively.

The technical details of this paper were not presented, but the Committee noted that these calving intervals do not strongly suggest a population undergoing a high rate of population increase (e.g., Noad *et al.*, 2011). The cause of this apparent discrepancy requires further evaluation.

10.2.1.2 REVIEW ASSESSMENT MODELS

The Committee reviewed the progress of assessment modelling of breeding stocks BSD, BSE and BSF. Last year, a three-stock model with feeding and breeding ground interchange was proposed to address two inconsistencies that arose in single-stock assessments: (1) the model-predicted population trajectory for BSD was unable to simultaneously fit the absolute abundance estimate of 28,830 whales in 2011 (Hedley *et al.*, 2011a) and the high growth rate suggested by the relative abundance series; and (2) the model-predicted minimum population size in Oceania violated the N_{min} constraint informed from haplotype data.

Intersessionally, three-stock (BSD+BSE1+Oceania) and two-stock (BSD+BSE1) models were developed that included mixing on the feeding grounds. These did not substantially improve model fit unless customary Antarctic stock boundaries were shifted eastward to allow for more Antarctic catches to be allocated to BSD and fewer to Oceania. SC/65a/SH01 presented the results of single-stock, two-stock and three-stock models that used the original Antarctic boundaries, as well as new proposed boundaries based on this finding.

During the meeting, further model runs were attempted to improve model fits to the BSD data. An examination of

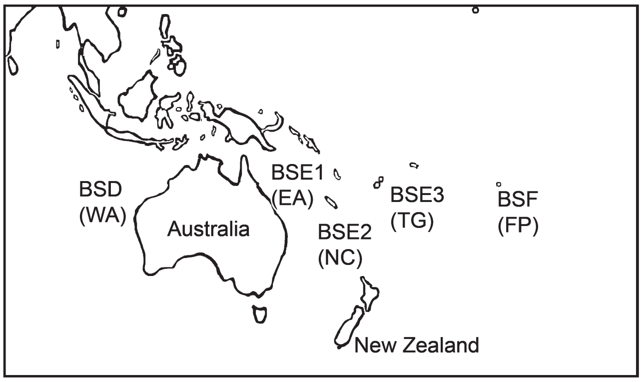

Fig.3. Distribution of Southern Hemisphere humpback whales breeding stocks grounds BSD, BSE1, BSE2, BSE3 and BSF2. Note the following abbreviations: WA=Western Australia, EA=Eastern Australia, NC=New Caledonia, TG=Tonga and FP=French Polynesia.

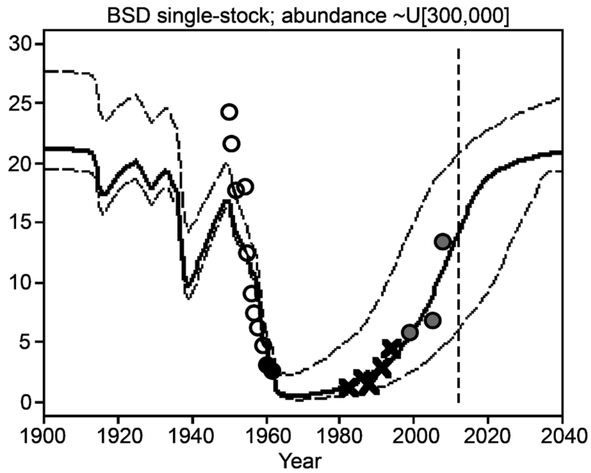

Fig.4. Posterior median population trajectories for BSD, showing the trajectories and the 90% probability envelopes. Results are shown for a single-stock model using the original catch boundaries. Plots show fits to the Chittleborough (1965) CPUE series (open circles), the Bannister and Hedley (2001) and relative abundance series (crosses), the Hedley *et al.* (2011b) relative abundance series (grey circles). The model is fit to both the Hedley *et al.* (2011b) and Bannister and Hedley (2001) relative abundance series only. The BSD abundance prior is set at U[0; 30,000]). The Chittleborough (1965) CPUE series is shown as consistency check. The trajectory to the right of the vertical dashed 2012 line shows projection into the future under the assumption of zero catch.

the BSD absolute abundance estimate (Hedley *et al.*, 2011a) identified irregularities in the underlying survey data which called into question the validity of the estimate. This could not be resolved during the meeting, but given this, and the strong influence of this estimate on the model results, single-stock BSD models were used to explore the effects of a lower, fixed abundance estimate and a model that was not fitted to absolute abundance but included an uninformative prior on this value. These models for BSD produced relatively good fits to all the relative abundance series (see Fig. 4). The Committee recognised that any abundance measurement method that could provide a lower bound to this prior (i.e. a value other than zero) would be useful in improving future model fits to BSD, and **recommends** that analyses to achieve this be attempted.

Three-stock models were also run using mixing proportions calculated with revised Antarctic area boundaries (Annex H, Appendix 2). One key result was that in order to fit the BSD relative abundance trends, the model removed more westerly Antarctic catches from BSE1, which

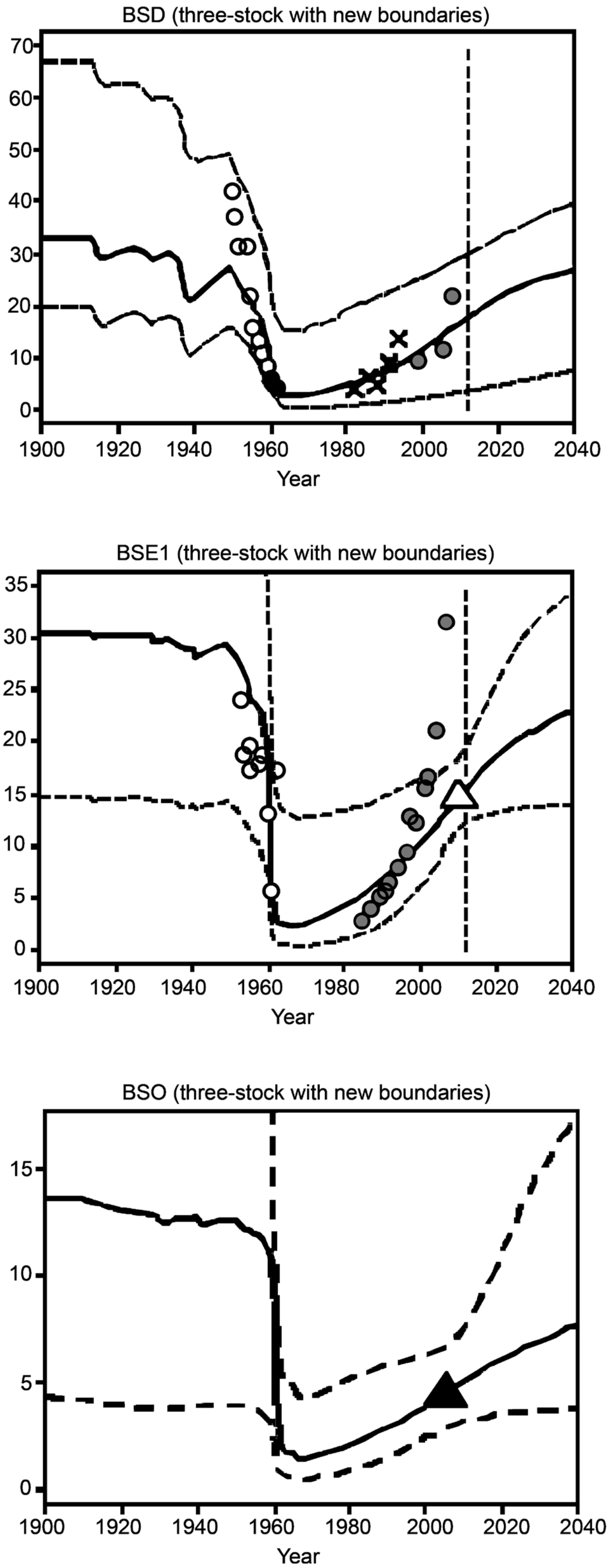

Fig.5. Three-stock model results assuming 'new' Antarctic catch boundaries proposed in SC/65a/SH01. The BSD abundance prior is set at U[0; 30,000]). BSO refers to Oceania (New Caledonia (E2)+Tonga (E3)+French Polynesia (F2)). SC/65a/SH01 details the data fitted for each breeding stock but in essence these are the Bannister and Hedley (2001) and Hedley *et al.* (2011b) relative abundance series for BSD (crosses and grey circles, respectively), the Noad *et al.* (2011) abundance estimate and relative abundance series for BSE1 (open triangles and grey circles, respectively), and the Constantine *et al.* (2011) photo-id mark-recapture data for Oceania. The black triangle for Oceania is the separate abundance estimate from mark-recapture data reported by Constantine *et al.* (2011) and the open circles for BSD and BSE1 are the CPUE data from Chittleborough (1965); these data are not fitted directly, but shown as consistency checks.

in turn led to the removal of Antarctic catches from Oceania to allocate to BSE1. Even so, the whales removed from BSE1 by the model did not deplete the population enough by the late 1960s (when most harvesting ceased) to reflect the rapid recent increases shown later by the east Australian surveys (Noad *et al.*, 2011). Use of an uninformative prior abundance on BSD in these models (with and without new Antarctic boundaries) did not improve the fit of the model to the BSE1 relative abundance data (see Fig. 5). Furthermore, none of the model formulations were consistent with the mixing proportions estimated by genetic data from the feeding grounds. Additional details of these results are provided in Annex H.

Other potential explanations for poor model fit were explored. Cooke (2009) describes situations in which attempts to fit a deterministic density-dependent population model to a recovering whale stock sometimes fail, because there are insufficient historic catches to account for the recent increase. His analyses suggested that lack of model fit should not be regarded as an anomaly to be explained, but a normal situation that is to be expected beyond a certain level of recovery and can be better fitted by accounting for environmental variability. Attempts to repair the lack of fit by allowing an arbitrary increase in carrying capacity could be expected to make the overestimation worse. Possible ways of addressing this in the current assessment models were discussed.

With respect to model fits to Oceania in SC/65a/SH01, the Committee **recommends** replacing the photo-id mark-recapture data with genetic mark-recapture data.

SC/65a/SH07 presented other progress toward modelling the population dynamics for East Australia and Oceania. This paper used logistic Bayesian FITTER models to co-measure population trajectories for pairs of South Pacific breeding grounds which share common high latitude feeding grounds. Two stock models were undertaken for East Australia (BSE1)/New Caledonia (BSE2), Tonga (BSE3)/ French Polynesia (BSF2) and East Australia (BSE1)/ Oceania (BSE2+BSE3+BSF2). In these preliminary results, East Australia carrying capacity varied between models (medians 26-42,000) while population increase rates were uniformly high. Median estimates of carrying capacity for New Caledonia ranged from 5,200-6,100, for Tonga 5,600-8,700 and for French Polynesia 4,000-5,700, with median recovery levels of 13-33%, 31-44% and 24-32% respectively.

The Committee thanked the authors for this work and noted several technical issues that still need to be addressed, including the use of a uniform prior on carrying capacity which leads to a biased estimate of MSYR.

In conclusion, the Committee **strongly agrees** that the assessment of breeding stocks D, E and F should be completed at next year's meeting. The following final **recommendations** were made to complete this work:

(1) a lower bound on the BSD abundance estimate should be obtained;
(2) a single-stock model for BSD will be run for a range of choices of the Antarctic feeding ground catches between 120°E and 150°E;
(3) two stock BSE1-Oceania models (with further breeding stock division within Oceania) will be explored; and
(4) if time permits after sufficient exploration of the models above, more complex options may be examined. These could include a three-stock model covering all of BSD, BSE1 and Oceania, together perhaps with more complex models for the dynamics of BSD, as discussed above.

The work plan for completing this work is provided in Item 10.2.6.

10.2.1.2 FUTURE WORK

SC/65a/SH09 described efforts by the South Pacific Whale Research Consortium to plan future sampling in Oceania with a view toward a future humpback whale assessment. Simulations and power analyses were used to evaluate planned field research in light of three main objectives: (1) to determine population size with a coefficient of variation of less than 20%; (2) to determine if the population is increasing or decreasing; and (3) to detect if population growth is significantly different from that of East Australia. Details are available in Annex H. The Committee welcomed this work, noting the importance of such planning and the value to future assessments of BSE2 and BSE3.

A modified POPAN model (Carroll *et al.*, 2013a) was discussed that explicitly accounts for heterogeneity in capture probability related to breeding cycles. The latter can cause substantial positive bias (+19%) in female abundance estimates and may be a consideration in the mark-recapture modelling of many cetacean species.

10.2.2 Review new information on other breeding stocks

New information was available for humpback whale Breeding Stocks B, C and G.

10.2.2.1 BREEDING STOCK B

SC/65a/SH24 collated humpback whale data from small boat surveys off Namibia (~23°S), 2005-12. Photo-id images were compared with catalogues from Gabon (2000-06) and West South Africa (WSA, 1983-2007). No confirmed matches were found, likely due to catalogue size and sampling period. However, a study of wounds from cookie cutter sharks (*Isistius brasiliensis*) and killer whales was used to infer relationships among these three areas in BSB.

The Committee welcomed this study, noting the potential utility of indirect indicators of stock structure for the Namibia region, where insights from photo-id and genetic data are still limited.

SC/65a/IA13 reported on cetacean sighting survey results in Gabon coastal waters from 4-10 September 2011 and in the Gulf of Guinea (Côte d'Ivoire, Ghana, Togo and Benin) from 23 March to 6 April 2013. The Committee thanked the authors for presenting these survey data. More information is available in Annex H, item 3.2.

10.2.2.2 BREEDING STOCK C

Two papers were received on satellite tagging projects to study the movements of humpback whales in this breeding stock. SC/65a/SH22 reported movements of twelve humpback whales satellite tagged off northeast Madagascar (BSC3). A wide range of movements were observed, including use of areas not previously recognised as preferred habitat. No tagged whales travelled to the west coast of Madagascar, Mozambique or the Mascarene Islands, where breeding aggregations are well documented. Observed movements between Madagascar and central-east Africa were likely not detected previously because of a lack of surveys in northern BSC1.

The Committee welcomed this work and noted its value for helping to clarify stock structure within BSC. Details of further discussion are available in Annex H.

SC/65a/SH02 described the results of satellite tagging eight humpback whales in the Comoros Islands (BSC2) in 2011 and 2012. Whales either remained at their breeding site for several weeks after tagging (n=3), dispersed to the northwest (n=2) or to southwest (n=3) coast of Madagascar. Of those tracked toward the Antarctic, one moved south-eastward towards the French sub-Antarctic islands and the other travelled to Antarctic Area III. These are the first detailed reports of humpback whale movement for this breeding sub-stock.

10.2.2.3 BREEDING STOCK G

SC/65a/SH04 described the results of small-boat surveys in the Gulf of Chiriqui (western Panama) during the austral winter season from 2002 through 2012. Initial catalogue comparisons have established matches to southern Costa Rica, and to feeding areas off Chile and Antarctica. Future plans include genetic analysis, comparing mother-calf habitat use to other breeding areas and long term acoustic monitoring. Discussion of this paper focused on the prevalence of mother/calf pairs in the area, which will be investigated further by the authors. This discussion can be found in Annex H.

10.2.3 Review new information on feeding grounds

Three studies (SC/65a/SH10, SC/65a/SH20 and SC/65a/O09) reported sightings of humpback whales during surveys in the Antarctic. Further details can be found in Annex H, item 3.3.

10.2.4 Antarctic Humpback Whale Catalogue

SC/65a/SH15 presented the interim report of IWC Research Contract 16, the Antarctic Humpback Whale Catalogue (AHWC). During the contract period, the AHWC catalogued 938 images representing 774 individual humpback whales submitted by 36 individuals and research organisations. Catalogue details are provided in Annex H, item 3.4.

The Committee recognises the contribution of the AHWC to humpback whales studies in the Southern Hemisphere and **recommends** its continuation (and see Item 26).

10.2.5 Other new information

SC/65a/SH05 reported on a study of Type 1 satellite tag performance and health impacts in humpback whales. This study has already informed tag modifications that have substantially increased tag duration, and are expected to reduce impacts on individuals. The Committee **thanks** the authors for this work, noting its value to future satellite tagging research.

10.2.6 Work plan

The Committee **confirms** that it will complete its assessment of Breeding Stocks D/E/F at next year's meeting, and thus also the Comprehensive Assessment of Southern Hemisphere Humpback Whales. Further details are given under Items 23 and 24.

10.3 Southern Hemisphere blue whales

10.3.1 Review new information

10.3.1.1 ANTARCTIC BLUE WHALES

Several papers reported results from the SORP Antarctic Blue Whale Project. SC/65a/SH21 provided an overview of activities undertaken on the Antarctic blue whale voyage between January and March 2013. This 47-day voyage focused on an area south of 60°S between 135°E and 170°W. Acousticians processed 26,545 Antarctic blue whale calls in 'real-time' and acoustically 'targeted' 51 groups of vocalising animals for photo-id and biopsy sampling. Further detail on tracking, sampling and other activities are provided below and in Annex H, item 5.1.1.

SC/65a/SH18 summarised the long-range acoustic tracking undertaken during the Antarctic Blue Whale Project. DIFAR sonobuoys were used to detect, localise and track Antarctic blue whales. In total, 85% of acoustic targets resulted in visual encounters and yielded 32 encounters with groups of blue whales. The project demonstrated the ability of acoustic tracking to locate Antarctic blue whales that are widely dispersed over a large area as well as the capacity to acoustically track whales for days at a time.

SC/65a/SH11 reported on the 50 Antarctic blue whales photo-identified as a result of acoustic-tracking during the 2013 voyage. The re-sighting rate of individuals during the voyage was similar to recent IWC SOWER cruises. Time between re-sights ranged from one to 27 days and straight-line distances ranged from 15km to 1,172km. Three individuals were matched to the Antarctic Blue Whale Catalogue and one had moved a minimum of 6,550km and 145° of longitude. Photo-identification data collected during the voyage will contribute towards a new abundance estimate of Antarctic blue whales using mark-recapture methods.

SC/65a/SH03 reported on the movements of satellite tagged Antarctic blue whales on their feeding grounds in 2013. Two tags collected movement data for 14 and 74 days, over 1,433km and 5,300km, respectively. Both whales performed long-scale movements interspersed with patches of searching, often in close association with the ice edge. Additional satellite tag deployments are planned to increase understanding of fine and large scale movements of Antarctic blue whales.

The Committee discussed these papers largely in the context of the ultimate aim of the Antarctic Blue Whale Project to estimate abundance through mark-recapture methods. It also highlighted the success of the SORP Antarctic Blue Whale Project to date and the significant advance it represents in non-lethal research on blue whales in the Southern Ocean. Additional details of this discussion can be found in Annex H, item 5.1.1.

SC/65a/O09 summarised sightings of blue whales during JARPAII of 2012/13. Details can be found in Annex H, item 5.1.1.

10.3.1.2 PYGMY BLUE WHALES

Three papers provided new information on blue whales off New Zealand. SC/65a/SH12 reported on blue whales observed and photo-identified in the coastal waters of New Zealand from 2004-13. Of 18 whales identified, 14 were observed during the SORP Antarctic Blue Whale Voyage in 2013, on transit to the Antarctic. Further details are available in Annex H, item 5.1.2.

SC/65a/SH19 reported additional findings from a combination of acoustics and visual observations at New Zealand, including data obtained during the 2013 SORP Antarctic Blue Whale Voyage noted above. Acoustic tracking confirmed blue whales to be the source of low frequency sounds recorded in this area. Comparison to recordings from 1964 and 1997 suggested that song types have persisted over several decades, are distinct from the Antarctic blue whales, and indicate a year-round presence around New Zealand. Blue whale song in this region has changed slowly, but consistently, over the past 50 years.

Torres (2013) presented evidence that the South Taranaki Bight is a blue whale foraging habitat and called for a greater understanding of their habitat use patterns to manage anthropogenic activities.

The Committee discussed the taxonomic status of blue whales in New Zealand waters. Based on available data on morphology, timing, distribution and acoustics, these whales are most likely to represent a form of pygmy blue whales. This is consistent with a growing body of evidence that populations of pygmy blue whales show considerable variation across the Southern Hemisphere.

The Committee **reiterates** that the relationship among pygmy blue whales in different areas is unclear and merits further investigation.

10.3.1.3 BLUE WHALES OFF CHILE

SC/65a/SH17 provided an update on surveys, photo-identification and biopsy research off the Isla de Chiloe and Isla de Chañaral (northern Chile) in 2013. Research at multiple sites has highlighted the importance of continued monitoring and increased photo-identification efforts to better understand the dynamics of the blue whales in this area. Concerns were also raised about the overlap of blue whales and vessels at the mouth of Chacao Channel. One blue whale stranding was documented north of this area in 2013, but cause of death was not determined.

The taxonomic status of Chilean blue whales was discussed by the Committee. They are intermediate in size between Antarctic and pygmy blue whales (Branch *et al.*, 2007). Furthermore, blue whales off Chile and Australia are as different genetically from each other as each is from Antarctic blue whales. Ongoing genetic analyses using additional samples from the Southern Hemisphere, Eastern Tropical Pacific and North Pacific will be undertaken to try to resolve their taxonomic status (see SC/65a/SH25).

10.3.1.4 PHOTO-IDENTIFICATION CATALOGUES

SC/65a/SH16 reported on the comparison of Antarctic blue whale photographs from JARPA to the Antarctic Blue Whale Catalogue (ABWC). Thirty-one individual Antarctic blue whales were photo-identified during JARPA cruises in the Antarctic during 12 austral summer seasons between 1992/93 and 2004/05. Photos were obtained in IWC Management Areas III, IV, V and VI. No new matches were found. This work brings the ABWC catalogue total to 305 individuals and notably increases available coverage from Area III (n=165) and in Area V (n=93). The Committee **recommends** that the 380 additional JARPA II blue whale photographs be compared to the ABWC.

SC/65a/SH23 describes efforts to consolidate all blue whale catalogues in the Southern Hemisphere. The Southern Hemisphere Blue Whale Catalogue (SHBWC) now contains 884 individual blue whales. Catalogues from South America, the Eastern Tropical Pacific (ETP) and Antarctica are now included and catalogues from the Indonesia/Australia/New Zealand area are in the process of being added. Comparisons between the eastern South Pacific and ETP have been completed and no matches were found. Comparisons between ETP and the Southern Ocean, as well as those from eastern South Pacific and the Southern Ocean are approximately 50% complete, with no matches found. The Committee **recommends** that the SHBWC continue its work and that all relevant data holders submit their photos to the catalogue.

10.3.1.5 NEW GENETIC INFORMATION

Attard *et al.* (2012) reported on hybridisation between pygmy and Antarctic blue whales, and a genetic estimate of the proportion of blue whale sub-species in the Antarctic. Further details and the discussion is provided in Annex H, item 5.1.5.

10.3.2 Work plan

The Committee's views on the work plan are given under Item 24.

10.4 North Pacific sei whale in-depth assessment

10.4.1 Review intersessional progress

Last year, an issue had been identified with the division of Japanese catch records between sei and Bryde's whales in the period 1955-72. This year the Committee heard that this had been a misunderstanding: the division of the catch figures had already been accomplished in the context of the Bryde's whale assessment.

Owing to other Committee priorities, it had not been possible to complete the incorporation of the Soviet and Canadian catch records intersessionally; this remains in the work plan for the forthcoming year (see Item 10.4.3).

10.4.2 Assessment

Although it was not possible to proceed with the assessment, analyses were presented that will inform the assessment when it is undertaken. Relating to stock structure, SC/65a/IA05 described the results of microsatellite DNA analysis conducted on North Pacific sei whale samples obtained from the 2010-12 IWC-POWER surveys (Annex G, item 5.2). The genetic data from 14 microsatellite loci from these samples were compared with previously reported genetic data from JARPN II (from 2002-07) and from commercial whaling samples (from 1972-73) across a range of locations within the North Pacific. The study supports the author's previous view that the open waters of the North Pacific were occupied by the individuals from a single stock of sei whales. This paper was discussed extensively by the Working Group on Stock Definition (Annex I), which made three recommendations for further analyses: (i) estimate the power of the data set to detect subtle population structure that might nevertheless be important for management; (ii) undertake a clustering analysis using STRUCTURE or a similar approach; and (iii) undertake a relatedness analysis when the sample size is sufficient to expert to find a reasonable number of close relatives.

It was reported that the recommended studies will be carried out, but not before 2016 because of other priorities. The Committee did not expect that these analyses would materially change the current understanding of stock structure; it **agrees** that it is not necessary to await the results before proceeding with the in-depth assessment.

Two preliminary analyses using sightings data from IWC-POWER were presented. SC/65a/IA09 provided a standard line transect analysis to estimate abundance of sei whales from the 2012 IWC-POWER survey (see Annex G, item 3 for a map showing the survey area). SC/65a/IA10 modelled the spatial distribution of fin, sei and humpback whales using data from the first three IWC-POWER surveys (2010-12). The Committee welcomed this analysis, and made a number of technical suggestions. Updated and revised analyses from both SC/65a/IA09 and SC/65a/IA10, using all available data, will be undertaken intersessionally; the Committee looks forward to receiving these and considering them in more detail at the in-depth assessment next year.

10.4.3 Work plan

Corrected Soviet catch data are documented by Ivashchenko *et al.* (2013). The Committee **agrees** that these represent the best possible reconstruction of the Soviet catch history in the North Pacific at this time, and that they should be incorporated into the IWC database (if this has not already been done). The Committee requests that Allison complete the remaining catch history additions or revisions (such as the revised Canadian catch data) during the coming intersessional period.

10.5 North Pacific gray whales

10.5.1 New information on stock structure and movements

There was considerable discussion of genetic information (see especially SC/65a/BRG16) on gray whale stock structure for the North Pacific both within the working group on stock definition (see Annex I, item 3.1.3) and the sub-committee on bowhead, right and gray whales (Annex F, item 3.1.2). Considerable attention was paid to developing the range of plausible hypotheses about the gray whales that summer in the Sea of Okhotsk near Sakhalin Island. The outcome of these discussions was the development of a list of seven hypotheses presented in Annex F, Appendix 3.

SC/65a/BRG04 summarises the results of the second year of the collaborative Pacific-wide study developed under the auspices of the IWC. The paper reported on the comparison of the gray whales photo-identified off Sakhalin Island (n=232) and the Kamchatka Peninsula (n=150) with the Mexican gray whale catalogue (n=4,352). A total of nine confirmed matches was found. Two whales were observed in the three places, three in Sakhalin and Mexico and four in Kamchatka and Mexico. These results provide new information important to the evolving understanding of gray whale population structure in the North Pacific.

The Committee thanks all the collaborators for the excellent progress on this project. The comparison of photographs between Sakhalin Island and Kamchatka, Russia with photos from lagoons in Baja California Sur, Mexico provides improved understanding of the connections between feeding and breeding/calving areas and interactions between western and eastern gray whales.

The Committee received papers summarising the work of two ongoing photo-identification and biopsy programmes off Sakhalin Island. Details are given in Annex F, item 3.2.1 and only a short summary is provided here. SC/65a/BRG03 reviewed findings from the ongoing 18-year collaborative Russia-US research programme on western gray whales summering off north eastern Sakhalin Island, Russia. When 2012 data are combined with results from 1994-2011, a catalogue of 214 photo-identified individuals has been compiled.

SC/65a/BRG08 reported on the programme being undertaken by the Russian Institute of Marine Biology (IBM) team that has been working off Sakhalin Island since 2002 and Kamchatka since 2004. The Sakhalin photo catalogue now contains 219 individual gray whales over the period of 2002-12. At present, the Kamchatka Gray Whale Catalogue contains 155 gray whales identified in 2004 and 2006-12 of which 85 were also photographed offshore of Sakhalin. Information on body condition was also presented. While the population remains small and therefore vulnerable, individual animals appeared to be in good body condition in 2012 compared with indicators from previous years. Few skinny whales were observed and those that were, had restored their body condition to normal over the course of the summer feeding season.

SC/65a/BRG18 reported on the results of the shore- and vessel-based surveys conducted in August-September 2012 under the Western Gray Whale Monitoring Program funded by Exxon Neftegas and Sakhalin Energy. The authors concluded that the results of the 2012 distribution surveys and photo-identification studies indicate that the Sakhalin gray whale feeding aggregation is gradually increasing in size and that the distribution of the whales remains similar to previous years.

The Committee welcomed these papers, recognising the importance of long-term monitoring of the animals off Sakhalin. It **strongly recommends** that the studies continue.

In addition to the work in Russia, the Committee received information from Japan and Korea. SC/65a/BGR20 reported on the status of conservation and research on North Pacific gray whales from May 2012 to April 2013 in Japan (including sightings surveys and morphological comparisons), while SC/65a/BRG26 reported on sighting surveys in Korean waters from 2003 to 2011. Neither the Japanese nor the Korean surveys saw any gray whales.

The Committee thanks Japan and Korea for providing this information and continuing work on gray whales. It **encourages** further comparison of skeletal morphology of gray whales across the North Pacific. It also thanked Japan for providing photographs of a juvenile gray whale sighted off Japan in March 2012; comparison with both Sakhalin and eastern catalogues produced no matches.

Given the large amount of new information related to population structure of gray whales in the North Pacific and the potential implications of this for conservation and management advice (see also Annex E, item 2), the Committee **endorses** a proposal for a rangewide review of the population structure and status of all North Pacific gray whales with an initial focus on an international Workshop (Annex F, Appendix 2).

10.5.2 Conservation advice

SC/65a/BRG27 presented an updated population assessment of the Sakhalin gray whale aggregation using photo-id data collected from 1994 to 2011 in the Piltun area by the Russian-US team. Details are provided in Annex F, item 3.2.1. The results showed evidence for between-year variability in calving rates and calf survival rates. The calving rate was found to be correlated with the calf survival rate with a two-year time lag. Under the assumptions made, no immigration in recent years was detected, suggesting that the population has been demographically self-contained, consistent with a high degree of maternally-directed feeding site fidelity. The 1+ (non-calf) population size in 2012 is estimated at 140 (±6) whales, increasing at 3.3 (±0.5) % per annum.

A number of matters for further consideration were raised. Work is underway to incorporate both Sakhalin catalogues into the assessment but certain issues needed to be resolved first. The Committee **agrees** that if possible both datasets should be included in a final assessment. Given the implications for conservation, a more thorough investigation of immigration should occur and the incorporation of body condition information into the model was also encouraged.

Annex F, Appendix 5 provided an update on the progress of the Western Gray Whale Advisory Panel (WGWAP), which is convened by IUCN.

10.5.4 Conservation advice

The Committee **reiterates** its support for the important work of the IUCN. As previously, the Committee **recommends** that oil and gas development activities (including exploratory seismic surveys) in areas used by gray whales be undertaken only after careful planning for mitigation and monitoring, noting the guidance provided by the WGWAP in this regard[16].

10.6 Southern Hemisphere right whales

The Committee completed an assessment of Southern Hemisphere right whales last year and the report is published as IWC (2013f).

10.6.1 Review new information

The Committee received a number of papers providing new information on southern right whales and details can be found in Annex F, item 4. A short summary of this work is provided below.

[16]*http://www.iucn.org/wgwap/wgwap/seismic_survey_monitoring_and_mitigation_plan/.*

SC/65a/BRG10 reported on the results of the aerial survey for right whales in South African waters in October 2012 funded by the IWC and part of a long-term monitoring programme. The number of identified cow-calf pairs was the fifth highest since surveys began in 1979, and an exponential fitted to the data over the 34-year period provides a significant rate of increase (0.0625±0.0035 SE per annum).

SC/65a/BRG17 extended the analyses of Brandão *et al.* (2012) which applied the three-mature-stages (receptive, calving and resting) model of Cooke *et al.* (2003) to photo-identification data from the long-term monitoring programme available from 1979 to 2010 for southern right whales in South African waters, by taking two further years of data into account. The 2012 number of parous females was estimated to be 1,321, the total population (including males and calves) 5,062, and the annual population growth rate 6.6%.

Carroll *et al.* (2013b) provided information of a return of southern right whales to former habitat around the main islands of New Zealand including the first evidence of female site fidelity to the mainland New Zealand calving ground. There was some discussion as to whether this represented a re-establishment of primary habitat by a remnant stock that survived in the New Zealand sub-Antarctic.

Carroll *et al.* (2013a) reported on methods to extend the 'superpopulation' capture-recapture model (POPAN) to explicitly account for heterogeneity in capture probability linked to reproductive cycles, such as the 2-5 year birth intervals observed in southern right whales. This model extension, referred to as POPAN-τ, has potential application to a range of species that have temporally variable life stages. The authors demonstrate the utility of this model in simultaneously estimating abundance and annual population growth rate (λ) in the New Zealand southern right whale from 1995-2009, with a total 'superpopulation' estimate from the best model of around 2,100 (95% CL1,836-2,536).

SC/65a/O09 reported that four schools and five individuals of southern right whales were sighted in 2012/13 of JARPA II in the Antarctic. One southern right whale was photographed for photo-identification.

10.6.2 Complete assessment

SC/65a/BRG15 reported on a Workshop on the ongoing southern right whale die-off at Península Valdés. The 2010 IWC Workshop on this topic (IWC, 2011f) reviewed the significant number of right whale calf deaths and *inter alia* drew attention to the increasing incidence of parasitic behaviour of kelp gulls which peck at the outer skin and then feed on the blubber of live whales, and recommended that management measures be taken with respect to kelp gulls displaying this behaviour.

SC/65a/BRG15 also reviewed the most recent information on gull lesions and calf mortality. There is a strong signal of gull attacks as a unique, increasing, and acute element of the lifecycle of young right whale calves. The participants developed hypotheses on the mechanisms by which these attacks and injuries can lead to death and agreed to continue to work on these. The Workshop commended the work of the SRWHMP team.

Solving the kelp gull harassment problem is a priority action within the CMP developed for this region. Information was received on a feasibility study was carried out last year testing the use of different gun types - a 12-gauge shotgun was deemed to be the most successful. The reactions of the southern right whales to gun discharge were also recorded and no changes in their behaviour were observed. For the 2013 southern right whale season the objective is to continue this programme.

The Committee **expresses concern** over the continued large annual mortality of calves at Península Valdés, and its potential significance to the population. The increase in gull populations is driven by anthropogenic factors such as open landfills and discharge from fisheries. It **recommends** that investigation of the causes of this mortality, including the hypothesis that gull attacks are contributing to calf deaths, should continue as a matter of priority and **recommends** that strategies and actions to reduce the risk of gull attacks on southern right whales at Península Valdés should be further developed and implemented. The Committee **commends** the SRWHMP for their hard work and diligence in trying to resolve this situation and **encourages** continuation and further support of this important work.

The Committee received information on progress with the IWC Conservation Management Plan for the Southern Right Whale Southwest Atlantic Population as a result of a Workshop held in Argentina (SC/65a/BRG07). The overall objective of the CMP is to protect SRW habitat and minimise anthropogenic threats to maximise the likelihood that SRW will recover to healthy levels and recolonise their historical range. The CMP (details in Annex F, item 4.4) developed nine high priority actions, ranging from public awareness and capacity building through research to mitigation. Iñíguez has been appointed co-ordinator of the programme for a two-year period and a Steering Committee has been established including range state representatives, the Chairs of the Conservation Committee, Scientific Committee and the CMP SWG and the IWC Head of Science. A panel of experts will also be established.

The Committee **welcomes** the progress with the CMP and is willing to assist with scientific advice if required.

The Committee also **endorses** the holding of a workshop to develop and implement a strategy to minimise kelp gull harassment on southern right whales as proposed by the CMP. Such a workshop would be held in early 2014 and developed in consultation with the Province of Chubut. A budget request for partial funding is given under Item 26.

SC/65a/BRG14 noted that the southern right whale is listed as 'least concern' in the IUCN Red List of Threatened Species. Although not a threatened species, data from a review of strandings and sightings reveal a real reduction in southern right whales records for the southeast coast of Brazil. The authors stated that this should be considered as a cause of conservation concern**.**

Galletti Vernazzani *et al.* (In press) reported on behaviour and habitat use patterns of eastern South Pacific southern right whale sub-population. This population is likely to contain less than 50 mature individuals, and has been classified as critically endangered by IUCN. In 2012, the IWC endorsed a CMP to promote its long-term recovery. One of the highest priorities of the CMP is to identify the breeding area(s) which is difficult given the length of the coastline and and the low number of individuals. The first resighting between years of a known individual, the southernmost sighting of a cow-calf pair and the first documented record of likely reproductive behaviour in these whales has been reported in a small area off coastal waters off northwestern Isla Grande de Chiloe (Isla de Chiloe), southern Chile. This new information highlights the importance of this area for this population and suggests that it is part of a breeding area. Isla de Chiloe is the northern limit of the Chilean fjord system and was a former whaling ground for southern right whales, therefore it seems that whales are reoccupying their former range. However, a large wind farm project and associated port is being proposed to be built at northwestern Isla de Chiloe and it is likely it will affect this important habitat for this critically endangered population.

The Committee welcomed this information and, in light of this critically endangered status and the importance of this area for the recovery of the population, it **strongly recommends** relocation of the wind farm project away from shore, and **reiterates** the need for the urgent development of an environmental impact assessment that considers possible impacts on cetacean habitats.

10.7 North Atlantic right whales

10.7.1 Review any new information

No new information was presented.

10.7.2 Conservation advice

The Committee **repeats** its concern over North Atlantic right whale stocks and notes that it is a matter of urgency that every effort be made to reduce anthropogenic mortality (e.g. see IWC, 2012a). It requests that updated information on the status of any of these stocks be provided to the next Annual Meeting.

10.8 North Pacific right whales

10.8.1 New information

The Committee welcomed new information of sightings of North Pacific right whales: (1) one animal amongst several bowhead whales in July 2011 in the Western Okhotsk Sea; (2) two separate animals in 2012 as part of the JARPN II programme (both photographed and one biopsy sample); and (3) one animal (photographed) southeast of Kodiak Island during the 2012 IWC-POWER cruise.

10.8.2 Conservation advice

The Committee **reiterates** its previous concern over the status of this endangered species throughout the North Pacific. Noting that significant new data has accumulated from survey work in recent decades, especially in the western North Pacific and Sea of Okhotsk, the Committee **recommends** that the survey data on North Pacific right whales (including search effort, sightings, photo-id and biopsy results) be synthesised and presented by Matsuoka and colleagues to next year's meeting.

10.9 North Atlantic bowhead whales

10.9.1 Review any new information

No new information was presented.

10.10 Okhotsk Sea bowhead whales

10.10.1 New information

The Committee received considerable new information on bowhead whales from Ulbansky Bay in the Okhotsk Sea in 2011 and 2012 (SC/65a/BRG28 and SC/65a/BRG29). Details can be found in Annex F, item 2.2. Local observations indicate bowhead whales appeared in early May and were present in the area during the study from early July to early September. Large groups (up to 43 in 2011 and 51 in 2012) were seen. An individual biopsied in 2001 was recaptured in 2012. Approximate abundance based on the 2012 genetic recaptures (105 whales genotyped in 1995-2011 with 5 recaptures in 31 whales biopsied in 2012) suggest values about twice that of the earlier estimate of about 300 animals. However, false negatives resulting from differences in laboratory analyses for earlier samples could result in fewer recaptures and cause positive bias to any estimates. For mtDNA analyses, complete sequences of the control region were obtained for 64 individuals. Seven haplotypes were found including one not found in the earlier study by MacLean (2002), who also identified seven haplotypes.

In discussion, the Committee commended Shpak and colleagues for their excellent work. It **strongly encourages** further research on this small and little-studied stock, including: (1) continue biopsy collection in the Shantar region during summer; (2) calibration of samples collected in 1994-2001 and 2011-12 via an exchange of samples between US and Russian laboratories; (3) determining if whales in the various Bays of the Shantar region represent an homogeneous group; and (4) examining the relationship between bowhead whales observed in spring in the Shelikhov Bay and those from the Shantar region.

It was further noted that combining data from bowhead genetic studies conducted in the 1990s would allow updated capture-recapture (minimum) population estimates.

Brownell reported on new plans for offshore oil and gas development in the northern Okhotsk Sea. It was noted that oil and gas exploration lease blocks were purchased 50 to 14km offshore of the city of Magadan approximately in water depths of 120 to 180m. It is expected that exploration will start in 2017 and drilling by the mid-2020s. This area is north of Sakhalin Island and likely in the areas used by Okhotsk Sea bowhead whales when they migrate back and forth across the north Okhotsk Sea. In discussion it was noted that bowhead whales use the Shelikov region in spring but that there have been no reported sightings of bowhead whales off Magadan. There have been sightings of gray whales.

10.11 Arabian Sea humpback whales

10.11.1 Review new information

SC/65a/SH06 reported recent information on a discrete and non-migratory population of humpback whales in the Arabian Sea. A small vessel survey was conducted in Oman in 2012, and made three humpback whale sightings (five individuals) in 1,250km of survey effort. Sightings occurred in the Gulf of Masirah, which was previously identified through habitat modelling as a critical area for the population. Passive acoustic data are pending analysis and units will be re-deployed over the next year. Photo-id data were not adequate to revise population estimates as requested last year. Fishing and shipping in the region were reported in the context of potential threats to this population.

Information was also provided on progress toward the regional conservation initiative mentioned in SC/65a/SH06. Members of the intersessional correspondence group on the Arabian Sea population, together with regional NGO partners have begun work to establish a regional research and conservation programme for this population. The programme would help to initiate and foster collaborative research amongst range state partners, increase local capacity and generate awareness of Arabian Sea humpback whale conservation issues. Additional details are available in Annex H, item 4.

The Committee welcomed these important updates on the Arabian Sea humpback whale population. Given the critical status of this population, it **recommends** that this research be allocated a high priority. The regional conservation initiative was strongly supported as a positive opportunity for range states to work together towards improving the status of this population. Such work could also benefit a CMP, should one ultimately be established for this population (see Item 10.11.2).

Plans were described to satellite tag Arabian Sea humpback whales with implantable tags. Tagging would involve no more than 20% of the population, which has most recently estimated at 84 individuals (Minton *et al.*, 2011), and would address priority research questions identified previously by the Committee. The proponents stated that they have carefully reviewed the present state of tag development and will be following international best practice including using a well-designed and tested tag and an expert tagging team. Further project details and precautions are outlined in Annex H, item 4.

The Committee noted the importance of the proposed work, given how little is known about the Arabian Sea humpback whale population. While the proposed sample size is modest, even a small number of tags has the potential to significantly increase what is known about this population. At least seven dead humpbacks have been detected in the last 10 years and this casts doubt on the sustainability of the population, e.g. it exceeds the estimated Potential Biological Removal (PBR) for this population (Wade, 1998). As noted above, Oman has experienced a rapid increase in the development of fisheries, high speed ferries and coastal infrastructure projects, many of which overlap with known humpback habitat. Given the observed mortality and known threats, there is an urgent need for better information on movement and habitat use. This project has the potential to considerably improve knowledge in the short term and is in fact the only way to collect this information given the nature of this population and the available resources.

It was noted in discussion that the results of recent satellite tag assessment studies on the health of animals (SC/65a/SH05) will be available in the next few years and that consideration should be given to waiting for those results. However, the Committee also recognised the urgency of this issue and the potential benefit to the conservation management of this critically endangered population. The Committee **recommends** that this work be undertaken as a high priority. An important caveat is that any untested tag modifications should be evaluated on other populations and not used first on Arabian Sea humpbacks.

10.11.2 Progress toward the development of a Conservation Management Plan

In 2010, the Committee recommended the development of a Conservation Management Plan (CMP) for Arabian Sea humpback whales. A CMP could address concerns for this population as well those for other species of large whale. To date, neither of the two range state members of the IWC (India, Oman) has yet volunteered to lead the development of a CMP, although there is some recognition of urgent conservation concerns and research needs.

10.12 International cruises

10.12.1 IWC-POWER cruises in the North Pacific

The Committee has now agreed objectives for the IWC-POWER programme, and this year reviewed the results of the 2012 cruise (Item 10.12.2), the Planning Meeting report for the 2013 survey (Item 10.12.3) and discussed plans for the 2014 cruise (Item 10.12.4).

The 2014 cruise will mark the end of the short-term phase of the programme, completing coverage of a large area of the North Pacific (see Annex G, fig. 2). This phase had been designed to cover the whole survey area in as short a time as possible to provide baseline information on distribution and abundance for several large whale species/populations. Alongside sightings data, dedicated time for biopsy sampling and photo-identification work has been allocated, providing information on stock structure, movements and potentially further information on abundance.

10.12.2 Review of the 2012 IWC-POWER sighting survey

The 3rd IWC-POWER cruise was successfully conducted from 13 July-10 September 2012, in the eastern North Pacific using the Japanese Research Vessel *Yushin-Maru No.3* (SC/65a/IA08). The cruise was organised under the auspices of the IWC. Researchers from Japan, Korea and the US participated in the survey. The cruise had five main objectives (see Annex G, item 3.1). The survey plans had been endorsed by the Committee (IWC, 2012a, p.32). The Committee **agrees** that it was duly conducted following the guidelines of the Committee.

Further details of the cruise, including summaries of the sightings made, may be found in Annex G, item 3.1. The Committee, thanks the Cruise Leader, researchers, captain and crew for completing the third cruise of the IWC-POWER programme. The Governments of Canada and the USA had granted permission for the vessel to survey in their respective waters, without which this survey would not have been possible. The Governments of the Republic of Korea and the USA provided one scientist each, and the Government of Japan again generously provided the vessel and crew, as it had done for the 2010-11 cruises. The Committee recognised the value of the data contributed by this and the other IWC-POWER cruises, collected in accordance with survey methods agreed by the Committee, covering many regions not surveyed in recent decades, and addressing an important information gap for several large whale species.

In discussion of the 2012 POWER cruise results, the Committee heard that weather conditions in the North Pacific in summer tend to be poor. For future planning of the medium- and long- term phases of the programme, the Committee agreed that the sighting conditions during the 2010-14 cruises should be investigated. This is relevant both to the feasibility of estimating abundance of various whale species from current North Pacific surveys, and also for considering any changes in design required for subsequent cruises after 2014. These considerations were referred to the IWC-POWER Technical Advisory Group (TAG) Workshop scheduled for later in 2013 (see also Annex G, Appendix 2).

10.12.3 Planning for 2013 IWC-POWER cruise

SC/65a/Rep01 presented the report of the detailed Planning Meeting for the 2013 IWC-POWER cruise. The Meeting received preliminary results from the 2012 IWC-POWER cruise and these were used, along with overall objectives of the first phase of the IWC-POWER surveys, to formulate a plan for the 2013 cruise, which will take place between 30-40°N, and from 135-160°W. The vessel (kindly supplied by Japan) will depart on 12 July 2013. The Meeting also agreed to a suggestion to highlight the IWC-POWER surveys on the IWC website with the ultimate aim of inspiring multinational collaboration in the survey programme. Fortunately, there will be no problems arising from requirements for CITES permits during the 2013 survey as the tracklines do not enter any EEZs; however, the problems will return in 2014, when the planned survey design will take the vessel into US waters (see Item 10.12.4 below). The Committee was informed that the Japanese and US authorities are working to solve this issue. SC/65a/Rep01 also covered a number of items related to the short, medium and long-term objectives of IWC-POWER, which were later discussed by the IWC-POWER TAG (Annex G, Appendix 2).

The Committee **thanks** the members of the Planning Meeting for their report and **endorses** their recommendations.

10.12.4 Recommendations for 2014 cruise

SC/65a/O05 outlined the plan for the IWC-POWER cruise in 2014. The proposed research area is the eastern north Pacific, between 170°E and 160°W, from 30°N to 40°N (Annex G, fig. 2). Photo-id and biopsy experiments are also planned. The plan was drawn up following general guidelines agreed in 2012 at the Tokyo Planning Meeting (SC/65a/Rep01). Information collected from this survey will provide essential information for the intersessional Workshop to plan for a medium-long term international survey programme in the North Pacific.

On receiving these plans, the Committee **recommends** that permission be sought to operate in the US EEZ far enough in advance for the 2014 cruise. The Committee was informed that the Japanese and US governments are working to solve the problems before the 2014 survey. It thanked the Government of Japan for its generous offer of providing a vessel for this survey.

The Steering Group for IWC North Pacific Planning appointed last year was re-established, convened by Kato (see Annex R). Final planning will take place at a Planning Workshop to be held in Tokyo (see Item 26).

10.12.5 IWC-SOWER cruises (progress on website, publications and analyses)

Last year, the Committee nominated an Editorial Board, and tasked it with responsibility for the preparation of a commemorative IDCR/SOWER volume. As Convenor, Bannister reported that in accordance with the Committee's wishes, a timetable has been developed, a contents list has been proposed and authors have been approached to prepare brief outlines of their contributions.

The volume is intended to be a book reviewing the cruises: not a series of original scientific papers, but rather a series of review chapters bringing together all the work that has been accomplished so far (see Annex G, item 4.1). The volume will provide an introduction to the IDCR/SOWER programme and its fieldwork, including its original aims and objectives, and cruise narratives. There will be major chapters on whale distribution and movements, particularly of minke and blue whales, on taxonomy and population structure, on acoustics, and on abundance (including the development of DESS). An extremely important chapter will be devoted to conclusions and lessons for the future, with emphasis on achievements and lessons learned.

The Committee thanked Bannister and the Editorial Board, and looked forward to an update next year.

In order to facilitate analyses for some of the planned contents, the Committee considered that the production of standard datasets (similar to those produced for the analysis of Antarctic minke whales) would be useful. The Secretariat will make the data available when requested although additional information must be provided if any additional verification is needed to that which is already incorporated into IWC-DESS.

10.12.6 Other cruises

10.12.6.1 REPORT OF JAPANESE CETACEAN SIGHTING SURVEYS IN THE NORTH PACIFIC IN 2012

SC/65a/O04 reported on three systematic dedicated sighting surveys conducted in 2012 summer by Japan (ICR) as a part of JARPN II to examine the distribution and abundance of large whales in the western North Pacific. Over 8,700 n.miles were searched in total, and of the baleen whales, Bryde's whales were most frequently encountered, with only five individual minke whales observed in the offshore strata.

The Committee welcomed this report and **recognises** the value of the data. As noted under Item 10.12.2, sighting conditions might need to be accounted for when estimating abundance in the North Pacific (particularly for common minke whales), and indeed when designing surveys for that purpose. Although the small number of sightings of common minke whales in the offshore strata might well be largely due to poor weather, it was considered premature to conclude that no abundance estimate could be made without first seeing a weather-stratified analysis.

10.12.6.2 PLANS FOR A JAPANESE CETACEAN SIGHTING SURVEYS IN THE NORTH PACIFIC IN 2013

Plans for a systematic dedicated sighting survey in the North Pacific by Japan (ICR) as part of JARPN II in 2013 are described in SC/65a/IA03; the survey is currently underway. The main objective is to examine the distribution and estimate the abundance of common minke and sei whales for management. Notwithstanding a possible minor trackline design issue, the Committee **endorses** the proposal.

10.12.6.3 REPORT OF CETACEAN SIGHTING SURVEYS IN THE ANTARCTIC IN 2012/13

Plans for a dedicated sighting survey in the Antarctic in the 2012/13 austral summer were presented last year and subsequently endorsed by the Committee (IWC, 2013a, p.41). Two research vessels were to survey Area III E, Area IV, and the western part of Area V, using the same methods as in the IWC-SOWER surveys, and in accordance with the guidelines agreed by the SC (IWC, 2005b). Unfortunately the research could not be conducted due to violent interference from an anti-whaling NGO (SC/65a/IA07).

The Committee noted and expressed its concurrence with the Commission's previous consideration of this issue and its 2011 Resolution on Safety at Sea (2011-12) in which the Commission and its Contracting Governments condemned any actions that were a risk to human life and property in relation to the activities of vessels at sea. In particular, the Committee expressed its regret that the actions prevented the sighting survey from being conducted, just as in 2011/12. Following the cessation of the IDCR/SOWER programme in 2009 (and notwithstanding smaller-scale national projects to collect sightings data in particular regions), surveys such as in SC/65a/IA07 provide the only dedicated cetacean sightings that are synoptic over a wide area, and as such are extremely valuable for the work of the Scientific Committee.

10.12.6.4 PLANS FOR CETACEAN SIGHTING SURVEYS IN THE ANTARCTIC IN 2013/14

A systematic cetacean sighting survey for abundance estimation is planned in the Antarctic in the 2013/14 austral summer, as part of JARPA II (SC/65a/IA06). The planned research area comprises Area IV, Area V and the western part of Area VI, from December 2013 to March 2014. Details, which also incorporate biopsy sampling and photo-id work, are in Annex G, item 4.3.

In discussion, the Committee recognised the difficulty of fully reviewing a proposal without detailed design information, but noted that this seems unavoidable given security considerations (see Item 10.12.6.3). The use of consistent protocols over time makes this series of cruises a valuable resource, not least for analysing ice effects. The Committee recalled that photos of blue, right, and humpback whales from similar surveys in the past have been submitted to the relevant catalogue-holders for those species (and will continue to be submitted in future). The Committee broadly **endorses** the proposal, **recommending** that the proposed trackline design be changed if a survey of the Ross Sea was actually able to proceed.

10.13 Other

10.13.1 Photographic archiving

SC/65a/IA14 presented a progress report of a major archiving and cataloguing exercise being undertaken by the Secretariat for the photographic collections arising out of the IDCR/SOWER and continuing IWC-POWER cruises. The photographs have a wide range of potential uses ranging from photo-identification through education to contributing to assessments of human impacts.

The Committee **expresses** its appreciation for the efforts of Taylor and Donovan in archiving and cataloguing the collections and looks forward to a further update next year.

10.13.2 Sperm whales

SC/65a/SH14 investigated the potential population recovery of sperm bulls off Albany, Western Australia. This segment of the population was reduced by commercial whaling by 74% between 1955 and 1978. In 2009, an aerial survey was undertaken to replicate the behaviour of the 'spotter' planes employed by the Albany whaling fleet from 1968-78. The mean number of sperm bulls seen on transect per day (morning) in 2009 was substantially lower than the mean number seen in any of the years between 1968 and 1978. The authors emphasised the preliminary nature of the results, but considered them indicative of a lack of increase in the number of sperm whales frequenting this area compared to when whaling was taking place.

The Committee discussed possible interpretations of these findings, including the potential for population shifts due to ecological changes. It also noted a relevant discussion on sperm whales off New Zealand in Annex M, item 8.8. However, the possibility of population decline led the Committee to discuss the feasibility of undertaking a future assessment of sperm whales. There was general agreement that such an assessment would concentrate on sperm whales in the Southern Hemisphere, but include equatorial nursery groups and the Arabian Sea. The Committee discussed the availability of data on: (1) population structure within ocean basins; (2) population size within ocean basins (and abundance in smaller areas); (3) catch history; and (4) considerations in the development of a new assessment model.

The Committee **agrees** that data availability and feasibility of future assessment would continue to be evaluated intersessionally and reported to the Committee next year. It **recommends** that a dedicated agenda item be added for this species for next year's meeting. More details can be found in Annex H, item 6.1.

11. STOCK DEFINITION

This agenda item was established in 2000, and has been handled since then by a Working Group. The Terms of Reference for this Working Group were changed in 2012 to reflect the evolving needs of the Committee. During this meeting, the Working Group continued to develop guidelines for preparation and analysis of genetic data within the IWC context (see Item 11.1), provided the Committee with feedback and recommendations concerning stock structure related methods and analyses presented to other sub-committees (see Item 11.2), and developed a draft reference glossary of stock related terms, to aid consistent definition of 'stocks' in a management context for the Committee (see Item 11.4 and Annex I, Appendix 5). The report of the Working Group is given as Annex I.

11.1 Guidelines for DNA data quality and genetic analyses

Two sets of reference guidelines have been developed and endorsed by the Committee (IWC, 2009d) and form 'living documents' that can be updated as necessary[17]. The first set addresses DNA validation and systematic quality control in genetic studies. The second set provides guidelines for some of the more common types of statistical analyses of genetic data used in IWC contexts, and contains examples of management problems that are regularly faced by the Committee. Three new sections were added to the data quality guidelines during SC/65a. Substantial progress on the genetic analysis guidelines was also made during this meeting and this document will now be completed intersessionally (see Item 11.5). Both guidelines will also be published in the peer-reviewed literature.

11.2 Statistical and genetic issues related to stock definition

A number of Committee stock related papers were discussed by the Working Group. These were submitted to the following sub-committees: Revised Management Procedure (Annex D), Bowhead, Right and Gray Whales (Annex F), In-Depth Assessments (Annex G), Other Southern Hemisphere Whale Stocks (Annex H) and Review of Special Permit Proposals (Annex P). Technical comments on these papers are given in Annex I.

Gray whale stock structure was discussed in the context of SC/65a/BRG16 and Annex I, Appendix 2. An initial set of hypotheses were developed from these documents to describe the stock structuring of western and eastern gray whales, with particular reference to the Sakhalin Island feeding ground. These initial hypotheses are shown in Annex I, Appendix 3. They will be further developed intersessionally and assigned levels of plausibility. This will contribute to the proposed rangewide Workshop on gray whale stock structure and status (see Item 26).

A general comment was raised that is relevant to many discussions of stock related papers presented to the Committee. With new 'next-generation' DNA sequencing (NGS) techniques, it is now relatively inexpensive to increase the number of genetic markers analysed, so that more information can be gained from each sample in a population study. More genetic markers are often called for in circumstances where the existing marker set cannot detect population differentiation, either due to lack of discriminatory power or lack of population subdivision. Increasing the number of genetic markers increases the power to detect subtle population structuring and can facilitate future studies of relatedness patterns among sampled animals. Simulation analysis of the power of DNA markers to measure departures from panmixia and to reject demographically significant (i.e. sufficiently high) migration rates between putative differentiated populations can provide a useful means of measuring whether the existing DNA marker dataset is sufficient to answer the management question being posed. In all Committee studies, it is important to consider the level at which structure population needs to be detected in order for it to be of management concern. Increased numbers of loci can increase power to detect subtle population structure and also allow for improved inference of the population history underlying the substructure. However, they can also increase resolution to the point where even individuals can be discriminated and can also amplify spurious signals from genotype errors and small departures from random sampling. With the rapid recent developments in NGS technology and analysis, there are some emerging issues of relevance to the Scientific Committee, in terms of: (1) assessment of NGS data quality, and how best to curate such data; and (2) new methods for measuring stock structuring and measurement of other statistical quantities of interest to the Committee. New and published papers on this topic are therefore solicited for submission next year, where they will be considered in the context of the existing Committee guideline documents on DNA analysis and quality (see Item 11.5).

[17] *http://iwc.int/scientific-committee-handbook#ten.*

11.3 Testing of Spatial Structure Models (TOSSM)

The aim of TOSSM is to facilitate comparative performance testing of population structure methods intended for use in conservation planning. From the Committee's perspective, the IWC-developed TOSSM software package allows evaluation of methods for detection of genetic structure, in terms of how well the methods can be used to set spatial boundaries for management. It is available for all to use and simulated datasets exist for three of the five stock-structure archetypes previously proposed by the Committee (IWC, 2009b, p.51). Progress has been made on the work items suggested at last year for the Pacific Coast Feeding Group (PCFG) of gray whales (see Item 8.1) and will be presented at the 2014 Annual Meeting.

The Committee noted that the potential for using simulated datasets generated by TOSSM for work to evaluate dispersal rates and new methods for genetic clustering, as proposed under RMP (Annex D, Appendices 3 and 4), particularly in relation to stock hypothesis under review for the Scientific Committee.

11.4 Terminology and unit-to-conserve

Defining and standardising the terminology used to discuss 'stock issues' is still a long standing objective of the Working Group on Stock Definition, in order to help the Committee report on these issues according to a common reference of terms. Appendix 5 of Annex I has been developed by the Working Group with the aim of encouraging consistent use of stock related terms within Committee reports and in papers submitted to the Committee. The Appendix provides initial draft definitions of Committee terms such as 'biological stock', 'sub-stock', 'population' and 'management stock' which will be further discussed and refined intersessionally by members of the Committee. A list of agreed terms will be finalised next year. A challenging example set of cetacean populations that have been discussed by the Scientific Committee over the last five years will be chosen and their stock 'definitions' agreed intersessionally, also for presentation and discussion at next year.

11.5 Work plan

The Committee's work plan is given under Item 24.

12. ENVIRONMENTAL CONCERNS

The Commission and the Scientific Committee have increasingly taken an interest in the possible environmental threats to cetaceans. In 1993, the Commission adopted resolutions on research on the environment and whale stocks and on the preservation of the marine environment (IWC, 1994a; 1994b). A number of resolutions on this topic have been passed subsequently (e.g. IWC, 1996b; 1997; 1998a; 1999a; 1999b; 2001a). As a result, the Committee formalised its work on environmental threats in 1997 by establishing a Standing Working Group that has met every year since.

12.1 State of the Cetacean Environment Report (SOCER)

SOCER provides an annual update, requested by the Commission, on: (a) environmental matters that potentially affect cetaceans; and (b) developments in cetacean populations/species that reflect environmental issues. It is tailored for a non-scientific audience. The 2013 SOCER (Annex K, Appendix 4) had the Mediterranean and Black Seas as the regional focus. Publications summarised ranged from impacts of fisheries removals on cetacean prey to strategies aimed at reducing bycatch in the severely reduced population of common dolphin, to contaminants in Mediterranean cetaceans. Disease continued to be an important issue in the Mediterranean. Finally, an overview published by ACCOBAMS identified the main threats to cetaceans in the Mediterranean and Black Seas.

Globally, numerous studies on climate change and ocean acidification are starting to show impacts on marine species. Data on the impacts of underwater noise are increasing with new models becoming available on stress responses in cetaceans linked to underwater noise.

The Committee encourages continued contributions to this effort. Next year, the focus of the SOCER will be on the Atlantic Ocean region.

12.2 Pollution

12.2.1 Update on POLLUTION 2000+ Phase II progress

At the intersessional POLLUTION 2000+ Phase II Workshop, held in 2010 (IWC, 2011a), four objectives for the cetacean pollutant exposure and risk assessment modelling component were agreed: (1) improve the existing concentration-response function for PCB-related reproductive effects in cetaceans (completed in 2011); (2) derive additional concentration-response functions to address other endpoints (e.g. survival, fecundity) in relation to PCB exposure (completed in 2012); (3) integrate improved concentration response components into a population risk model (individual-based model) for two case study species: bottlenose dolphin and humpback whale; and (4) implement a concentration-response component for at least one additional contaminant of concern.

SC/65a/E04 provided a summary of the intersessional work that was completed in POLLUTION 2000+, Phase III. The objective of this work was to develop a framework for assessing the health risks associated with contaminant exposure on cetacean populations. Two previous papers on the first phases of this work are Hall *et al.* (2011) and Hall *et al.* (2012).

Bioaccumulation of contaminants and their population level effects were explored using a stochastic model that integrates measured tissue concentrations with a dose-response relationship to estimate potential impact on population dynamics. Two examples were examined using this framework: bottlenose dolphins and humpback whales. One of the model outputs was an annual accumulation rate for blubber PCB levels (e.g. 1.2 mg/kg lipid for female bottlenose dolphins and 0.2 mg/kg lipid for Gulf of Maine humpback whales). These exposure levels would produce no discernible effects on population growth. Analyses of model parameter sensitivity and uncertainty indicate that the model is reasonably robust and would be acceptable for making population inferences and management decisions.

An approach that would allow concentrations of total blubber PCBs in cetaceans to be estimated from data on concentrations in their prey was also explored, assisting in situations where biopsy samples are not obtainable. In an example again using bottlenose dolphins, data on energy requirements and consumption rates on concentrations of total PCBs in prey were combined in a physiology-based toxicokinetic model.

These modelling approaches provide a risk assessment tool that can be used to determine the population consequences of exposure to contaminants. The model framework also has the potential for investigating the impact of a variety of stressors on cetaceans and is currently being converted into a web-based program with a user-friendly interface that will be accessible from the Commission website.

Since the Pollution 2000+ Phase III risk assessment work plan is near completion, the Committee began planning the next phase. The Committee established a Pollution 2020 steering group, which will next focus on assessing the toxicity of microplastics and polycyclic aromatic hydrocarbons and dispersants in cetaceans (see Annex K, item 11.2 and Appendix 2).

The Committee **commends** the progress on Pollution 2000+ Phase III objectives and **strongly supports** its continued work to further develop the necessary tools to assess cetacean pollutant exposure risk. The Committee **agrees** to the Pollution 2020 framework plan.

12.2.2 Oil spill impacts

After the Deepwater Horizon oil spill in April 2010, oil spill response was followed immediately thereafter by a Natural Resource Damage Assessment (NRDA) to investigate the injuries and impacts to cetaceans in the Gulf of Mexico. The NRDA investigation has included stranding response in the northern Gulf of Mexico; photo-id and biopsy surveys for bay, sound and estuary dolphins; aerial and boat-based surveys, including biopsy and tagging activities, for cetacean abundance and distribution in coastal and offshore habitats; and live capture/release health assessments.

An Unusual Mortality Event (UME) was declared in November 2010 for cetaceans in the northern Gulf of Mexico that started in February 2010 and now includes over 1,000 cetacean strandings. The Deepwater Horizon oil spill has not been ruled out as a possible contributing factor to this UME, which is the longest lasting and largest dolphin mortality event in US recorded history. In addition to the UME investigations, live capture/release health assessments of bottlenose dolphins from Barataria Bay, Louisiana (oiled area) and Sarasota Bay, Florida (reference site) were performed in 2011. Dolphins from Barataria Bay showed significant health issues, including pulmonary lesions and adrenal abnormalities, as compared to animals in Sarasota Bay. Chemical analyses associated with these stranded and live-capture dolphin studies have been completed and are currently being validated. In addition, a number of monitoring and assessment efforts on cetaceans have been conducted in offshore areas, including photo-id, passive acoustic monitoring, and tagging studies on pelagic species (e.g. sperm whales), as well as aerial and boat-based surveys.

The Committee **expresses great concern** about the continued high number of dolphin strandings in 2013. The Committee **agrees** that funding gaps are problematic for long-term monitoring projects, recognising that 3-5 year funding cycles are not geared toward such studies. The Committee welcomes the new information on marine mammal studies in the Gulf of Mexico and **encourages** scientists to provide restoration ideas for cetaceans to NOAA.

Information on oil spill preparedness was also presented. Details were provided on the Arctic Council's efforts to address oil spill preparedness (and response) based on the 1990 International Convention on Oil Pollution Preparedness

Response and Cooperation (OPRC), administered by the International Maritime Organization (IMO), to which all eight Arctic States are Parties[18]. Additionally, the Committee was given details on the US National Research Council's review of the capabilities, limitations, and needs for responding to an oil spill in the Arctic[19], as well as the US Arctic Research Commission's recently published white paper examining the state of oil spill preparedness, response and damage assessment in the Arctic[20].

Several workshops focused on Arctic resource development and policy will be held in the next year. Developing recommendations related to cetacean conservation and management may provide the Convenors of these workshops with information necessary for sound decision-making. The Committee **reiterates** its previous conclusion (IWC, 2011b, p.41) that a review of the capacity for oil spill response in the Arctic was an urgent priority in the aftermath of the Deepwater Horizon oil spill. The Committee **concludes** that it would be useful to know more about the current capacities and mechanisms of oil spill recovery. Given the amount of activity occurring related to oil spill preparedness and the fact that oil spill preparedness and response plans are being developed, the Committee **recommends** an increased exchange of information between the IWC Secretariat and the Arctic Council's Emergency Prevention, Preparedness, and Response Working Group (EPPR-WG).

12.2.3 Other pollution-related issues

In response to the statement in Resolution 2012-1 encouraging the World Health Organization (WHO) to conduct reviews of recent scientific publications regarding contaminants in certain cetacean products and give updated advice for consumers, the Committee **recommends** that the Secretariat reinitiate discussions with the WHO as a preliminary step, to ensure that they are in need of this information and would be willing to receive it, prior to moving forward on this Item.

Hunt *et al.* (2013) focused on methods that can produce information on parameters relevant to stress physiology, reproductive status, nutritional status, immune response, health and disease using non-lethal sampling techniques (see Annex K, item 7.3.2). Field application of these techniques has the potential to improve our understanding of the physiology of large whales, better enabling assessment of the relative impacts of many anthropogenic as well as ecological pressures. SC/65a/BRG23 reported on the progress of a programme to analyse biopsy samples of gray whales feeding off of Sakhalin Island, Russia that will include pregnancy testing, determination of stable isotope ratios and genetic analyses.

The Committee **commends** the recent advances in methods for non-lethal sampling, noting that information on stress physiology, reproductive status, nutritional status, immune response, health and disease are valuable to health assessment efforts. The Committee **endorses** this work and **strongly recommends** further development and improvement of these methodologies. The Committee **commends** the application of such techniques to the gray whales feeding off of Sakhalin Island, Russia.

The Committee received several contaminant-related papers associated with the Icelandic Research Programme, including those reporting concentrations of legacy persistent organic pollutants, trace elements, radioactivity and new contaminants of concern in Icelandic minke whales. A summary of the findings of these studies is listed in Annex K, item 7.3.3. The Committee thanked the Icelandic scientists for summarising these findings.

[18]*http://www.Arctic-council.org/index.php/en/reources/news-and-press/press-room/733-press-release-15-may-kiruna-2.*

[19]*http://www.dels.nas.edu/study-in-progress/responding-spills-Arctic/DELS-OSB-09-02.*

[20]*http://www.Arctic.gov/publications/oil_spills.2012.html.*

12.3 Cetacean Emerging and Resurging Disease (CERD)

In 2007, the Committee recognised the need for increased research and standardised reporting in a wide range of disciplines dealing with cetacean health (IWC, 2008d), which led to the creation of the Cetacean Resurging and Emerging Disease (CERD) Working Group.

12.3.1 Update from CERD Working Group

An update to the CERD work plan agreed in 2011 (IWC, 2012e, Appendix 3) included: (i) identification of regional and national experts/points of contact via Steering Committee membership; (ii) creation of a listserve and a website; (iii) creation of a Framework Document; and (iv) identification of and contact with organisations synergistic with the goals of CERD.

12.3.2 CERD website and work plan

Data on infectious and non-infectious diseases, general cetacean disease, nutritional disorders and biotoxins have been compiled and await entry. Additional input on skin diseases, visual health assessment and mortality events or unusual mortality events (UMEs) is needed. Although significant progress had been made the final website had not yet been completed. It was noted that an internship programme with projects aimed at expanding specific sections related to skin diseases, mortality events and visual health assessment would aid in this process.

The Committee **agrees** that supporting the aggregation of website information and input, and the ability to post and manipulate high-resolution images and video, are critical to the success of the CERD website. The Committee also **agrees** that there is value in linking to social websites in order to direct inquiries and information to the CERD website (for appropriate material). The Committee **encourages** continued development.

12.3.3 Strandings and mortality events

SC/65a/SM27 reported on a mass stranding event (MSE) in which 20-30 short-beaked common dolphins stranded on a beach in the Rio de Janeiro State, Brazil, and were returned to the water by tourists. The authors proposed that these pelagic dolphins were probably acoustically trapped or restricted by some noise source that caused them to panic and swim toward the beach and strand. An update also was received on a highly unusual event involving the long-term displacement and mass stranding of approximately 100 melon-headed whales that occurred in May-June 2008 in northwest Madagascar. An Independent Stranding Review Panel was formed to review all the information and a report is expected in a few months. Details of the response can be found in Annex K, item 8.3. The Committee **commends** industry and response organisations for a tremendous and successful effort in responding to and investigating this event.

Park *et al.* (2012) reported on a mass mortality of 249 finless porpoises that occurred on 3 February 2011 at a dyke in the Saemangeum Sea, Korea. This MSE was due to freezing surface water in the enclosed area and the animals died of suffocation. The Committee **expresses concern** about this MSE, especially with respect to the potential impact of dykes and encouraged the continued evaluation of animals in this area. The Committee **commends** the efforts made to investigate the stranding event.

SC/65a/BRG15 reported on a workshop held in April 2013 dealing with the ongoing southern right whale die-off at Península Valdés, Argentina. A previous IWC Workshop on the southern right whale die-off in 2010 (IWC, 2011f) drew attention to the increasing incidence of parasitic behaviour of kelp gulls, which peck at the outer skin and then feed on the blubber of live whales at Península Valdés. The recent workshop developed an additional hypothesis on the possible contribution of gull attacks to calf mortality at Península Valdés (see Annex F, item 4.4 for additional details).

The Committee **commends** the investigative team in Argentina for their thorough investigation. The Committee **encourages** continued work to evaluate the cause(s) of these mortalities, the implications to the population and the effectiveness of planned gull mitigation measures (and see Item 26).

Information on the International Workshop for Capacity Building on Marine Mammal Stranding (NOAA-IMARPE) was also received. The Government of Peru requested this workshop to help increase capacity for cetacean stranding response after a large die-off of common dolphins occurred in early 2012, in northern Peru. For more details see Annex K, item 8.3. Additional information on strandings and the detection of human-induced mortality was provided to a joint meeting of the SWG on Environmental Concerns and the Working Group on non-deliberate Human Induced Mortality. Furthermore, two papers on categorisation of human-induced trauma and interactions in cetaceans (Moore and Barco, 2013; Moore *et al.*, 2013a) were presented. Summaries of these papers can found in Annex J, item 6.

12.3.4 Other disease-related issues

The Committee received a summary of three disease-related papers reporting on the occurrence and prevalence of parasitic organisms and pathogens in Icelandic minke whales, associated with the Icelandic Research Programme. Discussion points related to these papers are listed in Annex K, item 8.4. The Committee thanked the Icelandic scientists for summarising these findings.

12.4 Anthropogenic sound

12.4.1 New information on the effects of anthropogenic sound on cetaceans

SC/65a/HIM01 discussed underwater bow-radiated ship noise in the Canary Islands (Spain), where a large fleet of commercial ferries operates on a year-round basis, and at the same time a high number of stranded cetacean carcasses in the area have shown injuries typically attributed to ship strikes. Whales may be capable of hearing approaching vessels at reasonable distances, enabling them to react fast enough to avoid collision; however, there are numerous factors to be considered in evaluating the actual collision risk. Overall, ferry traffic appears to contribute significantly to noise pollution in the Canary Islands archipelago.

SC/65a/E03 reported that significant progress has been made on the issue of marine noise pollution beginning in the mid-1990s. Within a few years, agencies such as the US Marine Mammal Commission had acknowledged the significance of marine noise pollution, as did some regional conventions, and later other legislative measures, such as the EU Marine Strategy Framework Directive – which specifically addresses noise – were developed.

New tools are under development to assess the cumulative effects of noise, such as cumulative noise and cetacean distribution mapping. Marine Spatial Planning and Marine Protected Areas are increasingly considering noise and disturbance, and industry is investing in noise reduction and alternative technologies. For at least some noise sources, there seems to be a general consensus that time-area closures represent one of the most effective available means of reducing impacts on marine mammals. Ship-quieting technologies for commercial vessels are also being developed. For further details see Annex K, item 9.1.

The Committee **encourages** time/area closures and the development of new quieting technologies to address noise pollution. The Committee **encourages** further scientific investigations to better understand the effects of sound on cetaceans and their habitats and to better understand the effectiveness of mitigation measures.

12.4.2 Update on new tools and approaches to mitigate effects of anthropogenic sound on cetaceans

The status of current noise management is one of traditional focus on relatively short-term and relatively small-scale human activities, emphasising thresholds of noise exposure from high intensity and short duration sources, with limited abilities to incorporate knowledge of background noise or look at the broader cumulative impacts. However, recently there has been a shift underway to focus on more ecologically-relevant spatial and temporal scales, in order to address chronic, perhaps lower intensity, sources.

Work being undertaken on soundscape mapping was presented last year. An update on progress intersessionally was provided and a joint IWC/IQOE (International Quiet Ocean Experiment) technical Workshop on soundscape modelling was proposed (see Annex K, item 9.2.1; the full proposal can be found as Annex K, Appendix 3). The goals of the Workshop are to exchange, evaluate and analyse soundscape modelling methodologies, examine and assess priority regions and important sound sources, and develop scientific recommendations.

The Committee **commends** the work on soundscape modelling. The creation of 'soundscapes' and noise maps was considered a valuable initiative. The Committee **encourages** the Workshop planners to consider not only the identification of sites of highest noise impacts, but also the direct benefits that could be realised by the reduction of noise impacts. A direct link to conservation outcomes such as reducing noise impacts on cetaceans could be of particular interest to the Commission. For additional discussion of the proposed Workshop, see Annex K, item 9.2.1.

The Committee **strongly supports** this proposal for a Workshop to be held intersessionally (Item 26).

12.5 Climate change

12.5.1 Update on recommendations from previous climate change Workshops

No updates on previous climate change Workshop recommendations were submitted for review and no papers were submitted under this topic.

12.5.2 Other climate change-related issues

The Committee recognised that climate change is an issue of increasing importance and should be kept on the agenda. In order to better identify topics for future climate change studies, the Committee **agrees** to the formation of an intersessional correspondence group (see Annex R). The Committee **agrees** to use the outputs of the intersessional group to develop future priorities under this topic.

12.5.3 Planning for Intersessional Arctic Anthropogenic Impacts Workshop

In 2010, the Commission requested that the Committee develop an agenda for a Workshop on Arctic Anthropogenic Impacts on Cetaceans. The Committee drafted an agenda and formed a Workshop steering group to further develop a plan for the Workshop (IWC, 2012f). A revised agenda that focused on anthropogenic activities related to oil and gas exploration, commercial shipping and tourism was developed by the Workshop steering group and presented last year (IWC, 2013j, p.255).

In discussion, it was noted that this will be a Commission Workshop and is planned for the next intersessional period. The agenda, venue, timing and participant list are still being developed.

The Committee recognises that the topic of anthropogenic impacts to cetaceans in the Arctic is broad and complex and **encourages** further efforts to address these impacts. The Committee noted that the activities recommended above under Item 12.2.2 on oil spill preparedness and responses represent one immediate effort to better coordinate with Arctic IGOs.

12.6 Other habitat-related issues

12.6.1 Interactions between Marine Renewable Energy Devices (MREDs) and cetaceans

SC/65a/E02 reviewed public knowledge of the Marine Renewable Energy Devices (MRED) Workshop report from last year (IWC, 2013b), as well as its larger impacts, to better understand whether the recommendations from such reports are reaching the appropriate audiences and providing them with useful information. Workshop participants were surveyed and whilst the respondents found the Workshop useful personally and the meeting generally well run, the replies provided little evidence yet that the Workshop has had any influence on policy-making or other processes related to marine renewables. There is also little sign of any footprint of the Workshop in any recent scientific or other related literature. Related to this, several participants raised concerns about the inability to find and access the report, as well as how to cite it.

The Committee **agrees** that the visibility and accessibility of its reports needs to be improved and **encourages** the Secretariat and the Committee to consider additional mechanisms to enhance access to, and distribution of, Committee reports.

12.7 Work plan

This is discussed under Item 24.

13. ECOSYSTEM MODELLING

The Ecosystem Modelling Working Group was first convened in 2007 (IWC, 2008c). It is tasked with informing the Committee on relevant aspects of the nature and extent of the ecological relationships between whales and the ecosystems in which they live.

Each year, the Working Group reviews new work on a variety of issues falling under three areas:

(1) reviewing ecosystem modelling efforts undertaken outside the IWC;
(2) exploring how ecosystem models can contribute to developing scenarios for simulation testing of the RMP; and
(3) reviewing other issues relevant to ecosystem modelling within the Committee.

The report of the Working Group on Ecosystem Modelling is given as Annex K1.

13.1 Review ecosystem modelling efforts undertaken outside the IWC

13.1.1 Modelling of the direct relationship between baleen whale populations and the abundance of their prey

Two invited presentations were made on ecosystem models of the effects on predators of fishing on forage fish, summarising the results of two large studies commissioned by the Marine Stewardship Council, MSC (Smith *et al.*, 2011) and the Lenfest Ocean Program (Pikitch *et al.*, 2012), that were completed in recent years. An important message from these studies is that fishing of forage fish down to their MSY level may have major impacts on predators, including birds and marine mammals, in some ecosystems. SC/65a/EM03, which summarised the MSC study, explored the effects of different levels of depletion of forage fish in five different ecosystems (the southern Benguela Current, the northern Humboldt Current, the California Current, the North Sea, and southeastern Australia) using three modelling frameworks (Ecopath with Ecosim [EwE], OSMOSE and Atlantis). The results showed a trade-off between yield from the forage fish species and impacts on the rest of the ecosystem. Although the broad results were relatively robust to the type of model used, predictions about impacts of and on particular species or groups varied considerably between models, suggesting that their use for 'tactical purposes' is not yet warranted.

SC/65a/EM05, which summarised the Lenfest study, conducted a meta-analysis of 72 published studies that used Ecopath models on a variety of marine ecosystems, with the goals of characterising the role of forage fishes and fisheries, and of providing general recommendations for conservative fisheries management. Further analyses using EwE models for 10 ecosystems suggested that minimum biomass levels to avoid predator declines should be about 75% of the unfished biomass – much higher than those predicted by single-species, MSY-based management. A tiered management approach was recommended where more conservative harvest limits are applied when there is high uncertainty about forage fish dynamics or predator dependencies. This study did not evaluate the impacts on marine mammals, and the general approach would need modification to address important aspects of whale populations which do not exhibit the high degree of variability that is characteristic of forage fish populations, or the effects of 'prey switching' that occurs when several forage species are present in an ecosystem.

The Committee **concurs** with the authors of the presented studies that the models used in the studies to date are useful for their broad-scale strategic conclusions, but are not yet suitable guides for short-term tactical management decisions. The Committee **agrees** that, in broad terms, the case has been established that forage fisheries are expected to impact predator populations including cetaceans, and considers that the priority for this Group should now be on more detailed models for specific cases involving whales, with more attention being paid to the dynamics, including stochastic factors. The Committee **agrees** that the framework discussed in Item 13.2 is a promising basis for modelling the effect of changes in prey species on whale populations.

13.1.2 Update from CCAMLR's Ecosystem Monitoring and Management Programme (WG-EMM) on krill and its dependent predators

The Committee held a joint Workshop with CCAMLR in 2008 (IWC and CCAMLR, 2010). Since then, the

Committee has identified significant knowledge gaps in aspects such as spatial variability and trends in prey species, on the relationships between predators and prey, and on the effects of environmental variability on predators. Given CCAMLR's considerable expertise on these aspects, the Committee **agrees** that the Chair of the Committee should write to CCAMLR in time for the meeting of the WG-EMM in Bremerhaven, Germany, in early July 2013, to discuss how to establish future collaborations.

13.2 Explore how ecosystem models can contribute to developing scenarios for simulation testing of the RMP

De la Mare (2013) described a modelling framework originally presented at the fourth MSYR Workshop (SC/65a/Rep05) that uses spatially resolved individual animal behaviour and detailed energy budgets to determine reproductive success and mortality in an environment where food has a patchy spatial distribution. One immediate application relates to the characterisation of yield curves for populations in stochastic environments, including assessing the relative advantages of defining yield curves in terms of number or biomass.

The Committee identified nine issues (listed in Annex K1, item 3) relating to ecosystem effects and the RMP that could be usefully explored either with this individual-base model (IBM) or with simplified emulator models that mimic the behaviour of the IBM. The Committee appointed a correspondence group under de la Mare to develop specific trials for the RMP for one of these issues (characterisation of yield curves for populations in stochastic environments) and **agrees** to make two of the remaining items a high priority for next year:

(1) effects of competition, including effects on whales from fisheries on prey species; and
(2) observable environmental and population characteristics likely to be indicators of ecosystem effects.

The Committee **encourages** analyses on these issues and **agrees** to invite outside expertise as needed.

13.3 Review of other issues relevant to ecosystem modelling within the Committee

13.3.1 Update on Antarctic minke whale body condition analyses

For the last three years, the Committee has discussed apparent declining trends in blubber thickness and body condition in Antarctic minke whales (Konishi *et al.*, 2008) over the 18 years (1987-2006) of the JARPA special permit programmes (e.g. IWC, 2013i). At the heart of the discussion has been the validity of the statistical methods that were used to derive these trends and more specifically whether the models fitted so far adequately captured the main sources of variability in the data, given the nature of the sampling (de la Mare, 2011; 2012). This discussion is relevant to ecosystem modelling because the findings have implications for energetics, reproductive fitness, foraging success and the prey base itself, all of which are important as input in models.

Previously, the Committee has requested further analyses of the data, including:

(1) determining whether the models fitted so far capture all the main features of the data,
(2) determining whether the estimate of trend could be made more precise,
(3) analysing the two sexes separately,
(4) including the interaction of slopes by latitudinal band with year as a random effect, and
(5) investigating independence issues by using mixed-effects models with trackline as a random effect (IWC, 2011e; 2012d).

Two reanalyses of the data were conducted at the 2011 meeting (IWC, 2012d, p.260), one using the jack-knife method with one year as the unit on the published regression model, the other using mixed-effect models to account for some of the variance structure. Both reanalyses resulted in a much higher variance of the estimated trend, but the point estimates were little changed and were still significant.

This year, SC/65a/EM04 presented jack-knife estimates of the variance of the trend by taking individual years or groups of up to three years as the jack-knifing unit. Unexpectedly, the variance of the trend estimate was much less than the variance calculated by Skaug (2012) from the model itself. This led to considerable discussions within the Working Group on the appropriate statistical procedures to use. These are detailed in Annex K1 under item 4.1 and are not repeated here. In addition, a new analysis of total body fat was also presented (Annex K1, Appendix 6) that the authors believed supported the earlier conclusion of a decline in energy storage in Antarctic minke whales during the JARPA period but that others questioned.

The Committee **reiterates** its recommendations from previous years that the outstanding issues raised at recent meetings should be examined (for details see Annex K1, item 4.1). A number of additional suggestions were also made this year. The Committee **encourages** additional analyses to be undertaken on both the blubber thickness and body fat data and noted that papers should ideally be submitted to the forthcoming JARPA II review Workshop (see Item 17.3).

13.3.2 Other, if new information is available

SC/65a/EM02 outlined plans for conducting ecosystem modelling for baleen whale species in Antarctic Area IV, based on data from the JARPA and JARPA II programs. Two types of approaches will be employed; one is a comprehensive, 'whole ecosystem' model (EwE), and the other is a 'model of intermediate complexity' for ecosystem assessments (a multi-species production model). Baleen whales and krill play key roles in both, and the results will be applied to available time series data of baleen whales, seals and krill. Results from these two approaches will be reported at the JARPA II review.

The Committee **welcomes** these plans but suggested that the aims of the modelling exercise be better clarified. The author explained that one aim is to compare the results from a broad-sweep model such as EwE that encompasses most components of the ecosystem with those from a model that includes more detail on the dynamics of the main species of interests. Documentation of the input sources will be provided and options for diagnostic tests of the predictions should be developed. This information should be included in any paper presented to the forthcoming JARPA II review.

SC65a/EM01 presented a preliminary report from a multi-species modelling effort to study the role of minke whales in the marine ecosystem around Iceland, including consumption of sand eel and cod. In its initial phase the focus is on implementing single-species models in the Gadget statistical framework, but the medium to long-term plans are to build multi-species models and to compare different modelling approaches such as Gadget, FishSums, EwE and Atlantis, in order to assess their value to the management of living resources in Icelandic waters as part of the MareFrame project.

The Committee **welcomes** these efforts and **encourages** further refinements to include the effects of environmental variability on prey species and to incorporate prey switching in the next version. It was also noted that these exercises typically require a substantial amount of exploration to determine what is driving the observed trends in the predicted abundance of the target species.

SC/F13/SP02rev, SC/F13/SP03rev and SC/F13/SP04rev were initially presented at the Icelandic Special Permit Expert Panel Review Workshop in February 2013 and then revised in the light of comments made by the expert panel (see SC/65a/Rep03). These papers presented new information on the feeding ecology of common minke whales based on analyses of stomach contents, fatty acid profiles in blubber and blood tissues, and stable isotopes measured in blood, muscle, and skin tissues. The studies showed pronounced spatial and temporal variations. The fatty acid and stable isotope analyses further revealed tissue specificity, indicating that the results need to be interpreted with their limitations in mind. Together, these papers indicated that the differences between the stomach contents, fatty acid and stable isotope analyses can best be explained by the different time periods reflected by these methods, such that the stomach content analysis represents the most recent feeding and is therefore the best measure for local diet composition within the time-frame of their model, while the other two methods reflect feeding before arrival on the Icelandic feeding grounds in spring.

Tamura and Murase welcomed the information on diet data from these studies stating that they are useful in ecosystem models. Detecting changes in prey requires long time-series of data and fatty acid analyses complement data from stomach analyses.

SC/65a/O02 presented estimates of seasonal energy deposition in minke whales from Icelandic waters, based on measured increase in weight and energy of different tissues. Minke whales increase their weight by 27% over the feeding season, but due to increases in energy density of tissues, the total increase in energy content of the body is around 90%. Most of the energy is stored in adipose tissue (blubber and visceral fat), but posterior dorsal muscle and bone tissue are also important sites for energy storage.

13.4 Development of a list of priority populations as candidates for Conservation Management Plans

The Committee **agrees** that the Ecosystem Modelling Working Group can best assist in this process in the context of provide specific advice once CMPs have been identified (see Item 21).

13.5 Work plan

The Committee's views on the work plan for Ecosystem Modelling can be found under Item 24.

14. SMALL CETACEANS

14.1 Review current status of selected populations of small cetaceans in east Asian waters (China [including Taiwan], Korea, Japan and Russia [white whales only])

This year, the priority topic was to review the current status of selected populations of small cetaceans in east Asian waters (see Annex L, fig. 1). The selection of species was based primarily on concerns about conservation status and the expectation that new information would be available.

14.1.1 Narrow-ridged finless porpoise (Neophocaena asiaeorientalis)

14.1.1.1 TAXONOMY AND NOMENCLATURE

SC/65a/O01 proposed that the general acceptance of two identified species in the genus *Neophocaena* – the narrow-ridged finless porpoise (*N. asiaeorientalis*) and the Indo-Pacific finless porpoise (*N. phocaenoides*) – should be recognised by the IWC. The change in taxonomy was based on clear morphological differences, genetic data and partial sympatry of the two forms in the Taiwan Strait (Jefferson and Wang, 2011). The Committee **endorses** the updating of the IWC list of recognised species (see Item 20).

SC/65a/SM24 presented a genetic analysis of finless porpoises in Japanese waters. The Committee **agrees** that these results confirmed previous ecological, morphological and molecular studies showing that there are at least five separate local populations of finless porpoises in Japanese waters that should be treated as different management units.

14.1.1.2 BYCATCH: REPUBLIC OF KOREA

Korea reported a total bycatch of more than 1,000 finless porpoises in 2011, including 249 that died under ice after being trapped inside a newly constructed 33km dike within the Saemangeum reclamation project (Yellow Sea). In 2012, Korea reported bycatches of 2,050 finless porpoises in the Yellow Sea and 128 in the Sea of Japan/East Sea (see details in Annex L, table 1).

Deliberate killing of cetaceans has been illegal in Korean waters since 1986 and a requirement has been in place since 1996 to monitor whale meat coming from incidental catches. This was amended in 2011 to intensify monitoring of the circulation of whale meat in markets. Currently, every incidental catch must be reported to the Korean Coast Guard and a tissue sample from each animal must be submitted to the Cetacean Research Institute for its DNA registry established to detect and trace illegal catches. The Korean government has intensified its monitoring effort since 2011 and consequently the reported number of finless porpoises bycaught in the Yellow Sea has increased dramatically. Korea will prepare a mitigation programme to reduce the finless porpoise bycatch, including consideration of gear modifications, changes to fishing practices and 'pingers'.

Zhang *et al.* (2005) provided uncorrected (and thus minimum) estimates of finless porpoises of 21,532 animals in offshore waters and 5,464 animals in near-shore waters along the west coast of the Korean Peninsula (South Korean waters) to Jeju Island. At that time (IWC, 2006b), the Committee had welcomed the studies and looked forward to their future refinement. The Committee noted that the current bycatch of 2,000 porpoises would be about 7.4% of an estimate of total uncorrected abundance of 27,000 porpoises in 2004.

The Committee **appreciates** the valuable information on finless porpoise bycatch provided by the Korean scientists. It **encourages** researchers and managers to continue their efforts to improve reporting and investigate ways to assess and manage the bycatch, particularly given the uncertainty regarding sustainability. The Committee **recommends** that an analysis be conducted to estimate past bycatches of finless porpoises using data on historical and recent fishing effort together with recently documented bycatch levels. It further **recommends** that available abundance data on finless porpoises in Korean waters be summarised for consideration at next year's meeting together with bycatch data to allow a better evaluation by area. The Committee **commends** the Korean authorities for their efforts to reduce this bycatch and **requests** that a report summarising progress on bycatch mitigation measures be submitted next year.

14.1.1.3 BYCATCH: JAPAN

Reported bycatch in Japan is low; a provisional figure of only 15 finless porpoises were reported as bycaught for January-December 2011[21]. Provisional data on strandings in Japan over the same time period indicated a total of 181 finless porpoises of which 178 were necropsied; it is not known to what extent the strandings were a result of bycatch.

14.1.1.4 IUCN RED LIST STATUS[22]

In 2012, IUCN listed *N. asiaeorientalis* as Vulnerable (see Annex L, item 3.1.4, for full details). Reeves reported that a new assessment of the Yangtze subspecies *N. asiaeorientalis asiaeorientalis* will soon be published listing the subspecies as Critically Endangered.

14.1.2 Populations of Tursiops aduncus *in Korean and Japanese waters*

Wang and colleagues (Wang *et al.*, 1999, 2000a, 2000b) distinguished the Indo-Pacific bottlenose from the common bottlenose dolphin using genetic, osteological and external morphological data. Around Japan, Kurihara and Oda (2006; 2007) concluded that the Indo-Pacific bottlenose dolphin occurs in at least three locations: (1) Amami Islands; (2) Amakusa-Shimoshima Island; and (3) Mikura Island. Kim *et al.* (2010) confirmed the presence of this species around Jeju Island, Korea.

14.1.2.1 JAPAN

SC/65a/SM26 summarised the abundance of, and threats to, nine populations of Indo-Pacific bottlenose dolphins in the Japanese Archipelago (details are given in Annex L, item 3.2.1). The Committee **notes with concern** an apparently serious bycatch problem around Amakusa-Shimoshima Island (Shirakihara and Shirakihara, 2012). It **recommends** that this problem is monitored closely and that efforts are made to reduce bycatches.

SC/65a/SM29 reported on a stranding of a 2.7m male Indo-Pacific bottlenose dolphin in Kagoshima for which gross and histological examinations suggested the animal had a Lobomycosis-like disease. Analyses are underway to confirm this diagnosis.

The Committee **agrees** that it is important to understand the origins and routes of spreading of this disease and **recommends** further investigation and continued close monitoring of the population around Amakusa-Shimoshima Island in western Kyushu.

While recognising the responsibility of the range state for the conservation and management of small cetacean species, Japan reconfirmed its position on the involvement of IWC in the management of small cetaceans and reserved its position on all management recommendations regarding small cetaceans.

14.1.2.2 KOREA

Korean scientists provided information on the year-round resident population of Indo-Pacific bottlenose dolphins in the coastal waters of Jeju Island. The total population was estimated[23] as 124 (95% CI=104-143) in 2008 and 114 (95% CI=109-133) in 2009 using photo-identification mark-recapture methods. The animals are most regularly observed along the northern coast of the island. Bycatch has been investigated since 2009 and the annual bycatch rate was estimated at 7%, with most of the animals being trapped in pound nets (a type of set net or trap). More than 80% of the dolphins have been alive when found in pound nets; if released alive, a gradual increase in the local dolphin population might be expected.

An effort is underway to release three dolphins back into the wild in summer 2013 after being instrumented with satellite tags in the area of Jeju Island (where they were caught before being sold illegally to Korean oceanaria). They are among at least 11 bottlenose dolphins brought into captivity from the Jeju population in the last four years.

The Committee thanked H-W Kim and colleagues for providing information on the small local population of bottlenose dolphins around Jeju. It **encourages** their work to continue and **requests** updates on this including the satellite-tagged released animals and efforts to release dolphins in fishing gear.

14.1.3 Short-finned pilot whales (Globicephala macrorhynchus) *in Japan*

SC/65a/SM12 reviewed available information on the status of the southern and northern form short-finned pilot whales in Japan. Available abundance estimates of both forms are more than twenty years old. Catches have declined but the cause or causes are uncertain. Changes in catch composition of the northern form in the 1980s, with a declining proportion of old and large individuals (probably mostly males) observed in the catch, was inferred to indicate a decline in the population. No recent information has been published on the catch composition of either form. In the absence of an analysis of relevant data on effort, catch locations, etc., the most parsimonious assumption would be that the decline in catches has been due to a decline in the availability of pilot whales in the whaling areas.

In the absence of new information, the Committee **recalls** its previous concerns regarding these stocks (IWC, 1987; 1992). A **recommendation** relating to catches of small cetaceans by Japan (including this species) is given under Item 14.4.1.

Morishita stated that the declines in catches of small cetaceans in Japan are largely attributable to economic factors such as low prices of the products, high fuel prices and the effects of the 2011 earthquake and tsunami.

14.1.4 Dall's porpoise (Phocoenoides dalli)

SC/65a/SM11 reviewed available information on the status of Dall's porpoise populations taken in hand harpoon hunts in Japan. Details are given in Annex L, item 3.4. The most recent available abundance estimates of the hunted *dalli*-type population date from 2003 (Miyashita *et al.*, 2007)[24]. The Committee previously recommended that a complete survey of the ranges of the populations be undertaken as soon as feasible (IWC, 2009e).

Catches of both forms have declined, particularly those of the *dalli* form, with only 16% of the quota taken in 2010. Available data are insufficient to determine the cause of catch declines and no up-to-date information on catch composition has been published for either form of the species. In 2012-13 the catch limits were set at 7,147 *dalli*-type and 6,908 *truei*-type porpoises; around 4% of the 2003 abundance estimates.

The Committee notes that abundance estimates are now ten years old and catch limits are still probably unsustainable (Wade *et al.*, 2008). The Committee **reiterates** its previous concerns (IWC, 2002a, pp.57-8; 2008a, p.51). A **recommendation** relating to catches of small cetaceans by Japan including this species is given under Item 14.4.1.

[21] *http://www.jfa.maff.go.jp/j/whale/w_document/pdf/130531_progress_report.pdf.*
[22] *http://www.iucnredlist.org/.*
[23] The Committee did not review this estimate.

[24] The estimates were not assessed by the Committee.

14.1.5 White whales of the Okhotsk Sea

SC/65a/SM23 summarised available information on population structure, abundance and historical catches of white whales in the Okhotsk Sea. Based on aerial surveys in 2009-10, the entire population was estimated to be a minimum of 6,113 (CV=0.068), and when corrected for availability bias was estimated at 12,226 (see Annex L, Appendix 2 for more details). Two-thirds of satellite-tagged animals (2007-10, *n*=22) that summered in the Sakhalin-Amur region stayed in or visited the eastern part of the Shantar region in the autumn. In the winter, the whales travelled northward and offshore, where they used different wintering grounds. None of the 22 animals went to the area which a single tagged animal from western Kamchatka visited in winter.

SC/65a/SM23 also reported genetic data that suggested the existence of at least two Okhotsk populations: northeastern Okhotsk Sea and western Okhotsk Sea. Animals from the western population have been subject to live-capture for the last 30 years under an annual quota system. The average annual catch from 2000-12 was 23 (range 0 to 44). In 2012, the quota for the North-Okhotsk subzone was increased by a factor of five (to 212) and then in 2013 to 263; 44 were live-captured in 2012. There is a quota of 45 for the West-Kamchatka subzone in 2013.

After reviewing the information from both SC/65a/SM23 and a recent assessment by Reeves *et al.* (2011) the Committee **concludes** that the Russian domestic quota of 263 for the North-Okhotsk subzone was at least 6 to 8 times higher than that likely to be sustainable for the Sakhalin-Amur portion of the total regional population. In practical terms, the live captures are likely to be conducted at a single site which means they will target only the Sakhalin-Amur summer aggregation which raises concerns about local depletion.

Given this, the Committee **recommends** that the live-capture quota for the North-Okhotsk subzone be reduced to a level that is consistent with available scientific data and that at least four summer aggregations in the North-Okhotsk subzone should be managed separately such that the total allowable quota is broken down into separate quotas for Sakhalin-Amur, Ulbansky Bay, Tugursky Bay and Udskaya Bay (a fifth aggregation, in Nikolaya Bay, should have a zero quota as the number of animals using that bay is very small; SC/65a/SM23).

The Committee further **recommends** that no removals are authorised for the West-Kamchatka subzones, until sufficiently rigorous analyses of sustainability are provided that are at least as rigorous to those currently available for the North-Okhotsk subzone.

14.2 Report on the Voluntary Fund for Small Cetacean Conservation Research

14.2.1 Update on the 2011 awarded projects

Of the nine projects awarded in 2011, four were completed in 2012 and two projects will be completed in 2013. A further three will end at the beginning of 2014. See details in Annex L, item 4.1.

At this meeting, information was received from five projects (Annex L, item 4.1). The Committee was informed that the Secretariat is preparing a dedicated section for the IWC website on projects funded by the Small Cetacean Conservation Research Fund that will summarise projects' main achievements and ongoing activities.

14.2.2 Update on the 2013 selection process

Thanks to recent voluntary funding from Italy, the Netherlands, UK, USA, WWF-International and World Society for Protection of Animals, the Small Cetacean Conservation Research Fund (SCCRF) was replenished sufficiently to allow funding of a few new projects, fully or partially depending on their budget requests. A new call for proposals was announced by the Secretariat in April 2013. A total of 19 proposals were received by the deadline. In accordance with the agreed procedure, the Review Group (Bjørge, Donovan, Fortuna, Gales, Reeves, Rojas-Bracho) recommended five projects from this year's call for proposals (Table 4). The Committee **endorses** these five projects.

Table 4

Summary of projects recommended to be funded by the Voluntary Fund for Small Cetacean Research, and their principle investigators (PI).

PI	Project title
Chen	Defining the units of conservation and historic population dynamics for two small cetacean species affected by directed and incidental catches in the North Pacific. (F)
Kelkar	Strengthening the meaning of a freshwater protected area for the Ganges river dolphin: looking within and beyond the Vikramshila Gangetic Dolphin Sanctuary, Bihar, India. (P)
Mustika	A pilot study to identify the extent of small cetacean bycatch in Indonesia using fisher interview and stranding data as proxies. (P)
Rajamani	Capacity building in conducting cetacean abundance surveys in southeast Asia through a training workshop and actual surveys. (P)
Wakid	Investigating the abundance of Ganges river dolphin (*Platanista gangetica gangetica*) and factors affecting their distribution in Indian Sundarban. (F)

Key: F=full funding; P=partial funding.

Given the large number of requests and the limited funding available, for future calls for proposals the Review Group had recommend that priority is given to projects with clear potential for effective conservation outcomes in areas of particular need (e.g. critical conservation problem known or suspected, but not likely to be addressed without support). The Committee **agrees** with this recommendation.

14.3 Progress on previous recommendations

14.3.1 Vaquita

The plight of the critically endangered vaquita has been discussed by this Committee and the International Committee for the Recovery of the Vaquita (CIRVA) for many years. In recent years, the focus of the recommendations has been that the only way to prevent the extinction of this species is to eliminate gillnets from its entire range.

SC/65a/SM13 provided information on the continuation of the Acoustic Monitoring Scheme for Vaquita. Preliminary analyses show with 60% credibility that the acoustic encounter rate has decreased between the sampling periods, indicating continued decline of the population.

The new Mexican Administration established the 'Advisory Commission to the Presidency of Mexico for the Recovery of Vaquita' which includes the Minister of Environment, the National Commissioner of Fisheries, two members of Congress, NGO representatives, four scientific advisors, fishing representatives and the Navy. At its first meeting in February 2013, one key agreement was to eliminate gillnets and other entangling nets throughout the vaquita's range and to establish a compensation programme for fishermen. At its second meeting in March 2013, it was agreed that Federal and State Government officials and representatives of civil society would visit the fishing communities to inform the fishermen of the alternatives that the federal government has prepared to address the social problems arising from vaquita conservation measures in the region. It was also agreed that the head of the National Institute of Ecology and Climate Change would explore the feasibility of carrying out a new vaquita population survey cruise in Autumn 2013.

On 6 June 2013, the Mexican government approved the new Mexican Official Standard NOM-002-PESC that requires fishermen to switch from shrimp gillnets to alternative fishing gear (specifically purpose-built light trawls) over a three-year period (30%, 30% and 40% annual reduction over the three-year period).

The Committee **commends** the Government of Mexico for establishing the Advisory Commission to the Presidency of Mexico for the Recovery of Vaquita and for the final approval of the Mexican Official Standard NOM-002-PESC.

CIRVA members produced an analysis, required by the Government of Mexico, which uses a Bayesian model to estimate current (i.e. 2013) abundance of the vaquita population. The posterior distribution for 2013 abundance indicates a best estimate of 189 individuals. This result confirms the urgent need to remove all entangling nets from the vaquita's range to allow the population to recover.

In light of the significance of this updated estimate, the Committee **agrees** to include the full analysis as an appendix to its report (see Annex L, Appendix 3). The Committee **notes with great concern** the model's prediction that if the status quo is maintained, the species population will continue to decline towards extinction.

It is a recurring problem that the rarer a species is, the harder it becomes to collect sufficient sightings to generate robust abundance estimates and detect population declines. As a result, the Committee **strongly endorses** the decision to embed empirical estimates of vaquita abundance and trends (such as in this case the acoustic monitoring data) into rigorous statistical models, using all available relevant data and information to predict population trajectories. The Committee **expresses** confidence that the best estimate of vaquita abundance in 2013 is **189 individuals** (see Annex L, Appendix 3).

In addition, the Committee **reiterates its previous recommendations** that further actions to eliminate bycatch should **not** be delayed in favour of efforts to collect more population survey data.

14.3.2 Hector's dolphin

SC/65a/SM07 reported on efforts to improve estimates of abundance for local populations of Hector's dolphins using capture-recapture (CR) methods based on genotyping and photo-identification. The authors presented three consistent abundance population estimates: (1) a genotype CR (Lincoln-Petersen estimator with Chapman Correction); (2) a photo-identification CR; and (3) a single-sample, linkage disequilibrium method, giving the effective number of breeding individuals in the parental generation. Details are given in Annex L, item 5.2.

14.3.2.1 MAUI'S DOLPHIN

Maui's dolphin is the North Island (New Zealand) coastal endemic sub-species of Hector's dolphin. The Committee was informed that the management measures it recommended last year were incorrectly attributed to a proposal by the New Zealand Government. The Committee **acknowledges and regrets** this mistake.

SC/65a/SM06 presented an update on the status of Maui's dolphins. The population has declined significantly with the latest genetic mark-recapture analysis in 2010/11 estimating a population size of 55 individuals one year and older (Hamner *et al.*, 2012). The author suggested that unless their full range out to the 100m depth contour (including harbours) is protected against gillnetting and trawling (95.5% of human-caused mortality; Currey *et al.*, 2012), Maui's dolphins will decline to 10 adult females in six years and become functionally extinct (<3 breeding females) in less than 20 years, even under maximum population growth (0.018 according to Slooten and Lad, 1991). Additional threats to Maui's dolphins (besides bycatch) include seismic survey work in or near their habitat and a plan to begin development of the world's largest marine iron sand mining operation.

SC/65a/SM22 reviewed the response of the New Zealand Government to the 2012 recommendations of the Committee for urgent action. Although some measures were taken to limit bycatch, the author considered that they were insufficient because they did not cover the entire range. The paper stated that the protected area should be expanded, all gillnetting and trawling should be banned within it (including harbours), and restrictions should be placed on oil and gas development and on other potentially harmful activities where the dolphins are found, including a buffer zone.

Currey *et al.* (2012) described the risk assessment undertaken in June 2012 to inform the Maui's Dolphin Threat Management Plan. The risk assessment identified 23 activities or processes that pose a threat to the sub-species, with bycatch in commercial set net, commercial trawl, and recreational/customary set net fisheries assessed as likely to have the greatest impacts. The risk posed by the cumulative impact of all threats was assessed as significant, resulting in a high likelihood of, and a potentially rapid rate of, population decline. The spatial overlap between dolphin distribution and commercial fishing effort helped to identify specific areas where risk posed by commercial fishing activities remained, given management measures already in place. There was a reported capture of a dolphin in the south end of the Maui's range in January 2012 but no specimen was available to determine whether it was a Maui's dolphin or a specimen of the other Hector's dolphin subspecies. In response, interim measures were put in place in July 2012 that either restrict fisheries activities or require 100% observer coverage in the set net fishery in much of the area where the risk assessment indicated a continuing risk to Maui's dolphins from commercial fisheries.

Maas stated that the 100m depth contour is used to define the offshore limit of the range for Maui's dolphins; this ranges from 4 to 39 n.miles. However, Currey noted that the risk assessment expert panel estimated the offshore distribution as out to 7 n.miles based on modelling, public sightings, strandings and historical information on the dolphins' alongshore range. The fishery restrictions are based on distance from shore and vary between 2 to 7 n.miles.

New Zealand has a limited observer programme for Maui's dolphins in the trawl fisheries and the limited data suggests some risk of bycatch in trawl gear. The great uncertainty surrounding aspects of Maui's dolphin ecology and distribution makes evaluation of the efficacy of management very difficult. Emergency measures could be triggered by further bycatch.

The Committee **agrees** that management measures must be precautionary. If any fisheries with the potential for bycatch were to remain active within the range of Maui's dolphins, 100% observer coverage would maximise the chance of identifying any bycatch and providing information that might trigger immediate further area closures.

In conclusion, the Committee **reiterates its extreme concern** about the survival of Maui's dolphin given the evidence of population decline, contraction of range and low current abundance. The Committee **agrees** that the human-caused death of even one dolphin in such a small population would increase the extinction risk for this subspecies.

The Committee therefore **recommends** that rather than seeking further scientific evidence, the highest priority should be given to immediate management actions that will lead to the elimination of bycatch of Maui's dolphins. This includes full closures of any fisheries within the range of Maui's dolphins that are known to pose a risk of bycatch of small cetaceans.

The Committee **commends** the New Zealand Government on its initial and interim measures to protect Maui's dolphins. However, the Committee **emphasises** that the critically endangered status of this sub-species and the inherent and irresolvable uncertainty surrounding information on small populations require the immediate implementation of precautionary measures. Ensuring full protection of Maui's dolphins in all areas throughout their habitat, together with an ample buffer zone, will minimise the risk of bycatch and maximise the chances of population increase.

14.3.3 Irrawaddy dolphins

SC/65a/SM05 presented work on Irrawaddy dolphins in Laos where on the Laos-Cambodia border only six individuals remain in the trans-boundary pool, compared to at least 17 present in 1993. Despite efforts at protection on both sides of the border, the continuing use of gillnets, explosives and electric fishing gear as well as the proposed Don Sahong dam will very likely cause the extirpation of this small group of dolphins.

The Committee **agrees** that the situation in Laos was of serious concern and that without urgent conservation measures in the trans-boundary pool and the surrounding area as recommended in SC/65a/SM05, the remaining dolphins will not persist for much longer.

Porter reported that individuals from six populations of Irrawaddy dolphins in Malaysia, India and Bangladesh had developed cutaneous nodules. Disease prevalence ranged from 2.2% to 13.9% with the two most affected populations inhabiting the most polluted of the six areas. In India, prevalence was significantly higher in 2009-11 than in 2004-06. The emergence of this disease in several populations is of concern given the possible link to degraded environmental conditions and the vulnerability of this species to other threat factors.

The Committee thanked Porter for this information and **encourages** further investigation in collaboration with health experts and biologists working in these (and other) regions.

14.3.4 Atlantic humpback dolphin

SC/65a/SM16rev provided an update on an IWC Small Cetacean Research and Conservation Fund (SCRCF) project on the Atlantic humpback dolphin in Congo and Gabon. Details can be found in Annex L, item 5.4.

The Committee **welcomes** the important contribution to research and conservation made by this project and looks forward to receiving further information in future meetings.

14.3.5 Indo-Pacific humpback dolphin

Updates from three projects funded under the IWC SCRCF were presented at this meeting (see Annex L, item 5.5 for details). Smith *et al.* (2013) provided an update on their project to determine the population identity for animals in the northern Bay of Bengal, Bangladesh and to contribute to the resolution of taxonomy within the genus *Sousa*; Wang (2013) reported on progress on photo-identification monitoring of the Eastern Taiwan Strait Population, and information was presented on the project on the ecology, status, fisheries interactions and conservation of coastal Indo-Pacific humpback and bottlenose dolphins on the west coast of Madagascar.

The Committee **welcomes** the important contribution to research and conservation made by these projects and looks forward to receiving further information in future meetings.

14.3.6 Harbour porpoise

SC/65a/SM21 reported on a ship board double-platform line-transect survey to assess harbour porpoise abundance in the 'GAP area' between the North Sea and the Baltic Proper. Details can be found in Annex L, item 5.6. The abundance of harbour porpoises within the survey area was estimated at 40,475 animals (95% CI: 25,614-65,041, CV=0.235). Large areas of the northern part of the study region were not surveyed due to poor weather. The GAP plan identifies key areas for porpoises and focuses conservation measures on special areas of conservation for porpoises.

The Committee **welcomes** this work and **accepts** the abundance estimate.

SC/65a/SM25 reported on a National Programme in Mauritania ('Biodiversité, Gaz, Pétrole', BGP) that includes monitoring beaches for stranded cetaceans four times per year. Between November 2012 and May 2013, high numbers of stranded harbour porpoises and other species were found. The Northwest African population of harbour porpoises is probably reproductively isolated from the Iberian and other European populations (Van Waerebeek and Perrin, 2007). No abundance estimates are available but the population is believed to be small. Of ten individuals for which the cause of death could be established (from a total of 27 examined) all appeared to be bycaught.

Based on sightings recorded from 2003-11, SC/65a/SM20 provided an uncorrected abundance estimate of 683 animals (95% CI: 345-951) of harbour porpoises in northern Spanish waters that are considered part of the separate Iberian Peninsula Management Unit (ICES, 2013). The Committee **endorses** the authors' view of the need for unbiased estimates of both abundance and bycatch for this area in order to provide reliable advice for conservation and management actions. It **strongly encourages** Portuguese and Spanish authorities to promote collaborative research projects towards this end.

14.3.7 Solomon Islands update on both live-capture and drive fisheries

Oremus *et al.* (2013) contained the final report to the Government of the Solomon Islands on small boat surveys, photo-identification and genetic sampling to assess the population status of Indo-pacific bottlenose dolphins which are subject to live capture for international trade. Since 2003, more than 100 Indo-Pacific bottlenose dolphins have been shipped from the Solomon Islands to facilities around the world. The Committee **notes** that the new survey results presented by Oremus *et al.* (2013) reinforce previously expressed concerns regarding the sustainability of live-capture removals from this small island-associated population of Indo-pacific bottlenose dolphins. This project was partially funded by the IWC SCCRF. Details are given in Annex L, item 5.7.

The Committee:

(1) **emphasises** the importance of verifying the true number of live-captures and associated dead dolphins - the new survey results **reinforce** previously expressed concerns regarding the sustainability of live-capture removals from this small island-associated population;
(2) **endorses** the recommendation of Oremus *et al.* (2013) calling for the development of a DNA register, i.e. genetic samples of all dolphins captured should be collected systematically and archived to allow verification of their origin and legitimacy; and
(3) **reiterates its previous encouragements** for comparison of existing photo-id catalogues (e.g. that of RH Defran and this study) in order to produce a synthesis of sighting information.

SC/65a/SM08 described efforts to document the numbers and species of dolphins killed recently in the traditional drive hunts on the island of Malaita in early 2013. The Committee thanked the authors for this report, and:

(1) **commends** the Government of the Solomon Islands and the Ministry of Fisheries and Marine Resources for the substantial funding provided to conduct the surveys and for facilitating the work on the traditional drive hunts;
(2) **agrees** that there is an urgent need for estimates of the abundance of small cetaceans around Malaita and, if possible, the Solomon Islands as a whole; and
(3) **expresses concern** regarding the potential depletion of local populations given the scale of the recent (and historical) catches.

In this context, the extensive programme of aerial surveys for cetaceans and other megafauna in the South Pacific being undertaken by the French Government can provide valuable and reliable baseline estimates of abundance for previously unsurveyed or little surveyed areas. It was noted that this programme is planning to survey the New Caledonia area in 2014. The Committee **recognises** the great potential conservation value that would result if it was possible to extend the surveyed area to include the Solomon Islands. The Committee therefore **recommends** that the Secretariat forward a letter on behalf of the Committee expressing its appreciation for the current survey programme, explaining the benefits of extending the 2014 survey to the Solomon Islands and respectfully requesting this to be considered if at all possible.

The Committee also **encourages** the Australian Museum, Sydney to grant the authors of SC/65a/SM08 access to pantropical spotted dolphin teeth and teeth from other specimens from the Solomon Islands hunt that could be used to compare past and modern genetic diversity.

Finally, the Committee **endorses the recommendations** of SC/65a/SM08 encouraging the Solomon Islands Ministry of Fisheries and Ministry of Environment to:

(1) collect information on all future hunts and, if possible, provide some verification of species and numbers through independent observers or photographs;
(2) collect genetic samples (e.g. skin, meat, teeth) from each hunt, to confirm species identification and monitor changes in diversity and population identity over time; and
(3) support further surveys of waters around Malaita (and other islands, if possible) to estimate the abundance of small cetaceans.

14.3.8 Boto and tucuxi

Recalling last year's recommendations regarding the illegal capture and use of botos and tucuxis for fishing within Brazilian territory, the Brazilian Government has been taking steps to counteract this activity through enforcement actions. Details of these actions can be found in Annex L, item 5.8.

The Committee **commends** Brazil for its National Action Plan for the Conservation of Aquatic Mammals and Small Cetaceans, and **welcomes** the report on implementation relative to these two species.

The Committee also **reiterates its previous recommendation** that an international scientific Workshop be organised involving scientists and managers from the range states, with the goal of addressing research and conservation priorities, standardising methodologies and planning long-term strategies.

SC/65a/SM17 reported on the distribution of botos in the Amazon delta; they are regular and widespread in Marajó Bay and the surrounding coastline of Marajó Island. To investigate genetic variation in Amazon river dolphins and make inferences about possible subspecies of boto, analyses of the control region and cytochrome b were conducted. One specimen from the east coast of Pará state appeared to represent an isolated geographic form, genetically distinct from other known subspecies.

Iriarte and Marmontel (2013) reported that interactions of botos and tucuxis with fishing activities are common in the western Brazilian Amazon, but the prevalence of incidental and intentional catches is not known.

Williams and others conducted analyses to infer trends in boto and tucuxi numbers in the Colombian Amazon. They estimated an 87% chance that the boto is declining and an 80% chance that the tucuxi is stable or increasing.

The Committee **expresses its appreciation** for this information on the boto and tucuxi.

14.4 Takes of small cetaceans

14.4.1 New information on takes

Funahashi provided the Committee with a translation of the records of directed catches and associated quotas for small cetaceans from 1997-2011 obtained from the Japanese National Research Institute of Far Seas Fisheries website (Annex L, Appendix 4, table 4).

The Committee also received from the Secretariat the summary of catches of small cetaceans in 2012 extracted from this year's National Progress Reports (Annex L, Appendix 4). The Committee agreed to further explore, intersessionally, more specific terms of reference for evaluating direct take data, including the idea of developing case studies or other analyses from this information.

The Committee thanked Funahashi and the Secretariat for their work in compiling this information for the Scientific Committee each year and reiterated the importance of having complete and accurate catch information, encouraging all countries to submit appropriately qualified and annotated catch data.

SC/65a/SM12 presented information on small cetaceans targeted by direct hunts in Japan. In 2012 there was an increase in the hunting season for Baird's beaked whales in some areas. With respect to drive hunts of other species in Taiji, the number of live captures has increased in the last decade whilst the number of animals killed has gradually declined. The increase in live captures has been accompanied by an increase in exports.

Catch limits for all species were established in 1993 and remained largely constant until 2007. Since then catch limits for most species have been reduced, with the exception of Baird's beaked whales, Pacific white-sided dolphins and northern form short-finned pilot whales which have remained constant. The catch limit for false killer whales has increased. A recent assessment submitted to the 2011 Society for Marine Mammalogy Conference indicated that for all species assessed, catch limits were above sustainable levels (Funahashi and Baker, 2011), with those of striped and spotted dolphins and false killer whales particularly high, exceeding calculated PBR values by a factor of more than five.

For all species reviewed, with the exception of Baird's beaked whales, Risso's dolphins and the Pacific white-sided dolphins (which was only recently added to the quota scheme), catches have declined and have not filled the reduced quotas. See Annex L, item 6.1 for more details.

Published assessments of the abundance of targeted populations are now ten years old or older and exceed the maximum period for which a population estimate should be considered reliable (Moore and Leaper, 2011). Given the indications of population decline in some species (IWC, 1992; 1993; 1998c; Kasuya, 1985; 1999), the long history of intensive exploitation, the lack of information on changes in catch composition and that catch limits and catches remain above sustainable levels, SC/65a/SM12 concluded that there is an urgent need to suspend catches of species taken in direct hunts in Japan and conduct up to date assessments of the exploited populations.

Regarding the species that are subject to direct exploitation in Japan (i.e. common bottlenose dolphins, striped dolphins which apparently experienced a collapse of the coastal population, spotted dolphins, Risso's dolphins, false killer whales and Pacific white-sided dolphins), the Committee expresses **concern** that catch limits exceed sustainable levels and that abundance estimates of all species are now more than ten years old, particularly given the indications of population decline in a number of the species (IWC, 1992; 1993; 1998c; Kasuya, 1985; 1999). The Committee therefore **re-iterates** its previous concerns (IWC, 1992; 1993; 1998c) and **recommends** that:

(1) up-to-date assessments of these exploited populations be undertaken, including studies of population structure and life-history;
(2) up-to-date data on struck and lost rates, bycatch rates, directed hunting effort, stock identity and reproductive status and age composition of catches be collected and made available; and
(3) catch limits take into account struck and lost and bycatch rates and be based on up-to-date population assessments, and be sustainable with allowance for population recovery.

Some members expressed a different view concerning the problems mentioned above, for example regarding the existence of coastal populations of common bottlenose dolphins and striped dolphins (see Annex L).

14.4.2 Follow up on the Workshop on 'poorly documented hunts of small cetaceans for food, bait or cash'

Ritter presented a proposal on the growing and emerging problem of poorly documented hunts of small cetaceans for food, bait or cash (sometimes referred to as the 'marine bushmeat' problem). A provisional agenda was provided for an open symposium and a two-day Workshop (Annex L, Appendix 5). The scope was limited to Africa, Madagascar, Sri Lanka and southeast Asia.

It was agreed that the Workshop steering group shall focus its initial work on:

(1) appointing new members to be included in the steering group (September 2013): new members shall be experts working in the areas the Workshop focuses on that are not related to cetacean assessment;
(2) producing a final draft budget (September 2013), including costs for the venue and for (French) interpretation;
(3) determining additional expertise to be invited to the Workshop (October 2013);
(4) identifying a definitive venue (December 2013); and
(5) liaising with international organisations dealing with bushmeat and emerging infectious diseases (e.g. Eco Health Alliance [US] and others).

The steering group shall at the same time start finding funds from NGOs and other organisations. The progress on the work on the above points shall be referred to the co-Convenors of the sub-committee on small cetaceans and the Head of Science for consideration.

14.4.3 Significant direct and incidental catches of small cetaceans: an update

Donovan drew attention to the Committee's 'Report on Significant Direct and Incidental Catches of Small Cetaceans' that was prepared for the United Nations Conference on Environment and Development (UNCED) in 1992 (Bjørge *et al.*, 1994). Whilst recognising that this was a major undertaking, he suggested that there was a need for a single, up-to-date, authoritative reference on this topic and that the sub-committee on small cetaceans was an appropriate group for producing such a document.

After a short discussion on the merit and the difficulties of this idea, the Committee **agrees** to consider it in more detail next year.

14.5 Update on the proposed joint Workshop on monodontids

In 2012, the Committee established a Steering Group (Bjørge [Convenor], Acquarone, Donovan, Ferguson, Reeves and Suydam) to plan for a global review of monodontids (IWC, 2013k, p.296). The terms of reference were: (1) continue planning for a joint Workshop on monodontids with the NAMMCO SC, the Canada-Greenland Joint Commission on Narwhal and Beluga (JCNB), the Alaska Beluga Whale Committee, and others; (2) prepare a proposal for global review with a Workshop to be held in the autumn of 2013; and (3) facilitate exchange of data between the involved groups.

After consultation with NAMMCO, the deadline of autumn 2013 was considered unrealistic. However, the NAMMCO Secretariat, with the IWC Scientific Committee as co-sponsor, has indicated it can convene a global review workshop back-to-back with the joint meeting of the NAMMCO SC Working Group on Belugas and Narwhals and the JCNB, to be held in Copenhagen in the second half of 2014 (or first half of 2015). Experts from all range states (Greenland, Canada, USA, Russia and Norway) should be invited and a list of possible participants in the workshop has been developed. NAMMCO has indicated that it is prepared to cover part of the costs for invited participants and funding for this workshop will be sought from the IWC. Suydam noted that with the workshop and funding coming together, other interested organisations would help support participant travel. In response to a question on participation of observers, Bjørge noted that he was not familiar with NAMMCO procedures but that observer participation should be possible.

The Committee **welcomes** this report and thanked the NAMMCO Secretariat for its willingness to host the meeting and help fund invited participants. Bjørge and Fortuna will work with the Secretariat to ensure that the request for IWC funding of this workshop is considered in a timely manner. The Steering Group will continue to advance the plans for the workshop intersessionally and report back at next year's meeting.

14.6 Other information on small cetaceans
The sub-committee reviewed information in several additional papers that were not relevant to its priority topics. Details are given in Annex L, item 8.

14.7 Work plan
The Committee's work plan is given under Item 24.

15. WHALEWATCHING

The report of the sub-committee on whalewatching is given as Annex M. Scientific aspects of whalewatching have been discussed formally within the Committee since a Commission Resolution in 1994 (IWC, 1995b). The Commission also has a Standing Working Group on Whalewatching that reports to the Conservation Committee.

15.1 Assess the impact of whalewatching on cetaceans
SC/65a/WW01 summarised four papers addressing the impacts of whalewatching on cetaceans: Peters *et al.* (2013) documented the effects of swim-with-dolphin tourism on the behaviour of the 'burrunan dolphin' (*Tursiops australis*[25]) in South Australia; Lundquist *et al.* (2012) sought to estimate the potential impact of dolphin watching and swimming on dusky dolphins in Kaikoura, New Zealand; Dans *et al.* (2012) investigated changes in behavioural budget of dusky dolphins in Golfo Nuevo, Patagonia, Argentina; and Ayres *et al.* (2013) collected data on hormone levels from the faeces of southern resident killer whales to assess factors in population decline. Summaries are to be found in Annex M, item 5.

The Committee noted that hormone analysis, using faecal and blow sampling, is a potentially valuable methodology for examining impacts of whalewatching. Clearly the efficacy of these methods will be species-specific. A third methodology to measure stress responses is telemetry using tags that can monitor heart rates The impact of research vessels (for all these sampling methods) can be significant and a good experimental design is needed to control for this.

The Committee **agrees** that a joint session on stress responses related to vessel presence and shipping noise be held next year by the sub-committee on whalewatching and the SWG on environmental concerns, provided sufficient information is available. The Committee **requests** the Convenors of those two sub-groups to invite experts to submit papers next year on the use of faecal and blow sampling to measure stress hormones in relation to whalewatching, as well as in relation to other stressors where the methodology could be applied to whalewatching.

New provided an update on the mathematical models for the behavioural, social and spatial interactions of bottlenose dolphins first described in New *et al.* (2012). The model has been adapted to incorporate ecological and geographical features and also has the potential to assess the relative impact of different vessel types, as well as their cumulative effects. The model is an individual-based model, so it can also be modified to assess individual characteristics. The Committee **welcomes** this work and **encourages** future development and its use in case studies.

[25]The Committee has not included *Tursiops australis* in its list of recognised species.

15.2 Review whalewatching in the Republic of Korea
Whalewatching from one vessel began in 2009 in Ulsan. Species encountered include long-beaked common dolphins, common minke whales, Pacific white-sided dolphins, false killer whales, common bottlenose dolphins and occasional finless porpoises. Tourism numbers are increasing and are expected to reach 20,000 in 2013.

There is a resident population of *T. aduncus* in the waters of Jeju Island; however, the Ministry of Oceans and Fisheries has advised against developing boat-based dolphin watching due to this population's small size, which led to a protected species designation in 2012. The local government has decided to pursue land-based dolphin watching only. The Committee **commends** the Jeju Government and the Ministry of Oceans and Fisheries for their precautionary approach and **recommends** that research be continued on the bottlenose dolphin population of Jeju.

Guidelines are being developed for Korean whale-watching and the Committee **refers** the developers to the Commission's guiding principles and the Compilation of Worldwide Whalewatching Regulations[26]. Ulsan, given the early stages of its whalewatching development, may be a suitable location for a study under the Modelling and Assessment of Whalewatching Impacts (MAWI) project (see Item 15.3.1 and Annex M, item 7.1).

15.3 Progress on Commission's Five-Year Strategic Plan including guidelines and regulations
15.3.1 Large-scale Whalewatching Experiment (LaWE) steering group
There was no intersessional communication or formal update on LaWE submitted to this year. Consequently the Committee **agrees** to re-evaluate the project.

The primary objectives of LaWE were to assess the population-level impacts of whalewatching and determine the effectiveness of suggested mitigation measures in avoiding any potential negative effects of the activity. These objectives remain relevant to the work of the sub-committee; it is important that research addressing these objectives continues. The Committee **agrees** to establish a new intersessional working group, with New as Convenor, tasked with developing a revised work plan to move forward with this project, now named the Modelling and Assessment of Whalewatching Impacts (MAWI), which will seek to build on what was learned in LaWE (see Annex M). The group, using the Five-Year Strategic Plan research objectives and actions as guidance, will seek to define the specific research questions and hypotheses that will most benefit understanding of the impact of whalewatching, identify those whalewatching locations that would be suitable and amenable for targeted studies addressing these questions, and summarise the current modelling tools available to analyse the data that will be collected. Once these issues have been addressed, it will be possible to identify a timeline, benchmarks, budgets and any additional resource or support needs.

[26]*http://iwc.int/whalewatching*.

15.3.2 LaWE budget development group
This item was not discussed, as there was no intersessional communication with this Working Group.

15.3.3 Swim-with-whale operations
A questionnaire seeking more detail on these operations was successfully beta-tested in the Dominican Republic in early 2012 and was distributed to operators in Tonga and New Caledonia in May 2013. A summary of results from these surveys will be presented at next year (see Annex M).

15.3.4 In-water interactions
A scientific study was conducted in October 2012 off La Gomera (Canary Islands), where in-water interactions with different small cetacean species were examined. During experimental in-water encounters, specific behaviours exhibited by the animals were observed, recorded and videotaped. Results from this study will be presented at next year (see Annex M).

15.3.5 Guiding principles development
SC/65a/WW03 was a draft of the guiding principles produced per Action 1.1 of the Commission's Five-Year Strategic Plan for Whalewatching. The principles include general management considerations and guidelines for cetacean watching. These guiding principles are fundamental to the development of the Handbook as part of the Commission's Five-Year Strategic Plan for Whalewatching.

The Committee **agrees** to develop a 'background document' to annotate the guiding principles, with an explanation of their origin and evolution, as well as definitions of terms and other explanatory background (which might include illustrations of descriptive content). A draft of this document will be presented next year (see Annex M).

The Committee **endorses** the guiding principles, which can be found in Annex M, Appendix 2, and **recommends** that they are posted on the Commission website.

15.4 Other issues

15.4.1 Review scientific aspects of the Commission's Five-Year Strategic Plan for Whalewatching
The Committee reviewed elements of the Five-Year Strategic Plan for Whalewatching and the Commission's Whalewatching Handbook relevant to its work. Objective 1, Research, details three action items tasked to the Committee:

1.1 Develop (and/or review), pending further comprehensive scientific research and assessment (refer to action 1.3), guiding principles to be followed in whalewatching operations including swim with and provisioning programs to minimise potential adverse impacts;
1.2 Identify data deficient and critically endangered populations likely to be subject to whalewatching. Develop precautionary guidance and advice on additional mitigation measures that may be required for whalewatching operations on such populations; and
1.3 Consider an integrated research program (a form of long term experiment) to better understand the potential impacts of whalewatching on the demographic parameters of cetacean populations. Seek to:
    - demonstrate a causal relationship between whalewatching exposure and the survival and vital rates of exposed cetacean individuals;
    - understand the mechanisms involved in causal effects, if they exist, in order to define a framework for improved management; and
    - establish standard methodologies for the conduct of assessments.

Action item 1.1 is addressed in SC/65a/WW03 and Parsons agreed to collate data for action item 1.2 and report to the Committee next year. The Committee noted that the MAWI intersessional working group will address action item 1.3 (see Annex M, item 7.1).

15.4.2 Report of 2013 IWC Whalewatch Operator's Workshop
A Whalewatch Operator's Workshop, funded by the Governments of Australia and the USA, was held in Brisbane, Australia on 24-25 May 2013. The main objective of the workshop, attended by over 60 representatives of industry, science and government, was to get input from operators and industry representatives for the Whalewatching Handbook to be posted on the Commission's website, with continued oversight by the Commission's Standing Working Group on Whalewatching and an on-going and iterative monitoring, evaluation and review of the Five-Year Strategic Plan for Whalewatching. In addition, the workshop sought to help the Commission understand what role it can play in identifying and promoting 'best practices' and responsible whalewatching, what the industry might like to see or have in an online Whalewatching Handbook, actions in the plan that might require further engagement with industry and how to continue to integrate work at the Commission with industry expertise.

The Committee **agrees** to establish an intersessional working group, with Rojas-Bracho as Convenor, to determine how the Committee can best assist and contribute to the Whalewatching Handbook (see Annex R).

15.4.3 Consider information from platforms of opportunity of potential value to the Scientific Committee
A 'citizen science' handout drafted by the Tonga Whalewatching Operators Association was examined (see details in Annex M, item 8.3).

The Committee noted that this type of handout could allow 'citizen scientists' to provide data directly to research groups and **suggests** that the simple data form developed in (the Data Reporting Scheme) is revived and made available as a resource through the Commission's website.

In late 2009, researchers began collecting data from whalewatching vessels as platforms of opportunity in Ballena Marine National Park in Costa Rica. Tour operators were trained in the use of data forms and GPS. The first year of data collection by operators has been completed and these data will be compared with data collected by researchers, to determine if there are significant differences in data quality. A paper will be prepared for next year's meeting.

Denkinger *et al.* (2013) studied cetacean presence and diversity in the Galápagos Marine Reserve (GMR) during El Niño, La Niña, and neutral conditions, using wildlife viewing vessels as platforms of opportunity. These data showed that most species seem to move out of the GMR during El Niño years.

SC/65a/SH25 reported on a meeting of the Southern Ocean Research Partnership (SORP) held on Jeju Island, Republic of Korea, on 31 May-2 June 2013. The meeting's primary objective was to present the scientific results stemming from the five on-going SORP research projects. Recommendation 4 of the meeting report asked partners in SORP to employ all platforms of opportunity and, where applicable, 'citizen science', to collect data for inclusion in SORP research projects, thereby reducing the logistical constraints of circumpolar coverage and overall expenditure. Recommendation 5 was to store and archive data collected from international, collaborative research efforts such as SORP in open-access, central repositories that have the capacity to handle both primary scientific data and information derived from 'citizen science', e.g. image catalogues.

SORP is coordinating with the International Association of Antarctic Tour Operators to solicit data from platforms of opportunity. Cruise ships were identified as excellent potential platforms, as experienced biologists are often on board as naturalist guides, making them a potential source of good-quality data. 'Citizen science' efforts should be coordinated, because photographs in particular often come from tourists and key matches can come from this source.

15.4.4 Review whalewatching guidelines and regulations

SC/65a/WW01 reviewed two studies that addressed compliance with whalewatching guidelines and regulations: Kessler and Harcourt (2013) studied the levels of compliance with regulations by commercial and recreational whalewatching boats off Sydney, Australia; and Chinon *et al.* (2013) looked at the effectiveness of a proposed regulation for white whale watching in the Saguenay-Saint Lawrence Marine Park, Quebec, Canada, using an agent-based modelling approach. Summaries are presented in Annex M, item 8.4.

The Committee noted that this modelling approach is a technique that could be applied to other locations to assess the effectiveness of whalewatching regulations.

The 2013 Compilation of Worldwide Whalewatching Regulations[27] is almost complete and should be online by August 2013.

15.4.5 Review of collision risks to cetaceans from whalewatching vessels

SC/65a/WW04 investigated the probability of vessel collisions with humpback whales in the waters of Maui County, Hawaii, USA. Surprise encounters and near-misses, defined as a group of whales sighted (at abeam and forward angles) within 300m and 80m of a vessel respectively, were used as proxies for probability of whale-vessel strikes. The rate of surprise encounters increased with vessel speed, from 1.5 encounters/hr at 5 knots to 4.2 encounters/hr at 20 knots. No near-misses occurred at 5 knots. Calves were present in 28.3% of surprise encounters and 58.3% of near-misses, which coincides with previous reports that calves may be more susceptible to vessel collisions. Continued research will contribute to developing a predictive model of vessel strikes for management purposes.

The Committee noted that risk of vessel collision should be factored into models developed under MAWI. The model to be developed in Hawaii will be compared to data from the Hawaiian reporting network for ship strikes, which also reports 'encounters' (the equivalent of near misses), to see if the model matches the network's reports.

Ritter presented relevant aspects of Neilson *et al.* (2012), which analysed all reported whale-vessel collisions in Alaska between 1978 and 2011. Many types and sizes of vessels collided with whales; however, small recreational vessels as well as commercial vessels were most commonly involved in collisions. When vessel speed was known, 49% of the collisions occurred at vessel speeds ≥12knots.

[27] *http://iwc.int/whalewatching.*

15.4.6 Swim-with-whale operations

SC/65a/WW01 summarised four papers addressing swim-with-whale operations: Curnock *et al.* (2013) explored effort and spatial distribution of tourists swimming with dwarf minke whales across time on the Great Barrier Reef, Australia; Kessler and Harcourt (2013) studied human-whale value transition in Tonga across time and the current impact of humpback whale tourism; Kessler *et al.* (2013) documented humpback whale responses to experimental swim-with-whale encounters in Tonga; and Lundquist *et al.* (2013) documented responses by southern right whales in Argentina to simulated swim-with-whale encounters. Summaries are presented in Annex M, item 8.6.

The Committee noted that Hervey Bay, Australia, is an important resting area for humpback mother-calf pairs. Currently swimming with whales is not occurring but tour operators there are interested in conducting such encounters, The Committee **recommends** that the IWC's guiding principles (see Annex M, Appendix 2) be applied to any management decisions in Hervey Bay.

SC/65a/SM26 refers to swim-with-cetacean excursions in Japan and recommends monitoring the situation. The Committee **agrees** to add this to its agenda in 2014 and invites submissions on this situation at next year's meeting.

15.4.7 Emerging whalewatching industry in Oman

The Committee received an update on the emerging whalewatching industry in Oman and an initiative to guide and regulate the industry, as previously recommended (IWC, 2013c, p.64).

The objectives of the new initiative to educate the industry are to protect whales and habitat from impact whilst raising the industry's 'best practice' standards. Progress has been made with securing support of ministries, developing an inventory of operators, assessing operator performance and drafting a set of whalewatching guidelines. Operator workshops are planned for the last quarter of 2013.

The Committee **welcomes** the progress demonstrated by this initiative, and invites the continued submission of updates on this emerging situation. It encouraged local stakeholders, including non-governmental organisations, to continue their commitment to taking this initiative forward. In addition, the Committee **recommends** that the whalewatching guidelines in Oman consider the growing body of research on swim-with-whale encounters and the guiding principles (see Annex M, Appendix 2), which discourage this activity.

15.4.8 Assessing 'whalewatching carrying capacity'

Childerhouse reported on the situation in Kaikoura, New Zealand and whalewatching targeting sperm whales. A moratorium on new commercial whalewatching permits for sperm whales at Kaikoura expired on 1 August 2012. Thus, the New Zealand Government commissioned a two-year research programme into the impact of commercial whalewatching on sperm whales at Kaikoura (Markowitz *et al.*, 2011). The research identified a decline in the abundance of sperm whales over the period since whalewatching started, although the cause of the decline is unknown. After public consultation, another 10-year moratorium was recommended and has been implemented. A 10-year period will allow for meaningful monitoring of the effects of whalewatching activity on sperm whales.

In discussion, other plausible hypotheses for the decline were suggested (see Annex M, item 8.8).

The Scientific Committee **welcomes** this research and **commends** New Zealand for active assessment and management of whalewatching in this region.

15.4.9 IWC Conservation Management Plans
This is discussed under Annex M, item 8.9 and Item 21.

15.5 Work plan
This is discussed under Item 24.

15.6 Other matters
SC/65a/WW05 reported on results from a survey of whalewatching passengers designed to identify causes of a decline in the number of whalewatchers in Hervey Bay, Australia. Details are found in Annex M, item 10.

SC/65a/SM15 summarised a genetic analysis of bottlenose dolphins in Bocas Del Toro, Panama, which showed that this small population (~150 dolphins) has a unique haplotype not seen elsewhere in the Caribbean, confirming its genetic isolation. Last year (IWC, 2013c, p.61), the Committee strongly recommended that the Panamanian authorities enforce national whalewatching regulations and recommended continued research to monitor this dolphin population and the impacts of dolphin watching. However, the Committee received information that enforcement has not happened, and that there has recently been a confirmed report of a dolphin watching vessel striking a dolphin. In light of this observed mortality, the Committee **strongly reiterates** its previous recommendations.

16. DNA TESTING

The report of the Working Group on DNA is given as Annex N. This particular agenda item has been considered since 2000 in response to a Commission Resolution (IWC, 2000a).

16.1 Review genetic methods for species, stock and individual identification
SC/65a/SD01 was prepared in response to a recommendation from the Icelandic Scientific Permit Review Workshop (SC/65a/Rep05) to provide details of the protocol used for the genetic analyses presented to the Workshop, to ensure that genetic sampling and analysis followed the IWC guidelines for genetic research. SC/65a/SD01 provided a comprehensive and clear description of the Icelandic DNA registry protocol, on which the genetic analyses presented to the Review Workshop were based. The Committee **welcomes** this document and **agrees** that it responded appropriately to the recommendation from the Icelandic Scientific Permit Review Workshop.

The Committee **encourages** the preparation of technical documents on methods for species, stock and identification for discussion at the next year meeting under this agenda item.

16.2 Review results of the 'amendments' of sequences deposited in GenBank
During the first round of sequence assessment in *GenBank* (IWC, 2009f, p.347) some inconsistencies were found but these appear to be due to a lag in the taxonomy recognised by *GenBank* or uncertainty in taxonomic distinctions currently under investigation (IWC, 2013l, pp.330). After the assessment, some of the inconsistencies were corrected but further corrections have been hampered by the fact that only the original submitter can alter taxonomy fields in *GenBank*. Last year, the Committee agreed that Cipriano should make a request to *GenBank* to add an additional field for comments (IWC, 2013c, p.64).

Cipriano contacted *GenBank* during the intersessional period and received a response that *GenBank* is willing to work with the IWC on this. They requested that a list of accession numbers associated with problematic taxonomic designations be provided. This would help *GenBank* to understand the scope of the problem while considering a mechanism to allow taxonomy corrections and notations by request.

The Committee **agrees** that the list of accession numbers involving inconsistencies (Annex N, Appendix 2) should be sent to *GenBank* by Cipriano with a letter explaining the background and the main reasons for the inconsistencies, which include:

(1) species for which the taxonomy is still being worked out (e.g. the 'Brydes whale' species complex);
(2) species that have been recently split into new (or redescribed) species (e.g. the right whales and minke whales); and
(3) subspecies for which the taxonomy is still being investigated (e.g. the recognised sub-species of blue whales and minke whales).

Cipriano will also communicate about the need for an annotation indicating uncertainty in subspecies identity for a specimen.

16.3 Collection and archiving of tissue samples from catches and bycatch
The Committee previously endorsed a new standard format for the updates of national DNA registers to assist with the review of such updates (IWC, 2013c, p.53), and the new format worked well last year. This year the updates of the DNA registers by Japan, Norway and Iceland were based on this new format. Details are given in Appendices 3-5 of Annex N for each country, respectively, covering the period up to and including 2012. The Committee **thanks** the countries involved for providing this information.

16.4 Reference databases and standards for diagnostic DNA registries
Annex N, Appendices 3-5 summarise the status of mtDNA and microsatellite analyses of the stored samples for Japan, Norway and Iceland, respectively. In almost all cases, the great majority of samples have been analysed for at least one of either mtDNA or microsatellites and in most cases both. Work on unanalysed samples is continuing although in Japan's case 100% coverage was not possible because many samples were lost in the 2011 tsunami. Details on the exact number of samples collected and analysed are provided in Annex N.

The Committee **appreciates** the efforts of Japan, Norway and Iceland in compiling and providing this detailed information of their registries. The Committee **reiterates** its view that the information provided in the new format greatly facilitated the annual review.

16.5 Work plan
The work plan is discussed under Item 24.

Members of the Committee are encouraged to submit papers in response to requirements placed on the Committee by the IWC Resolution 1999-8 (IWC, 2000a). Relevant information in documents submitted to other groups and sub-committees of the Committee will be reviewed next year. Results of the 'amendments' work on sequences deposited in *GenBank* will be reported next year.

17. SCIENTIFIC PERMITS

This Agenda Item was discussed by the Working Group on Special Permits and its report is given as Annex P. In order to assist the reader, this section provides a summary of Annex P and it also includes a summary of the expert Workshop (SC/65a/Rep03) on the Icelandic special permit held in accordance with the Committee's guidelines (IWC, 2013m).

17.1 Review report of Workshop for Icelandic special permit whaling

In 2003, Iceland presented and the Committee reviewed a special permit research programme to the Committee for review that had included proposed takes of 200 fin whales, 100 sei whales and 200 common minke whales spread over a two-year period that was intended as feasibility study (IWC, 2004). In the event, the programme was reduced to considering only common minke whales and the catch period was extended such that the 200 common minke whales were taken from 2003-07. Due to practical difficulties in Iceland, review of the final results from the programme was delayed. Following the Committee's revised guidelines and timetable for such a review (IWC, 2013m), the expert panel meeting took place in February 2013. All due dates for availability of data, documents, reports and revised documents were met.

17.1.1 Panel Chair's summary of the panel report

The Panel was chaired by Kitakado and its composition was decided upon by a steering group comprising the past four Scientific Committee chairs and the Head of Science. Difficulties in the availability of proposed candidates meant that participation by scientists who had no connection with the Committee proved very difficult. In the event, the Panel comprised the present Committee Chair and the Head of Science (in accord with the guidelines), two ex-Committee Chairs, one current member of the Committee, one scientist who has not participated in the Committee for several years and two scientists who have never participated. Expertise in all areas of the research programme was available. In addition to the proponents, four observers were present. Thirty papers were submitted by proponents (SC/F13/SP01-30) and three additional papers were submitted by other scientists (SC/F13/O01-03).

The Panel report (SC/65a/Rep03) is divided into sections based on the stated objectives of the programme: abundance; stock structure; biological parameters, feeding ecology; energetics; pollution; parasites and pathology. Each of these contained the proponents' summary of their results followed by an analysis of the results by the Panel including conclusions and specific recommendations. The final section presents the Panel's general overview and conclusions followed by a summary of all of the recommendations divided into short, medium and long-term.

The report is a long and detailed review. What follows here is a short Panel Chair's summary of only the broad conclusions (SC/65a/Rep03); it does not provide a substitute for reading the full report. In reaching its conclusions and recommendations, the Panel noted that no further special permit programme was envisaged by Iceland at present. With respect to consideration of the effect of the catches on stocks, it noted that the level of catches was considerably below the level for the CIC *Small Area* that would have been allowed under the RMP (IWC, 2011b, p.64). The Panel emphasised that its task was to provide an objective scientific review of the results of the Icelandic programme; its task was not to provide either a general condemnation or approval of research under special permit. Consideration of that would require examination of some issues way beyond the purview of a scientific panel.

The Panel made a number of general points in addition to its review of individual topics. The first related to the objectives of the programme. The general nature of the objectives of the original proposal and its characterisation as a feasibility/pilot study made it difficult for the Panel to fully review how well the programme could be said to have met its own objectives. It agreed that it is important that any special permit programme provides careful objectives and sub-objectives for which performance can more easily be assessed, as is now the case in the guidelines for proposed permits in IWC (2013m), developed since the Iceland permit was presented in 2003.

The Panel also commented that better information on sampling design and an evaluation of sample size and representativeness at the local and population level was required. While the method used was probably sufficient for a feasibility study, it would not be the case for a full programme.

A common thread throughout the report related to the need for integrated analyses of the individual components of the programme; it regarded such work as essential and this was the subject of several recommendations. Given the objective of multi-species modelling to improve management, this should also include consideration of the results in the context of a modelling framework. The Panel noted that the programme had tried to maximise the information obtained from the whales taken. It stressed the importance of archiving material collected as well as storing analytical results and data in a relational database linked to the tissue archive.

With respect to abundance, the Panel agreed that the Icelandic survey data have improved knowledge about the abundance and distribution of the common minke whale in Icelandic waters both for use in the RMP and for input to potential multispecies modelling. Despite the logistical difficulties, the spring and autumn surveys provided valuable new information, especially in the context of any future multi-species modelling.

With respect to stock structure, the Panel agreed that the data will assist in the Committee's work on this topic. With respect to feasibility component, it was of course already well-known that it is possible to collect samples to better understand stock structure from carcases (as well as from biopsy samples as the proponents' note). It welcomed the efforts to compare genetic data across the North Atlantic but recommended further effort to integrate information regarding stock structure from the variety of genetic and non-genetic sources.

With respect to biological parameters, the Panel recognised the extensive amount of field and laboratory work that had been undertaken and presented. It noted that evaluating the feasibility of collecting information on biological parameters of sufficient precision and accuracy to inform multi-species modelling requires examining the sensitivity of model results to the parameters concerned. As the modelling was not as advanced as had been originally planned, this evaluation cannot yet be conducted. One of the most important feasibility questions relates to the issue of ageing common minke whales and the Panel commended the work to examine a new approach for common minke whales, recognising that further work needs to be undertaken.

With respect to feeding ecology, a primary component of the programme, the Panel acknowledged the large amount of effort undertaken and the generally thorough analyses using a variety of techniques. The temporal changes observed as a result of the extension of the sampling period could be related to climate change or a regime shift in the waters around Iceland and this is an important issue for further research.

The general nature of the objectives made evaluation of the success of the feasibility study more complex but the Panel agreed that knowledge of the general feeding ecology of common minke whales around Iceland has been advanced. It also acknowledged the efforts to collect data in such a way as to allow a more systematic than usual examination of the results that can be obtained from lethal and non-lethal methods (see SC/65a/Rep03, table 4). Finally, the Panel strongly recommended that integrated analyses including comparison of the information from each approach be developed and submitted to the Scientific Committee.

With respect to energetics, again the Panel recognised the considerable field, laboratory and analytical effort. These provided valuable insights into aspects of the energetics of common minke whales around Iceland but further effort is required to integrate the various analyses to provide quantitative input to energetics models and multispecies modelling and allow an evaluation of the sensitivity of the results to the inevitable uncertainty.

With respect to modelling, the Panel recognised the practical difficulties explained by the proponents but concluded that this important part of the programme is as yet poorly developed. In particular, a simple preliminary model should have been developed to inform discussions of which are key parameters with respect to obtaining robust results, evaluating how sensitive results are to different levels of uncertainty and determining appropriate sample sizes. This was a major weakness in the programme. However, the Panel welcomed the modelling work presented to the Workshop as a small but valuable initial step toward the programme's overall objective.

With respect to pollutant studies, the Panel acknowledged the considerable field, laboratory and analytical work that had resulted in a number of published papers. It also appreciated the effort made to compare results across the North Atlantic and to examine relationships between concentration levels in different tissues including 'pseudo' biopsy samples. However, it agreed that the objective of assessing health status had not been fully addressed and cautioned against broad assumptions that low levels necessarily indicate no effect. The sample size of the feasibility study was insufficient to properly address any toxic-related cause-effect relationships.

With respect to parasites and pathology, the objective had been to investigate the feasibility of monitoring and evaluating the morbidity of potential pathogens. The Panel recognised the difficulty of conducting full post-mortems of animals and undertaking thorough examination for parasites and pathogens at sea. While the study of the epibiotic macro fauna has resulted in a good baseline for future analyses, overall, the Panel concluded that the approaches adopted in the feasibility study would be insufficient to achieve the objective outlined.

The Panel briefly noted that the Commission had passed several resolutions relevant to research on the ecosystem, contaminants and environmental change. It agreed that many aspects of the programme were relevant to these topics and that the information had been made available to the Scientific Committee.

With respect to the utility of lethal and non-lethal techniques the Panel referred to extensive discussions at the JARPN II review (IWC, 2010a) and the SORP conference (Baker *et al.*, 2012). The Panel welcomed the efforts of the programme to provide data to allow a more thorough and quantitative comparison of some lethal and non-lethal techniques than has previously been possible (see recommendation in IWC, 2010a). The Panel developed a simple qualitative table to summarise the situation for North Atlantic common minke whales but stressed that is not intended to represent a complete or comprehensive evaluation of lethal or non-lethal techniques, either in general or for this specific programme and drew attention to a number of caveats.

Finally the report provided a summary of its recommendations. Seventeen addressed specific issues that might be termed 'short-term' while twelve addressed 'medium to long-term' issues.

In conclusion, the Panel's Chair thanked the Panel, the proponent scientists and the observers for their constructive and patient approach to the Workshop and the Marine Research Institute for providing excellent facilities.

17.1.2 Proponents response to the Panel report

SC/65a/SP01 provides an overview of the response of scientists from the Icelandic research programme (IRP) to the report of the Panel (SC/65a/Rep03). The IRP scientists consider that in general the evaluation of the IRP by the Panel was constructive, objective and balanced.

SC/65a/SP01 also responded to the Panel's request to provide further documentation of the sampling design. The authors emphasised that the objective was to cover the Icelandic continental shelf area and not to be representative of the Central stock of common minke whales. Sampling was distributed in relation to relative abundance in nine small areas used as part of the Bormicon framework for multispecies modelling of boreal systems. In addition, sampling was stratified seasonally into five units. The purpose of such a fine-scale stratification in this feasibility study was to ensure good distribution of the sampling around Iceland and to allow for post-stratification as appropriate for the different sub-projects.

While agreeing with most of the suggestions and recommendations of the Panel, as can be seen in Table 5, the IRP scientists have not been able to fully respond to all of these within the short period determined by the review process protocol (40 days). However, the IRP plan to conclude most of these before the 2014 Annual Meeting with a particular emphasis on those considered relevant for the upcoming RMP *Implementation Review* of North Atlantic common minke whales and the joint AWMP/RMP Workshop on the stock structure of North Atlantic common minke whales (see Annex D). For example, collaboration has already been established to investigate the isotope ratios in baleen plates.

SC/65a/SP01 also noted additional collaborations and studies that were initiated during the project on subjects outside the original objectives (brain anatomy, radioactivity, climate change aspects, genetic relatedness methodology, and analysis of additional pollutants).

In conclusion, the IRP scientists noted that the Panel had acknowledged the quality and scientific relevance of the presented results to common minke whale research, while identifying areas where further work was required. IRP scientists had responded positively to the comments and recommendations of the Panel as shown in Table 1. They also noted that the guidelines for review of scientific permit programs call for special considerations of the utility of non-lethal and lethal research techniques. This comprised a special objective of the IRP and the Panel had welcomed the efforts of the IRP to provide data to allow a more thorough and quantitative comparison of some lethal and non-lethal techniques than has previously been possible. This is relevant for other populations and species. The Panel had

Table 5

IRP scientists' summary of status of progress (based on table 2 in SC/65a/SP01) in responding to the Panel's recommendations (SC/65a/Rep03), including the list of papers submitted to the Committee in response to SC/65a/Rep03 and the sub-groups at which they were presented.

Recommendations (sub-group); Item no. in SC/65a/Rep03	Status of work
Abundance (RMP)	
12.1.1.1	To be addressed in the near future. Further recommendations may be needed as to the approach to take (before the North Atlantic common minke whale *Implementation Review*).
Stock structure (RMP, SD)	
Short term recommendations	
12.1.2.1	A fully integrated stock structure paper was submitted (SC/65a/SD02).
12.1.2.2	A paper describing the genetic protocols employed during the IRP was submitted (SC/65a/SD01).
12.1.2.3	This has been dealt with in the fully integrated stock structure paper (SC/65a/SD02).
12.1.2.4	This has been partly dealt with in the fully integrated stock structure paper (SC/65a/SD02).
12.1.2.5	To be addressed in the near future.
Biological parameters (EM)	
Short term recommendations	
12.1.3.1	Addressed in SC/F13/SP15rev.
12.1.3.2	Addressed; changes in reproductive status considered in SC/F13/SP10rev and SC/F13/SP05rev.
12.1.3.3	To be addressed in the near future.
Feeding ecology (EM)	
Short term recommendations	
12.1.4.1	To be addressed in the near future.
12.1.4.2	A revised paper on the diet composition was submitted (SC/F13/SP02rev).
12.1.4.3	An update of status and response to specific recommendations is given in SC/65a/EM01 and Daníelsdóttir and Ohf (2013).
Energetics (EM)	
Short term recommendations	
12.1.5.1	A fully integrated paper was submitted (SC/65a/O02).
12.1.5.2	The revised paper was submitted (SC/F13/SP10rev).
12.1.5.3	The revised paper was submitted (SC/F13/SP05rev).
Pollution (E, EM)	
Short term recommendations	
12.1.6.1	Addressed in SC/F13/SP22rev and SP23rev.
12.1.6.2	Addressed in SC/F13/SP23rev.

also noted that the level of catches was considerably below the level that would have been allowed under the RMP. Finally the IRP scientists noted the relevance of the research programme to the work of the Scientific Committee and the RMP in particular.

17.1.3 Committee's discussion

The Committee **thanks** the Panel for its thorough review of the Icelandic programme. It also **acknowledges** the work of the IRP scientists in producing revised papers after the Workshop so that they were available 40 days prior to the Annual Meeting.

In discussion, some members noted that while the Panel had agreed that 'many aspects of the Icelandic programme were directly relevant' to a number of Commission Resolutions on the environment and climate change, they believed that it was more appropriate to say that they were 'potentially' relevant to Commission Resolutions. They also believed that the Icelandic Programme fell short of meeting the Resolution on Whaling under Special Permit (IWC, 1996a).

Some members, having taken account of the expert review, expressed some broader critical views of the Icelandic programme and these are provided in Annex P1. This was not discussed and neither was the response from the proponents given in Annex P2. Noting the previous discussions on special permit whaling, the Committee did not discuss an overall evaluation of the Icelandic program.

Without questioning the quality of the members of the Panel, the future need for increased participation from experts outside of the Scientific Committee was noted. The Steering Group explained that this was the intention but despite a long list of potential candidates developed, the availability and/or interest of outside scientists in participating in the review had proved extremely challenging.

A large number of scientific papers originated from the Icelandic programme. Several of these papers were presented to the relevant sub-committees and working groups (RMP, SD, EM and E) as shown in Table 1 of the report. However, some members of the Committee suggested that further consideration be given to how to manage the time allocated to review such papers in the future, as they felt that not enough time was available for review in some sub-groups.

17.2 Review of results from ongoing permits

As in previous years, the Committee received short cruise reports on activities undertaken but spent relatively little time on discussion of the details. For long-term programmes, the Committee has agreed that regular periodic detailed reviews (following its guidelines, IWC, 2013m) were more appropriate.

17.2.1 JARPN II

SC/65a/O03 presented the results of the 2012 JARPN II (Second Phase of the Japanese Whale Research Program under Special Permit in the Western North Pacific) offshore component. A detailed summary is given in Annex P. There were three main research components: whale sampling survey, dedicated sighting survey and whale sighting and prey survey. A total of five research vessels were used: two sighting/sampling vessels (whale sampling survey component), one research base vessel (whale sampling survey component), three dedicated sighting vessels (dedicated sighting survey component) and one whale sighting and prey survey vessel (whale sighting and prey survey component). Catches occurred between 16 May and 3 August 2012 (74 common minke, 100 sei, 34 Bryde's and three sperm whales). Sightings surveys covered over 2,300 n.miles and eight species of large whales were seen including five blue and two North Pacific right whales. Preliminary results of biological and feeding ecology analyses are presented in this document. Data obtained during the 2012 JARPN II survey will be used in the elucidation of the role of whales in the marine ecosystem through the study of whale feeding ecology in the western North Pacific.

SC/65a/O06 presented the results of the 2012 JARPN II coastal component off Kushiro, northeastern Japan (middle part of sub-area 7CN). A more detailed summary is given in Annex P. Research occurred from 9 September to 28 October 2012, using four small sampling vessels. Catches (48 common minke whales) occurred within 50 n.miles of Kushiro port, and animals were landed at the JARPN II research station for biological examination. The frequency of whales feeding on Japanese anchovy was much lower in 2012 than in previous Kushiro surveys.

In discussion, it was clarified that search areas and vessel course were determined from weather conditions, whale distribution and information on fishing ground of coastal fisheries.

SC/65a/O07 presented results of the 2012 JARPN II coastal component off Sanriku (northeastern Japan, corresponding to a part of sub-area 7). A more detailed summary is given in Annex P. Research occurred from 12 April to 26 May 2012. Catches (60 common minke whales) occurred within 50 n.miles of Ayukawa port and all animals collected were landed at the JARPN II research station for biological examination. Information on sighting distribution, biological characteristics and prey species of whales collected during the 2012 survey was similar to that recorded before the 2011 earthquake and tsunami.

In response to a question, Sakamoto explained that samples from 32 individuals of four species from 2012 JARPN II were screened for radioactivity for the purpose of food safety. Ten of them were below the detection limit and the other 22 were well below the National Food Safety Limit set by the ministry of Health, Labor and Welfare. This information is available on the website of the Fisheries Agency of Japan[28].

17.2.2 JARPA II

SC/65a/O09 presented results of the eighth cruise of the JARPA II (Second Phase of the Japanese Whale Research Program under Special Permit in the Antarctic) survey in the 2012/13 austral summer season. A more detailed summary is given in Annex P. Research was conducted from 26 January to 14 March 2013 in Areas III East, IV, V West and part of Area V East. Four research vessels were used: three sighting/sampling vessels (SSVs) and one research base vessel. The SSVs surveyed a total of 2,103.3 n.miles in a period of 48 days. Unfortunately, the research activities were interrupted several times by members of Sea Shepherd, which directed violent sabotage activities against Japanese research vessels. A total of 103 Antarctic minke whales were caught and examined on board the research base vessel. Photo-identification, biopsy sampling and oceanographic work was also conducted. The main results of were as follows: (1) humpback whales were widely distributed in the research area with a higher density index than that of the Antarctic minke whales in all areas except in Prydz Bay; (2) the ice-free extent of the research area was substantially larger than in past seasons; (3) mature female Antarctic minke whales were observed only in Prydz Bay; and (4) all Antarctic minke whales sampled in Area IV east were immature animals.

[28]*http://www.jfa.maff.go.jp/e/inspection/.*

17.3 Planning for periodic review of results from JARPA II

JARPA II is due for a periodic review during the next intersessional period. According to the revised guidelines (IWC, 2013m), the proponents should submit a document explaining the data to be made available to the Workshop one Annual Meeting prior to the review Workshop. This information is provided in SC/65a/O08.

SC/65a/O08 summarised the data available for the next JARPA II Review Workshop to be held early in 2014. The summary was made for the six first surveys of JARPA II (2005/06-2010/11). The summary of the data followed the revised guidelines (IWC, 2013m):

(a) outline of the data that will be available;
(b) references to data collection and validation protocol;
(c) references to documents and publications of previous analyses; and
(d) contact details.

Data in SC/65a/O8 were summarised into the following sections:

(a) data for abundance estimate for several baleen and toothed whale species;
(b) ecological data;
(c) biological, feeding ecology, pollutant and stock structure data of Antarctic minke whale;
(d) biological, feeding ecology, pollutant and stock structure data of fin whale; and
(e) stock structure data of other species. Details of these data are given in Annex P5.

The next step of the review process is that the proponents make data available in electronic form one month after the end of the Annual Meeting. Then the proponents will send a document to the Secretariat describing the analytical methods to be discussed at the Workshop. This will happen nine months prior to the next Annual Meeting; i.e. the beginning of September. Based on the description of analytical methods, the Steering Group (Chair[29], Vice Chair, Head of Science and the last four Scientific Committee Chairs) will begin the process of identifying experts to participate in the Workshop. The need to try to find experts from outside the Committee was stressed. The full timetable for the process is summarised in Table 6 and details can be found in IWC (2013m).

The Committee **reaffirms** its guidelines (IWC, 2013m) that when members submit substantive analyses for a review panel, the Panel Chair, in exercising their discretion, may allow presentation of such analyses in the same manner allowed for proponents.

17.4 General comments regarding Special Permit whaling

Some members of the Committee stressed that the lack of review and comment outside the periodic reviews under the Committee's revised guidelines should not be interpreted as an indication that any of the serious scientific concerns

[29]Given his involvement in the programme, the Scientific Committee Chair, Kitakado, will not take part in the Steering Group. Palka (as immediate past Chair) will act on his behalf.

Table 6

Timetable for the periodic review of JARPA II assuming that the Annual Scientific Committee Meeting is on 1 June.

Item	Schedule	Date
Information on likely analytical methods to be used in the documents to the Workshop.	9 months before Annual Meeting	1 Sep.
Distribute documents to Vice Chair, Head of Science and Standing Steering Group (SSG).	1 week later	8 Sep.
SSG suggest names for the Specialist Workshop. Announcement of review to IWC and call for observers.	2 weeks later	22 Sep.
Chair, Vice Chair and Head of Science develop draft list of specialists and reserves.	2 weeks later	6 Oct.
Final comments from SSG.	1 week later	13 Oct.
Invitation and documents to Specialists.	1 week later	20 Oct.
Receipt and circulation of results/review documents from Special Permit research (including to IWC Scientific Committee members).	>6 months prior to Annual Meeting	1 Dec.
Observer reviews/papers due at the Secretariat.		30 Dec.
Observer's reviews sent to Specialists and Proponents.		6 Jan.
Hold Workshop.	>100 days prior to Annual Meeting	23 Feb.
Final Workshop report made available to Proponents.	>80 days prior to Annual Meeting	13 Mar.
Distribution of result documents, Workshop report and comments from Proponents to the Scientific Committee.	>40 days prior to Annual Meeting	22 Apr.
Discussion and submission of documents to the Commission.	Annual Meeting	1 Jun.

expressed about Special Permit whaling programmes have been addressed. This statement is included as Annex P3. Other members opposed this view and their statement is included as Annex P4.

17.5 Review of new or continuing proposals

17.5.1 JARPA II

Japan reported that there was no plan to change the JARPA II programme.

17.5.2 JARPN II

Japan reported that there was no plan to change the JARPN II programme.

18. WHALE SANCTUARIES

There were no new proposals for IWC Sanctuaries this year. The Committee **agrees** to keep this item on the Agenda. General matters relevant to marine protected areas were dealt with by relevant sub-groups (and see Item 4.7).

19. SOUTHERN OCEAN RESEARCH PARTNERSHIP (SORP)

SC/65a/SH25 reported on a Southern Ocean Research Partnership (SORP) meeting (31 May-2 June 2013, Jeju, South Korea). The aims of the conference were to: (1) present the scientific results from the five ongoing SORP research projects; (2) update the existing project plans and discuss new research proposals (refer to Annex 1 of SC/65a/SH25rev for details of these plans); and (3) make recommendations for the continuation and development of the SORP.

The SORP meeting made key recommendations in relation to the SORP initiative:

(1) to ensure all SORP Partners are seeking funding from all suitable sources to ensure the five existing SORP research projects are resourced adequately;
(2) to improve communication with the Commission on SORP-related outcomes to ensure that they are aware of the scientific products and to encourage financial support;
(3) to improve the dissemination of information on SORP projects and initiatives;
(4) for SORP Partners to encourage all platforms of opportunity and, where applicable, citizen science, to collect data for inclusion in SORP research projects, thereby reducing the logistic constraints of circumpolar coverage and overall expenditure;
(5) that all data and samples collected from international, collaborative research efforts such as SORP are stored and archived in recognised central repositories; and
(6) that the holders of large, long-term datasets that contain valuable information relevant to SORP, particularly acoustic data, should be strongly encouraged to analyse and publish these data as soon as possible.

The Committee **congratulates** the many scientists engaged in SORP for the significant progress and new information presented to the Scientific Committee. It **endorses** the recommendations above and notes that the scientific results were being integrated into the broader work of the Committee.

The Committee **agrees** that the preliminary objective of the Antarctic blue whale project had now been met; the identification of the most appropriate survey design method. The project has also developed a passive acoustic tracking technique that has ramifications for all future whale surveys in Antarctica. The Committee **agrees** that the data from this SORP project are key to the assessment of the Antarctic blue whale population.

The Committee also **recognises** that the acoustic trends project is extremely ambitious; it will take many years to complete but may be the only way to assess the recovery of fin whales. In time it may become the most efficient way to describe the abundance and distribution of many Antarctic whale species.

The first objectives of the Oceania humpback whale project have been completed through the collaborative analysis of biopsy and photo-identification data and those results are being used in the current assessment of Breeding Stock E humpback whales. The results of SC/65a/SH13 are also informative to this project.

The Committee **agrees** that the collection of data through platforms of opportunity may be a highly effective way to collect data in the remote Southern Ocean.

20. IWC LIST OF RECOGNISED SPECIES

The recent literature in cetacean taxonomy (SC/65a/O01) was reviewed and discussed (see Annex L) and it was agreed to add two newly recognised species to the List. *Inia geoffrensis* has been split into the Amazon river dolphin, *I. geoffrensis* and the newly recognised Bolivian bufeo, *I. boliviensis* (Ruiz-García and Shostell, 2010). *Neophocaena phocaenoides* has been split into the Indo-Pacific finless porpoise, *N. phocaenoides* and the newly recognised narrow-ridged finless porpoise, *N. asiaeorientalis* (Jefferson and Wang, 2011). New analyses based on the cytochrome b gene (SC/65a/SM03) have confirmed the split of the finless porpoises. The Burrunan dolphin *Tursiops australis* was recently described (Charlton-Robb *et al.*, 2011) but its validity is uncertain[30] and the Committee **agrees** to not add it to the List at present, pending further studies. It was noted that the extent of sympatry of the two finless porpoise species (Taiwan Strait) is thought to be small, and further sampling (molecular and morphological) to investigate possible divisions within the two recognised species is encouraged.

The Committee also recalled the open questions remaining about the taxonomy of the Bryde's whale species complex and the holotype of the common minke whale. With respect to the former, the genetic identity of the holotype specimen of *Balaenoptera edeni* remains to be identified; the Committee **reiterates** its previous recommendation that this be done.

21. CONSERVATION MANAGEMENT PLANS

Conservation Management Plans (CMPs) and their role in the IWC was first discussed by the Committee in 2008 (IWC, 2009b, p.70). A key feature of CMPs is that they provide a framework for international collaboration to address threats to populations that occur within the waters of more than one country and in offshore waters i.e. they are complementary or supplementary to individual national initiatives.

The IWC has identified some key components of CMPs (see IWC/63/CC5). These are as follows.

(1) The focus should be on practical and achievable actions (including protection for critical habitats) that have the greatest chance of resulting in improved conservation status; actions fall broadly under a number of headings (co-ordination, research, monitoring, public awareness, mitigation) all of which must be driven by the need for positive conservation outcomes.
(2) CMPs are living documents that are to be reviewed periodically against measureable milestones based on monitoring, assessment, and compliance with agreed measures.
(3) CMPs are designed to complement existing measures (e.g. national recovery plans or other national or regionally agreed measures) not to replace them; in particular they can fill identified gaps given the geographical and seasonal range of the populations involved. IWC involvement can *inter alia* bring in additional range state support, the involvement of other IGOs and scientific/technical expertise.

The approach for identifying populations for which CMPs can be developed will depend on the level of information that is available on abundance, status and threats. In addition, CMPs will only be effective where there are identified threats that are practicable to address. If management measures to address threats are already being taken by the range states involved, or if there is only one range state, then there may be little additional benefit in coordinated action through a CMP. In addition, the IWC will need to give consideration as to how CMPs might interact with other efforts such as that of the Convention on Biological Diversity for defining 'Ecologically or Biologically Significant Areas (EBSAs)' or regional agreements such as ACCOBAMS.

[30]Society for Marine Mammalogy, Committee on Taxonomy. List of marine mammal species and subspecies. *http://www.marinemammalscience.org* [16 April 2013].

The Committee noted that there were different approaches to identify whether a population that meets at least one of the following criteria (1)-(4) might be considered as a candidate:

(1) population status (i.e. knowledge of where the population is now in relation to its unexploited abundance, with an estimate of future trend) has been assessed and is of concern, and actual or likely human activities that can threaten the population have been identified;
(2) population status has not been assessed but the impacts of human activities are believed by the Committee to be substantial and thus of concern;
(3) present abundance is known and actual or likely human activities that can threaten the population have been identified; and
(4) present abundance and trend are not well known but abundance is believed by the Committee to be small such that any adverse impacts as a result of human activity may be critical.

The approach taken, for example whether the primary motivation is driven by concerns over status or the level of threat, will depend on what data are available. The Committee discussed CMPs during the work of different sub-committees, some of which considered the issue from the perspective of threats while others from the perspective of population status. The Committee **agrees** that the focus for initial discussions this year is on large whales; it is a much larger and more complex task for small cetaceans. The Committee **seeks guidance** from the Commission on whether or not it wishes the Committee to develop a priority list of populations of small cetaceans for which CMPs might be of value. The Committee **recognises** that consultation with range states is an essential first step in developing a CMP.

The Committee **agrees** that those populations with draft CMPs already in place (western gray whales – collaboratively with IUCN; southwest Atlantic population of southern right whales; and southeast Pacific population of southern right whales) remain a high priority for CMPs.

The Committee also identified the populations that could be considered for a CMP if supported by the range states. This list illustrates different examples, including agreement that populations were high priorities for a CMP, populations where their status would merit a CMP but it is difficult to identify practicable conservation measures, and populations where there were different views on whether the conservation status required a CMP.

21.1 Populations considered based on assessments by the Scientific Committee

Arabian Sea humpback whales

This population was first suggested as a possible priority candidate by the Committee in 2010. It is believed to have numbered as few as 82 individuals in 2004 (95% CI 60-111) based on dorsal fin and fluke photo identification work around Oman. No trend information is available and there are few data available from other range states (India, Pakistan, Sri Lanka, with occasional sightings for Iran and Iraq) to be sure to whether this reflects total abundance of the humpback whales in the Arabian Sea or just around Oman. Known and likely threats include entanglement in fishing gear and ship strikes but the full extent of these is unknown.

The Committee **agrees** that the Arabian Sea population remains a high priority for a CMP if support was provided by the range states.

Common minke whales in the coastal waters of China, Japan (especially the west coast) and Republic of Korea
Of the common minke whale populations in the North Pacific considered by the Committee, only common minke whales in the coastal areas of Japan, China and the Republic of Korea might satisfy the guidelines for populations which could be subject to a CMP. China, Republic of Korea, North Korea, Japan, Russian Federation are the range states. Information on the animals in these waters comes primarily from the discussions of stock structure and the modelling work undertaken as part of the RMP *Implementation Review* (Annex D1, item 10). The stock structure issue led to no agreement within the Committee: there are three hypotheses (A, B, C of increasing numbers of stocks or sub-stocks). Stock structure hypothesis C leads to most concern for the 'J-like stocks' and the 'Y-stock'; the high levels of incidental take, in particular, cause substantial projected future decline (see Annex D1). In addition to the stock structure discussions, a major information gap is the poor survey coverage, particularly the sub-areas 5 and 6W.

Despite the uncertainties, some members believed that the results from assessments underlying the *Implementation Simulation Trials* undertaken during the *Implementation Review* were sufficient to warrant consideration of the value of a CMP, given the projected impact of incidental bycatch. Other members believed that it was premature to put this proposal forward given the uncertainty regarding stock structure and the poor survey coverage in some areas.

North Atlantic right whales
The Committee reiterated its concerns over the status of North Atlantic right whales, a small population subject to high levels of human impacts from entanglement and ship strikes. However, the two range states (USA and Canada) are already taking management action and the Committee did not identify any specific ways in which a CMP would assist their conservation efforts.

North Pacific right whales
The Committee noted concern over the small size of this population, particularly in the eastern part of the species' range, and the need for more research to understand distribution, assess threats and identify actions that could be taken to reduce these. It was also noted that the range states for right whales in the North Pacific were the same as for gray whales and so there may be options for integrating North Pacific right whales with the current western gray whale CMP.

21.2 Populations considered based on knowledge of threats

Blue whales in the northern Indian Ocean
The Committee noted that there are no population estimates for blue whales in the northern Indian Ocean but there have been a number of reported ship strikes of blue whales off Sri Lanka. This highlights the urgent need for long-term monitoring of the blue whales in Sri Lankan waters and elsewhere in the northern Indian Ocean. Further assessment is needed on whether this population may benefit from a CMP.

Fin whales in the Mediterranean
This population is Red-Listed as *Vulnerable* by IUCN and is known to be subject to a high level of ship strikes. The IWC and ACCOBAMS have a joint work plan to address ship strikes in the Mediterranean. Further evaluation is required as to whether an IWC CMP would assist in the current work by IWC, ACCOBAMS and range states.

Sperm whales in the Mediterranean
This population is considered as *Endangered* by IUCN and is at risk from driftnet entanglement and ship strikes. As for fin whales in the Mediterranean, further evaluation is required to determine whether an IWC CMP would assist in the current work by IWC, ACCOBAMS and range states.

Other populations that were tentatively considered in some sub-group reports as potentially benefitting from a CMP in the future include: Antarctic blue whales; a small southeast Pacific (Isla de Chiloe) group of blue whales; and a small southeast Pacific group of 'pygmy' fin whales. However, the current information on status and/or threats in these cases was not adequate to support a recommendation at this time. In particular, in the case of these blue whale and fin whale populations, no major threats amenable to practical management action have been identified. The Committee **agrees** that other populations will be re-evaluated for priority listing as additional information becomes available.

Entanglement and ship strikes are the highest cause of non-deliberate anthropogenic mortalities for large whale populations. In addition to assessments including abundance and status, the Committee has discussed ways of estimating the numbers of entanglement and ship strike mortalities and evaluating mitigation measures. The Committee also noted that any population which is known to spend significant time in areas of high entanglement risk or high density shipping may be considered, even with a low number of reports. This is especially true if there is no local stranding network or ship strike reporting infrastructure. The Committee **agrees** that it is not currently in a position to propose any populations for CMPs based only on risk analysis where reporting is very limited.

Once a CMP is developed, the mitigation aspects of measures considered within it will need to be evaluated to assess what risk reduction is expected or being achieved. The Committee therefore **encourages** studies that fill any data gaps regarding ways that entanglement or ships strikes may be reduced, for input into CMPs. This may be in areas where CMPs have already been developed (western gray whales; southwest Atlantic population of southern right whales; and southeast Pacific right whales); are currently under consideration as candidates (Arabian Sea humpback whales) or are high on the list of priority candidates. Recognising that CMPs continue to evolve, the Committee **agrees** that it would welcome requests for further scientific input into existing CMPs.

For ship strikes, the IWC has consultative status to the International Maritime Organization (IMO) and so can assist with IMO involvement. The IMO is responsible for all measures outside of national waters that affect shipping and so an effective dialogue with IMO is critical for all measures related to ship strikes. In addition it was noted that as part of the CMP for the southwest Atlantic population of southern right whales, the range states have agreed to collect information on ship strikes with this species and report them to the IWC.

For entanglements, the IWC has established a large whale entanglement expert advisory group, with members from Australia, Canada, New Zealand, South Africa and the USA, to advise countries on the issue, and has initiated a programme to build capacity in prioritised areas, when requested (IWC, 2013a). In addition, the Committee **recommends** that the Secretariat bring the IWC's most current scientific and mitigation information to the relevant bodies within the FAO.

22. COMPILATION OF AGREED ABUNDANCE ESTIMATES

The Committee has recognised the need for consistency in evaluating abundance estimates across sub-groups, recognising that to some extent 'acceptance' depends on the use to which the estimate is being put. It is also valuable for the Commission to have an updated overview of how many whales there are by broad ocean area. This year the Committee began a process to develop such lists and summaries by placing this as an item on the agendas of the relevant sub-groups. It established an *ad hoc* working group whose report is given as Annex Q.

The Committee **agrees** with the *ad hoc* group that the most appropriate way to make progress on further development of summary tables for both its use and that of the Commission is to establish an intersessional Working Group that will consider doubtful and potentially missing estimates, compile and summarise existing estimates and report to next year's Annual Meeting (Annex R).

The membership of this Working Group should comprise members representative of the Committee's relevant sub-groups and those familiar with methods for estimating abundance. It will also produce a draft strategy for discussion at the next Annual Meeting for a process to ensure:

(a) regular updating of the tables; and
(b) a strategy to ensure consistency of the review of abundance estimates across sub-committees and Working Groups.

The objective is for this group to complete its work and circulate draft tables by the beginning of January 2014.

23. RESEARCH AND WORKSHOP PROPOSALS AND RESULTS

23.1 Review results from previously funded research proposals

Table 7 shows the progress of funded proposals from last year (IWC, 2013c).

23.2 Review Workshop proposals for 2013/14

Table 8 summarises the Workshop proposals agreed at this year's meeting. Detailed information on funding is given under Item 26.

Table 7
Progress on Research Proposals and Workshops funded last year.

Title		Status
(1)	Development of an operating model for West Greenland humpback and bowhead whales	Completed (SC/65a/Rep02)
(2)	Workshop on development of *SLA*s for Greenlandic hunts	Completed (SC/65a/Rep02)
(3)	AWMP developers funds	Used to fund work in SC/65a/AWMP02
(4)	Ship strike database coordinator	Completed (SC/65a/HIM04)
(5)	Right whale survey off South Africa	Completed (SC/65a/BRG10)
(6)	Genomic diversity and phylogenetic relationships among right whales	Not funded
(7)	Photographic matching of gray whales	Completed (SC/65a/BRG04)
(8)	Contribution to the preparation of the State of the Cetacean Environment Report (SOCER)	Completed (SC/65a/E01)
(9)	Pre-meeting Workshop on assessing the impacts of marine debris	Completed (SC/65a/Rep06)
(10)	Develop simulation of Southern Hemisphere minke line transect data	Completed (S/65a/IA15)
(11)	IWC-POWER cruise	Completed (SC/65a/Rep01 and SC/65a/IA8)
(12)	Statistical catch-at-age assessment method for Antarctic minke whales	Completed (SC/65a/IA01)
(13)	'Second' *Implementation Review* Workshop for western North Pacific common minke whales	Completed (SC/65a/Rep04)
(14)	Essential computing for RMP/NPM and AWMP	Completed (Annexes D, D1, AWMP)
(15)	MSYR review Workshop	Completed (SC/65a/Rep05)
(16)	Review and guidelines for model-based and design-based line transect abundance estimates	Postponed until this year
(17)	Modelling of Southern Hemisphere humpback whale populations	Completed (SC/65a/SH01 and SC/65a/SH07)
(18)	Antarctic humpback whale catalogue	Completed (SC/65a/SH15)
(19)	Photo matching of Antarctic blue whales	Completed (SC/65a/SH16)
(20)	Southern Hemisphere blue whale catalogue 2012/13	Completed (SC/65a/SH23)
(21)	Expert workshop for review of Iceland's Special Permit programme	Completed (SC/65a/Rep03)
(22)	Whalewatching guidelines and operator training in Oman	Completed

Table 8
Summary of proposed Workshops and pre-meetings.

Subject	Annex	Dates	Venue
IWC-POWER Technical Advisory Group meeting	Annex G	September 29-30	Tokyo, Japan
IWC-POWER planning meeting for the 2014 cruise	Annex G	October 2-3	Tokyo, Japan
Oman whalewatching Workshop	Annex M	October	Oman
IWC/IQOE soundscape Workshop	Annex K	'Winter'	The Netherlands
Workshop on developing *SLA*s for the Greenland hunts	Annex E	Early January (*)	Copenhagen, Denmark
Workshop on the North Atlantic fin whale *Implementation Review*	Annex D	Early January	Copenhagen, Denmark
International gray whale Workshop on stock structure and status	Annex F	March/April	TBD
Workshop on the problem of kelp gulls and southern right whales	Annex F	April	Puerto Madryn, Argentina
AWMP/RMP North Atlantic minke whale stock structure	Annex D, E	April	CPH (or Bergen)
JARPA II review	Annex P	Late February	Japan
North Atlantic common minke whale *Implementation Review*	Annex D	Pre-meeting (3days)	TBD
Southern Hemisphere humpback whale assessment	Annex H	Pre-meeting (2days)	TBD

24. COMMITTEE PRIORITIES AND INITIAL AGENDA FOR THE 2014 MEETING

The Committee **notes** that the Commission's decision to move to biennial meetings means that it will need to develop a two-year proposed work plan at next year's meeting. The Committee **agrees** the following priorities below based on consideration in the plenary of the recommended work plans of the sub-committees and working groups. In addition, all relevant sub-groups will continue to consider updated abundance estimates and CMPs. Given its workload, the Committee **stresses** that papers considering anything other than priority topics will not be addressed at next year's meeting. The new online system for submitting papers will be updated during the year such that Convenors will be notified directly when papers are submitted for their sub-group; they may then contact authors directly if they believe that the papers are unlikely to be discussed.

Revised Management Procedure (RMP)

The following issues are high priority topics.

General issues

(1) Finalise the approach for evaluating proposed amendments to the *CLA*;
(2) evaluate the Norwegian proposal for amending the RMP;
(3) update the requirements and guidelines for conducting surveys to reflect considerations related to model-based methods for abundance estimation;
(4) specify how to deal with imbalanced sex ratios in incidental catches under the RMP;
(5) develop guidelines for handling situations in which survey coverage in time-series of abundance estimates changes over time; and
(6) consider the use of surveys carried out in different months in the *Implementation* process and in actual implementation of the RMP.

Implementation-*related issues*

(1) Finalise work on western North Pacific common minke whales:
    (a) review results from 'hybrid' variants with respect to variants with research;
    (b) review any research proposals with respect to variants with research; and
    (c) agree estimates of abundance for use in actual applications of the RMP;
(2) complete the *Implementation Review* for the North Atlantic fin whales;
(3) begin preparations for a focused basin-wide stock structure study for North Atlantic fin whales to be completed in time to inform the next *Implementation Review*;
(4) start an *Implementation Review* for the North Atlantic minke whales beginning with a three day pre-meeting (Convenor: Walløe) including review report of the joint AWMP/RMP Workshop on the stock structure of common minke whales;
(5) review the information available for North Atlantic sei whales in the context of a *pre-Implementation assessment*; and
(6) review new information on western North Pacific Bryde's whales.

Aboriginal Whaling Management Procedure (AWMP)

The following issues are high priority topics.

(1) Participate in the North Atlantic fin whale RMP process and review the implications of this for *SLA* development for the Greenland hunt;
(2) hold joint AWMP/RMP Workshop on the stock structure of common minke whales in the North Atlantic;
(3) submit need envelopes for West Greenland fin and common minke whales;
(4) finalise the trials for the West Greenland humpback and bowhead whales (including coding) to allow developers to work intersessionally. Ensure that standard software is available to produce agreed performance statistics, as well as tabular and graphical output;
(5) present overview of photo-identification work with respect to movements to inform stock structure and human induced mortality outside West Greenland;
(6) finalise removals series including consideration of human-induced mortality outside the West Greenland area;
(7) continue initial exploration of potential *SLA*s for the Greenland humpback and bowhead whale hunts; and
(8) produce a full report on the Greenlandic conversion factor programme.

Bowhead, right and gray whales (BRG)

The following issues are high priority topics.

(1) Review report from Workshop on the rangewide review of the population structure and status of North Pacific gray whales;
(2) perform the annual review of catch information and new scientific information for the B-C-B stock of bowhead whales;
(3) perform the annual review of catch information and new scientific information for eastern gray whales;
(4) review any new information on all stocks of right whales, especially results of assessments for southern right whales and the kelp gull Workshop; and
(5) review any other new information on western North Pacific gray whales and other stocks of bowhead whales.

In-depth assessment (IA)

The following issues are high priority topics.

(1) Further investigation and application of the SCAA models;
(2) further work examining the factors which drive Antarctic minke whale distribution and abundance;
(3) complete preparations for an in-depth assessment on North Pacific sei whales, specifically:
    (a) update the IWC catch data to include new data from Canadian and Soviet catches; and
    (b) analyse available survey and genetic data from the North Pacific, including from the IWC-POWER surveys;
(4) investigate the distribution and density of baleen and toothed whales in the Antarctic relative to spatial and environmental covariates;
(5) plan and undertake the 5th IWC-POWER survey in the North Pacific; and
(6) plan the next phase of the POWER cruises in the light of the Technical Advisory Group report.

Non-deliberate human-induced mortality (HIM)

The following issues are high priority topics.

(1) Review progress in including information in National Progress Reports;
(2) entanglement;

(3) ship strikes;
(4) review of information on other sources of non-deliberate human induced mortality; and
(5) develop five year plan for suggestions for priority work by the Committee to estimate and address non-deliberate human-induced mortality; review work of intersessional group.

Stock definition (SD)
The following issues are high priority topics.
(1) Genetic analysis guidelines;
(2) stock definition terminology;
(3) statistical and genetic issues concerning stock definition;
(4) testing of spatial structure models (develop new terms of reference); and
(5) providing advice to sub-groups as appropriate.

DNA
The following issues are high priority topics.
(1) Review genetic methods for species, stocks and individual identifications;
(2) review of results of the 'amendments' work on sequences deposited in *GenBank*;
(3) examine the technical information relevant to the TORs of the Group;
(4) collection and archiving of tissue samples from catches and bycatch; and
(5) reference databases and standard for diagnostic DNA registries.

Environmental concerns (E)
The following issues are high priority topics.
(1) SOCER;
(2) pollution (including POLLUTION 2020);
(3) Cetacean Emerging and Resurging Diseases (CERD) and mortality events;
(4) effects of anthropogenic sound on cetaceans and approaches to mitigate these effects (including the results of the intersessional joint Workshop);
(5) climate change;
(6) other habitat related issues including the report of the Conservation Committee's Workshop on marine debris; and
(7) Conservation Management Plans.

Ecosystem modelling (EM)
The following issues are high priority topics.
(1) Review ecosystem modelling efforts undertaken outside the IWC (competition and environmental variability);
(2) explore how ecosystem models contribute to developing scenarios for simulation testing of the RMP (linking individual based models to the RMP); and
(3) review other issues relevant to ecosystem modelling within the Committee.

Southern Hemisphere whales other than Antarctic minke whales and right whales (SH)
The following issues are high priority topics.
(1) Complete assessment of Breeding Stocks D/E/F humpback whales - this will complete the Comprehensive Assessment of Southern Hemisphere humpback whales;
(2) review new information on Southern Hemisphere blue whales in preparation for assessment;
(3) consider the feasibility of undertaking a future assessment of sperm whales; and
(4) Arabian Sea humpback whales.

Small cetaceans (SM)
The following issues are high priority topics.
(1) Voluntary funds for small cetacean conservation research;
(2) review of small cetaceans in the eastern Mediterranean and Red Seas; and
(3) progress on previous recommendations.

Whalewatching (WW)
The following issues are high priority topics.
(1) Assess the impacts of whalewatching on the physiology, behaviour, and fitness of cetaceans (individuals and populations) and their habitats;
(2) review reports from Intersessional Working Groups;
(3) review progress on Five-Year Strategic Plan for Whalewatching;
(4) review whalewatching in the region of the next meeting;
(5) consider information from platforms of opportunity of potential value to the Scientific Committee;
(6) review whalewatching guidelines and regulations; and
(7) consider emerging whalewatching industries of concern.

Scientific Permits (SP)
The following issues are high-priority topics.
(1) Review results of specialist JARPA II meeting;
(2) review of activities under existing permits; and
(3) review of new or continuing proposals.

25. DATA PROCESSING AND COMPUTING NEEDS FOR 2013/14

Allison reported on the computing needs and requirements identified for the forthcoming year. These are summarised in Table 9.

26. FUNDING REQUIREMENTS FOR 2013/14

This year, the sub-groups of the Committee's recommended projects for funding greatly exceeded (>£180,000) the allocated funding by the Commission within the two-year budget (Table 10). Reducing the budget to within the Commission's allocation was therefore a much greater task than is usually the case. For example, last year the full budget request was less than £24,000 over the available budget. The Scientific Committee's handbook states that one of the tasks for a Convenor is:

> 'f. 'To develop with other members of the Convenors' Group a prioritised list for funding that should to be made available to the full Committee at least by 6pm on the penultimate day of the Scientific Committee Annual Meeting.'

Given the difficult situation this year, the Convenors circulated to the Committee the full budget request and the full background information on the 13 June i.e. two days before the close of the meeting, before it had managed to meet to discuss a 'prioritised list' for circulation.

After a suggested budget had been developed on the afternoon of 14 June but before a document including the suggestions and rationale could be circulated to the full Committee, it was agreed to hold a Heads of Delegation meeting in the late afternoon of 14 June; this was followed by another on the morning of 15 June. During the second meeting, it was agreed that the option for a reduced budget

Table 9

Computing tasks for the coming year.

Group	Item
RMP	
(1)	Complete final compilation of tables and plots from the *Implementation Review* of North Pacific minke whales.
(2)	Run hybrid trials (variants with research) of North Pacific minke whales as required.
(3)	Redo conditioning and rerun existing trials of North Atlantic fin whales.
(4)	Other work related to the *Implementation Review* of North Atlantic fin whales (e.g. revision of the control program; conditioning and running of final trials to be specified by the intersessional Workshop (Annex D, Appendix 2).
(5)	Run a full set of trials for western North Pacific Bryde's whales and North Atlantic minke whales using the Norwegian version of the *CLA* and place the results on the IWC website.
(6)	Work with the Norwegian Computing Centre to standardise the Norwegian catch limit program code (Annex D, item 2.4).
(7)	Work to specify and run additional trials for testing amendments to the *CLA* (Annex D, item 2.2).
AWMP	
(1)	Finalise the catch and other removals series for use in trials including ship strikes and other human induced mortality outside West Greenland and data from Canada (see Annex E, item 3.2 and 3.3).
(2)	Work on the control program for the West Greenland humpback and bowhead whales (see Annex E, item 3.2 and 3.3).
IN-DEPTH ASSESSMENT	
(1)	Prepare catch series for North Pacific sei whales including inclusion of revised Canadian catch data and new analysis of Soviet North Pacific catch records to extent possible in time available, noting any discrepancies (see Annex G, item 5.1).
(2)	Validation of the POWER cruise data and work towards standard IDCR/SOWER dataset (see Annex G, item 5.3).
(3)	Complete validation of the 1995-97 blue whale cruise data and incorporate into the DESS database (carried over).
(4)	Eliminate discrepancies between the IWC individual catch data for Antarctic minke whales and the Japanese special permit data held by scientists.
BRG	
(1)	Update the catch series for North Pacific gray whales (Annex F).

developed by the Convenors should be submitted to the full Committee, noting that it had been seen by the Heads of Delegations but that there had been insufficient time for them to fully review it. In doing so, it was recognised that the Convenors had given full consideration to the reduced budget; the revised budget discussion document was annotated with comments made by individual Heads of Delegations.

The Committee **agrees** that it is important to consider possible new systems for future budget allocations; it will add this topic to its agenda next year. In this regard it also noted the need to develop a two-year budget request next year. The Heads of Delegations **requested** that the Secretary review the governance rules, procedures and practices of the Scientific Committees of the other intergovernmental organisations and report back to the Scientific Committee in 2014 in order to assist discussions of the working methods of the Committee. They also requested a more substantial role in Committee governance. Recognising that these are funds provided by the Commission, the Committee **agrees** that *inter alia* Heads of Delegations should play a substantial role in discussions of how the budget should be allocated in future. Convenors should continue to play an important role since they are familiar with the research needs and priorities of each sub-group. The advice of the Commission will also be sought on both the process and its priorities.

As noted above, trying to balance the budget this year was an extremely difficult task. The approach taken by the Convenors for the discussion document is summarised below.

Check the feasibility of voluntary reductions

Each budget line was examined to see if any proposal could be lowered (based on the knowledge of single projects, discussions with proposers where possible or discussions within the sub-committee itself) e.g. by reducing the number of participants to workshops/meetings, finding external funders (for research, workshops or participants), removing part of the research programme, etc.

Checking the feasibility of projects' postponement, in the light of the sub-group priorities

In some cases the amount was either lowered or cut, according to the feasibility to defer some work by one year.

Final cuts based on the strength of recommendations in sub-group reports and an assessment by all Convenors of overall Committee priorities

This was by far the most difficult part of the process, given a remaining overrun of more £100,000.

Table 10 summarises the complete list of recommendations for funding made by the Committee as well as the reduced budget developed in light of the known available funding. The Committee **recommends** all of these proposals to the Commission. In **recommending** its reduced budget, the Committee **stresses** that projects for which it has had to suggest reduced or no funding are still important and valuable.

(1) AWMP-1 INTERSESSIONAL WORKSHOP ON DEVELOPING *SLA*S FOR THE GREENLAND HUNTS

The Committee has identified completion of the development of long-term *SLA*s for these hunts as high priority work. In order to meet the proposed timeframe, an intersessional Workshop is required. The focus of the proposed Workshop is to: (1) to review the results of the developers of *SLA*s for humpback whales and bowhead whales; (2) finalise the modelling framework/trial structure for these hunts; (3) develop a workplan to try to enable completion of work on *SLA*s for these two hunts at the 2014 Annual Meeting; and (4) consider possible input (e.g. using AWMP/RMP-lite) for the joint AWMP/RMP Workshop on North Atlantic common minke whale stock structure. The Workshop will be held in early 2014 in Copenhagen, Denmark. It is intended to hold this back-to-back with the RMP Workshop on fin whales to save travel costs given some common participants.

(2) AWMP-2 AWMP DEVELOPERS' FUND

The developers fund has been invaluable in the work of *SLA* development and related essential tasks of the SWG. It has been agreed as a standing fund by the Commission.

Table 10

Budget requests (see text). Note that the Committee's agreement on the Small Cetacean Conservation Research Fund is given under Item 14.2. Asterisks indicate alternative funding has been found.

Number	Summary of item	Plenary Agenda Item, Annex item	Full cost (£)	Reduced budget (£)
AWMP-1	AWMP Intersessional Workshop on developing *SLA*s for the Greenlandic hunts	Item 8.3. Annex E, item 9.2	8,000	8,000
AWMP-2	AWMP developers fund	Item 8.3. Annex E, item 9.2	7,000	7,000
BRG/AWMP/SD-1	Gray whale rangewide Workshop	Items 8.1.2, 9.2.1, 10.5.3, 11. Annexes E, F and I	15,000	10,000
BRG-1	Southern right whale kelp gull Workshop	Item 10.6.2. Annex F, item 4.4	6,000	6,000
BRG-2	Southern Ocean right whale survey	Item 10.6. Annex F, item 4.1	23,000	*
E-1	State of the Cetacean Environment Report (SOCER)	Item 12.1. Annex K, item 6	5,000	4,000
E-2	POLLUTION 2020	Item 12.2.1. Annex K, item 7.1	27,000	20,000
E-3	Complete implementation of the CERD website	Item 12.3.2. Annex K, item 8.2	5,000	4,000
E-4	Joint IWC/IQOE Workshop predicting soundfields-global soundscape modelling	Item 12.4.2. Annex K, item 9.2	26,900	19,700
E-5	2nd phase Workshop on marine debris	Item 7.5.1. Annex K, item 11.2	5,000	*
HIM-1	Ship strike data coordinator	Item 7.4. Annex J, item 8.1	10,000	8,000
HIM-2	Bryde's whale abundance, distribution and risk of ship strike in the Hauraki Gulf	Item 7.4.3. Annex J, item 8.3	27,1	0,000
IA-1	Satellite tagging of Antarctic minke whales to provide information on breeding grounds, habitat utilisation and availability bias	Item 10.1.2. Annex G, item 8	69,500	0,000
IA-2	Statistical catch-at-age issues for further investigation	Item 10.1.3. Annex G, item 2.1	12,500	12,500
IA-3	2014 IWC-POWER North Pacific survey	Item 10.12.1 Annex G, item 3.3	62,600	58,600
RMP-1	Intersessional Workshop on North Atlantic fin whales	Items 6.2.1, 8.3.1. Annex D, item 5	4,000	4,000
RMP-2	Pre-meeting on North Atlantic minke *Implementation Review*	Item 6.3.2. Annex D, item 3.2	2,000	2,000
RMP/AWMP/SD	Simulations to evaluate power and precision of genetic clustering at critical [demographic] dispersal rates	Items 6.3.2, 8.3.1. Annex D, Appendix 3, adjunct 2	15,000	15,000
RMP/AWMP-1	Joint AWMP-RMP Workshop on stock structure hypotheses for North Atlantic minke whales	Items 6.3.2, 8.3.1. Annex D, item 3.2	10,000	10,000
RMP/AWMP-2	Computing support for RMP and AWMP	Item 22. Annexes D and E	8,000	4,000
SH-1	Minimum abundance estimates of Breeding Stock D humpback whales from Western Australian aerial surveys	Item 10.2.1.2. Annex H, item 3.1	4,000	4,000
SH-2	Modelling work to complete assessments of Breeding Stocks D, E and F	Item 10.2.1.1. Annex H, item 3.1	3,000	3,000
SH-3	Antarctic Humpback Whale Catalogue	Item 10.2.4. Annex H, item 3.4	15,000	10,000
SH-4	Comparison of photographs from JARPA II to the Antarctic Blue Whale Catalogue	Item 10.3.1.4. Annex H, item 5.1.4	7,500	5,000
SH-5	Southern Hemisphere Blue Whale Catalogue 2012/13	Item 10.3.1.4. Annex H, item 5.1.4	15,000	5,000
SH-6	Pre-meeting Workshop to complete the assessment of humpback whale Breeding Stocks D/E/F	Item 10.2.1. Annex H, item 3.1	7,000	7,000
SP-1	Expert Workshop to review JARPA II	Item 17.3. Annex P, item 7.3	30,000	25,000
IPs	IPs	All	64,000	64,000
Total			**498,000**	**315,800**

The primary development tasks facing the SWG are for the Greenlandic fisheries. These tasks are of high priority to the Committee and the Commission. The fund is essential to allow developers to work and thus allow progress to be made.

(3) BRG/AWMP/SD RANGEWIDE GRAY WHALE WORKSHOP ON STOCK STRUCTURE AND STATUS

Recent information has led to the need for a reappraisal of the population structure and movements of North Pacific gray whales. Sufficient new information exists to justify an international Workshop dedicated to developing new models to evaluate the question of North Pacific gray whale stock structure, and to better assess the potential impact of human activities on the status and develop appropriate strategies and mitigation measures. It will also suggested revisions to the background information sections of CMP. The issue has been an important part of discussions in AWMP, BRG, SD and is also relevant to CMPs and it is hoped the results will inform discussions at the 2014 Commission Meeting. The funding is for eight Invited Participants.

(4) BRG-1 SOUTHERN RIGHT WHALE KELP GULL WORKSHOP

The mass mortality of southern right whale calves has been an important issue for the Committee. This year, the Committee expressed concern and recommended that investigation of the causes of this mortality, and actions to reduce the risk of gull attacks on southern right whales at Península Valdés should be further developed and implemented. This is also a high priority action for the CMP.

(5) BRG-2 SOUTHERN RIGHT WHALE SURVEY

After consultation with the proposer this was reduced to zero as outside funding is expected.

(6) E-1 SOCER REPORT

SOCER is a long-standing effort to provide information to Commissioners and Committee members on environmental matters that affect cetaceans in response to several Commission resolutions. Funds are for salaries, library services, and printing.

(7) E-2 POLLUTION 2020

POLLUTION 2000+ has been a flagship programme of the Committee and the Commission has supported it and continued work on pollution in several Resolutions. POLLUTION 2020 is in effect Phase III of POLLUTON 2000+ and has two main priority areas of research; the toxicity of microplastics and the impact of polyaromatic hydrocarbons on cetaceans.

(8) E-3 COMPLETE IMPLEMENTATION OF CERD WEBSITE

The CERD website is being developed in two phases. The first phase focuses on large cetacean species and relies on a 'consultation and sharing' approach. The second phase is intended to include all cetacean species and incorporate a potential 'reporting' role. This website will have 'public' and 'registered user' levels. The public level will provide basic information on diseases in cetaceans, as well as access to selected discussion forum content. Registered users will have full access to the site, including in-depth information on cetacean disease, as well as to discussion forums and posting ability. Links will be provided for quick access to discussion boards that can be shared with groups focused on other topics such as pollution, ship strikes and marine debris.

(9) E-4 JOINT IWC/IQOE ACOUSTIC WORKSHOP

This is a co-sponsored Workshop dealing with global soundscape modeling to inform management of cetaceans and anthropogenic noise. Noise has been an important topic for the Committee since a 2004 Workshop. An increasing number of scientific efforts (International Quiet Ocean Experiment (IQOE), US's National Oceanic and Atmospheric Administration CetSound effort) directed at this topic reflect this broader scope. In September 2011, the IQOE held an open science planning meeting where research into soundscape characterisation and modelling were identified as one of the four key themes to be contained in the IQOE's draft Science Plan. This proposal for a joint IWC/IQOE Workshop will work to expand these tools and their application to a more global scale where they can be used to inform management of potential impacts on cetaceans.

(10) E-5 FUNDING FOR INVITED PARTICIPANTS FOR THE 2ND PHASE WORKSHOP ON MARINE DEBRIS

The Committee is working on this issue with the Conservation Committee. The first Workshop has taken place and the second is due. This is a high priority issue. The money (£5,000) was for two SC participants at the 2nd Workshop. The funds are available from an alternative source.

(11) HIM-1 SHIP STRIKE DATA COORDINATOR

The ongoing development of the IWC ship strike database requires data gathering, communication with potential data providers and data management. Co-ordinators were appointed last year and HIM agreed this should continue and a list of tasks was developed. It relates directly to the Commission's Conservation Committee Working Group on the topic.

(12) HIM-2 BRYDE'S WHALE ABUNDANCE, DISTRIBUTION AND RISK OF SHIP-STRIKE IN THE HAURAKI GULF

This money was requested to partially fund an aerial survey to estimate abundance of a small stock of Bryde's whales around New Zealand where the number of ship strikes has been giving cause for possible conservation concern.

(13) IA-1 DETERMINATION OF BREEDING GROUNDS, HABITAT UTILISATION AND AVAILABILITY BIAS IN ANTARCTIC MINKE WHALES

Habitat utilisation, location of breeding grounds and diving behaviour of Antarctic minke whales represent major data gaps in the Committee's knowledge in relation to four major issues. Research reported in SC/65a/IA12 has demonstrated that the deployment of these types of tags is practical and efficient and can provide a great deal of valuable data. Tags are intended to be deployed in the Ross Sea in December 2013/January 2014. One researcher has a pending research proposal with the US NSF that would provide ship time for tag deployment later in 2014-15 in the Ross Sea. The cost is for 15 Splash MK10A Satellite-linked time-depth recording LIMPET tags (location and dive data) 10 Spot 5 Satellite-linked LIMPET Tags (location only data).

(14) IA-2 DISTRIBUTION OF BALEEN AND TOOTHED WHALES RELATIVE TO SPATIAL AND ENVIRONMENTAL COVARIATES

This was reduced to zero as alternative funding was found.

(15) IA-3 STATISTICAL CATCH-AT-AGE (SCAA) ISSUES FOR FURTHER INVESTIGATION

This approach is one that has been guided and funded by the Committee for several years. The SCAA can be used to evaluate various hypotheses regarding the dynamics of Antarctic minke whales, such as whether growth and carrying capacity have changed. The Committee has identified where further work might solidify some of the conclusions, and a number of detailed technical suggestions were made by the Committee. This proposal addresses the main remaining suggestions made. The Committee also suggested that work be made available for the JARPA II review. The funds will allow the recommended analytical work to be completed.

(16) IA-4 2014 IWC-POWER NORTH PACIFIC SURVEY

The Committee has strongly advocated the development of an international medium- to long-term research programme involving sighting surveys to provide information for assessment, conservation and management of cetaceans in the North Pacific, including areas that have not been surveyed for decades. The Committee developed objectives for the overall plan and this will fund the final leg of the initial phase. The money is for: (1) IWC researchers and equipment as the vessel is provided free by Japan; (2) to allow the Committee's Technical Advisory Group to meet to review the multi-year results thus far and develop the plans for the next phase of POWER based on the results obtained from Phase I; and (3) to enable analyses to completed price to the 2014 Annual Meeting.

(17) RMP-1 INTERSESSIONAL RMP WORKSHOP ON NORTH ATLANTIC FIN WHALES

The objective of this short Workshop is to review the results of conditioning and trials for North Atlantic fin whales, modify these if necessary and determine an intersessional workplan to ensure that the *Implementation Review* can be completed at the 2014 Annual Meeting. It is also relevant to developing *SLA*s for the Greenland hunt. It will be held back-to-back with the AWMP Workshop to save costs. Costs are for five IPs. This work should allow the *Implementation Review* to be completed in 2014 and greatly assist the work on the AWMP.

(18) RMP-2 PRE-MEETING NORTH ATLANTIC MINKE *IMPLEMENTATION REVIEW*

The Committee has agreed to undertake a full *Implementation Review* of common minke whales in the North Atlantic. This is a large exercise that will build upon discussions at the joint AWMP/RMP Workshop on stock structure. A pre-meeting will maintain progress such that it should be able to be completed within two years.

(19) RMP/AWMP/SD SIMULATIONS TO EVALUATE POWER AND PRECISION OF GENETIC CLUSTERING AT CRITICAL [DEMOGRAPHIC] DISPERSAL RATES

On many occasions the Committee has found that identifying stocks from genetic analyses often yielded ambiguous results because the values of key parameters at which management recommendations change are not defined. Realising that such 'tipping points' are likely to be case specific it has been agreed to use the North Atlantic minke whale as a case study. This study will: (1) conduct demographic simulations under reasonable range of stock hypotheses and management scenarios to determine the dispersal rates such that management performance is acceptable from a conservation point; and (2) the second step is to conduct genetic simulations to assess the ability of genetic clustering methods to robustly determine the number of breeding populations and assign individuals to a breeding population. It will enable similar work to be undertaken for other large whale species of conservation and management concern.

(20) AWMP/RMP-1INTERSESSIONAL JOINT AWMP-RMP MEETING ON STOCK STRUCTURE HYPOTHESES FOR NORTH ATLANTIC MINKE WHALES

This Workshop addresses common issues for AWMP/RMP and will use the work of proposal 19 above. It was discussed and agreed last year. The costs are for eight invited participants.

(21) AWMP/RMP-2 ESSENTIAL COMPUTING FOR RMP AND AWMP

This is to provide assistance to the Secretariat with the large computing tasks it is facing in the coming year.

(22) SH-1 OBTAINING MINIMUM ABUNDANCE ESTIMATES OF BREEDING STOCK D HUMPBACK WHALES FROM WESTERN AUSTRALIAN AERIAL SURVEYS

This work was identified as of great importance if the Assessment of Breeding Stock D is to be completed. The cost is for new analyses of data from western Australian aerial surveys, 1999, 2005 and 2008. The observers' search pattern during these aerial surveys had not followed conventional protocols for conducting aerial surveys. The effect of such search patterns on the estimates is unknown, but sufficient concerns about their effect reduces confidence in the use of the resulting abundance estimates as absolute (rather than relative) estimates within the modelling exercise being undertaken (see next project).

(23) SH-2 MODELLING OF SOUTHERN HEMISPHERE HUMPBACK WHALE POPULATIONS

The project will focus on a combined assessment of humpback breeding stocks D, E1 and Oceania using a three-stock model which allows for mixing on the feeding grounds. Methods used will be based upon the Bayesian methodology as developed and presented for BSC and BSB Comprehensive Assessments recently completed. Exploration of alternative models which may be able to explain the observed data will be explored. These will include models that address anomalies identified regarding the population model fit to data for breeding stock D, and approaches suggested there to account for them, such as use of an environmental variation model and changes in carrying capacity over time.

(24) SH-3 ANTACTIC HUMPBACK WHALE CATALOGUE

The Antarctic Humpback Whale Catalogue collates photo-identification information from Southern Hemisphere humpback whales. Increasing awareness of the project among research organisations, tour operators and other potential contributors has widened the scope of the collection; research efforts in areas that had not previously been sampled have extended the geographic coverage. This catalogue has grown by 25% in the last two years, adding 1,127 new individuals, and increasing the time required to analyse photographs. In addition to these requested IWC funds, additional funds from other sources will be sought.

(25) SH-4 COMPARISON OF ANTARCTIC BLUE WHALE IDENTIFICATION PHOTOGRAPHS FROM JARPA II TO THE ANTARCTIC BW CATALOGUE

This work follows on from previous recommendations and work by the Committee on the assessment of Southern Hemisphere blue whales. It is also be of relevance to the SORP blue whale project. The sighting histories of individual Antarctic blue whales from photo-id provide data for a mark-recapture estimate of abundance as well as information on the movement of individual blue whales within the Antarctic region. The addition of more samples to the collection of Antarctic blue whale identification photographs would be extremely useful for these analyses. A total 380 blue whale identification photographs were collected during JARPA II cruises but need to be compared to the Antarctic Blue Whale Catalogue (305 individuals) and the associated sighting data added to the sighting history database.

(26) SH-5 SOUTHERN HEMISPHERE BLUE WHALE CATALOGUE 2012/13

The Southern Hemisphere Blue Whale Catalogue (SHBWC) is an international collaborative effort to facilitate cross-regional comparison of blue whale photo-identifications catalogues. In 2006, the Committee of the agreed to initiate an in-depth assessment of Southern Hemisphere blue whales and in 2008, it endorsed a proposal to establish the SHBWC. Currently the SHBWC holds photo-identification catalogues of researchers from major areas off Antarctica, Australia, Eastern South Pacific and the Eastern Tropical Pacific. A total of 884 blue whales are catalogued. Results of comparisons among different regions in Southern Hemisphere will improve the understanding of population boundaries, migratory routes and model abundance estimates. In addition, assessment of blue whales and estimates abundance of populations will require improving software capabilities to access encounter histories of individuals.

(27) PRE-MEETING WORKSHOP TO COMPLETE THE ASSESSMENT OF HUMPBACK WHALE BREEDING STOCKS D/E/F

This pre-meeting is required to facilitate the timely completion of the assessment of humpback whales breeding stocks D, E and F (Item 3.1.2). These are the last stocks remaining in the in-depth assessment of Southern Hemisphere humpback whales. The Committee has agreed that this assessment should be completed in SC/65b, as a matter of high priority. The meeting will evaluate the results of intersessional modelling efforts. Costs are for eight Invited Participants.

(28) EXPERT WORKSHOP TO REVIEW JARPA II

The Committee has agreed a procedure for periodic and final reviews of results from Special Permit research (IWC, 2013m). This procedure outlines an intersessional review meeting by an expert panel. The report from the intersessional expert meeting will be reviewed and discussed at the 2014 Scientific Committee Annual Meeting, SC/65b. The experts to the review Workshop will be identified by September 2013 and the expert Workshop will be convened during four days in February/March 2014. The requested funds are for travel for the invited experts. The Committee noted that after discussion at the Commission Meeting last year, a budget for the review of the Icelandic permit was approved.

27. WORKING METHODS OF THE COMMITTEE

27.1 Annual Meetings

Last year (IWC, 2013c, pp.78-9), after considerable discussion of the balance between cost savings and the efficiency of the Committee, it was agreed that primary documents would be distributed only electronically at Scientific Committee meetings thereby making significant cost savings in terms of freight (paper and pigeon holes) and copying (paper, Xeroxing and staff).

This year, the Committee continued to review its procedures both in terms of efficiency and cost savings. As part of this, careful consideration was given as to whether it might be possible to reduce the number of days of the Committee's meetings (e.g. removing the initial reading day from the start of the meeting, removing the rest day, reducing the length of Plenary, reducing the number of sub-committees, reducing sub-committee agendas or having some sub-committees meet only biennially). With its present workload and agenda, the Committee **agrees** that changing the number of days in an already full schedule was not practical at this time. However, it **agrees** to keep this item on its Agenda. In particular, it **agrees** to a trial period of introducing an earlier deadline for paper submission.

At present, authors are requested to submit at least preliminary titles, authors and ideally an abstract about six weeks before the meeting using an online system. Whilst authors are strongly encouraged to submit papers as early as possible, the final deadline is that primary papers must be submitted by the end of the first day of the Annual Meeting. This procedure recognises that participants voluntarily submit papers and most have other responsibilities than the IWC; some papers are also the result of recommendations made by the Committee or intersessional Workshops and are essential to the Committee's progress in a timely fashion. After considerable discussion, the Committee **agrees** to establish a deadline for primary papers as a trial for the 2014 Annual Meeting of seven days before the start of the meeting. In doing so it **agrees** that this has the potential to improve the Committee's efficiency in a number of ways; however, at least as a measure on its own, it will not result in cost savings but will provide information to inform discussions of cost savings next year.

The Committee will review the trial next year in the light of information to be provided on a number of factors to be finalised by the Convenors intersessionally including: improvements to efficiency of Convenors in terms of developing annotated agendas; number of papers available by the deadline; timing of overall submission in the weeks leading up to the meeting; download data; questionnaire to the Committee.

The Committee also agreed to improvements with the National Progress Reports database as discussed under Item 3.2 and Annex O.

27.2 Increasing the support of the Scientific Committee on conservation related issues

The Committee welcomed information that a number of scientists (Galletti Vernazzani, Iñíguez, Luna, Marzari, Peres and Rodríguez-Fonseca) will present next year a review of the Committee's reports, IWC Resolutions and information on population status since 1986. The review will highlight *inter alia* when the Committee has commented/recommended on as scientific matters (when a comment/conclusion is aimed to continue gathering scientific information), whaling management matters (when a comment/conclusion is aimed towards whaling management) and conservation matters (when a comment/conclusion is aimed to call the attention on threats and/or status, or improve the conservation of a species/subspecies/population). The objective of this work is to stimulate discussion within the Committee as to how best to improve communications on conservation matters to the Conservation Committee and Commission, in order to better contribute to the long term survival of cetacean species, sub-species and populations.

The Committee **agrees** that this item will be placed on its Agenda next year.

28. ELECTION OF OFFICERS

This is the first year for both the Chair and the Vice-Chair and so no elections were necessary.

29. PUBLICATIONS

The Committee was pleased to hear that the *Journal of Cetacean Research and Management* was now to become open access and freely available. It **agrees** that the *Supplement* should continue to be available in hard copy for participants given its central role at the meeting. The Committee **re-emphasises** the importance of the *Journal* to its work and **thanks** the Secretariat and the Editorial Board for its work.

30. OTHER BUSINESS

There was no other business.

31. ADOPTION OF REPORT

The completed parts of the report were adopted at 17:10hrs on 15 June 2013. As is customary, those parts that were only discussed on the final afternoon were agreed by the Chair, rapporteur and Convenors. The Chair thanked all of the participants for their co-operative attitude on this his first meeting, the rapporteurs, Secretariat and especially the host government and the hotel for their provision of excellent facilities. The meeting thanked the Chair for his expert and fair handling of the meeting.

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Annex E

Report of the Standing Working Group on Aboriginal Subsistence Whaling Management Procedures

Members: Donovan (Convenor), Allison, Baba, Baulch, Bickham, Brandão, Broker, Brownell, Butterworth, Childerhouse, Chilvers, Cipriano, Collins, Cooke, De Moor, Double, Dupont, Efirmchuk, Elvarsson, Fortuna, Givens, Holloway, Holm, Iñíguez, Kelly, Kim, H., Kitakado, Kock, Lang, Legorreta-Jaramillo, Litovka, Marzari, Nelson, Palsbøll, Perkins, Punt, Reeves, Ritter, Robbins, Roel, Rose, Sakamoto, Scheidat, Scordino, Simmonds, Skaug, Stachowitsch, Suydam, Tajima, Tiedemann, Víkingsson, Vinnikov, Walløe, Waples, Wilson, Witting, Yasokawa, Yoshida.

1. INTRODUCTORY ITEMS

1.1 Convenor's opening remarks
Donovan welcomed the participants to the meeting. He noted that the major part of the work of the SWG this year is to build upon the progress made at the intersessional workshop (SC/65a/Rep02) held in Copenhagen in December 2012 on developing *SLA*s for the Greenlandic hunts, with an initial emphasis on humpback whales and bowhead whales. That Workshop dealt with a number of topics and they are dealt with where appropriate on the SWG's agenda. The SWG will also consider management advice for the hunts of Greenland and St Vincent and The Grenadines.

1.2 Election of Chair
Donovan was elected Chair.

1.4 Appointment of rapporteurs
Givens, Scordino, Butterworth and Punt acted as rapporteurs with assistance from the Chair.

1.5 Adoption of Agenda
The adopted agenda is given as Appendix 1.

1.6 Documents available
The new primary documents available to the SWG were SC/65a/AWMP01-07.

2. GRAY WHALES WITH EMPHASIS ON THE PCFG (PACIFIC COAST FEEDING GROUP)

2.1 Report of intersessional Workshop (SC/65a/Rep02)
In 2010, the Committee agreed that PCFG (Pacific Coast Feeding Group) whales should be treated as a separate management unit. PCFG whales are defined as gray whales observed (i.e. photographed) in multiple years between 1 June and 30 November in the PCFG area (IWC, 2011a, p.22). Not all whales seen within the PCFG area at this time will be PCFG whales and some PCFG whales will be found outside the PCFG area at various times during the year. The Makah tribe would like to take gray whales in the Makah usual and accustomed fishing grounds (U&A) in the future and the objective of the *SLA*s they proposed is to minimise the risk to the PCFG whales and meet the Commission's conservation objectives. An important component of this is to restrict hunting to the migratory season, i.e. prior to 1 June. The Committee began the evaluation process in 2011.

Last year, the Committee had agreed that two *SLA* variants (one with research provisions) met the conservation objectives of the Commission (IWC, 2013b, p.19). *SLA* variant 1 proposed that struck-and-lost whales did not count towards the APL (the 'allowable PCFG limit' – a protection level) i.e. there is no management response to PCFG whales struck but not landed. *SLA* variant 2 proposed that all struck-and-lost whales counted to the APL irrespective of hunting month, i.e. the number of whales counted towards the APL may exceed the actual number of PCFG whales struck. However, the Committee also noted that the two variants did not exactly mimic the proposed hunt and expressed concern that the actual conservation outcome of the proposed hunt had not been fully tested. The reason for this relates to how strikes in May are treated in *SLA* calculations. In the variants, the APL is adjusted to account for how many whales the Makah hunting plan would permit in May.

The two tested *SLA* variants bracketed the possible Makah hunting plans, assuming either 7 or 0 strikes in May for Variants 1 and 2, respectively. The Committee had approved Variant 2 but had stated that Variant 1 only met the Commission's conservation objectives if it was accompanied by a specific annual research programme (i.e. a photo-identification programme to monitor the relative probability of harvesting PCFG whales, the results of which are presented to the Scientific Committee for evaluation each year).

Donovan summarised progress made during the intersessional Workshop (SC/65a/Rep02). There are insufficient data to determine the proportion of strikes that would occur in May or prior to May, and the Workshop agreed to test six new variants to cover the full range of possible strikes occurring in May or prior to May, i.e. variants allowing x strikes prior to May where $x = 1,\ldots,6$. In particular, it had recommended that the full set of trials be repeated for these six variants (in addition to the two *SLA*s agreed by the Committee last year).

The Workshop also recommended that the photo-id catalogue for the eastern North Pacific gray whales (that will be used to assess whether landed whales are from the PCFG) be made publicly available as it is a key component of the management approach. It was pleased to be informed that funding is available to digitise the catalogue. Weller informed the SWG that NOAA still has funds available to digitise the catalogue of PCFG whales. Scordino noted that work is underway to compile photographs from a few key contributors for a photo catalogue of PCFG whales to be held at NOAA's National Marine Mammal Laboratory; this catalogue, at least initially, will not be publicly available.

2.2 New information and results
2.2.1 Further evaluation of proposed Makah Hunt
SC/65a/AWMP06 presented trial results for the six *SLA* variants discussed above. By examining the final depletion statistic for all evaluation and robustness trials for the six new *SLA* variants and Variants 1 and 2 used in the 2012 *Implementation Review*, the authors concluded that:

(1) the conservation performance of the new variants was intermediate between Variant 1 and Variant 2;
(2) there is not a uniform, linear increase in conservation performance caused by reducing the maximum number of strikes that occur prior to May;
(3) there is a point of saturation at which increasing the number of strikes prior to May does not lead to a decrease in conservation performance; and
(4) the results show that conservation performance changes as would be expected.

In summary, the performance of all the new variants was no worse than for Variant 1 and no better than for Variant 2. These conclusions also hold true for other conservation performance statistics examined.

The SWG thanked the authors for their work. The SWG recalled that the research requirement for Variant 1 had been imposed because its conservation performance was inferior to that of Variant 2 on a small number of trials. The SWG **agreed** that the newly tested *SLA*s performed acceptably and met the Commission's conservation objectives provided that they, like Variant 1, are accompanied by a photo-identification programme to monitor the relative probability of harvesting PCFG whales which is undertaken each year and the results presented to the Scientific Committee for evaluation.

SC/65a/AWMP03 presented an update on the availability of PCFG whales in the Makah U&A based on photo-identification surveys. With data collected from 1984 to 2011, strong evidence was found for PCFG whales being more available in the Strait of Juan de Fuca (56% of whales observed being PCFG whales) as compared to the Pacific Ocean (31%). This difference is statistically significant (Fisher's exact test, $p<0.01$). This finding supports the Makah Tribe's proposed prohibition of hunting in the Strait of Juan de Fuca. No significant differences were found for comparisons of the availability of PCFG whales by month in the Pacific Ocean. The updated availability of PCFG gray whales in Pacific Ocean waters of the Makah U&A presented in this paper was not appreciably different to the 30% availability used in the 2012 *Implementation Review*.

The SWG **welcomed** this update. It noted that the research program to monitor the availability of PCFG whales has the added benefit of collecting data that aids the assessment of risk that the Makah hunt would strike a whale identified in the western North Pacific (WNP) that has migrated to the US west coast discussed below. In response to the discussion, Scordino **agreed** to examine the possibility of trends in the data and include it in an updated paper for next year's meeting.

As noted last year (IWC, 2013b, p.20), observations of gray whales identified in the WNP migrating to areas off the coast of North America (Alaska to Mexico) raise concern about placing the WNP population at potential risk of being harmed or killed accidentally in the proposed Makah hunt. It was noted that the research programme to monitor the availability of PCFG whales has the added benefit of collecting data that aids the assessment of risk that the Makah hunt would strike a whale identified in the WNP that has migrated to the US west coast.

Given the ongoing concern about status of the gray whales in the WNP, in 2011 the Scientific Committee emphasised the need to estimate the probability of a western gray whale being killed during aboriginal gray whale hunts (IWC, 2012). Additionally, in the USA it is required that NOAA prepare an Environmental Impact Statement (EIS) pertaining to the Makah's request for a waiver under the US Marine Mammal Protection Act (MMPA) in order to hunt gray whales. The EIS will include an estimate of the likelihood of Makah hunters approaching, pursuing, and attempting to strike a WNP gray whale in addition to the likelihood of actual strikes (assumed to result in death or serious injury).

Moore and Weller (2013) estimated the probability that one or more whales identified in the WNP might be killed during the hunt proposed by the Makah Indian Tribe. This analysis updated the analysis of mortality risk provided to last year in Moore and Weller (2012) by incorporating Committee from feedback last year's meeting (IWC, 2013b, p.20). The probability of striking or taking a WNP gray whale during the proposed Makah hunt was estimated using four different sets of models (six models in total). The author's 'most plausible' model uses all available information and includes the least number of assumptions. Based on this model, the probability of striking at least one WNP gray whale in a single season ranged from 0.007 to 0.036, depending on whether the median or upper 95th percentile estimate is used and on which maximum is used for the total number of whales struck. The probability of striking at least one WNP gray whale during a five-year period ranges from 0.036 to 0.170 across the same scenarios. The expected number to be struck ranges from 0.01 to 0.04 for a single year and from 0.04 to 0.19 across 5 years.

Estimates from this analysis are considered by the authors to be precautionary since they assume that the Makah will achieve their proposed maximum strike limits. The results offer a conservative initial step in assessing the potential risk of WNP gray whales incurring mortality incidental to the proposed hunt on the ENP population by the Makah Indian Tribe.

The SWG **welcomed** this paper, recognising that it represents initial work. It notes that it will provide a contribution to the recommended workshop examining gray whales throughout the North Pacific (Annex F).

2.2.2 Other information

Mate summarised his recent satellite tagging work on PCFG gray whales. In 2012, Mate and his colleagues tagged nine additional gray whales off Oregon and northern California to those previously reported. Six of those continued transmitting until the whales visited the breeding grounds and returned to the Pacific Northwest; many are still providing data. In 2009, all of the satellite tagged whales visited the same lagoon, Ojo de Liebre, but in 2012 several whales travelled farther south to water offshore of San Ignacio Lagoon and Magdalena Bay. In 2009 and 2012 a tagged PCFG gray whale migrated as far north as Icy Bay, Alaska, beyond the management-defined range of the PCFG whales. Many of the tagged whales migrated further north initially in the spring than where they spent most of their PCFG feeding season. Considering the number of tags deployed and the success of their deployment, Mate noted that it will be possible to define home ranges and core areas for individuals. Mate also mentioned that ongoing research assessing the wound healing in tagged whales may be ready for presentation to the Scientific Committee next year. Finally, Mate reported on plans to deploy as many as 12 more tags in 2013. To the extent possible, attempts will be made to tag the same whales that were tagged in 2009 to see if those whales utilise the same home range, migration timing and routes, and breeding areas each year.

Weller briefly reported on a scientific task force (comprising eight NMFS scientists with expertise in fields relevant to stock structure assessment) workshop held by the US National Marine Fisheries Service (NMFS) to assess gray whale stock structure (Weller *et al.*, 2013). While the primary focus was to provide advice in terms of US domestic legislation, much of the work was also of scientific relevance to the IWC Scientific Committee. New information has suggested the possibility of recognising two additional stocks in US waters to the eastern North Pacific stock currently recognised: (1) the Pacific Coast Feeding Group (PCFG); and (2) the western North Pacific (WNP) stock. The task force reviewed new information relevant to gray whale stock structure, including the results of genetic, photo-identification, tagging and other studies. It agreed on a series of questions relevant to evaluating whether the PCFG and/or the WNP gray whales qualify as stocks under US guidelines and followed a structured decision-making process. The task force concluded that there was substantial uncertainty regarding whether the PCFG qualified as a separate stock and was unable to provide definitive advice. It did, however, advise that the WNP stock should be recognised as a stock. The task force provided recommendations for future work, including the continuation of field studies as well as additional analysis of the existing photo-identification and genetic data.

The SWG thanked Weller and noted that the report represented a thorough review of the current knowledge of PCFG and WNP gray whales. In response to a question on how the US defines a stock, Weller responded that the primary criterion is demographic independence. The SWG noted that the Scientific Committee continues to work on definitions relating to 'stock' and related terms and that this report will be of value to the working group on stock definition. It also **agreed** that it will provide valuable input to the recommended workshop examining gray whales throughout the North Pacific (see Annex F).

2.3 Summary and recommendations

The SWG **concluded** that the conservation performance of the proposed Makah whaling management plan has now been fully analysed within the *SLA* evaluation framework. It **agreed** that the proposed management plan meets the conservation objectives of the Commission provided that if struck and lost animals are not proposed to be counted toward the APL then a photo-identification research programme to monitor the relative probability of harvesting PCFG whales in the Makah usual and accustomed fishing grounds (U&A) is undertaken each year and the results presented to the Scientific Committee for evaluation. In other words, only Variant 2 was judged to meet the Commission's conservation objectives without the research requirement.

In regards to questions on whether the SWG should consider conducting an *Implementation Review* to evaluate the potential impacts of the Makah hunt on whales identified in the WNP, it was **agreed** that before an *Implementation Review* is conducted that the recommended workshop be held to review the range-wide population structure and status of North Pacific gray whales (see Annex F).

3. CONSIDERATION OF WORK REQUIRED TO DEVELOP *SLA*S FOR ALL GREENLAND HUNTS BEFORE THE END OF THE INTERIM PERIOD

3.1 Common minke whales and fin whales

3.1.1 Report from the intersessional Workshop (SC/65a/Rep02)

The Workshop noted the potential overlap between RMP and AWMP management with respect to common minke whales and fin whales in the North Atlantic. It agreed that the process of developing *SLA*s and RMP *Implementations* for stocks in regions where both commercial and aboriginal catches occur should include the following steps: (a) development of a common trials structure which adequately captures uncertainties regarding stock structure, mixing, MSYR, etc.; (b) identification of an *SLA* which performs as adequately as possible if there are no commercial catches; and (c) evaluation of the performance of RMP variants given the *SLA* selected at step (b). The work on RMP/AWMP-lite in this regard (see Item 3.1.3) was welcomed.

3.1.1.1 STOCK STRUCTURE

The Workshop recognised the need for consistency in stock structure hypotheses with RMP *Implementations.*

With respect to fin whales it had noted that the present hypotheses will be reviewed during the RMP *Implementation Review* scheduled for the 2013 meeting of the Scientific Committee. It also noted that it may be possible to base the *SLA* for fin whales off West Greenland on operating models which considered West Greenland only, i.e. in effect assuming that the animals found off West Greenland comprise a single stock that is adequately represented by the abundance estimates obtained off West Greenland. The rationale for this is that even if there are multiple stocks off West Greenland (as was suggested in some hypotheses considered during the RMP *Implementation*), it may be reasonable to assume that they are susceptible to capture in the aboriginal hunt proportionally to their abundance when the survey is conducted. In contrast, varying proportions of the multiple stocks over time would violate this assumption. The RMP *Implementation Review* should be asked to consider carefully any evidence that there may be more than one stock mixing off West Greenland.

With respect to common minke whales, the Workshop noted that it has been agreed that a joint AWMP/RMP stock structure workshop will be held in the intersessional period between the 2013 and 2014 annual meetings of the Scientific Committee (see Item 3.1.3 below). The results of this workshop will be essential to the *SLA* development process.

The SWG **endorsed** the conclusions and recommend-ations of the Workshop in this regard.

3.1.2 Joint RMP/AWMP Workshop(s) on stock structure

The SWG noted that the Steering Group for this meeting (which included SWG members including the Chair) had met to develop a work plan and that this had been reported to the sub-committee on the RMP (Annex D, Appendix 2). The SWG reiterated its support for this Workshop, first agreed last year (Donovan *et al.*, 2013), and the work plan developed.

3.1.3 AWMP/RMP-lite

SC/65a/Rep02 had introduced the idea of a new computer program called RMP/AWMP-lite, which is a platform written in R which implements a management strategy evaluation framework for evaluating the performance of catch and strike limit algorithms. The essence of RMP/AWMP-lite is the use of an age-aggregated model rather than an age-structured model to considerably speed up calculations; this will allow developers more easily to explore the properties of candidate *SLA*s before they are submitted to rigorous full testing. This framework can be used to evaluate management schemes where multiple stocks of whales are exploited by a combination of commercial and aboriginal whaling operations. The operating models can be conditioned to the actual data to allow an evaluation of whether stock structure assumptions and other hypotheses are comparable with the available data. The Workshop had suggested several improvements and extensions to the program. The SWG **endorsed** the conclusions and recommend-ations of the Workshop in this regard.

In discussion, Punt noted that all but one of the tasks had been completed (see SC/65a/RMP05). The ability to apply an *SLA* based on an independently-written routine has been implemented for the bowhead and humpback trials, but not in AWMP/RMP-lite. He noted that AWMP/RMP-lite had become complicated owing to the recent developments, which may warrant changing the way the code is implemented.

The Workshop recalled that the current approach to evaluating *SLA*s for the Greenlandic hunts treats each species independently even though need is expressed as a total amount of meat over multiple species. It was noted that once single-species *SLA*s are developed, a multispecies 'need surface' which expresses the trade-offs among need for several species in terms of a multi-dimensional inequality constraint could be considered because it should be easier to satisfy total need rather than satisfying maximum needs separately for several species.

The SWG **endorsed** the conclusions and recommend-ations of the Workshop in this regard, **reiterating** that work on single-species *SLA*s should be completed before multi-species considerations are examined.

The Workshop had also noted that the RMP and AWMP dealt with ship strikes and by-catch differently. The RMP catch limit is for all human-induced removals so that the commercial catch is the difference between the RMP catch limit and the expected removals due to, for example, ships strikes and bycatch. In contrast, the aim of the AWMP is not to maximize catch, but rather to satisfy need. Consequently, the strike limit is not reduced by ship strikes and by-catch. Rather, the trials used to select *SLA*s account for future levels of other human-caused removals, but the strike limit is still related only to need. Thus, the removals from the population in the case of aboriginal hunts would be the strike limit plus other human-caused removals.

The SWG **endorsed** the conclusions and recommend-ations of the Workshop in this regard, noting that this approach is used for other human-induced removals under Items 3.2 and 3.3 below.

3.1.4 Discussion and work plan

The work plan for SWG in relation to the development of *SLA*s for the hunts for fin and minke whales off West Greenland is partially dependent upon the associated work on RMP *Implementation Reviews* for fin and common minke whales. In terms of activity over the coming year the SWG will:

(1) examine the final modelling framework and trial specifications for North Atlantic fin whales being developed intersessionally including at an RMP intersessional workshop by a steering group (which includes AWMP members) and examine how this can be incorporated into *SLA* development;
(2) participate in the joint AWMP/RMP workshop on stock structure of common North Atlantic minke whales agreed last year to review stock structure hypotheses and review the results from the AWMP perspective an emphasis on Greenland;
(3) examine the discussions and results of the RMP *Implementation Review* for common North Atlantic minke whales that will start with a pre-meeting before SC/65b from an AWMP perspective; and
(4) receive need envelopes from Greenland for North Atlantic fin and common minke whale hunts off Greenland.

3.2 Humpback whales

3.2.1 Report from intersessional Workshop (SC/65a/Rep02)

Donovan briefly summarised the new information available for humpback whales off West Greenland from the Workshop (SC/65a/Rep02).

3.2.1.1 STOCK STRUCTURE

With respect to stock structure, the Committee agreed in 2007 that the West Greenland feeding aggregation was the appropriate management unit to consider when formulating management advice. Whales from this aggregation mix with individuals from other similar feeding aggregations on the breeding grounds in the West Indies (IWC, 2008, p.21).

The Committee also received valuable information from 30 satellite-tagged whales (Heide-Jørgensen, 2012). This found that few excursions were made outside the areas covered by the 2005 and 2007 aerial surveys which took place during August-September, although one animal left West Greenland in June and reached Newfoundland in July (i.e. would not have been available for counting). Two whales departed from West Greenland and took a route south along Labrador and Newfoundland. The Workshop recognised the value of such work to both stock structure and abundance and encouraged its continuation.

Photo-identification data are also valuable for stock structure and movement studies. Subsequent to the Workshop Witting confirmed that all photographs from West Greenland had been submitted to the North Atlantic humpback Catalogue who also informed the Chair that one match had been made with the Gulf of Maine in addition to matches from eastern Canada that confirmed the results from the telemetry studies.

The Workshop endorsed the previous Scientific Committee recommendation that the West Greenland feeding aggregation was the appropriate management unit and that it should be treated as a single stock in the trials.

3.2.1.2 ABUNDANCE

The Workshop reviewed the abundance estimates that had been received and adopted by the Scientific Committee. These are discussed further under Item 3.2.2.1 below.

The Workshop had agreed to use the estimates of relative abundance from aerial surveys to condition the trials. Since available abundance estimates from the mark-recapture studies covered a shorter period and were heavily correlated it was agreed that they would only be used in a *Robustness Trial*. However, the Workshop had also agreed that given that mark-recapture abundance estimates may become common in the future for both humpback and bowhead whales, efforts should be made to develop ways to better integrate them into the operating models for the *SLA* trials. It had also agreed that for future surveys, only absolute estimates of abundance would be generated.

3.2.1.3 REMOVALS

3.2.1.3.1 DIRECT CATCHES

Noting past difficulties in modelling the full western North Atlantic (including allocation of past catches) and the decision to treat the feeding aggregation as the appropriate management unit, it was agreed that trials would begin in 1960 under an assumption that the age-structure in that year is steady. The catch series for this period is known and this is treated as the best catch series and no alternatives are required. It can be found in the revised trial specifications to the present report (see Appendix 2).

None of the photographic recaptures of humpback whales from St. Vincent and the Grenadines have been made with animals from the West Greenland feeding aggregation, so these catches are not included in the catch series. However, given possible migration routes (e.g. from telemetry data), it was noted that known direct catches occurred from whaling stations off the east coast of Canada after 1960 that may have included some 'West Greenland' animals.

Making simple assumptions (Greenland whales are estimated to be off Newfoundland for ~1 month in comparison to Canadian whales which are there for ~ 6 months and taking the relative abundances of the two populations into account) leads to an estimated potential direct catch of Greenland humpbacks off Canada of up to 5% of the total direct catch. The Workshop agreed that this will be incorporated into the catch series in the revised trial specifications, but that no future direct catches off Canada will be simulated.

3.2.1.3.2 BYCATCHES AND SHIP STRIKES

The Workshop addressed the question of bycatches in both West Greenland and elsewhere. For West Greenland, noting that the crab fishery which was primarily responsible for bycatches has now peaked, it was agreed that future bycatches for Greenland will be generated assuming that the exploitation rate due to bycatch in the future equals that estimated for the trial in question over the most recent five-years. As no bycatches were reported for the 1960-2000 period for West Greenland, it was noted that this assumption is conservative in that bycatches will be assumed for the future.

With respect to bycatches of 'West Greenland' animals outside West Greenland, the Workshop agreed to an approach similar to that for direct catches, i.e. the estimated potential direct catch of Greenland humpbacks off Canada could be up to 5% of the total Canadian bycatch. Should ship strikes occur, the same approach would be used. The Secretariat agreed to investigate the available information on bycatch and ship strikes.

3.2.1.4 BIOLOGICAL PARAMETERS

The Workshop noted that prior distributions need to be specified for three biological parameters: (a) the non-calf survival rate; (b) the age-at-maturity; and (c) the maximum pregnancy rate. The objective is to develop priors (taken to be uniform for all three parameters) which are plausible based on the range of estimates in the literature. The values for these parameters used in the actual trials will encompass a narrower range than these priors because the priors will be updated by the data on abundance and trends in abundance during the conditioning process.

The Workshop agreed that the prior for non-calf survival, S_{1+}, will be U[0.9, 0.995]. The lower bound for this prior is the lower 95% confidence interval for the estimate of non-calf survival obtained by Larsen and Hammond (2004) while the upper bound is the upper 95% confidence interval for the estimate of non-calf survival rate for humpback whales in Prince William Sound, Alaska reported by Zerbini *et al.* (2010). Zerbini *et al*. (2010) based their estimates of maximum rates of increase on the non-calf survival rate estimate for this population.

The maximum pregnancy rate, f_{max}, is the pregnancy rate in the limit of zero population and thus is not measureable but is expected to be higher than observed pregnancy rates. Based on its review of the available information, the Workshop agreed that the prior will be U[0.4, 0.8]. The lower bound for this prior is close to the average of the estimates of pregnancy rate for humpback whale stocks reported by Zerbini *et al.* (2010). The upper bound was based on the view that the theoretical maximum (i.e. all mature females giving birth every year) is infeasible but that an estimate that involved a high proportion of animals on a one-year cycle (individuals have been observed to do this) should be considered.

The Workshop agreed that the prior for the age-at-maturity should be U[4, 12]. This is based on data from individually identified whales and incorporated the lower ages-at-first-parturition reported by Clapham (1992) and Gabriele *et al.* (2007) and the high value reported by Robbins (2007).

Recognising the great uncertainty in these priors given the paucity of data, the Workshop agreed that it was important to develop a *Robustness Trial* in which the priors for the biological parameters are modified by lowering the upper bounds for the priors for S_{1+} and f_{max} and increasing the lower bound for a_m.

The abundance data are not informative about carrying capacity and the Workshop agreed that trials should be based on the prior for carrying capacity, *K*, proposed in Punt (2012), U[0, 30,000], noting that the estimated total catch of North Atlantic humpback whales is approximately 30,000 (Reeves and Smith, 2002).

3.2.1.5 NEED

Need envelopes are an important component of developing a trial structure and are the responsibility of the relevant Governments. Need envelopes for humpback whales were submitted to the Workshop in Witting (2012) and these reflected the Greenlandic preference for humpback whales over fin whales and Greenland's desire for flexibility. The need envelope is summarised in Fig. 2. Reiterating that the determination of catch limits is a matter for the Commission but recognising that the Committee needs to be in a position to provide scientific advice on any need requests, the Workshop had agreed that need envelopes that increased over the initial three quota blocks from ten to twenty whales should capture this issue. Hence, the following three need envelopes were agreed [10, 15, 20-20], [10, 15, 20-40] and [10, 15, 20-60], with the middle envelope being considered the base case. Witting had also suggested consideration of an additional 'backup' scenario of initially adding ten humpback whales to the base case envelope (this was intended to compensate for any unforeseen decline in the common minke whale strike limits of up to approximately 60 minke whales).

3.2.1.6 *SLA*S TO BE CONSIDERED

The Workshop had agreed that all of the trials would be conducted for a bounding case and for two 'reference *SLA*s', in addition to any other *SLA*s which might be proposed by developers:

(1) the *Strike Limit* is set to the need;
(2) the *Strike Limit* is based on the interim *SLA* (IWC, 2009); and
(3) the *Strike Limit* is based on a variant of the interim *SLA* which makes use of all of the estimates of abundance, but downweights them based on how recent they are.

The Workshop had also agreed that the developers would be provided with:

(1) total need for the next block;
(2) catches by sex;
(3) mortalities due to bycatch in fisheries and ship strikes; and
(4) estimates of absolute abundance and their associated CVs.

3.2.1.7 TRIAL STRUCTURE
The Workshop developed proposed *Evaluation* and *Robustness* trials. These formed the basis for discussions under Item 3.2.3.

3.2.2 Discussion of the Workshop report and the results of intersessional work
The SWG **thanked** the Workshop for it comprehensive work and **broadly endorsed** its conclusions and recommendations; where appropriate they are either incorporated in the trial specifications (see Appendix 2) or provided the basis for further discussions under Item 3.2.3 below.

3.2.2.1 ABUNDANCE ESTIMATES
SC/65a/AWMP01 analysed surfacing time and availability bias for humpback whales in West Greenland, providing updated estimates of abundance. A total of 31 satellite-linked time-depth-recorders of three different types were deployed on humpback whales in West Greenland in May and July 2009-10. Over the period whales were tracked, the SLTDRs recorded the fraction of a 6-hour period that the whales spent at or above 2m depth. This depth is considered to be the maximum depth humpback whales are reliably detected on visual aerial surveys in West Greenland. Eighteen transmitters provided both data on the surface time and the drift of pressure transducer. The average surface time for these whales over the entire tracking period and during the two 6-hr periods with daylight was 28.3% (CV=0.06). Six whales that met data filtering criteria had reduced drift of the depth transmitter and their average surface time was 33.5% (CV=0.10). Previous analyses of visual aerial survey data have shown that the amount of time whales are available to be seen by observers is not an instantaneous process. Therefore the surface time needs to be corrected for a positive bias of about 10% when developing a correction factor for availability bias which increases the availability to 36.8% (CV=0.10). The most recent survey of humpback whales in West Greenland was conducted in 2007 and corrections with this availability factor provides fully corrected abundance estimates of 4,090 (CV=0.50) for mark-recapture distance sampling analysis and 2,704 (CV=0.34) for a strip census abundance estimate. These estimates are about 25% larger than previous estimates from the same survey. The annual rate of increase was 9.4% per year (SE 0.01) which was unchanged from the published paper.

The SWG noted that the methods behind the new estimates had been discussed fully at previous meetings when considering the 2007 survey. The revised estimate here was based on updated and improved information on the diving behaviour of whales from additional satellite tag data. It therefore **accepted** the new strip census abundance estimate as the best estimate. The full list of estimates accepted by the SWG is provided in Table 1. This information is also included in the trial specifications (see Appendix 2).

3.2.2.2 STOCK STRUCTURE
Noting the importance of information of photo-identification studies both to stock structure and the possibility of human-induced mortality outside the West Greenland area, the SWG **recommended** that Greenlandic scientists to work with the College of the Atlantic to develop a full overview of the available data and present this to the proposed intersessional Workshop.

3.2.2.3 REMOVALS
In the light of discussions at the workshop and at the present meeting, the SWG **agreed** that the Secretariat should continue to work with Canadian scientists and others to finalise the catch series (direct and indirect) following the guidelines agreed at the Workshop and present a final series to the proposed intersessional Workshop.

3.2.2.4 INITIAL INVESTIGATIONS OF *SLA*S
The SWG proceeded to discuss the results provided by the two sets of developers of candidate *SLA*s, which were based on trials as developed at the Intersessional Workshop. As the SWG discussed the results of this work for humpback and bowhead whales together, these are considered further under Item 3.4.

3.2.3 Trial structure
Based on the Workshop report and discussions above, the SWG revised the final trial structure for evaluation of *SLA*s for the West Greenland humpback whale hunt (also see Appendix 2).

During review of the trial specifications, it was noted that the prior distribution for f_{max} had been defined to be Unif[0.4,0.8], whereas data from Zerbini *et al.* (2010) included some lower estimates. In response to a question as to whether the lower end of the f_{max} prior should be adjusted downward accordingly, it was noted, however that the Zerbini *et al.* (2010) data referred to *observed* increase rates, whereas f_{max} referred to *theoretical maximum* rates. Values of f_{max} below 0.4 were regarded as very unlikely, and no change to the specifications was made.

The SWG **agreed** to replace need envelope D with C for trials 3A and 3B. The justification was that envelope D (involving pre-emptively higher initial need) would be very unlikely to be sought if the first survey was delayed until year 15. The SWG also agreed to add trials using need envelope C for all evaluation trials numbered 2A, 2B, and 4 or higher since it was important to consider the case when no initial jump in need was requested.

The SWG **agreed** that it was appropriate to include trials based on the environmental variability model for population dynamics developed by Cooke (2007) be included. This model reflects the impact of this variability on the population growth rate. The effect is not symmetrical because this growth rate is bounded for demographic reasons. This results in a qualitative difference being predicted in the behaviour of recovering populations. These first follow a steady exponential trend, but once somewhat higher abundance is reached much more variable behaviour can ensue (as indeed appears evident, for example, for the South West Atlantic right whale and Eastern North Pacific gray whale population). The SWG **agreed** that these environmental variability trials were plausible and thus should be considered *Evaluation Trials*. Since conditioning using this approach may prove problematic, it was also **agreed** that this model would be used only for future projections. These new trials are referred to as 'asymmetric environmental stochasticity'. Trial 8 will be parameterised intersessionally (Witting).

The factors considered in the trials are summarised in Table 1.

In preparation for evaluating *SLA*s for subsistence hunting of bowheads and humpback whales off West Greenland, the SWG reviewed the performance statistics, tables, and graphs used for past *SLA* evaluation and *Implementation Reviews*, to identify what methods were found most effective and informative.

Statistic D8 ('rescaled final population') was clarified in light of the fact that known or projected incidental removals will occur for some stocks hunted in West Greenland (e.g. Canadian hunting of bowhead whales). D8 has previously

Table 1

Factors tested in the trials.

Factors	Levels (reference levels shown bold and underlined)	
	Humpback whales	Bowhead whales
$MSYR_{1+}$	1%, 3%, **5%**, 7%	1%, **2.5%**, 4%
$MSYL_{1+}$	0.6	**0.6**, **0.8**
Time dependence in K*	**Constant**, halve linearly over 100 years	
Time dependence in natural mortality, M*	**Constant**, double linearly over 100 years	
Episodic events*	**None**, 3 events occur between years 1-75 (with at least two in years 1-50) in which 20% of the animals die. Events occur every five years in which 5% of the animals die.	
Need envelope	A: 10, 15, 20; 20 thereafter **B: 10, 15, 20; 20->40 over years 18-100** C: 10, 15, 20; 20->60 over years 18-100 **D: 20, 25, 30; 30->50 over years 18-100**	**A: 2, 3, 5; 5 thereafter** B: 2, 3, 5; 5 -> 10 over years 18-100 **C: 2, 3, 5; 5 -> 15 over years 18-100**
Future Canadian catches	N/A	**A: 5 constant over 100 years** B: 5-> 10 over 100 years C: 5-> 15 over 100 years D: 2.5 constant over 100 years?
Survey frequency	5 year, **10 year**, 15 year	
Historic survey bias	0.8, **1.0**, 1.2	0.5, **1.0**
First year of projection, τ	**1960**	**1940**
Alternative priors	S_{1+} ~ U[0.9, 0.99]; f_{max} ~ U[0.4, 0.6]; a_m ~ U[5, 12]	N/A
Strategic surveys	Extra survey if a survey estimate is half of the previous survey estimate	
Asymmetric environmental stochasticity parameters	To be finalised by an intersessional group	

*Effects of these factors begin in year 2013 (i.e. at start of management). The adult survival rate is adjusted so that if catches were zero, then average population sizes in 250-500 years equals the carrying capacity. Note: for some biological parameters and levels of episodic events, it may not be possible to find an adult survival rate which satisfies this requirement.

been defined as the ratio of the final abundance (either 1+ or mature females) after 100 years with removals given by the *SLA* to the final abundance 'under a scenario of zero strikes'. For over a decade of AWMP *SLA* development for several fisheries no incidental take has been considered, so the condition of 'zero strikes' has been equivalent to 'zero removals'. Indeed, some SWG members had believed incorrectly that D8 was calculated relative to zero removals. The possibility of non-zero incidental removals now highlighted this point of confusion.

Therefore, the SWG defined statistic D8(0) to represent rescaled final population relative to a scenario with zero removals *of any kind*, and D8=D8(inc) to refer to the existing statistic which is relative to a scenario with zero strikes but possibly non-zero incidental removals. Statistic D8(0) is boldfaced to indicate that it is 'considered …more important'.

The same confusion about incidental removals applies to the abundance in year t under a scenario of zero strikes, denoted P_t^*. The SWG defined $P_t^*(0)$ and $P_t^*(inc)$ analogously to D8(0) and D8(inc).

The SWG promoted statistic N12 ('mean downstep') to the boldfaced 'more important' category, and demoted R1 ('relative recovery') to non-boldfaced.

Consistent with past efforts, the SWG **agreed** to produce two sets of output when evaluating candidate *SLA*s. The first is a comprehensive library of all output, including the 5%tile and median values of all statistics (boldfaced 'more important' or otherwise), and all graphs and other output listed in the trial specifications. The library will be available for inspection but not used as the primary basis for SWG discussion. The second output set is a subset of the comprehensive library. It contains only the tables and graphs anticipated to be the most useful for SWG evaluation of candidate *SLA*s. The elements of this review set are discussed below.

A table of 5%tile and median values of certain statistics will be included in the review set. The most important aspect of this table is that the same quantities for different *SLA*s should be arranged in a column with aligned decimal points, so that like numbers can be compared vertically. The next paragraph summarises the contents of the table and a possible format. Apart from the columnwise comparison requirement, the format may be adjusted to partition the contents and fit on the page(s) sensibly.

Columns of the table are 5%tile and median values for D1(1+), D1(mature females), D8(0), D8(inc), D9(1+), D10(1+), N9(20) and N9(100). Row blocks of the table correspond to trial scenarios. Rows within a block correspond to different strike limit rules. Within a block, there would be one row for each candidate SLA. Also included in the block would be rows for removals=0 (i.e. no strikes or incidental removals), strikes=0 (but incidental removals do occur), and strikes=need.

In addition to this table, the following plots will be included in the review set.

(1) The 'Zeh plots' (IWC, 2013c). The statistics to be displayed in the Zeh plots will be all those described for the table above, and N12 ('mean downstep'). Note that the Zeh plots rely on more quantiles of the statistics than just the 5th and 50th ones shown in the table.
(2) The plots defined as D6, i.e. abundance trajectory plots of P_t versus t (t = 0,…,100). All 100 simulated abundance trajectories for one algorithm are superimposed on this plot. Each plot pertains to a single *SLA* and a single trial scenario. Plots for 1+ abundance will be included in the review set, and analogous plots for the mature female component will be included in the comprehensive library.
(3) Plots of C_t versus t, as a step-function over 5-year blocks (t = 0,…,100). All 100 simulated quota trajectories for one algorithm are superimposed on this plot. Each plot pertains to a single *SLA* and a single trial scenario. Superimposed in this plot (in a different color and heavier line type) will be the pointwise 5%tile trajectory of C_t.
(4) The plots defined as D7 (pointwise quantile abundance trajectories). In these plots, the three pairs of trajectory

lines (i.e. 5%tiles and medians for P_t, $P_t^*(0)$ and $P_t^*(inc)$ will be superimposed on the same plot. Colour and line type will distinguish these.

(5) A new type of plot to compare depletion performance of several *SLA*s on a single graph. In this plot (one per trial scenario), the pointwise α^{th} percentile time trajectory of 1+ abundance is plotted, as in D7. However, the trajectories for all candidate *SLA*s are superimposed on the same plot. These are distinguished by color and line type. The three reference trajectories determined by assuming 0 strikes, 0 removals, and catch=need are *not* included in these plots. Two sets of such plots will be made, corresponding to α=5 and α=50.

3.3 Bowhead whales

3.3.1 Report from the intersessional Workshop (SC/65a/Rep02)

3.3.1.2 STOCK STRUCTURE

The current working hypothesis in the Scientific Committee is a single Baffin Bay-Davis Strait stock of bowhead whales (see Fig. 1). However, pending the availability of some genetic analyses, the Scientific Committee had agreed that the possibility that there are in fact two different stocks present in the overall area, with the second located in the Foxe Basin-Hudson Strait region, cannot be ruled out (e.g. see IWC, 2009, p.23).

No new information was available to the Workshop. Given that the objective was to develop an *SLA* for the Greenland hunt of bowhead whales, the Workshop had agreed to proceed first on a conservative basis that assumed that the absolute abundance of bowhead whales on the West Greenland wintering area would be informed by abundance estimates from data for that region only (see below). Only if such an *SLA* proved unable to meet need would abundance estimate information and stock structure considerations from the wider area shown in Fig. 1 be taken into account.

3.3.1.2 ABUNDANCE

The Workshop reviewed the available abundance estimates (SC/65a/Rep02, table 8). It is not possible to combine the Foxe Basin-Hudson Bay 2003 survey with the 2002 Prince Regent Inlet survey to obtain an estimate for the entire Davis Strait-Baffin Bay-Foxe Basin area. The Workshop therefore agreed to condition the operating model using data for Davis Strait-Baffin Bay stock only.

The 2002 survey in Prince Regent Inlet might not be conducted again whereas regular surveys will be conducted off West Greenland. The Workshop therefore agreed to conduct trials: (a) in which the estimate for Prince Regent Inlet is treated as an estimate of absolute abundance; and (b) in which the estimates from West Greenland are treated as estimates of absolute abundance.

While the sex ratio of animals in West Greenland is ~80:20 in favour of females (Heide-Jørgensen *et al.*, 2010b), it is expected that the sex ratio for the current whole population is 50:50 (based on historic catches over the whole region and present Canadian catches). The Workshop agreed that the trials will assume that the proportion of males available to the surveys will be the observed average male/female ratio in the biopsy samples.

Estimates of relative abundance from aerial surveys were also considered by the Workshop which agreed that an overdispersion parameter should be estimated for these sightings data under the assumption that the data are negative binomially distributed. Estimates of relative abundance are also available from genetic mark recapture studies. For similar reasons to those given for humpback whales above,

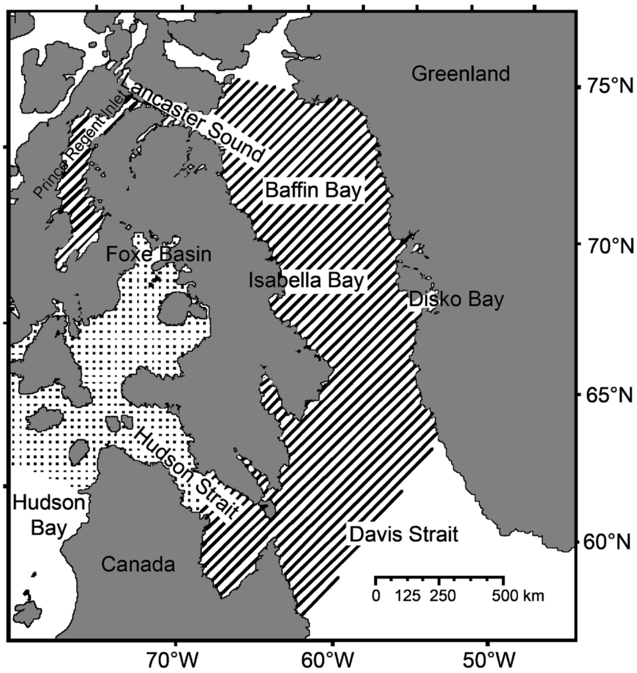

Fig. 1. Stock structure hypotheses for bowhead whales and place names referred to in the text. Hashed lines are for a Davis Strait-Baffin Bay stock while the dotted area refers to a Foxe Basin – Hudson Bay stock.

the Workshop agreed that these are not suitable for use now but that work should continue to enable these data to be used in the future; however, it accorded the work low priority at this time.

The Workshop agreed that the information provided to the *SLA* will be the results of surveys off West Greenland (relative indices if the operating model is conditioned to the estimate of abundance for Prince Regent Inlet and absolute if the operating model is conditioned to the estimate of abundance for West Greenland).

3.3.1.3 REMOVALS

For reasons similar to those agreed for humpback whales given above, the Workshop agreed that population projections should begin from a recent year (1940). This is earlier than for humpback whales because of the extended age-structure of the population.

The Workshop agreed that all the recent (post-1940) direct catches of bowhead whales by Canada and Denmark (Greenland) are known and thus that there was no need to consider an alternative catch series.

For 2011, Canada set an allowance of a maximum of four bowhead whales to be hunted in the Eastern Canadian Arctic. It is not known whether this allowance is for landed whales alone or whether it includes struck and lost whales; this is being investigated by the Secretariat.

The Workshop agreed that four scenarios regarding future Canadian catches should be considered (constant 5, 5 increasing to 10 over 100 years, 5 increasing to 15 over 100 years, constant 2.5; the last case reflects a situation in which half of the Canadian catches are taken from a different stock than the West Greenland catches). The sex-ratio for the West Greenland catches will be set to the sex ratio observed in the biopsy samples taken off West Greenland over the 2002-11 period while that for the Canadian catches should be set to the observed sex-ratio (the observed ratio for the Baffin Bay/Davis Strait whales taken by Canada is 4 male, 1 female, 4 unknown – this is being confirmed by the Secretariat).

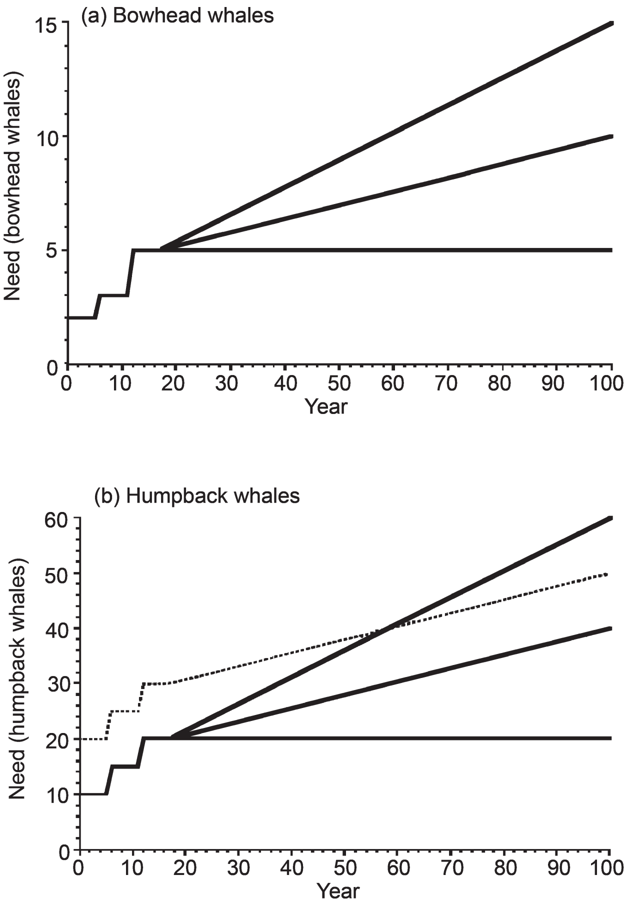

Fig. 2. Need envelopes A-D established for West Greenland bowhead and humpback whale trials.

Recent bycatches of bowhead whales by Denmark (Greenland) and any information for Canada that can be found by the Secretariat will be will be included in the revised trials specification. The Workshop noted that if the number of ship strikes increases as the Northwest Passage opens up, this could trigger an *Implementation Review*.

3.3.1.4 BIOLOGICAL PARAMETERS

In the absence of information for this region, the Workshop agreed to use the priors for f_{max}, S_{1+} and a_m used for the *Implementation* for the Bering-Chucki-Beaufort Seas bowhead whales, noting that these incorporate considerable uncertainty for all three parameters.

3.3.1.5 NEED

Brandon and Scordino (2012), presented to the Workshop, had suggested three scenarios, each of which involves an increase to the need from 2 to 5 at the start of the projection period followed by either: (1) no increase of need; (2) a doubling; and (3) a tripling of need in a linear fashion over the total time period. This is shown in Fig. 2.

3.3.1.6 TRIALS

The Workshop developed proposed *Evaluation* and *Robustness* trials. These formed the basis for discussions under Item 3.3.3.

3.2.2 Discussion of the Workshop report and the results of intersessional work

The SWG thanked the Workshop for it comprehensive work and **broadly endorsed** its conclusions and recommendations; where appropriate they are incorporated in the trial specifications (Appendix 2) or provided the basis for further discussion under Item 3.3.3 below.

3.3.2 RESULTS OF INITIAL WORK ON *SLA*S

The SWG received initial results provided by the two sets of developers of candidate *SLA*s, which were based on trials as developed at the Intersessional Workshop. As the SWG discussed the results of this work for humpback and bowhead whales together, these are considered further under Item 3.4.

3.3.3 Trial structure

The SWG finalised the trial structure (see Appendix 2) for evaluation of *SLA*s for the West Greenland bowhead whale hunt.

The SWG adopted the same planned evaluation strategies (statistics, tables, graphs) as described in Item 3.2.3 for the humpback case. This includes clarification of the abundance and depletion statistics in the situation of zero strikes and/or incidental removals.

SC/65a/Rep02 described *Evaluation Trials* 8A and 8B in which Canadian bowhead strikes tripled over 100 years. The SWG **agreed** to change these from *Evaluation Trials* to *Robustness Trials* (now 4A and 4B). It noted that a situation where Canadian bowhead strikes increased so much would trigger an *Implementation Review*, and therefore it was not necessary to incorporate such a scenario in the tested parameter space.

For the same reasons documented for humpback whales (see Item 3.2.3), the SWG **agreed** to add *Evaluation Trials* involving 'asymmetric environmental stochasticity'. It also **agreed** to include need scenario B in all *Evaluation Trials.*

A number of the preliminary results considered under Item 3.4 illustrated that it would be difficult to meet conservation objectives satisfactorily when the need level was high, especially if Canadian catches (which are taken by a non-IWC member country) increase. The SWG discussed whether it would be advisable to reconsider how strike quotas and incidental removals (i.e. by Canadian hunters) are accounted for in the *SLA* computations. However, it **agreed** to continue with the current framework but also **agreed** that this topic should be further considered at the next intersessional workshop.

3.4 Results from initial work on *SLA*s for humpback and bowhead whales

The SWG discussed the results provided by the two sets of developers of candidate *SLAs*, which were based on trials as developed at the intersessional Workshop.

Witting introduced SC/65a/AWMP04 which describes candidates *SLA*s for the West Greenland hunt on humpback whales. Two candidates based on the current interim *SLA* are proposed. They are both simple data based procedures with no internal population model, and they were selected from a total set of 48 examined procedures. All procedures were tested on a selected set of evaluation trials that included nearly all low production trials, and here they were set to pass a test of acceptable conservation performance (5th percentile of D10 larger than one) before they could be chosen as an acceptable procedure dependent upon their need satisfaction performance and other features. Both procedures estimate the strike limit as a function of 3% of the 2.5th percentile of an estimate of abundance. They put additional limits on the strike limit if the point-estimate of abundance is below 1,200, and one of the two procedures sets the strike limit to need if it exceeds 80% of need.

Witting then presented SC/65a/AWMP05 which describes candidates *SLA*s for the West Greenland hunt on bowhead whales. A similar approach to that taken in SC/65a/AWMP04 was followed. However, none of the 29

*SLA*s initially considered were able to pass the conservation criterion for the low production trials of the two alternative B and C scenarios for future Canadian catches, where annual Canadian catches are assumed to increase from 5 to 10, and from 5 to 15 over the simulation period. Not even a zero-*SLA*, which assumed zero Greenlandic catches for the whole period, was able to pass the conservation criterion when the Canadian catches increased from 5 to 15. Hence, the *SLA* development was restricted to trials where the annual Canadian catches were assumed to be no higher than five. The procedure with highest need satisfaction and acceptable conservation performance on these trials was then selected as a candidate *SLA*. This ($r_{.5}N_{2.5}$PS) procedure sets the strike limit as a function of 0.5% of the 2.5th percentile of an estimate of abundance, it puts additional limits on the strike limit if the point-estimate of abundance is below 1,200, and it sets the strike limit to need if it exceeds 80% of need. Another candidate ($r_1N_{2.5}$Pa) was selected to optimise need satisfaction should annual need not exceed 5 in the future. This procedure provides higher need satisfaction than $r_5N_{2.5}$PS, and it sets the strike limit as a function of 1% of the 2.5th percentile putting additional limits on the strike limit if the point-estimate of abundance is below 800. While selected to have acceptable D10 conservation performance only on the low need trials, conservation performance for $r_1N_{2.5}$Pa on the high need trials failed only marginally on trial B03BC.

Brandão presented results for four possible *SLA*s from SC/65a/AWMP02. One of the *SLA*s considered is the Interim *SLA* which is based on the most recent estimate of abundance, while the other three *SLA*s are variants of a weighted-average interim *SLA* which uses all abundance estimates, but earlier abundance estimates are downweighted compared to more recent ones. A simple integrative approach to provide a ready coarse comparison of the performance of each *SLA* across all the evaluation and robustness trials was put forward, based on the lower 5%-iles of the N9 (need satisfaction) and D1 (depletion) performance statistics. An index of depletion (D_{imp}) is first computed that measures the extent by which the *SLA* under consideration improves depletion compared to the *Strike Limit = Need SLA*. A statistic is put forward that gives a measure (Q) of the deviation from the ideal scenario of obtaining a result given values of the lower 5%-ile need satisfaction (N9) and of the index of depletion from a trial of both to be (close to) 1. There are two simple approaches to comparing the performance of *SLA*s under trials using this statistic, where averages are readily taken over all trials. These averages could apply either to the *Q* statistic itself or to a ranking for each trial based on the value of *Q* across the *SLA*s considered. There was generally little to choose between the four *SLA*s considered in terms of performance measured by these statistics. There was a qualitative difference between the two species: for humpback whales the *SLA* using the most recent abundance estimate only was preferred, whereas for bowheads the preference was to use all estimates with little downweighting for time since the survey. However, none of the *SLA*s considered performed adequately in terms of resource depletion for the lowest $MSYR_{1+}$ values considered.

In discussion both sets of developers responded to questions of clarification. The protection level concept introduced in the Witting *SLA*s was noted with interest, and it was suggested that this concept might be introduced to the Brandão *SLA*s to attempt to arrest the poor conservation performance on some trials. It was noted that at this stage, each set of developers had developed their own approaches to choose amongst the *SLA* candidates which they had tested. The SWG noted that this was an acceptable approach for developer to take when investigating the performance of their initial *SLA*s before deciding to put 'official' candidates forward but **re-iterated** that final choices would need to be based on the full set of performance statistics agreed for the trials.

3.5 Future consideration of multispecies advice

3.5.1 Report of intersessional Workshop (SC/65a/Rep02)

The Workshop referred to earlier discussions (IWC, 2011b; Witting, 2008) on this matter which have noted that Greenland's need is expressed in terms of tonnes of edible products, and for operational reasons some flexibility (to allow for temporal variability in the species composition of this tonnage) is important and would be preferred. The inclusion of such flexibility within a set of *SLA*s for a number of species, where these *SLA*s would need to be inter-linked, is a challenging scientific task in terms of designing the necessary simulation tests. The Workshop had re-iterated previous advice that this aspect is best pursued only after separate *SLA*s, which operate independently for each species, have been developed and accepted.

3.5.2 Conclusions and recommendations

The SWG endorsed the Workshop's conclusion and **re-iterated** previous advice (IWC, 2012) that this issue is best pursued only after separate *SLA*s, which operate independently for each species, have been developed and accepted.

4. ANNUAL REVIEW OF MANAGEMENT ADVICE

The SWG noted that the Commission had not reached agreement on strike limits for Greenland at the 2012 Annual Meeting (IWC, 2013a). It based its management advice on the same limits considered last year. In providing this advice it noted that the Commission has endorsed the interim safe approach (based on the lower 5th percentile for the most recent estimate of abundance) for providing advice for the Greenland hunts developed by the Committee in 2008 (IWC, 2009, p.16); it was agreed that that this should be considered valid for two blocks, i.e. up to the 2018 Annual Meeting.

4.1 Common minke whales off West Greenland

4.1.1 New information (incl. catch data and agreed abundance estimates)

In the 2012 season, 144 minke whales were landed in West Greenland and 4 were struck and lost. Of the landed whales, there were 109 females, 33 males and two of unknown sex. Genetic samples were obtained from 112 of these whales. Last year, the Committee has re-emphasised the importance of collecting genetic samples from these whales, particularly in the light of the proposed joint AWMP/RMP workshop (see Annex D). The SWG **welcomed** the fact that nearly 80% of the catch had been sampled in 2012 and encouraged continued sample collection.

This year, the SWG adopted a revised estimate of abundance for the 2007 survey. The revised published estimate (16,100 CV=0.43) was slightly lower than that first agreed in 2009. The SWG noted that this estimate is an underestimate of the total population by an unknown amount.

4.1.2 Management advice

In 2009, the Committee was for the first time able to provide management advice for this stock. This year, using the agreed

Table 2

Most recent estimates of abundance for the Central stock of common minke whales.

Small Area(s)	Year(s)	Abundance and CV
CM	2005	26,739 (CV=0.39)
CIC	2007	10,680 (CV=0.29)
CG	2007	1,048 (CV=0.60)
CIP	2007	1,350 (CV=0.38)

interim approach and the revised estimate of abundance given under Item 4.1.1, the SWG **advised** that an annual strike limit of 164 will not harm the stock. It **drew attention** to the fact that this is 14 whales lower than its advice of last year due to the revised 2007 abundance estimate.

4.2 Common minke whales off East Greenland

4.2.1 New information (incl. catch data and agreed abundance estimates)

Four female common minke whales were struck (and landed) off East Greenland in 2012. Two were females and the sex of the other two was unknown. The SWG was **pleased** to note that genetic samples were obtained from all minke whales caught in East Greenland (these could be used *inter alia* to determine the sex of the unknown animals). The Committee **again emphasised** the importance of collecting genetic samples from these whales, particularly in the light of the proposed joint AWMP/RMP workshop (see Annex D).

4.2.2 Management advice

Catches of minke whales off East Greenland are believed to come from the large Central stock of minke whales. The most recent strike limit of 12 represents a very small proportion of the Central Stock – see Table 2. The SWG **repeats** its advice of last year that the strike limit of 12 will not harm the stock.

4.3 Fin whales off West Greenland

4.3.1 New information (incl. catch data and agreed abundance estimates)

A total of four fin whales (all females) were landed, and one was struck and lost, off West Greenland during 2012. The SWG was **pleased** to note that genetic samples were obtained from three whales. The SWG **re-emphasised** the importance of collecting genetic samples from these whales, particularly in the light of the proposed work to develop a long-term *SLA* for this stock.

4.3.2 Management advice

Based on the agreed 2007 estimate of abundance for fin whales (4,500 95%CI 1,900-10,100), and using the agreed interim approach, the SWG **repeated** its advice that an annual strike limit of 19 whales will not harm the stock.

4.4 Humpback whales off West Greenland

4.4.1 New information (incl. catch data and agreed abundance estimates)

A total of seven (two males; four females; one unknown sex) humpback whales were landed (three more were struck and lost) in West Greenland during 2012. The SWG was **pleased** to learn that genetic samples were obtained from all of these whales and that Greenland was contributing fluke photographs to the North Atlantic catalogue – four have been submitted from whales taken since 2010. The SWG again **emphasised** the importance of collecting genetic samples and photographs of the flukes from these whales, particularly with respect to the MoNAH and YoNAH initiatives (Clapham, 2003; YoNAH, 2001).

This year, the SWG **endorsed** the revised fully corrected abundance estimate for West Greenland from the 2007 survey of 2,704 (CV=0.34) for the strip census abundance estimate (see Item 3 above). The agreed annual rate of increase of 0.0917 (SE 0.0124) remains unchanged.

4.4.2 Management advice

Based on the revised agreed estimate of abundance for humpback whales given above and using the agreed interim approach, the SWG **agreed** that an annual strike limit of 10 whales will not harm the stock.

4.5 Humpback whales off St Vincent and The Grenadines

4.5.1 New information (incl. catch data and agreed abundance estimates)

No new information or catch data were provided in time for consideration by the SWG although information has been requested by the Secretariat. Lang reported that there is one sample collected from a humpback whale taken on 11 April 2012 in the SWFSC tissue archive. The SWG **welcomed** this information.

Iñíguez reported information obtained from local newspapers on hunts on St Vincent and the Grenadines: a 35ft male (8 March 2013); a 41ft female and a 35ft male (both 18 March 2013); and another whale with no length or sex information (12 April 2013).

Regarding the same stock, he referred to reports that residents of Petite Martinique, Grenada, spent hours attempting to drive a mature whale onto a beach using five inflatable boatss, two large trader boats and a speedboat on 22 November 2012. The whale finally escaped but was harpooned four times. He has no further information on what happened with this whale.

4.5.2 Management advice

The SWG repeated its previous strong recommendations that St. Vincent and The Grenadines:

(1) provide catch data, including the length of harvested animals, to the Scientific Committee; and
(2) that genetic samples be obtained for any harvested animals as well as fluke photographs, and that this information be submitted to appropriate catalogues and collections.

The SWG has agreed that the animals found off St. Vincent and the Grenadines are part of the large West Indies breeding population (abundance estimate 11,570 95%CI 10,290-13,390). The Commission adopted a total block catch limit of 24 for the period 2013-18 for Bequians of St. Vincent and The Grenadines. The SWG **repeated** its advice that this block catch limit will not harm the stock.

The SWG draws the Commission's attention to the unofficial reports of attempts to land a humpback whale in Grenada; the Schedule specifies that the quota applies only to Bequians of St. Vincent and The Grenadines. The SWG requests that the Secretariat contact the Government of Grenada to obtain official information on this incident.

5. ABORIGINAL WHALING MANAGEMENT SCHEME

5.1 Guiding principles for *SLA* development and evaluation

The SWG noted that considerable effort had been put into general consideration of the development of *SLA*s at the beginning of the AWMP process (IWC, 2000; 2001; 2002).

It **agreed** that it would be useful to briefly outline some guiding principles for *SLA*s to assist developers of candidate *SLA*s for the Greenland hunts. These are summarised below.

(a) The primary objective of any *SLA* is to meet the objectives set by the Commission with respect to need satisfaction and conservation performance, with priority given to the latter.
(b) *SLA*s must incorporate a feedback mechanism.
(c) Once need has been met for the 'high' need envelope while giving acceptable conservation performance, then there is no need to try to improve the performance of an *SLA* further.
(d) Simple *SLA*s are to be preferred, providing this simplicity does not compromise achieving the Commission's objectives.
(e) With respect to (d), empirical procedures may prove preferable to population model based procedures because (1) they are more easily understood by stakeholders and (2) there is little chance for significant updating of population model parameters (e.g. MSYR) over time as the extent of additional data will probably be limited for populations subject to aboriginal whaling only. Nevertheless, the choice of the form for any candidate *SLA* lies entirely in the hands of its developer, with selection amongst candidates to be based only on performance in trials.
(f) If in developing *SLA*s, a situation arises where relatively simple *SLA*s fail on one or a few trials where the circumstances which might lead to the failure occur only many years in the future, rather than attempt to develop more complex *SLA*s to overcome this problem, a simpler *SLA* could be proposed despite this failure, and the difficulties dealt with by means of an *Implementation Review* should there be indications in the future that the circumstances concerned are arising. This principle applies only to: (1) circumstances in a scenario that are external and independent of the hunting/quota feedback loop, such as very high values of the future need envelope; and (2) are judged to be very unlikely to occur in the next few decades. Failure of an *SLA* to perform acceptably in some circumstance is not in itself a reason to apply this principle.

5.2 Scientific aspects of an aboriginal whaling scheme

In 2002, the Committee **strongly recommended** that the Commission adopt the Aboriginal Subsistence Whaling Scheme (IWC, 2003). This covers a number of practical issues such as survey intervals, carryover, and guidelines for surveys. The Committee has stated in the past that the AWS provisions constitute an important and necessary component of safe management under AWMP *SLA*s and it **reaffirms** this view as it has for the previous 11 years.

6. PROGRESS ON FOLLOW-UP WORK ON CONVERSION FACTORS FOR THE GREENLANDIC HUNT

6.1 New information

In 2009, the Commission appointed a small working group (comprising several Committee members) to visit Greenland and compile a report on the conversion factors used by species to translate the Greenlandic need request which is provided in tonnes of edible products to numbers of animals (Donovan *et al.*, 2010). At that time the group provided conversion factors based upon the best available data, noting that given the low sample sizes, the values for species other than common minke whales should be considered provisional. The group also recommended that a focused attempt to collect new data on edible products taken from species other than common minke whales be undertaken, to allow a review of the interim factors; and that data on both 'curved' and 'standard' measurements are obtained during the coming season for all species taken. The report was endorsed by the Scientific Committee (IWC, 2011a, p.21).

Since then the Committee has received progress reports but has commented that more detail and information is required. Last year the Committee recommended:

(1) the provision of a full scientific paper to the next annual meeting that details *inter alia* at least: a full description of the field protocols and sampling strategy (taking into account previous suggestions by the Committee); analytical methods; and a presentation of the results thus far, including information on the sex and length of each of the animals for which weight data are available; and
(2) the collection and provision of data on Recommendation No. 2 of Donovan *et al.* (2010) comparing standard versus curvilinear whale lengths. This should be done for all three species on as many whales as possible.

SC/65a/AWMP07 reports on the collection of weights and length measures from fin, humpback and bowhead whales caught in West Greenland. To improve the data collection process, information meetings involving biologists, hunters, wildlife officers and hunting license coordinators were held in the larger towns in 2012, and an information folder was produced and distributed to the hunters. The data collection process was also combined with an existing research project on hunting samples in order to get a stronger involvement of biologists. When researchers participate in hunts they train the hunters in measuring the lengths (curved and standard) and they make sure that the meat is weighed.

Until now the reporting rate has been lower than expected, with the data obtained in 2012 being from only one fin whale and one humpback whale, and the total number of reports since 2009 being from six bowhead whales, six humpback whales and three fin whales. These data provide preliminary yield estimates for all edible products of 9,014kg (SE:846) per humpback whale, of 6,967kg (SE:2,468) per fin whale, and of 8,443kg (SE:406) per bowhead whale. These numbers are all somewhat lower than the suggested yield in Donovan *et al.* (2010), and this is especially pronounced for fin whales. Nevertheless, the obtained estimates for fin whales fall within the range of previous yield weight estimates for fin whales in West Greenland.

A major reason for the low reporting rate has been the almost complete absence of weighing equipment where the whalers could weigh the different products. To increase the reporting rate, the Greenland Institute of Natural Resources has now purchased and distributed cranes to major towns for the hunters to use for weighing when landing a catch. It was also realised that the 'bin system' described in previous reports is more complicated than first anticipated because there is a large variation in the size of the bins used within the same hunt and between hunters. It is therefore now recommended that hunters weigh all edible products with the crane weight when they land the meat with the crane in the harbor. This approach will be investigated further in 2013 and discussed with the hunters. Owing to the logistical difficulties involved with whale hunts in Greenland (which

Table 3

Summary of absolute abundance estimates. Relative abundance estimates for use in the trials are given in Appendix 2 (Table 3).

Area	Year	Corr*	Estimate and approx. 95% CI and CV	IWC reference	Original reference
Common minke whale					
West Greenland	2007	A+P	16,100 (6,930-37,400) (CV:0.43)	IWC (2010); SC/65a	Heide-Jørgensen *et al.* (2010c)
West Greenland	2005	A+P	10,790 (3,400-34,300) (CV:0.59)	IWC (2008)	Heide-Jørgensen *et al.* (2008)
West Greenland	1993	A	8,370 (3,600-19,440) (CV:0.43)	IWC (1995)	Larsen (1995)
Fin whale					
West Greenland	2007		4,360 (1,810-10,530) (CV:0.45)	IWC (2009)	Heide-Jørgensen *et al.* (2010a)
West Greenland	2005	P	3,230 (1,360-7,650) (CV:0.44)	IWC (2008)	Heide-Jørgensen *et al.* (2008)
West Greenland	1988	A	1,100 (554-2,180) (CV:0.35)	IWC (1993)	IWC (1993)
Humpback whale					
West Greenland	2007	A+P	4,090 (1,690-9,880); (CV:0.45) MRDS	IWC (2009); SC/65a	Heide-Jørgensen *et al.* (2012); SC/65a/AWMP01
West Greenland	2007*	A+P	2,700 (1,390-5,270) (CV:0.34) strip census	IWC (2009); SC/65a	Heide-Jørgensen *et al.* (2012); SC/65a/AWMP01
Bowhead whale					
Prince Regent Inlet	2002	A+P	6,340 (3,119-12,906) (CV:0.36)	IWC (2009)	IWC (2009)
Foxe Basin – Hudson Bay	2003	A+P	1,525 (333-6,990) (CV:0.78)	IWC (2009)	IWC (2009)
West Greenland	2007	A+P	1,229 (489-3,090) (CV: 0.47)	IWC (2008)	Heide-Jørgensen *et al.* (2007);
Isabella Bay	2009	A+P?	1,105 (515-2,370) (CV: 0.39)	SC/65a/Rep02	Hansen *et al.* (2012)

*Indicates whether the estimate has been corrected for availability bias and/or perception bias.

are widespread along the coast and occur at unpredictable times during a long season) and the required change in the reporting system and subsequent need for training, it is likely that it will take several years to collect sufficient data on edible products.

6.2 Discussion

In response to questions, a number of clarifications were made. The original intention of weighing ten boxes had been so that an average weight per box could be developed to be multiplied by the total number of boxes to obtain an estimated total weight. However, with the efficient crane weights that are now in place in three cities, and with the finding that hunters may use different sized boxes even for the same whale, it has now been decided to weigh all boxes.

There were only five cases when scientists were able to be present at a humpback catch, and the low number illustrates the logistical difficulties in having scientists present at hunts. Witting did not have the precise details of this work or of the number of wildlife officers who may be able to assist in the work but will consult in Greenland. Efficient reporting requires not only training of hunters, but also the distribution of weighing equipment, so that hunters can report on their own.

In conclusion, the SWG **agreed** that the report was an advance on those previously received (and provided the first information on curvilinear lengths). However, it also **agreed** that it still did not provide sufficient information to fulfil the recommendations of last year. While aware of the logistical difficulties involved in obtaining these data, it **repeated its recommendations** of last year given in the second paragraph of this section. It **encouraged** Witting to assist in the writing of such a report to ensure that it better meets the request of the SWG next year.

7. CONSERVATION MANAGEMENT PLANS (CMPS)

The SWG noted the request for sub-groups to consider potential priority candidates for CMPs (SC/65a/SCP01). After considering the criteria given in that document the SWG **agreed** that it had no candidates for CMPs.

8. UPDATED LIST OF ACCEPTED ABUNDANCE ESTIMATES

The SWG noted the request to develop a list of accepted abundance estimates for consideration as part of an overall summary for all species to be developed by the Plenary. This was developed and has been forwarded for Plenary compilation. The abundance estimates agreed by this SWG are summarised above in Table 3.

9. WORK PLAN AND BUDGET REQUESTS

9.1 Work plan

The SWG **agreed** that the Chair should develop the work plan based upon the substantive items in the report. This is give in Table 4.

9.2 Budget requests

Intersessional Workshop on Developing SLA*s for the Greenlandic hunts*

The existing interim safe procedure for the Greenlandic hunts agreed in 2008 (IWC, 2009, p.16) was agreed to be valid for up to quota blocks so up to 2018. The Committee has identified completion of the development of long-term *SLA*s for these hunts as high priority work. In order to meet the proposed timeframe, an intersessional Workshop is required. The focus of the proposed Workshop is to: (1) to review the results of the developers of *SLA*s for humpback whales and bowhead whales; (2) finalise the modelling framework/trial structure for these hunts; (3) develop a work plan to try to enable completion of work on *SLA*s for these two hunts at the 2014 Annual Meeting; and (4) consider possible input (e.g. using AWMP/RMP-lite) for the joint AWMP/RMP workshop on North Atlantic common minke whale stock structure. The Workshop will be held in early 2014 in Copenhagen, Denmark, hosted by the Greenland representation; the costs are for IPs travel. It is intended to hold this back-to-back with and RMP Workshop on fin whales to save travel costs given some common membership.

AWMP Developers' fund

The developers fund has been invaluable in the work of *SLA* development and related essential tasks of the SWG.

Table 4

Work plan.

Item	Topic	Responsible persons	Deadline/target
3.1	Participate in the RMP North Atlantic fin whale RMP *Implementation* process and report back on the implications of this for *SLA* development for the Greenland hunt.	Donovan, Punt, Witting, Butterworth.	2014 Annual Meeting
3.1	Hold joint AWMP/RMP workshop on the stock structure of common minke whales in the North Atlantic (also see Annex D).	Joint Steering Group under Palsbøll.	Expected spring 2014
3.1	Submit need envelopes for West Greenland fin and common minke whales.	Witting.	Early Jan. 2014
3.2 and 3.3	Finalise the trials for the West Greenland humpback and bowhead whales (including coding) to allow developers to work intersessionally. Ensure that standard software is available to produce agreed performance statistics, as well as tabular and graphical output.	Steering Group convened by Donovan (Punt, Givens, Butterworth, Witting). Coding to be undertaken by Punt and Allison and developers.	(1) Agree specification and parameterisation by email and Skype: end Jul. 2013. (2) Complete coding and supply to developers: end Aug. 2013
3.2	Present overview of photo-identification work with respect to movements to inform stock structure and human induced mortality outside West Greenland.	Greenlandic scientists and College of the Atlantic (to be co-ordinated by Witting).	As soon as possible – ideally end of Aug. to assist Allison (see below), at latest in time for intersessional Workshop in early Jan. 2014
3.2 and 3.3	Finalise removals series including consideration of human-induced mortality outside the West Greenland area.	Allison.	End Aug. 2013
3.2 and 3.3	Continue initial exploration of potential *SLA*s for the Greenland humpback and bowhead whale hunts.	Developers.	For presentation at intersessional Workshop in early Jan. 2014
6.2	Produce full report on Greenlandic conversion factor programme.	Greenlandic authorities (assisted by Witting).	2014 Annual Meeting

It has been agreed as a standing fund by the Commission. The primary development tasks facing the SWG are for the Greenlandic fisheries. These tasks are of high priority to the Committee and the Commission. The fund is essential to allow progress to be made. It now stands at £8,000 and a request of £7,000 is made to restore it to the initial target level of £15,000.

10. ADOPTION OF REPORT

The report was adopted at 1900hrs on 11 June 2103. The SWG authorised the Chair to make editorial changes to the report as necessary to improve clarity. It also agreed that he should develop the work plan based upon the substantive items. The Chair thanked the participants for the constructive and co-operative attitude throughout these important discussions, some of which are highly technical. In particular, he thanked the developers for their work during the intersessional period that had greatly facilitated progress and the rapporteurs for their dedicated work. The SWG thanked the Chair for his efficient and good-humoured guidance.

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Appendix 1

AGENDA

1. Introductory items
    - 1.1 Convenor's opening remarks
    - 1.2 Election of Chair
    - 1.4 Appointment of rapporteurs
    - 1.5 Adoption of Agenda
    - 1.6 Documents available
2. Gray whales with emphasis on the PCFG (Pacific Coast Feeding Group)
    - 2.1 Report of intersessional Workshop (SC/65a/Rep02)
    - 2.2 New information and results
        - 2.2.1 Further evaluation of proposed Makah Hunt
        - 2.2.2 Other information
    - 2.3 Summary and recommendations
3. Consideration of work required to develop *SLAs* for all Greenland hunts before the end of the interim period
    - 3.1 Common minke whales and fin whales
        - 3.1.1 Report from the intersessional Workshop (SC/65a/Rep02)
        - 3.1.2 Joint RMP/AWMP Workshop(s) on stock structure
        - 3.1.4 Discussion and work plan
    - 3.2 Humpback whales
        - 3.2.1 Report from the intersessional workshop (SC/65a/Rep02)
        - 3.2.2 Discussion of the Workshop report and the results of intersessional work
        - 3.2.3 Trial structure
    - 3.3 Bowhead whales
        - 3.3.1 Report from the intersessional Workshop (SC/65a/Rep02)
        - 3.2.2 Discussion of the Workshop report and the results of intersessional work
        - 3.3.3 Trial structure
    - 3.4 Results from initial work on *SLA*s for humpback and bowhead whales
        - 3.5.2 Conclusions and recommendations
4. Annual review of management advice
    - 4.1 Common minke whales off West Greenland
        - 4.1.1 New information (incl. catch data and agreed abundance estimates)
    - 4.2 Common minke whales off East Greenland
        - 4.2.1 New information (incl. catch data and agreed abundance estimates)
        - 4.2.2 Management advice
    - 4.3 Fin whales off West Greenland
        - 4.3.1 New information (incl. catch data and agreed abundance estimates)
        - 4.3.2 Management advice
    - 4.4 Humpback whales off West Greenland
        - 4.4.1 New information (incl. catch data and agreed abundance estimates)
        - 4.4.2 Management advice
    - 4.5 Humpback whales off St Vincent and The Grenadines
        - 4.5.1 New information (incl. catch data and agreed abundance estimates)
        - 4.5.2 Management advice
5. Aboriginal Whaling Management Scheme
    - 5.1 Guiding principles for *SLA* development and evaluation
    - 5.2 Scientific aspects of an aboriginal whaling scheme
6. Progress on follow-up work on conversion factors for the Greenlandic hunt
    - 6.1 New information
    - 6.2 Discussion
7. Conservation Management Plans (CMPs)
8. Updated list of abundance estimates
9. Work plan and budget requests
    - 9.1 Work plan
    - 9.2 Budget requests
10. Adoption of report

Appendix 2

TRIAL SPECIFICATIONS FOR HUMPBACK AND BOWHEAD WHALES OFF WEST GREENLAND

[NB: Aspects of these specifications, including those highlighted, will be finalised prior to the 2014 Annual Meeting by an Intersessional Steering Group and Workshop]

A. The population dynamics model

The underlying dynamics model is deterministic, age- and sex-structured, and based on the Baleen II model (Punt, 1999).

A.1 Basic dynamics

Equations A1.1 provide the underlying 1+ dynamics.

$$\begin{aligned} R^{m/f}_{t+1,a+1} &= (R^{m/f}_{t,a} - C^{m/f}_{t,a})S_a + U^{m/f}_{t,a} S_a \delta_{a+1} && 0 \le a \le x-2 \\ R^{m/f}_{t+1,x} &= (R^{m/f}_{t,x} - C^{m/f}_{t,x})S_x + (R^{m/f}_{t,x-1} - C^{m/f}_{t,x-1})S_{x-1} && \\ U^{m/f}_{t+1,a+1} &= U^{m/f}_{t,a} S_a (1-\delta_{a+1}) && 0 \le a \le x-2 \end{aligned} \quad \text{(A1.1)}$$

$R^{m/f}_{t,a}$ is the number of recruited males/females of age a at the start of year t;

$U^{m/f}_{t,a}$ is the number of unrecruited males/females of age a at the start of year t;

$C^{m/f}_{t,a}$ is the catch of males/females of age a during year t (whaling is assumed to take place in a pulse at the start of each year);

δ_a is the fraction of unrecruited animals of age a-1 which recruit at age a (assumed to be independent of sex and time);

S_a is the annual survival rate of animals of age a:

$$S_a = \begin{cases} S_0 & \text{if } a = 0 \\ S_{1+} & \text{if } 1 < a \le a_a \\ & \text{if } a > a_a \end{cases} \quad \text{(A1.2)}$$

S_0 is the calf survival rate;

S_{1+} is the survival rate for animals aged 1 and older; and

x is the maximum (lumped) age-class (all animals in this and the x-1 class are assumed to be recruited and to have reached the age of first parturition). x is taken to be 15 for humpback whales and 35 for bowhead whales for these trials.

A.2 Births

The number of births at the start of year t+1, B_{t+1}, is given by Equation A2.1:

$$B_{t+1} = b_{t+1} N^f_{t+1} \quad \text{(A2.1)}$$

N^f_t is the number of mature females at the start of year t:

$$N^f_t = \sum_{a=a_m}^{x} (R^f_{t,a} + U^f_{t,a}) \quad \text{(A2.2)}$$

a_m is the age-at-maturity (the convention of referring to the mature population is used here, although this actually refers to animals that have reached the age of first parturition);

b_{t+1} is the probability of birth/calf survival for mature females:

$$b_{t+1} = \max(0, b_K\{1 + A(1 - [N^{1+}_{t+1} / K^{1+}]^z)\}) \quad \text{(A2.3)}$$

$$N^{1+}_t = \sum_{a=1}^{x} (R^f_{t,a} + U^f_{t,a} + R^m_{t,a} + U^m_{t,a})$$

$$K^{1+} = \sum_{a=1}^{x} (R^f_{-\infty,a} + U^f_{-\infty,a} + R^m_{-\infty,a} + U^m_{-\infty,a}) \quad \text{(A2.4)}$$

b_K is the average number of live births per year per mature female at carrying capacity;
A is the resilience parameter; and
z is the degree of compensation.

The number of female births, B_t^f, is computed from the total number of the births during year t using Equation A2.5:

$$B_t^f = 0.5 \;\; B_t \tag{A2.5}$$

The numbers of recruited/unrecruited calves is given by:

$$\begin{aligned} R_t^f &= \alpha_0 \, B_t^f & R_t^m &= \alpha_0 \,(B_t - B_t^f) \\ U_t^f &= (1-\alpha_0)\, B_t^f & U_t^m &= (1-\alpha_0)(B_t - B_t^f) \end{aligned} \tag{A2.6}$$

α_0 is the proportion of animals of age 0 which are recruited (0 for these trials).

A.3 Catches

The historical (t<2013) removals are taken to be equal to the total reported removals (including struck and lost, by-catch, ship strikes, etc.) catches (Table 1). The sex-ratio of future aboriginal catches is assumed to be 50:50 F:M (bowheads) and 20:80 F:M (humpbacks) while the sex ratio of by catches, ship strikes and Canadian catches is assumed to be 50:50 F:M. Catches are taken uniformly from the recruited component of the population:

$$C_{t,a}^m = C_t^m \, R_{t,a}^m / \sum_{a'} R_{t,a'}^m \, ; \qquad C_{t,a}^{m/f} = C_t^f \, R_{t,a}^f / \sum_{a'} R_{t,a'}^f \tag{A3.1}$$

$C_t^{m/f}$ is the catch of males/females during year t.

The total catch in a given future year is the sum of: (a) the minimum of the need for that year, Q_t, and the corresponding strike limit; (b) bycatches in fisheries; (c) ship strikes; and (d) aboriginal catches in Canada (only bowheads).

The total bycatch during future year y is computed by applying the average exploitation rate during 2007-11 to the number of 1+ animals in year y, i.e.:

$$\tilde{C}_t = \tilde{F} \, N_t^{1+} \tag{A3.2}$$

$\tilde{F}$ is the average exploitation rate due to by-catch during 2007-11:

$$\tilde{F} = \sum_{t=2007}^{2011} (\tilde{C}_t^f + \tilde{C}_t^m) / \sum_{t=2007}^{2011} N_t^{1+} \tag{A3.3}$$

A.4 Recruitment

The proportion of animals of age a that would be recruited if the population was pristine is a knife-edged function of age at age a_r, i.e.:

$$\alpha_a = \begin{cases} 0 & \text{if } \; 0 \le a < a_r \\ 1 & \text{otherwise} \end{cases} \tag{A4.1}$$

a_r is the age-at-recruitment (assumed to be 5 for humpbacks and 1 for bowhead whales).

The (expected) number of unrecruited animals of age a that survive to age a+1 is $U_{t,a}^{m/f} \; S_a$. The fraction of these that then recruit is:

$$\delta_{a+1} = \begin{cases} [\alpha_{a+1} - \alpha_a]/[1-\alpha_a] & \text{if } 0 \le \alpha_a < 1 \\ 1 & \text{otherwise} \end{cases} \tag{A4.2}$$

A.5 Maturity

Maturity is assumed to be a knife-edged function of age at age a_m.

A.6 Initialising the population vector

The numbers at age in the pristine population are given by:

$$\begin{aligned} R_{-\infty,a}^{m/f} &= 0.5 \;\; N_{-\infty,0} \;\; \alpha_a \prod_{a'=0}^{a-1} S_{a'} & & \text{if } \; 0 \le a < x \\ U_{-\infty,a}^{m/f} &= 0.5 \;\; N_{-\infty,0} \;\; (1-\alpha_a) \prod_{a'=0}^{a-1} S_{a'} & & \text{if } \; 0 \le a < x \\ R_{-\infty,x}^{m/f} &= 0.5 \;\; N_{-\infty,0} \prod_{a'=0}^{x-1} \frac{S_{a'}}{(1-S_x)} & & \text{if } \; a = x \end{aligned} \tag{A6.1}$$

Table 1
Total removals? of bowhead and humpback whales.

Year	M	F	Year	M	F	Year	M	F
(a) Bowhead whales								
1940	1	1	1970	0	0	2000	0.5	0.5
1941	0.5	0.5	1971	1	1	2001	0	0
1942	0	0	1972	0	0	2002	0	0
1943	0	0	1973	0.5	0.5	2003	0.5	0.5
1944	0	0	1974	0	0	2004	0.5	0.5
1945	1.5	1.5	1975	1.5	1.5	2005	0.5	0.5
1946	0.5	0.5	1976	0	0	2006	0	0
1947	0.5	0.5	1977	0	0	2007	0	0
1948	0	0	1978	0	0	2008	1.5	1.5
1949	0	0	1979	0.5	0.5	2009	3	3
1950	0	0	1980	0.5	0.5	2010	2.5	2.5
1951	0	0	1981	0	0	2011	0	1
1952	0	0	1982	0	0	2012	0	0
1953	0	0	1983	0	0			
1954	0	0	1984	0	0			
1955	0.5	0.5	1985	0.5	0.5			
1956	0.5	0.5	1986	0	0			
1957	0	0	1987	0	0			
1958	0	0	1988	0	0			
1959	0.5	0.5	1989	0	0			
1960	0	0	1990	0	0			
1961	0.5	0.5	1991	0	0			
1962	0	0	1992	0	0			
1963	0	0	1993	0	0			
1964	0.5	0.5	1994	0.5	0.5			
1965	0.5	0.5	1995	0	0			
1966	0	0	1996	0.5	0.5			
1967	0.5	0.5	1997	0	0			
1968	0	0	1998	0.5	0.5			
1969	0	0	1999	0	0			
1935	0	0						
1936	0	0						
1937	0	0						
1938	0	0						
1939	0.5	0.5						
(b) Humpbacks								
1960	0	1	1980	8	8	2000	0	2
1961	0	1	1981	6	6	2001	1	1
1962	1	1	1982	6	6	2002	2	1
1963	0	0	1983	7	9	2003	0	1
1964	0	0	1984	8	8	2004	2	1
1965	0	1	1985	4	4	2005	2	3
1966	2	2	1986	0	0	2006	0	0
1967	2	2	1987	0	0	2007	1	1
1968	2	3	1988	0	1	2008	1	2
1969	1	2	1989	1	1	2009	0	0
1970	0	0	1990	0	1	2010	4	6
1971	2	2	1991	0	1	2011	3	5
1972	1	2	1992	0	1	2012	4	9
1973	5	6	1993	0	0			
1974	4	5	1994	0	1			
1975	4	5	1995	0	0			
1976	4	5	1996	0	0			
1977	8	9	1997	0	0			
1978	12	12	1998	0	1			
1979	7	8	1999	0	1			

$R^{m/f}_{-\infty,a}$ is the number of animals of age *a* that would be recruited in the pristine population;

$U^{m/f}_{-\infty,a}$ is the number of animals of age *a* that would be unrecruited in the pristine population; and

$N_{-\infty,0}$ is the total number of animals of age 0 in the pristine population.

The value for $N_{-\infty,0}$ is determined from the value for the pre-exploitation size of the 1+ component of the population using the equation:

$$N_{-\infty,0} = K^{1+} / \left(\sum_{a=1}^{x-1} \left(\prod_{a'=0}^{a-1} S_{a'} \right) + \frac{1}{1-S_x} \prod_{a'=0}^{x-1} S_{a'} \right) \quad \text{(A6.2)}$$

In common with the trials for the Eastern North Pacific gray whales (IWC, 2013), the trials are based on the assumption that the age-structure at the start of year τ is stable rather than that the population was at its pre-exploitation equilibrium size at the start of (say) 1600, the first year for which catch estimates are available. The determination of the age-structure at the start of year τ involves specifying the effective 'rate of increase', γ, that applies to each age-class. There are two components contributing to γ, one relating to the overall population rate of increase (γ^+) and the other to the exploitation rate. Under the assumption of knife-edge recruitment to the fishery at age a_r, only the γ^+ component (assumed to be zero following Punt and Butterworth [2002] applies to ages a of a_r or less. The number of animals of age a at the start of year τ relative to the number of calves at that time, $N^*_{\tau,a}$, is therefore given by the equation:

$$N^*_{\tau,a} = \begin{cases} 1 & \text{if } a = 0 \\ N^*_{\tau,a-1} S_{a-1} & \text{if } a \le a_r \\ N^*_{\tau,a-1} S_{a-1}(1-\gamma^+) & \text{if } a_r < a < x \\ N^*_{\tau,x-1} S_{x-1}(1-\gamma^+)/(1-S_x(1-\gamma^+)) & \text{if } a = x \end{cases} \quad \text{(A6.3)}$$

B_τ is the number of calves in year τ and is derived directly from equations A2.1 and A2.3 (for further details see Punt, 1999).

$$B_\tau = \left(1 - \left[1/(N^f_\tau b_K) - 1\right]/A\right)^{1/z} \frac{K^{1+}}{N^{1+,*}_\tau} \quad \text{(A6.4)}$$

The effective rate of increase, γ, is selected so that if the population dynamics model is projected from year τ to a year Ψ, the size of the 1+ component of the population in a reference year Ψ equals a value, P_Ψ which is drawn from a prior.

A.7 z and A

A, z and S_0, are obtained by solving the system of equations that relate $MSYL$, $MSYR$, S_0, S_{1+}, $f_{\max}$ $a_{\rm m}$, A and z, where $f_{\max}$ is the maximum theoretical pregnancy rate (Punt, 1999).

A.8 Conditioning

The method for conditioning the trials (i.e. selecting the 100 sets of values for the parameters $a_{\rm m}$, S_0, S_{1+}, K^{1+}, A and z) is based on a Bayesian assessment. The algorithm for conducting the Bayesian assessment is as follows:

(a) Draw values for the parameters S_{1+}, $f_{\max}$, $a_{\rm m}$, $MSYR_{1+}$, $MSYL_{1+}$, K^{1+}, P_Ψ, CV_{add} (the additional variance for the estimates of 1+ abundance in Ψ) from the priors in Table 2. The additional variance for the estimates of absolute abundance and indices of relative abundance are assumed to be the same. It is not necessary to draw values for $MSYR_{1+}$ and $MSYL_{1+}$ because the values for these quantities are pre-specified rather than being determined during the conditioning process.

(b) Solve the system of equations that relate $MSYL$, $MSYR$, S_0, S_{1+}, $f_{\max}$, $a_{\rm m}$, A and z to find values for S_0, A and z.

(c) Calculate the likelihood of the projection which is given by[1]:

$L=L_1L_2$ (L_2 applies only to the sighting rates for bowheads) where:

$$L_1 = \prod_t \frac{1}{\sqrt{\Omega_t^2 + CV^2_{add2}}} \exp\left(-\frac{(\ell n P_t^{obs} - \ell n\left(B_c \hat{P}_t\right))^2}{2(\Omega_t^2 + CV^2_{add2,t})}\right) \quad \text{(A8.1a)}$$

$$L_2 = \prod_t (\rho \hat{P}_t)^{N_t^{obs}} e^{-\rho \hat{P}_t} \quad \text{(A8.1a)}$$

P_t^{obs} is the estimate of the (1+) abundance at the start of year t (Table 3);

$\hat{P}_t$ is the model-estimate of the (1+) abundance which pertain to the survey estimates of abundance at the start of year t;:

$$\hat{P}_t = \tilde{S}^f \sum_{a=1}^{x} (R^f_{t,a} + U^f_{t,a}) + \tilde{S}^m \sum_{a=1}^{x} (R^m_{t,a} + U^m_{t,a}) \quad \text{(A.8.2)}$$

Ω_t is the (sampling) standard deviation of the logarithm of P_t^{obs} (approximated by its coefficient of variation, $CV^{obs}_{est,t}$ - see Table 3);

$\tilde{S}^f, \tilde{S}^m$ is the relative selectivity for females and males (1:1 for humpbacks and 1:0.25 for bowheads);

$E(CV^2_{add2,t})$ is the square of the actual CV of the additional variation for year t:

[1]The priors for the survey bias and additional variation are integrated out as these are nuisance parameters.

$$E(CV^2_{add2,t}) = \eta(0.1 + 0.013P^* / \hat{P}_t) = CV^2_{add2}\frac{0.1 + 0.013P^* / \hat{P}_t}{0.1 + 0.013P^* / \hat{P}_\Psi} \qquad \text{(A8.3)}$$

N_t^{obs} is the number of animals counted during year t (a relative index of abundance; Table 3b),

ρ is the constant of proportionality between the number of 1+ animals and the population counts, and

B_c is the bias associated with a relative index of abundance (different for each relative index).

Steps (a)-(c) are repeated a large number (typically 1,000,000) of times.

100 sets of parameters vectors are selected randomly from those generated using steps (a)-(c), assigning a probability of selecting a particular vector proportional to its likelihood. The number of times steps (a)-(c) are repeated is chosen to ensure that each of the 100 parameter vectors are unique.

The bulk of the trials for humpbacks are conditioned on the estimate of absolute abundance (Table 3a) and the time series of relative abundance based on aerial surveys (Table 3b). The relative indices of abundance based on mark-recapture are used when conditioning one of the *Robustness Trials*.

Table 2
The prior distributions.

Parameter	Prior distribution (humpbacks)	Prior distribution (bowheads)
Non-calf survival rate, S_{1+}	U[0.90, 0.995]	N(1.059, 0.0378[2]), truncated at 0.995
Age-at-maturity, a_m	U[4, 12]	N(20,32) truncated at 13.5 and 26.5
Transition age	0	U[1,9]
K^{1+}	U[0, 30,000]	U[0, 40,000]
$MSYL_{1+}$	Pre-specified	Pre-specified
$MSYR_{1+}$	Pre-specified	Pre-specified
Maximum pregnancy rate, $1/f_{max}$	U[1.25, 2.5]	U[2.5, 4]
Additional variation (population estimates), CV_{add}, in year Ψ	U[0, 0.35]	U[0, 0.35]
Abundance in year Ψ, P_Ψ	$\ell nP_{2007} = N(\ell n2{,}154, (0.36^2 + CV_{add}^2))$	A: $\ell nP_{2002} = N(\ell n6{,}340; (0.38^2 + CV_{add}^2))$ B: $\ell nP_{2007} = N(\ell n1{,}229, (0.47^2 + CV_{add}^2))$
Additional variation (relative indices), CV_{add2}	U[0.2, 0.6]	U[0.2, 0.6]
Bias of relative abundance indices, B_c	$\ell nB_c \sim U[-\infty, \infty]$ (see[1])	$\ell nB_c \sim U[-\infty, \infty]$ (see[1])

[1]This is the non-informative prior for a scale parameter.

Table 3
Estimates of absolute abundance (a) and estimates of relative abundance (b).

Year	Estimate	CV
(a) Estimate of absolute abundance		
Bowhead whales		
2002	6,340	0.38
2007	1,229	0.47
Humpback whales		
2007	2,700	0.34

(b) Estimates of relative abundance

Bowhead whales

Year	Estimate	CV	Year	Effort L, (km)	Count
2006	1229	0.47	1981	951	1
2012	829	0.35	1982	2,273	1
			1990	591	1
			1991	1,088	3
			1993	577	0
			1994	1,092	0
			1998	1,184	5
			1999	1,104	0
			2006	791	9
			2012	1,574	25

Humpback whales

Year	Estimate	CV	Year[1]	Estimate[1]	CV[1]
1984	99	0.40	1982	271	0.13
1985	177	0.44	1989	357	0.16
1987	220	0.62	1990	355	0.12
1988	200	0.74	1991	566	0.42
1989	272	0.75	1992	376	0.19
1993	873	0.53	1993	348	0.12
2005	1,158	0.35			
2007	1,020	0.35			

[1]Not used in the *Evaluation Trials*.

B. Data generation

B.1 Absolute abundance estimates

The historic (t<2013) abundance estimates (and their CVs) are provided to the *SLA* and are taken to be those in Table 3a for humpback whales and the relative indices of abundance for bowhead whales in Table 3b. An estimate of abundance together with an estimate of its CV is generated, and is provided to the *SLA,* once every F years during the management period (starting in year 2017 for humpbacks and 2022 for bowheads; F=10 years beyond the year with the last estimate of abundance). The CV of the abundance estimate (CV_{true}) is different from the CV provided to the *SLA*.

The survey estimate, $\hat{S}$, may be written as:

$$\hat{S} = B_A \; P \; Y \; w / \mu = B_A \; P^* \; \beta^2 \; Y \; w \quad \text{(B1.1)}$$

B_A is the bias;

P is the current 1+ population size ($= \hat{P}_t$); (B1.2)

Y is a lognormal random variable: $Y=e^{\phi}$ where: $\phi \sim N[0;\sigma_\phi^2]$ and $\sigma_\phi^2 = \ell n(1+\alpha^2)$ (B1.3)

w is a Poisson random variable, independent of Y, with $E(w) = \text{var}(w) = \mu = (P / P^*) / \beta^2$; and (B1.4)

P^* is the reference population level (the pristine size of $\hat{P}_t$).

The steps used in the program to generate the abundance estimates and their CVs are given below[2].

The *SLA* is provided with estimates of CV_{est} for each future sightings estimate. The estimate of $CV_{est,t}$ is given by:

$$\hat{C}V_{est,t} = \sqrt{\sigma_t^2 (\chi_n^2 / n)} \qquad \sigma_t^2 = \ell n(1 + E(CV_{est,t}^2)) \quad \text{(B1.5)}$$

$E(CV_{est,t}^2)$ is the sum of the squares of the actual CVs due to estimation error:

$$E(CV_{est,t}^2) = \theta^2 (a^2 + b^2 / w\beta^2) \quad \text{(B1.6)}$$

χ_n^2 is a random number from a χ^2 distribution with n (=19; the value assumed for the single stock trials for the RMP) degrees of freedom; and

a^2, b^2 are constants and equal to 0.02 and 0.012 respectively.

The relationship between CV_{est} and CV_{true} is given by:

$$\eta = [E(CV_{true}^2) - E(CV_{est}^2)] / (0.1 + 0.013 P^* / P) \quad \text{(B1.7)}$$

where η is a constant known as the additional variance factor. The value of η is based on the population size and CVs for year Ψ:

$$\eta = CV_{add}^2 / (0.1 + 0.013 P^* / P_\Psi) \quad \text{(B1.8)}$$

The values of α and β are then computed as:

$$\alpha^2 = \theta^2 a^2 + \eta \;\; 0.1, \qquad \beta^2 = \theta^2 b^2 + \eta \;\; 0.013 \quad \text{(B1.9)}$$

C. Need

The level of need supplied to the *SLA* is the total need for the 6-year period for which strike limits are to be set. The scenarios regarding need are listed in Table 4.

D. Trials

Table 4 lists all of the factors considered in the trials. The set of *Evaluation Trials* is given in Table 5 and the *Robustness Trials* in Table 6.

[2]The steps used to generate estimates of abundance and their CVs are as follows (steps (i)-(iii) are part of the conditioning process).

(i) Read in CV_{est} (Table 3). Generate values of CV_{add}^2 for year Ψ.

(ii) Set η using equation B1.8 and the value of CV_{add} from step (i).

(iii) Set θ^2 using equation B1.6 and the values for CV_{est} from step (i) and $w\beta^2 = P/P^* = P_{1968}/P^*$. Set α^2 and β^2 using equation B1.9.

(iv) Generate w (Poisson random variable – equation B1.4) and ϕ (lognormal random variable –equation B1.3).

(v) Set abundance estimate $\hat{S}$ using equation B1.1.

(vi) Generate $\hat{C}V_{est,t}$ from a χ_n^2 distribution using equation B1.5.

Table 4

Factors tested in the trials.

Factors	Levels (reference levels shown bold and underlined) Humpback whales	Bowhead whales
$MSYR_{1+}$	1%, 3%, **<u>5%</u>**, 7%	1%, **<u>2.5%</u>**, 4%
$MSYL_{1+}$	0.6	<u>0.6</u>, 0.8
Time dependence in K*	**<u>Constant</u>**, Halve linearly over 100yr	
Time dependence in natural mortality, M*	**<u>Constant,</u>** Double linearly over 100yr	
Episodic events*	**<u>None</u>**, 3 events occur between years 1-75 (with at least 2 in years 1-50) in which 20% of the animals die, Events occur every 5 years in which 5% of the animals die	
Need envelope	A: 10, 15, 20; 20 thereafter B: 10, 15, 20; 20->40 over years 18-100 C: 10, 15, 20; 20->60 over years 18-100 D: 20, 25, 30; 30->50 over years 18-100	**<u>A: 2, 3, 5; 5 thereafter</u>** B: 2, 3, 5; 5 -> 10 over years 18-100 C: 2, 3, 5; 5 -> 15 over years 18-100
Future Canadian catches	N/A	**<u>A: 5 constant over 100 years</u>** B: 5-> 10 over 100 years C: 5-> 15 over 100 years D: 2.5 constant over 100 years?
Survey frequency	5 yr, **<u>10 yr</u>**, 15 yr	
Historic survey bias	0.8, **<u>1.0</u>**, 1.2	0.5, **<u>1.0</u>**
First year of projection, τ	1960	1940
Alternative priors	$S_{1+} \sim U[0.9, 0.99]$; $f_{max} \sim U[0.4, 0.6]$; $a_m \sim U[5, 12]$	N/A
Strategic surveys	Extra survey if a survey estimate is half of the previous survey estimate	
Asymmetric environmental stochasticity parameters	To be finalised by an intersessional group	

*Effects of these factors begin in year 2013 (i.e. at start of management). The adult survival rate is adjusted so that in catches were zero, then average population sizes in 250-500 years equals the carrying capacity. *Note*: for some biological parameters and levels of episodic events, it may not be possible to find an adult survival rate which satisfies this requirement.

Table 5

The *Evaluation Trials*. Values given in bold type show differences from the base trial.

Trial	Description	$MSYR_{1+}$	Need scenarios	Survey freq.	Historic survey bias	Conditioning option
(a) Humpback whales						
1A	$MSYR_{1+}$=5%	5%	A, B, C, D	10	1	Y
1B	$MSYR_{1+}$=3%	**3%**	A, B, C, D	10	1	Y
1C	$MSYR_{1+}$=7%	**7%**	A, B, C, D	10	1	Y
2A	5 year surveys	5%	B, C, D	**5**	1	1A
2B	5 year surveys; $MSYR_{1+}$=3%	3%	B, C, D	**5**	1	1B
3A	15 year surveys	5%	B, C	**15**	1	1A
3B	15 year surveys; $MSYR_{1+}$=3%	3%	B, C	**15**	1	1B
4A	Survey bias = 0.8	5%	B, C, D	10	**0.8**	Y
4B	Survey bias = 0.8; $MSYR_{1+}$=3%	**3%**	B, C, D	10	**0.8**	Y
5A	Survey bias = 1.2	5%	B, C, D	10	**1.2**	Y
5B	Survey bias = 1.2; $MSYR_{1+}$=3%	**3%**	B, C, D	10	**1.2**	Y
6A	3 episodic events	5%	B, C, D	10	1	1A
6B	3 episodic events; $MSYR_{1+}$=3%	**3%**	B, C, D	10	1	1B
7A	Stochastic events every 5 years	5%	B, C, D	10	1	1A
7B	Stochastic events every 5 years; $MSYR_{1+}$= 3%	**3%**	B, C, D	10	1	1B
8A	Asymmetric environmental stochasticity	5%	B, C, D	10	1	??
8B	Asymmetric environ. stochasticity; $MSYR_{1+}$=3%	**3%**	B, C, D	10	1	??

Trial	Description	$MSYR_{1+}$	Need scenario	Survey freq.	Canadian catches	Historic survey bias	Conditioning option
(b) Bowhead whales (each conducted conditioning to the estimate of abundance for West Greenland, treating it as absolute abundance)							
1A	$MSYR_{1+}$=2.5%	2.5%	A, B, C	10	A	1	Y
1B	$MSYR_{1+}$=1%	**1%**	A, B, C	10	A	1	Y
1C	$MSYR_{1+}$=4% (and $MSYL_{1+}$=0.8)	**4%**	A, B, C	10	A	1	Y
2A	5 year surveys	2.5%	A, B, C	**5**	A	1	1A
2B	5 year surveys; $MSYR_{1+}$=1%	**1%**	A, B, C	**5**	A	1	1B
3A	15 year surveys	2.5%	A, B, C	**15**	A	1	1A
3B	15 year surveys; $MSYR_{1+}$=1%	**1%**	A, B, C	**15**	A	1	1B
4A	Survey bias = 0.5	2.5%	A, B, C	10	A	**0.5**	Y
4B	Survey bias = 0.5; $MSYR_{1+}$=1%	**1%**	A, B, C	10	A	**0.5**	Y
5A	3 episodic events	2.5%	A, B, C	10	A	1	1A
5B	3 episodic events; $MSYR_{1+}$=1%	**1%**	A, B, C	10	A	1	1B
6A	Stochastic events every 5 years	2.5%	A, B, C	10	A	1	1A
6B	Stochastic events every 5 years; $MSYR_{1+}$=1%	**1%**	A, B, C	10	A	1	1B
7A	Alternative future Canadian catches	2.5%	A, B, C	10	**B**	1	1A
7B	Alternative future Canadian catches; $MSYR_{1+}$=1%	**1%**	A, B, C	10	**B**	1	1B
9A	Alternative future Canadian catches	2.5%	A, B, C	10	**D**	1	1A
9B	Alternative future Canadian catches; $MSYR_{1+}$=1%	**1%**	A, B, C	10	**D**	1	1B
10A	Asymmetric environmental stochasticity	2.5%	A, B, C	10	A	1	??
10B	Asymmetric environ. stochasticity; $MSYR_{1+}$=1%	**1%**	A, B, C	10	A	1	??

Table 6

The *Robustness Trials*.

Humpback whales				Bowhead whales			
Trial no.	Factor	Need scenario	Conditioning option	Trial no.	Factor	Need scenario	Conditioning option
1A	Linear decrease in K; $MSYR_{1+}$=5%	B, D	1A	1A	Linear decrease in K; $MSYR_{1+}$=2.5%	A, C	1A
1B	Linear decrease in K; $MSYR_{1+}$=3%	B, D	1B	1B	Linear decrease in K; $MSYR_{1+}$=1%	A, C	1B
2A	Linear increase in M; $MSYR_{1+}$=5%	B, D	1A	2A	Linear increase in M; $MSYR_{1+}$=2.5%	A, C	1A
2B	Linear increase in M; $MSYR_{1+}$=3%	B, D	1B	2B	Linear increase in M; $MSYR_{1+}$=1%	A, C	1B
3A	Strategic Surveys; $MSYR_{1+}$=5%	B, D	1A	3A	Strategic Surveys; $MSYR_{1+}$=2.5%	A, C	1A
3B	Strategic Surveys; $MSYR_{1+}$=3%	B, D	1B	3B	Strategic Surveys; $MSYR_{1+}$=1%	A, C	1B
4A	Alternative priors; $MSYR_{1+}$=5%	B, D	4A*	4A	Canadian catch 'C'; $MSYR_{1+}$=2.5%	A, C	1A?
4B	Alternative priors; $MSYR_{1+}$=3%	B, D	4B*	4B	Canadian catch 'C'; $MSYR_{1+}$=1%	A, C	1B?
4C	Alternative priors; $MSYR_{1+}$=7%	B, D	4C*				
5D	$MSYR_{1+}$=1%	B, D	5D*				
6A	Include mark-recapture estimates in the conditioning; $MSYR_{1+}$=5%	B, D	6A*				
6B	Include mark-recapture estimates in the conditioning; $MSYR_{1+}$=3%	B, D	6B*				

*Trial which needs to be conditioned.

F. Statistics

The risk- and recovery-related performance statistics are computed for the mature female and for the total (1+) population sizes (i.e. P_t is either the size of the mature female component of the population, N_t^f, or the size of the total (1+) population, N_t^{1+}). P_t^* is the population size in year t under a scenario of zero strikes over the years t≥2013 (defined as t=0 below) Note that incidental removals may still occur in the absence of strikes. To emphasize this distinction, $P_t^*(0)$ is used to denote the population size in year t under a scenario of zero strikes or removals of any kind, and $P_t^*(\text{inc})=P_t^*$ reflects the case when there are zero strikes but some incidental removals may occur. K^* is the population size in year t if there had never been any harvest or incidental removals???.

The trials are based on a 100-year time horizon, but a final decision regarding the time horizon will depend *inter alia* on interactions between the Committee and the Commission regarding need envelopes and on the period over which recovery might occur. To allow for this, results are calculated for T=20 and 100 (T^* denotes the number of blocks for a given T; T^* is 3 and 19 respectively for T=20 and T=100).

Statistics marked in bold face are considered the more important. Note that the statistic identification numbers have not been altered for reasons of consistency. Hence, there are gaps in the numbers where some statistics have been deleted.

F.1 Risk

D1. Final depletion: P_T/K. In trials with varying K this statistic is defined as P_T / K_t^*.

D2. Lowest depletion: $\min(P_t / K) : t = 0,1,...,T$. In trials with varying K this statistic is defined as $\min(P_t / K_t^*):\ t = 0,1,...,T$.

D6. Plots for simulations 1-100 of $\{P_t: t = 0,1,..,T\}$ and $\{P_t^*: t = 0,1,..,T\}$.

D7. Plots of $\{P_{t[x]}: t = 0,1,..,T\}$ and $\{P^*_{t[x]}: t = 0,1,..,T\}$ where $P_{t[x]}$ is the xth percentile of the distribution of P_t. Results are presented for x=5 and x=50.

D8. Rescaled final population: P_T / P_T^* . There are two versions of this statistic: D8(0)= $P_T / P_T^*(0)$ and D8(inc)= $P_T / P_T^*(\text{inc})$.

D9. Minimum population level: $\min(P_t)$: t=0,1,…,T.

D10. Relative increase P_T/P_0.

F.2 Need

N1. Total need satisfaction: $\sum_{t=0}^{T-1} C_t / \sum_{t=0}^{T-1} Q_t$

N2. Length of shortfall = (negative of the greatest number of consecutive years in which $C_b < Q_b$) / T^*, where C_b is the catch for block b, and Q_b is the total need for block b.

N4. Fraction of years in which $C_t = Q_t$

N7. Plot of $\{V_{t[x]} : t = 0, 1, T-1\}$ where $V_{t[x]}$ is the xth percentile of the distribution of $V_t = C_t / Q_t$

N8. Plots of V_t for simulations 1-100.

N9. Average need satisfaction: $\frac{1}{T}\sum_{t=0}^{T-1}\frac{C_t}{Q_t}$

N10. AAV (Average Annual Variation): $\sum_{b=0}^{T^*-1}\left|C_{b+1}-C_b\right| / \sum_{b=0}^{T^*-1}C_b$

N11. Anti-curvature: $\frac{1}{T^*-1}\sum_{b=0}^{T^*-2}\left|\frac{C_b-M_b}{\max\left(10,M_b\right)}\right|$ where $M_b=\left(C_{b+1}+C_{b-1}\right)/2$

N12. Mean downstep (or modified AAV): $\sum_{b=0}^{T^*-1}\left|\min\left(C_{b+1}-C_b,0\right)\right| / \sum_{b=0}^{T^*-1}C_b$

F.3 Recovery

R1. Relative recovery: $P_{t_r^*} / P_{t_r^*}^*$ where t_r^* is the first year in which P_t^* passes through *MSYL*. If P_t^* never reaches *MSYL*, the statistic is P_T / P_T^*. If P_0>*MSYL* the statistic is min (1, P_T/*MSYL*).

The following plots are to be produced to evaluate conditioning:

- Time-trajectories of 1+ population size in absolute terms and relative to carrying capacity, along with the fits to abundance estimates. This plot allows an evaluation of whether conditioning has been achieved satisfactorily.
- Histograms of the 100 parameter vectors for each trial. This plot allows an evaluation of whether and how conditioning has impacted the priors for these parameters.

H. References

International Whaling Commission. 2013. Report of the Standing Working Group on the Aboriginal Whaling Management Procedure (AWMP). *J. Cetacean Res. Manage.* 14 (Suppl.): 137-171.

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International Convention

for the

Regulation of Whaling, 1946

Schedule

As amended by the Commission at the 66th Meeting

Portorož, Slovenia, October 2016

INTERNATIONAL
WHALING COMMISSION

International Convention

for the

Regulation of Whaling, 1946

Schedule

EXPLANATORY NOTES

The Schedule printed on the following pages contains the amendments made by the Commission at its 66th Meeting in October 2016. The amendments, which are shown in ***italic bold*** type, come into effect on 5 February 2017.
In Tables 1, 2 and 3 unclassified stocks are indicated by a dash. Other positions in the Tables have been filled with a dot to aid legibility.
Numbered footnotes are integral parts of the Schedule formally adopted by the Commission. Other footnotes are editorial.
The Commission was informed in June 1992 by the ambassador in London that the membership of the Union of Soviet Socialist Republics in the International Convention for the Regulation of Whaling from 1948 is continued by the Russian Federation.
The Commission recorded at its 39th (1987) meeting the fact that references to names of native inhabitants in Schedule paragraph 13(*b*)(4) would be for geographical purposes alone, so as not to be in contravention of Article V.2(c) of the Convention (*Rep. int. Whal. Commn* 38:21).

I. INTERPRETATION

1. The following expressions have the meanings respectively assigned to them, that is to say:

A. Baleen whales

"baleen whale" means any whale which has baleen or whale bone in the mouth, i.e. any whale other than a toothed whale.

"blue whale" (*Balaenoptera musculus*) means any whale known as blue whale, Sibbald's rorqual, or sulphur bottom, and including pygmy blue whale.

"bowhead whale" (*Balaena mysticetus*) means any whale known as bowhead, Arctic right whale, great polar whale, Greenland right whale, Greenland whale.

"Bryde's whale" (*Balaenoptera edeni*, *B. brydei*) means any whale known as Bryde's whale.

"fin whale" (*Balaenoptera physalus*) means any whale known as common finback, common rorqual, fin whale, herring whale, or true fin whale.

"gray whale" (*Eschrichtius robustus*) means any whale known as gray whale, California gray, devil fish, hard head, mussel digger, gray back, or rip sack.

"humpback whale" (*Megaptera novaeangliae*) means any whale known as bunch, humpback, humpback whale, humpbacked whale, hump whale or hunchbacked whale.

"minke whale" (*Balaenoptera acutorostrata*, *B. bonaerensis*) means any whale known as lesser rorqual, little piked whale, minke whale, pike-headed whale or sharp headed finner.

"pygmy right whale" (*Caperea marginata*) means any whale known as southern pygmy right whale or pygmy right whale.

"right whale" (*Eubalaena glacialis*, *E. australis*) means any whale known as Atlantic right whale, Arctic right whale, Biscayan right whale, Nordkaper, North Atlantic right whale, North Cape whale, Pacific right whale, or southern right whale.

"sei whale" (*Balaenoptera borealis*) means any whale known as sei whale, Rudolphi's rorqual, pollack whale, or coalfish whale.

B. Toothed whales

"toothed whale" means any whale which has teeth in the jaws.

"beaked whale" means any whale belonging to the genus Mesoplodon, or any whale known as Cuvier's beaked whale (*Ziphius cavirostris*), or Shepherd's beaked whale (*Tasmacetus shepherdi*).

"bottlenose whale" means any whale known as Baird's beaked whale (*Berardius bairdii*), Arnoux's whale (*Berardius arnuxii*), southern bottlenose whale (*Hyperoodon planifrons*), or northern bottlenose whale (*Hyperoodon ampullatus*).

"killer whale" (*Orcinus orca*) means any whale known as killer whale or orca.

"pilot whale" means any whale known as long-finned pilot whale (*Globicephala melaena*) or short-finned pilot whale (*G. macrorhynchus*).

"sperm whale" (*Physeter macrocephalus*) means any whale known as sperm whale, spermacet whale, cachalot or pot whale.

C. General

"strike" means to penetrate with a weapon used for whaling.

"land" means to retrieve to a factory ship, land station, or other place where a whale can be treated.

"take" means to flag, buoy or make fast to a whale catcher.

"lose" means to either strike or take but not to land.

"dauhval" means any unclaimed dead whale found floating.

"lactating whale" means (a) with respect to baleen whales - a female which has any milk present in a mammary gland, (b) with respect to sperm whales - a female which has milk present in a mammary gland the maximum thickness (depth) of which is 10cm or more. This measurement shall be at the mid ventral point of the mammary gland perpendicular to the body axis, and shall be logged to the nearest centimetre; that is to say, any gland between 9.5cm and 10.5cm shall be logged as 10cm. The measurement of any gland which falls on an exact 0.5 centimetre shall be logged at the next 0.5 centimetre, e.g. 10.5cm shall be logged as 11.0cm.

However, notwithstanding these criteria, a whale shall not be considered a lactating whale if scientific (histological or other biological) evidence is presented to the appropriate national authority establishing that the whale could not at that point in its physical cycle have had a calf dependent on it for milk.

"small-type whaling" means catching operations using powered vessels with mounted harpoon guns hunting exclusively for minke, bottlenose, beaked, pilot or killer whales.

II. SEASONS

Factory Ship Operations

2. (*a*) It is forbidden to use a factory ship or whale catcher attached thereto for the purpose of taking or treating baleen whales except minke whales, in any waters south of 40° South Latitude except during the period from 12th December to 7th April following, both days inclusive.

   (b) It is forbidden to use a factory ship or whale catcher attached thereto for the purpose of taking or treating sperm or minke whales, except as permitted by the Contracting Governments in accordance with sub-paragraphs (*c*) and (*d*) of this paragraph, and paragraph 5.

   (c) Each Contracting Government shall declare for all factory ships and whale catchers attached thereto under its jurisdiction, an open season or seasons not to exceed eight months out of any period of twelve months during which the taking or killing of sperm whales by whale catchers may be permitted; provided that a separate open season may be declared for each factory ship and the whale catchers attached thereto.

   (d) Each Contracting Government shall declare for all factory ships and whale catchers attached thereto under its jurisdiction one continuous open season not to exceed six months out of any period of twelve months during which the taking or killing of minke whales by the whale catchers may be permitted provided that:

   (1) a separate open season may be declared for each factory ship and the whale catchers attached thereto;

   (2) the open season need not necessarily include the whole or any part of the period declared for other baleen whales pursuant to sub-paragraph (*a*) of this paragraph.

3. It is forbidden to use a factory ship which has been used during a season in any waters south of 40° South Latitude for the purpose of treating baleen whales, except minke whales, in any other area except the North Pacific Ocean and its dependent waters north of the Equator for the same purpose within a period of one year from the termination of that season; provided that catch limits in the North Pacific Ocean and dependent waters are established as provided in paragraphs 12 and 16 of this Schedule and provided that this paragraph shall not apply to a ship which has been used during the season solely for freezing or salting the meat and entrails of whales intended for human food or feeding animals.

Land Station Operations

4. (*a*) It is forbidden to use a whale catcher attached to a land station for the purpose of killing or attempting to kill baleen and sperm whales except as permitted by the Contracting Government in accordance with sub-paragraphs (*b*), (*c*) and (*d*) of this paragraph.

   (b) Each Contracting Government shall declare for all land stations under its jurisdiction, and whale catchers attached to such land stations, one open season during which the taking or killing of baleen whales, except minke whales, by the whale catchers shall be permitted. Such open season shall be for a period of not more than six consecutive months in any period of twelve months and shall apply to all land stations under the jurisdiction of the Contracting Government; provided that a separate open season may be declared for any land station used for the taking or treating of baleen whales, except minke whales, which is more than 1,000 miles from the nearest land station used for the taking or treating of baleen whales, except minke whales, under the jurisdiction of the same Contracting Government.

   (c) Each Contracting Government shall declare for all land stations under its jurisdiction and for whale catchers attached to such land stations, one open season not to exceed eight continuous months in any one period of twelve months, during which the taking or killing of sperm whales by the whale catchers shall be permitted; provided that a separate open season may be declared for any land station used for the taking or treating of sperm whales which is more than 1,000 miles from the nearest land station used for the taking or treating of sperm whales under the jurisdiction of the same Contracting Government.

   (d) Each Contracting Government shall declare for all land stations under its jurisdiction and for whale catchers attached to such land stations one open season not to exceed six continuous months in any period of twelve months during which the taking or killing of minke whales by the whale catchers shall be permitted (such period not being necessarily concurrent with the period declared for other baleen whales, as provided for in sub-paragraph (*b*) of this paragraph); provided that a separate open season may be declared for any land station used for the taking or treating of minke whales which is more than 1,000 miles from the nearest land station used for the taking or treating of minke whales under the jurisdiction of the same Contracting Government.

   Except that a separate open season may be declared for any land station used for the taking or treating of minke whales which is located in an area having oceanographic conditions clearly distinguishable from those of the area in which are located the other land stations used for the taking or treating of minke whales under the jurisdiction of the same Contracting Government; but the declaration of a separate open season by virtue of the provisions of this sub-paragraph shall not cause thereby the period of time covering the open seasons declared by the same Contracting Government to exceed nine continuous months of any twelve months.

(e) The prohibitions contained in this paragraph shall apply to all land stations as defined in Article II of the Whaling Convention of 1946.

Other Operations

5. Each Contracting Government shall declare for all whale catchers under its jurisdiction not operating in conjunction with a factory ship or land station one continuous open season not to exceed six months out of any period of twelve months during which the taking or killing of minke whales by such whale catchers may be permitted. Notwithstanding this paragraph one continuous open season not to exceed nine months may be implemented so far as Greenland is concerned.

III. CAPTURE

6. The killing for commercial purposes of whales, except minke whales using the cold grenade harpoon shall be forbidden from the beginning of the 1980/81 pelagic and 1981 coastal seasons. The killing for commercial purposes of minke whales using the cold grenade harpoon shall be forbidden from the beginning of the 1982/83 pelagic and the 1983 coastal seasons.*

7. (*a*) In accordance with Article V(1)(*c*) of the Convention, commercial whaling, whether by pelagic operations or from land stations, is prohibited in a region designated as the Indian Ocean Sanctuary. This comprises the waters of the Northern Hemisphere from the coast of Africa to 100°E, including the Red and Arabian Seas and the Gulf of Oman; and the waters of the Southern Hemisphere in the sector from 20°E to 130°E, with the Southern boundary set at 55°S. This prohibition applies irrespective of such catch limits for baleen or toothed whales as may from time to time be determined by the Commission. This prohibition shall be reviewed by the Commission at its Annual Meeting in 2002.☼

(*b*) In accordance with Article V(1)(*c*) of the Convention, commercial whaling, whether by pelagic operations or from land stations, is prohibited in a region designated as the Southern Ocean Sanctuary. This Sanctuary comprises the waters of the Southern Hemisphere southwards of the following line: starting from 40 degrees S, 50 degrees W; thence due east to 20 degrees E; thence due south to 55 degrees S; thence due east to 130 degrees E; thence due north to 40 degrees S; thence due east to 130 degrees W; thence due south to 60 degrees S; thence due east to 50 degrees W; thence due north to the point of beginning. This prohibition applies irrespective of the conservation status of baleen and toothed whale stocks in this Sanctuary, as may from time to time be determined by the Commission. However, this prohibition shall be reviewed ten years after its initial adoption and at succeeding ten year intervals, and could be revised at such times by the Commission. Nothing in this sub-paragraph is intended to prejudice the special legal and political status of Antarctica.**+

Area Limits for Factory Ships

8. It is forbidden to use a factory ship or whale catcher attached thereto, for the purpose of taking or treating baleen whales, except minke whales, in any of the following areas:
   (a) in the waters north of 66°N, except that from 150°E eastwards as far as 140°W, the taking or killing of baleen whales by a factory ship or whale catcher shall be permitted between 66°N and 72°N;
   (b) in the Atlantic Ocean and its dependent waters north of 40°S;
   (c) in the Pacific Ocean and its dependent waters east of 150°W between 40°S and 35°N;
   (d) in the Pacific Ocean and its dependent waters west of 150°W between 40°S and 20°N;
   (e) in the Indian Ocean and its dependent waters north of 40°S.

Classification of Areas and Divisions

9. (*a*) *Classification of Areas*
   Areas relating to Southern Hemisphere baleen whales except Bryde's whales are those waters between the ice-edge and the Equator and between the meridians of longitude listed in Table 1.
   (b) *Classification of Divisions*
   Divisions relating to Southern Hemisphere sperm whales are those waters between the ice-edge and the Equator and between the meridians of longitude listed in Table 3.
   (c) *Geographical boundaries in the North Atlantic*
   The geographical boundaries for the fin, minke and sei whale stocks in the North Atlantic are:

FIN WHALE STOCKS

NOVA SCOTIA
South and West of a line through:
47°N 54°W, 46°N 54°30'W,
46°N 42°W, 20°N 42°W.

NEWFOUNDLAND-LABRADOR
West of a line through:
75°N 73°30'W, 69°N 59°W, 61°N 59°W,
52°20'N 42°W, 46°N 42°W and
North of a line through:
46°N 42°W, 46°N 54°30'W, 47°N 54°W.

WEST GREENLAND
East of a line through:
75°N 73°30'W, 69°N 59°W,
61°N 59°W, 52°20'N 42°W,
and West of a line through
52°20'N 42°W, 59°N 42°W,
59°N 44°W, Kap Farvel.

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*The Governments of Brazil, Iceland, Japan, Norway and the Union of Soviet Socialist Republics lodged objections to the second sentence of paragraph 6 within the prescribed period. For all other Contracting Governments this sentence came into force on 8 March 1982. Norway withdrew its objection on 9 July 1985 and Brazil on 8 January 1992. Iceland withdrew from the Convention with effect from 30 June 1992. The objections of Japan and the Russian Federation not having been withdrawn, this sentence is not binding upon these governments.

☼At its 54th Annual Meeting in 2002, the Commission agreed to continue this prohibition but did not discuss whether or not it should set a time when it should be reviewed again.

**The Government of Japan lodged an objection within the prescribed period to paragraph 7(*b*) to the extent that it applies to the Antarctic minke whale stocks. The Government of the Russian Federation also lodged an objection to paragraph 7(*b*) within the prescribed period but withdrew it on 26 October 1994. For all Contracting Governments except Japan paragraph 7(*b*) came into force on 6 December 1994.

+Paragraph 7(*b*) contains a provision for review of the Southern Ocean Sanctuary "ten years after its initial adoption". Paragraph 7(*b*) was adopted at the 46th (1994) Annual Meeting. The first review was completed in 2004, and the second in 2016.

EAST GREENLAND-ICELAND
East of a line through:
Kap Farvel (South Greenland),
59°N 44°W, 59°N 42°W, 20°N 42°W,
and West of a line through:
20°N 18°W, 60°N 18°W, 68°N 3°E,
74°N 3°E, and South of 74°N.

NORTH NORWAY
North and East of a line through:
74°N 22°W, 74°N 3°E, 68°N 3°E,
67°N 0°, 67°N 14°E.

WEST NORWAY-FAROE ISLANDS
South of a line through:
67°N 14°E, 67°N 0°, 60°N 18°W,
and North of a line through:
61°N 16°W, 61°N 0°, Thyborøn
(Western entrance to Limfjorden, Denmark).

SPAIN-PORTUGAL-BRITISH ISLES
South of a line through:
Thyborøn (Denmark), 61°N 0°, 61°N 16°W,
and East of a line through:
63°N 11°W, 60°N 18°W, 22°N 18°W.

MINKE WHALE STOCKS
CANADIAN EAST COAST
West of a line through:
75°N 73°30'W, 69°N 59°W, 61°N 59°W,
52°20'N 42°W, 20°N 42°W.

CENTRAL
East of a line through:
Kap Farvel (South Greenland),
59°N 44°W, 59°N 42°W, 20°N 42°W,
and West of a line through:
20°N 18°W, 60°N 18°W, 68°N 3°E,
74°N 3°E, and South of 74°N.

WEST GREENLAND
East of a line through:
75°N 73°30'W, 69°N 59°W, 61°N 59°W,
52°20'N 42°W, and
West of a line through:
52°20'N 42°W, 59°N 42°W,
59°N 44°W, Kap Farvel.

NORTHEASTERN
East of a line through:
20°N 18°W, 60°N 18°W, 68°N 3°E, 74°N 3°E,
and North of a line through:
74°N 3°E, 74°N 22°W.

SEI WHALE STOCKS
NOVA SCOTIA
South and West of a line through:
47°N 54°W, 46°N 54°30'W, 46°N 42°W,
20°N 42°W.

ICELAND-DENMARK STRAIT
East of a line through:
Kap Farvel (South Greenland),
59°N 44°W, 59°N 42°W, 20°N 42°W,
and West of a line through:
20°N 18°W, 60°N 18°W, 68°N 3°E,
74°N 3°E, and South of 74°N.

EASTERN
East of a line through:
20°N 18°W, 60°N 18°W, 68°N 3°E, 74°N 3°E,
and North of a line through:
74°N 3°E, 74°N 22°W.

(d) *Geographical boundaries in the North Pacific*
The geographical boundaries for the sperm, Bryde's and minke whale stocks in the North Pacific are:

SPERM WHALE STOCKS
WESTERN DIVISION
West of a line from the ice-edge south along the 180° meridian of longitude to 180°, 50°N, then east along the 50°N parallel of latitude to 160°W, 50°N, then south along the 160°W meridian of longitude to 160°W, 40°N, then east along the 40°N parallel of latitude to 150°W, 40°N, then south along the 150°W meridian of longitude to the Equator.

EASTERN DIVISION
East of the line described above.

BRYDE'S WHALE STOCKS
EAST CHINA SEA
West of the Ryukyu Island chain.

EASTERN
East of 160°W (excluding the Peruvian stock area).

WESTERN
West of 160°W (excluding the East China Sea stock area).

MINKE WHALE STOCKS
SEA OF JAPAN-YELLOW SEA-EAST CHINA SEA
West of a line through the Philippine Islands, Taiwan, Ryukyu Islands, Kyushu, Honshu, Hokkaido and Sakhalin Island, north of the Equator.

OKHOTSK SEA-WEST PACIFIC
East of the Sea of Japan-Yellow Sea- East China Sea stock and west of 180°, north of the Equator.

REMAINDER
East of the Okhotsk Sea-West Pacific stock, north of the Equator.

(e) *Geographical boundaries for Bryde's whale stocks in the Southern Hemisphere*

SOUTHERN INDIAN OCEAN
20°E to 130°E,
South of the Equator.

SOLOMON ISLANDS
150°E to 170°E,
20°S to the Equator.

PERUVIAN
110°W to the South American coast,
10°S to 10°N.

EASTERN SOUTH PACIFIC
150°W to 70°W,
South of the Equator (excluding the Peruvian stock area).

WESTERN SOUTH PACIFIC
130°E to 150°W,
South of the Equator (excluding the Solomon Islands stock area).

SOUTH ATLANTIC
70°W to 20°E,
South of the Equator (excluding the South African inshore stock area).

SOUTH AFRICAN INSHORE
South African coast west of 27°E and out to the 200 metre isobath.

Classification of Stocks

10. All stocks of whales shall be classified in one of three categories according to the advice of the Scientific Committee as follows:

(a) A Sustained Management Stock (SMS) is a stock which is not more than 10 per cent of Maximum Sustainable Yield (hereinafter referred to as MSY) stock level below MSY stock level, and not more than 20 per cent above that level; MSY being determined on the basis of the number of whales.

When a stock has remained at a stable level for a considerable period under a regime of approximately constant catches, it shall be classified as a Sustained Management Stock in the absence of any positive evidence that it should be otherwise classified.

Commercial whaling shall be permitted on Sustained Management Stocks according to the advice of the Scientific Committee. These stocks are listed in Tables 1, 2 and 3 of this Schedule.

For stocks at or above the MSY stock level, the permitted catch shall not exceed 90 per cent of the MSY. For stocks between the MSY stock level and 10 per cent below that level, the permitted catch shall not exceed the number of whales obtained by taking 90 per cent of the MSY and reducing that number by 10 per cent for every 1 per cent by which the stock falls short of the MSY stock level.

(b) An Initial Management Stock (IMS) is a stock more than 20 per cent of MSY stock level above MSY stock level. Commercial whaling shall be permitted on Initial Management Stocks according to the advice of the Scientific Committee as to measures necessary to bring the stocks to the MSY stock level and then optimum level in an efficient manner and without risk of reducing them below this level. The permitted catch for such stocks will not be more than 90 per cent of MSY as far as this is known, or, where it will be more appropriate, catching effort shall be limited to that which will take 90 per cent of MSY in a stock at MSY stock level.

In the absence of any positive evidence that a continuing higher percentage will not reduce the stock below the MSY stock level no more than 5 per cent of the estimated initial exploitable stock shall be taken in any one year. Exploitation should not commence until an estimate of stock size has been obtained which is satisfactory in the view of the Scientific Committee. Stocks classified as Initial Management Stock are listed in Tables 1, 2 and 3 of this Schedule.

(c) A Protection Stock (PS) is a stock which is below 10 per cent of MSY stock level below MSY stock level.

There shall be no commercial whaling on Protection Stocks. Stocks so classified are listed in Tables 1, 2 and 3 of this Schedule.

(d) Notwithstanding the other provisions of paragraph 10 there shall be a moratorium on the taking, killing or treating of whales, except minke whales, by factory ships or whale catchers attached to factory ships. This moratorium applies to sperm whales, killer whales and baleen whales, except minke whales.

(e) Notwithstanding the other provisions of paragraph 10, catch limits for the killing for commercial purposes of whales from all stocks for the 1986 coastal and the 1985/86 pelagic seasons and thereafter shall be zero. This provision will be kept under review, based upon the best scientific advice, and by 1990 at the latest the Commission will undertake a comprehensive assessment of the effects of this decision on whale stocks and consider modification of this provision and the establishment of other catch limits.*•#

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*The Governments of Japan, Norway, Peru and the Union of Soviet Socialist Republics lodged objection to paragraph 10(*e*) within the prescribed period. For all other Contracting Governments this paragraph came into force on 3 February 1983. Peru withdrew its objection on 22 July 1983. The Government of Japan withdrew its objections with effect from 1 May 1987 with respect to commercial pelagic whaling; from 1 October 1987 with respect to commercial coastal whaling for minke and Bryde's whales; and from 1 April 1988 with respect to commercial coastal sperm whaling. The objections of Norway and the Russian Federation not having been withdrawn, the paragraph is not binding upon these Governments.

•Iceland's instrument of adherence to the International Convention for the Regulation of Whaling and the Protocol to the Convention deposited on 10 October 2002 states that Iceland 'adheres to the aforesaid Convention and Protocol with a reservation with respect to paragraph 10(*e*) of the Schedule attached to the Convention'. The instrument further states the following:

> 'Notwithstanding this, the Government of Iceland will not authorise whaling for commercial purposes by Icelandic vessels before 2006 and, thereafter, will not authorise such whaling while progress is being made in negotiations within the IWC on the RMS. This does not apply, however, in case of the so-called moratorium on whaling for commercial purposes, contained in paragraph 10(*e*) of the Schedule not being lifted within a reasonable time after the completion of the RMS. Under no circumstances will whaling for commercial purposes be authorised without a sound scientific basis and an effective management and enforcement scheme.'

#The Governments of Argentina, Australia, Brazil, Chile, Finland, France, Germany, Italy, Mexico, Monaco, the Netherlands, New Zealand, Peru, San Marino, Spain, Sweden, UK and the USA have lodged objections to Iceland's reservation to paragraph 10(*e*).

Table 1

BALEEN WHALE STOCK CLASSIFICATIONS AND CATCH LIMITS[+] (excluding Bryde's whales).

		SEI		MINKE		FIN		BLUE		RIGHT, BOWHEAD, HUMPBACK		PYGMY RIGHT		GRAY	
		Classi-fication	Catch limit	Classi-fication	Catch limit	Classi-fication	Catch limit	Classi-fication	Catch limit	Classi-fication	Catch limit	Classi-fication	Catch limit	Classi-fication	Catch limit
SOUTHERN HEMISPHERE-***2016/2017*** pelagic season and ***2017*** coastal season▲															
Area															.
I	120°W-60°W	PS	0	-	0	PS	0	PS	0	PS	0	PS	0	.	.
II	60°W- 0°	PS	0	-	0	PS	0	PS	0	PS	0	PS	0	.	.
III	0°- 70°E	PS	0	-	0	PS	0	PS	0	PS	0	PS	0	.	.
IV	70°E-130°E	PS	0	-	0	PS	0	PS	0	PS	0	PS	0	.	.
V	130°E- 170°W	PS	0	-	0	PS	0	PS	0	PS	0	PS	0	.	.
VI	170°W-120°W	PS	0	-	0	PS	0	PS	0	PS	0	PS	0	.	.
Total catch not to exceed:							0		0		0		0		
NORTHERN HEMISPHERE-***2017*** season▲															
ARCTIC		.	.	.	.	.	.	.	.	.	.	PS	0	.	.
NORTH PACIFIC															
Whole region		PS	0	.	.	PS	0	PS	0	PS	0	PS	0	.	.
Okhotsk Sea-West Pacific Stock		.	.	-	0	.	.	.	.	.	.	.	.	.	.
Sea of Japan-Yellow Sea-East China Sea Stock		.	.	PS	0	.	.	.	.	.	.	.	.	.	.
Remainder		.	.	IMS	0	.	.	.	.	.	.	.	.	.	.
Eastern Stock		.	.	.	.	.	.	.	.	.	.	.	.	SMS	.[1]
Western Stock		.	.	.	.	.	.	.	.	.	.	.	.	PS	0
NORTH ATLANTIC															
Whole region		.	.	.	.	.	.	PS	0	PS	0	PS	0	.	.
West Greenland Stock		.	.	PS	0	-	19[2]	.	.	.	.	.	.	.	.
Newfoundland-Labrador Stock		.	.	.	.	-	0	.	.	.	.	.	.	.	.
Canadian East Coast Stock		.	.	-	0	.	.	.	.	.	.	.	.	.	.
Nova Scotia Stock		PS	0	.	.	PS	0	.	.	.	.	.	.	.	.
Central Stock		.	.	-	.	.	.	.	.	.	.	.	.	.	.
East Greenland-Iceland Stock		.	.	.	.	SMS	0	.	.	.	.	.	.	.	.
Iceland-Denmark Strait Stock		-	0	.	.	.	.	.	.	.	.	.	.	.	.
Spain-Portugal-British Isles Stock		.	.	.	.	-	0	.	.	.	.	.	.	.	.
Northeastern Stock		.	.	PS*	0	.	.	.	.	.	.	.	.	.	.
West Norway-Faroe Islands Stock		.	.	.	.	PS	0	.	.	.	.	.	.	.	.
North Norway Stock		.	.	.	.	-	0	.	.	.	.	.	.	.	.
Eastern Stock		-	0	.	.	.	.	.	.	.	.	.	.	.	.
NORTHERN INDIAN OCEAN		.	.	IMS	0	.	.	PS	0	PS	0	PS	0	.	.

[1]Available to be taken by aborigines or a Contracting Government on behalf of aborigines pursuant to paragraph 13*(b)*2.

[2]Available to be struck by aborigines pursuant to paragraph 13*(b)*3. Catch limit for each of the years 2015, 2016, 2017 and 2018.

[+]The catch limits of zero introduced into Table 1 as editorial amendments as a result of the coming into effect of paragraph 10*(e)* are not binding upon the governments of the countries which lodged and have not withdrawn objections to the said paragraph.

*The Government of Norway presented objection to the classification of the Northeastern Atlantic stock of minke whales as a Protection Stock within the prescribed period. This classification came into force on 30 January 1986 but is not binding on the Government of Norway.

▲The Government of the Czech Republic lodged an objection within the prescribed period to the amendments to the Schedule arising from the 64th and 65th Meeting of the Commission.

Table 2

Bryde's whale stock classifications and catch limits.[+]

	Classification	Catch limit
SOUTHERN HEMISPHERE-***2016/2017*** pelagic season and ***2017*** coastal season▲		
South Atlantic Stock	-	0
Southern Indian Ocean Stock	IMS	0
South African Inshore Stock	-	0
Solomon Islands Stock	IMS	0
Western South Pacific Stock	IMS	0
Eastern South Pacific Stock	IMS	0
Peruvian Stock	-	0
NORTH PACIFIC-***2017*** season▲		
Eastern Stock	IMS	0
Western Stock	IMS	0
East China Sea Stock	PS	0
NORTH ATLANTIC-***2017*** season▲	IMS	0
NORTHERN INDIAN OCEAN-***2017*** season▲	-	0

[+]The catch limits of zero introduced in Table 2 as editorial amendments as a result of the coming into effect of paragraph 10*(e)* are not binding upon the governments of the countries which lodged and have not withdrawn objections to the said paragraph.

▲See footnote to Table 1.

Table 3

Toothed whale stock classifications and catch limits.[+]

Division	Longitudes	Classification	Catch limit
SOUTHERN HEMISPHERE-***2016/2017*** pelagic season and ***2017*** coastal season▲			
		SPERM	
Division	Longitudes	Classification	Catch limit
1	60°W-30°W	-	0
2	30°W-20°E	-	0
3	20°E-60°E	-	0
4	60°E-90°E	-	0
5	90°-130°E	-	0
6	130°E-160°E	-	0
7	160°E-170°W	-	0
8	170°W-100°W	-	0
9	100°W-60°W	-	0
NORTHERN HEMISPHERE-***2017*** season▲			
NORTH PACIFIC			
Western Division		PS	0[1]
Eastern Division		-	0
NORTH ATLANTIC		-	0
NORTHERN INDIAN OCEAN		-	0
		BOTTLENOSE	
NORTH ATLANTIC		PS	0

[1]No whales may be taken from this stock until catch limits including any limitations on size and sex are established by the Commission.

[+]The catch limits of zero introduced in Table 3 as editorial amendments as a result of the coming into effect of paragraph 10*(e)* are not binding upon the governments of the countries which lodged and have not withdrawn objections to the said paragraph.

▲See footnote to Table 1.

Baleen Whale Catch Limits

11. The number of baleen whales taken in the Southern Hemisphere in the ***2016/2017*** pelagic season and the ***2017*** coastal season shall not exceed the limits shown in Tables 1 and 2.▲
12. The number of baleen whales taken in the North Pacific Ocean and dependent waters in ***2017*** and in the North Atlantic Ocean in ***2017*** shall not exceed the limits shown in Tables 1 and 2.▲
13. (*a*) Notwithstanding the provisions of paragraph 10, catch limits for aboriginal subsistence whaling to satisfy aboriginal subsistence need for the 1984 whaling season and each whaling season thereafter shall be established in accordance with the following principles:
    - (1) For stocks at or above MSY level, aboriginal subsistence catches shall be permitted so long as total removals do not exceed 90 per cent of MSY.
    - (2) For stocks below the MSY level but above a certain minimum level, aboriginal subsistence catches shall be permitted so long as they are set at levels which will allow whale stocks to move to the MSY level.[1]
    - (3) The above provisions will be kept under review, based upon the best scientific advice, and by 1990 at the latest the Commission will undertake a comprehensive assessment of the effects of these provisions on whale stocks and consider modification.
    - (4) For aboriginal whaling conducted under subparagraphs (*b*)(1), (*b*)(2), and (*b*)(3) of this paragraph, it is forbidden to strike, take or kill calves or any whale accompanied by a calf. For aboriginal whaling conducted under subparagraphs (*b*)(4) of this paragraph, it is forbidden to strike, take or kill suckling calves or female whales accompanied by calves.
    - (5) All aboriginal whaling shall be conducted under national legislation that accords with this paragraph.

    (b) Catch limits for aboriginal subsistence whaling are as follows:
    - (1) The taking of bowhead whales from the Bering-Chukchi-Beaufort Seas stock by aborigines is permitted, but only when the meat and products of such whales are to be used exclusively for local consumption by the aborigines and further provided that:
        - (i) For the years 2013, 2014, 2015, 2016 2017 and 2018, the number of bowhead whales landed shall not exceed 336. For each of these years the number of bowhead whales struck shall not exceed 67, except that any unused portion of a strike quota from any year (including 15 unused strikes from the 2008-2012 quota) shall be carried forward and added to the strike quotas of any subsequent years, provided that no more than 15 strikes shall be added to the strike quota for any one year.▲
        - (ii) This provision shall be reviewed annually by the Commission in light of the advice of the Scientific Committee.
    - (2) The taking of gray whales from the Eastern stock in the North Pacific is permitted, but only by aborigines or a Contracting Government on behalf of aborigines, and then only when the meat and products of such whales are to be used exclusively for local consumption by the aborigines.
        - (i) For the years 2013, 2014, 2015, 2016, 2017 and 2018, the number of gray whales taken in accordance with this sub-paragraph shall not exceed 744, provided that the number of gray whales taken in any one of the years 2013, 2014, 2015, 2016, 2017 and 2018 shall not exceed 140.▲
        - (ii) This provision shall be reviewed annually by the Commission in light of the advice of the Scientific Committee.
    - (3) The taking by aborigines of minke whales from the West Greenland and Central stocks and fin whales from the West Greenland stock and bowhead whales from the West Greenland feeding aggregation and humpback whales from the West Greenland feeding aggregation is permitted and then only when the meat and products are to be used exclusively for local consumption.
        - (i) The number of fin whales struck from the West Greenland stock in accordance with this sub-paragraph shall not exceed 19 in each of the years 2015, 2016, 2017 and 2018.
        - (ii) The number of minke whales struck from the Central stock in accordance with this sub-paragraph shall not exceed 12 in each of the years 2015, 2016, 2017, and 2018, except that any unused portion of the quota for each year shall be carried forward from that year and added to the quota of any subsequent years, provided that no more than 3 shall be added to the quota for any one year.
        - (iii) The number of minke whales struck from the West Greenland stock shall not exceed 164 in each of the years 2015, 2016, 2017 and 2018, except that any unused portion of the quota for each year shall be carried forward from that year and added to the strike quota of any of the subsequent years, provided

▲See footnote to Table 1.

[1]The Commission, on advice of the Scientific Committee, shall establish as far as possible (a) a minimum stock level for each stock below which whales shall not be taken, and (b) a rate of increase towards the MSY level for each stock. The Scientific Committee shall advise on a minimum stock level and on a range of rates of increase towards the MSY level under different catch regimes.

that no more than 15 strikes shall be added to the strike quota for any one year. This provision will be reviewed if new scientific data become available within the 4 year period and if necessary amended on basis of the advice of the Scientific Committee.

(iv) The number of bowhead whales struck off West Greenland in accordance with this sub-paragraph shall not exceed 2 in each of the years 2015, 2016, 2017 and 2018, except that any unused portion of the quota for each year shall be carried forward from that year and added to the quota of any subsequent years, provided that no more than 2 shall be added to the quota for any one year. This provision will be reviewed if new scientific data become available within the 4 year period and if necessary amended on basis of the advice of the Scientific Committee.

(v) The number of humpback whales struck off West Greenland in accordance with this sub-paragraph shall not exceed 10 in each of the years 2015, 2016, 2017 and 2018, except that any unused portion of the quota for each year shall be carried forward from that year and added to the strike quota of any of the subsequent years, provided that no more than 2 strikes shall be added to the strike quota for any one year. This provision will be reviewed if new scientific data become available within the remaining quota period and if necessary amended on the basis of the advice of the Scientific Committee.

(4) For the seasons 2013-2018 the number of humpback whales to be taken by the Bequians of St. Vincent and The Grenadines shall not exceed 24. The meat and products of such whales are to be used exclusively for local consumption in St. Vincent and The Grenadines.▲

14. It is forbidden to take or kill suckling calves or female whales accompanied by calves.

Baleen Whale Size Limits

15. (*a*) It is forbidden to take or kill any sei or Bryde's whales below 40 feet (12.2 metres) in length except that sei and Bryde's whales of not less than 35 feet (10.7 metres) may be taken for delivery to land stations, provided that the meat of such whales is to be used for local consumption as human or animal food.

(*b*) It is forbidden to take or kill any fin whales below 57 feet (17.4 metres) in length in the Southern Hemisphere, and it is forbidden to take or kill fin whales below 55 feet (16.8 metres) in the Northern Hemisphere; except that fin whales of not less than 55 feet (16.8 metres) may be taken in the Southern Hemisphere for delivery to land stations and fin whales of not less than 50 feet (15.2 metres) may be taken in the Northern Hemisphere for delivery to land stations, provided that, in each case the meat of such whales is to be used for local consumption as human or animal food.

Sperm Whale Catch Limits

16. Catch limits for sperm whales of both sexes shall be set at zero in the Southern Hemisphere for the 1981/82 pelagic season and 1982 coastal seasons and following seasons, and at zero in the Northern Hemisphere for the 1982 and following coastal seasons; except that the catch limits for the 1982 coastal season and following seasons in the Western Division of the North Pacific shall remain undetermined and subject to decision by the Commission following special or annual meetings of the Scientific Committee. These limits shall remain in force until such time as the Commission, on the basis of the scientific information which will be reviewed annually, decides otherwise in accordance with the procedures followed at that time by the Commission.

17. It is forbidden to take or kill suckling calves or female whales accompanied by calves.

Sperm Whale Size Limits

18. (*a*) It is forbidden to take or kill any sperm whales below 30 feet (9.2 metres) in length except in the North Atlantic Ocean where it is forbidden to take or kill any sperm whales below 35 feet (10.7 metres).

(b) It is forbidden to take or kill any sperm whale over 45 feet (13.7 metres) in length in the Southern Hemisphere north of 40° South Latitude during the months of October to January inclusive.

(c) It is forbidden to take or kill any sperm whale over 45 feet (13.7 metres) in length in the North Pacific Ocean and dependent waters south of 40° North Latitude during the months of March to June inclusive.

IV. TREATMENT

19. (*a*) It is forbidden to use a factory ship or a land station for the purpose of treating any whales which are classified as Protection Stocks in paragraph 10 or are taken in contravention of paragraphs 2, 3, 4, 5, 6, 7, 8, 11, 12, 14, 16 and 17 of this Schedule, whether or not taken by whale catchers under the jurisdiction of a Contracting Government.

(b) All other whales taken, except minke whales, shall be delivered to the factory ship or land station and all parts of such whales shall be processed by boiling or otherwise, except the internal organs, whale bone and flippers of all whales, the meat of sperm whales and parts of whales intended for human food or feeding animals. A Contracting Government may in less developed regions exceptionally permit treating of whales without use of land stations, provided that such whales are fully utilised in accordance with this paragraph.

(c) Complete treatment of the carcases of "dauhval" and of whales used as fenders will not be required in cases where the meat or bone of such whales is in bad condition.

▲See footnote to Table 1.

20. (*a*) The taking of whales for treatment by a factory ship shall be so regulated or restricted by the master or person in charge of the factory ship that no whale carcase (except of a whale used as a fender, which shall be processed as soon as is reasonably practicable) shall remain in the sea for a longer period than thirty-three hours from the time of killing to the time when it is hauled up for treatment.

(*b*) Whales taken by all whale catchers, whether for factory ships or land stations, shall be clearly marked so as to identify the catcher and to indicate the order of catching.

V. SUPERVISION AND CONTROL

21. (*a*) There shall be maintained on each factory ship at least two inspectors of whaling for the purpose of maintaining twenty-four hour inspection provided that at least one such inspector shall be maintained on each catcher functioning as a factory ship. These inspectors shall be appointed and paid by the Government having jurisdiction over the factory ship; provided that inspectors need not be appointed to ships which, apart from the storage of products, are used during the season solely for freezing or salting the meat and entrails of whales intended for human food or feeding animals.

(b) Adequate inspection shall be maintained at each land station. The inspectors serving at each land station shall be appointed and paid by the Government having jurisdiction over the land station.

(c) There shall be received such observers as the member countries may arrange to place on factory ships and land stations or groups of land stations of other member countries. The observers shall be appointed by the Commission acting through its Secretary and paid by the Government nominating them.

22. Gunners and crews of factory ships, land stations, and whale catchers, shall be engaged on such terms that their remuneration shall depend to a considerable extent upon such factors as the species, size and yield of whales and not merely upon the number of the whales taken. No bonus or other remuneration shall be paid to the gunners or crews of whale catchers in respect of the taking of lactating whales.

23. Whales must be measured when at rest on deck or platform after the hauling out wire and grasping device have been released, by means of a tape-measure made of a non-stretching material. The zero end of the tape-measure shall be attached to a spike or stable device to be positioned on the deck or platform abreast of one end of the whale. Alternatively the spike may be stuck into the tail fluke abreast of the apex of the notch. The tape-measure shall be held taut in a straight line parallel to the deck and the whale's body, and other than in exceptional circumstances along the whale's back, and read abreast of the other end of the whale. The ends of the whale for measurement purposes shall be the tip of the upper jaw, or in sperm whales the most forward part of the head, and the apex of the notch between the tail flukes.

Measurements shall be logged to the nearest foot or 0.1 metre. That is to say, any whale between 75 feet 6 inches and 76 feet 6 inches shall be logged as 76 feet, and any whale between 76 feet 6 inches and 77 feet 6 inches shall be logged as 77 feet. Similarly, any whale between 10.15 metres and 10.25 metres shall be logged as 10.2 metres, and any whale between 10.25 metres and 10.35 metres shall be logged as 10.3 metres. The measurement of any whale which falls on an exact half foot or 0.05 metre shall be logged at the next half foot or 0.05 metre, e.g. 76 feet 6 inches precisely shall be logged as 77 feet and 10.25 metres precisely shall be logged as 10.3 metres.

VI. INFORMATION REQUIRED

24. (*a*) All whale catchers operating in conjunction with a factory ship shall report by radio to the factory ship:
(1) the time when each whale is taken
(2) its species, and
(3) its marking effected pursuant to paragraph 20(*b*).

(b) The information specified in sub-paragraph (*a*) of this paragraph shall be entered immediately by a factory ship in a permanent record which shall be available at all times for examination by the whaling inspectors; and in addition there shall be entered in such permanent record the following information as soon as it becomes available:
(1) time of hauling up for treatment
(2) length, measured pursuant to paragraph 23
(3) sex
(4) if female, whether lactating
(5) length and sex of foetus, if present, and
(6) a full explanation of each infraction.

(c) A record similar to that described in sub-paragraph (*b*) of this paragraph shall be maintained by land stations, and all of the information mentioned in the said sub-paragraph shall be entered therein as soon as available.

(d) A record similar to that described in sub-paragraph (*b*) of this paragraph shall be maintained by "small-type whaling" operations conducted from shore or by pelagic fleets, and all of this information mentioned in the said sub-paragraph shall be entered therein as soon as available.

25. (*a*) All Contracting Governments shall report to the Commission for all whale catchers operating in conjunction with factory ships and land stations the following information:
(1) methods used to kill each whale, other than a harpoon, and in particular compressed air;
(2) number of whales struck but lost.

(b) A record similar to that described in sub-paragraph (a) of this paragraph shall be maintained by vessels engaged in "small-type whaling" operations and by native peoples taking species listed in paragraph 1, and all the information mentioned in the said sub-paragraph shall be entered therein as soon as available, and forwarded by Contracting Governments to the Commission.

26. (*a*) Notification shall be given in accordance with the provisions of Article VII of the Convention, within two days after the end of each calendar week, of data on the number of baleen whales

by species taken in any waters south of 40° South Latitude by all factory ships or whale catchers attached thereto under the jurisdiction of each Contracting Government, provided that when the number of each of these species taken is deemed by the Secretary to the International Whaling Commission to have reached 85 per cent of whatever total catch limit is imposed by the Commission notification shall be given as aforesaid at the end of each day of data on the number of each of these species taken.

(b) If it appears that the maximum catches of whales permitted by paragraph 11 may be reached before 7 April of any year, the Secretary to the International Whaling Commission shall determine, on the basis of the data provided, the date on which the maximum catch of each of these species shall be deemed to have been reached and shall notify the master of each factory ship and each Contracting Government of that date not less than four days in advance thereof. The taking or attempting to take baleen whales, so notified, by factory ships or whale catchers attached thereto shall be illegal in any waters south of 40° South Latitude after midnight of the date so determined.

(c) Notification shall be given in accordance with the provisions of Article VII of the Convention of each factory ship intending to engage in whaling operations in any waters south of 40° South Latitude.

27. Notification shall be given in accordance with the provisions of Article VII of the Convention with regard to all factory ships and catcher ships of the following statistical information:

(a) concerning the number of whales of each species taken, the number thereof lost, and the number treated at each factory ship or land station, and

(b) as to the aggregate amounts of oil of each grade and quantities of meal, fertiliser (guano), and other products derived from them, together with

(c) particulars with respect to each whale treated in the factory ship, land station or "small-type whaling" operations as to the date and approximate latitude and longitude of taking, the species and sex of the whale, its length and, if it contains a foetus, the length and sex, if ascertainable, of the foetus.

The data referred to in (*a*) and (*c*) above shall be verified at the time of the tally and there shall also be notification to the Commission of any information which may be collected or obtained concerning the calving grounds and migration of whales.

28. (*a*) Notification shall be given in accordance with the provisions of Article VII of the Convention with regard to all factory ships and catcher ships of the following statistical information:

(1) the name and gross tonnage of each factory ship,

(2) for each catcher ship attached to a factory ship or land station:

(i) the dates on which each is commissioned and ceases whaling for the season,

(ii) the number of days on which each is at sea on the whaling grounds each season,

(iii) the gross tonnage, horsepower, length and other characteristics of each; vessels used only as tow boats should be specified.

(3) A list of the land stations which were in operation during the period concerned, and the number of miles searched per day by aircraft, if any.

(*b*) The information required under paragraph (*a*)(2)(iii) should also be recorded together with the following information, in the log book format shown in Appendix A, and forwarded to the Commission:

(1) where possible the time spent each day on different components of the catching operation,

(2) any modifications of the measures in paragraphs (*a*)(2)(i)-(iii) or (*b*)(1) or data from other suitable indicators of fishing effort for "small-type whaling" operations.

29. (*a*) Where possible all factory ships and land stations shall collect from each whale taken and report on:

(1) both ovaries or the combined weight of both testes,

(2) at least one ear plug, or one tooth (preferably first mandibular).

(b) Where possible similar collections to those described in sub-paragraph (*a*) of this paragraph shall be undertaken and reported by "small-type whaling" operations conducted from shore or by pelagic fleets.

(c) All specimens collected under sub-paragraphs (*a*) and (*b*) shall be properly labelled with platform or other identification number of the whale and be appropriately preserved.

(d) Contracting Governments shall arrange for the analysis as soon as possible of the tissue samples and specimens collected under sub-paragraphs (a) and (*b*) and report to the Commission on the results of such analyses.

30. A Contracting Government shall provide the Secretary to the International Whaling Commission with proposed scientific permits before they are issued and in sufficient time to allow the Scientific Committee to review and comment on them. The proposed permits should specify:

(a) objectives of the research;

(b) number, sex, size and stock of the animals to be taken;

(c) opportunities for participation in the research by scientists of other nations; and

(d) possible effect on conservation of stock.

Proposed permits shall be reviewed and commented on by the Scientific Committee at Annual Meetings when possible. When permits would be granted prior to the next Annual Meeting, the Secretary shall send the proposed permits to members of the Scientific Committee by mail for their comment and review. Preliminary results of any research resulting from the permits should be made available at the next Annual Meeting of the Scientific Committee.

31. A Contracting Government shall transmit to the Commission copies of all its official laws and regulations relating to whales and whaling and changes in such laws and regulations.

INTERNATIONAL CONVENTION FOR THE REGULATION OF WHALING, 1946
SCHEDULE APPENDIX A

TITLE PAGE
(one logbook per catcher per season)

Catcher name…………………………………………… Year built…………………………………………

Attached to expedition/land station ………………………………………………………………………

Season…………………………………………………

Overall length…………………………………………… Wooden/steel hull………………………………

Gross tonnage……………………………………………

Type of engine..………………………………………… H.P. ………………………………………………

Maximum speed………………………………………… Average searching speed…………………………

Asdic set, make and model no.……………………………………………………………………………

Date of installation………………………………………

Make and size of cannon…………………………………………………………………………………

Type of first harpoon used……………………………… Explosive/electric/non-explosive

Type of killer harpoon used………………………………………………………………………………

Length and type of forerunner……………………………………………………………………………

Type of whaleline…………………………………………………………………………………………

Height of barrel above sea level…………………………

Speedboat used, Yes/No

Name of Captain…………………………………………………………………………………………

Number of years experience……………………………

Name of gunner……………………………………………………………………………………………

Number of years experience……………………………

Number of crew…………………………………………

INTERNATIONAL CONVENTION FOR THE REGULATION OF WHALING, 1946

DAILY RECORD SHEET TABLE 1

Date .... Catcher name .... Sheet No.............

Searching: Time started (or resumed) searching
*Time whales seen or reported to catcher
Whale species
Number seen and no. of groups
Position found
Name of catcher that found whales

Chasing: Time started chasing (or confirmed whales)
Time whale shot or chasing discontinued
Asdic used (Yes/No)

Handling: Time whale flagged or alongside for towing
Serial No. of catch

Towing: Time started picking up
Time finished picking up or started towing
Date and time delivered to factory

Resting: Time stopped (for drifting or resting)
Time finished drifting/resting
Time ceased operations

WEATHER CONDITIONS

	Time	Sea state	Wind force and direction	Visibility
Total searching time............................				
Total chasing time				
A) with asdic				
B) without asdic				
Total handling time				
Total towing time				
Total resting time				
Other time (e.g. bunkering, in port)				

Whales Seen (No. and No. of schools)

Blue..	Bryde's
Fin..	Minke
Humpback.......................................	Sperm ....
Right..	Others (specify)
Sei..	....
Signed...	....

*Time whales reported to catcher means the time when the catcher is told of the position of a school and starts to move towards it to chase it. .

SCHEDULE APPENDIX A

SCHOOLING REPORT TABLE 2

To be completed by pelagic expedition or coastal station for each sperm whale school chased. A separate form to be used each day.

Name of expedition or coastal station

Date Noon position of factory ship

Time School Found

Total Number of Whales in School

Number of Takeable Whales in School

Number of Whales Caught from School by each Catcher

Name of Catcher

Name of Catcher

Name of Catcher ....

Name of Catcher

Total Number Caught from School

Remarks:

Explanatory Notes

A. Fill in one column for each school chased with number of whales caught by each catcher taking part in the chase; if catchers chase the school but do not catch from it, enter O; for catchers in fleet which do not chase that school enter X.

B. A school on this form means a group of whales which are sufficiently close together that a catcher having completed handling one whale can start chasing another whale almost immediately without spending time searching. A solitary whale should be entered as a school of 1 whale.

C. A takeable whale is a whale of a size or kind which the catchers would take if possible. It does not necessarily include all whales above legal size, e.g. if catchers are concentrating on large whales only these would be counted as takeable.

D. 1nformation about catchers from other expeditions or companies operating on the same school should be recorded under Remarks.

SC/67B/REP/07 Rev1

Fifth Rangewide Workshop on the Status of North Pacific Gray Whales

IWC

INTERNATIONAL WHALING COMMISSION

Fifth Rangewide Workshop on the Status of North Pacific Gray Whales[1]

1. INTRODUCTORY ITEMS

1.1 Convenors' opening remarks
The Workshop was held at the Granite Canyon Laboratory (Big Sur, California) of the Southwest Fisheries Science Center from 28-31 March 2018. The list of participants is given as Annex A. Brownell welcomed the participants and explained the history of the facility, which has been used for almost five decades to census gray whales during their southbound migration. Donovan and Punt (co-convenors) noted that the primary tasks of the workshop were to review the results of the modelling work identified at the Fourth Workshop and SC67a, to examine the new proposed Makah Management Plan (submitted by the USA on gray whaling off Washington state and to update as possible (and develop a workplan for) updating the scientific components of the Conservation Management Plan (CMP) for western gray whales.

1.2 Election of Chair
Donovan and Punt were elected Chairs (Donovan chaired from the 28-30 March and Punt on 31 March).

1.3 Appointment of rapporteurs
Calambokidis, Cooke, Lang, Punt, Reeves, Scordino and Weller served as rapporteurs.

1.4 Adoption of Agenda
The Adopted agenda is given as Annex B.

1.5 Documents and data available
The documents available to the meeting are listed in Annex C. Annex D summarizes the terminology used to designate breeding stocks and feeding aggregations.

2. PROGRESS ON 'NON-MODELLING' RECOMMENDATIONS AND NEW DATA

2.1 Updated information from co-operative genetics studies
Bickham presented the results of a multi-authored study of SNPs using samples from approximately 50 whales feeding off Sakhalin Island ('western' gray whales) and approximately 100 whales from the Mexican wintering grounds (assumed 'eastern' gray whales); the full study was to be presented at SC67a. The methods used are described in DeWoody *et al.* (2017). Bickham stated that a finished version of the paper will be presented at the 2018 IWC SC meeting. The authors believe that the results will have implications for prioritising the various stock structure hypotheses being modelled in the Rangewide Review (see below).

Multiple duplicate biopsies were found within both the Sakhalin and Mexico sample sets, but none were shared between the two localities. SNP genotypes were also presented for two mitochondrial and two sex-linked loci (Zfx and Zfy). One of the sex-linked SNPs (ZFY_342) had an apparent fixed heterozygosity in the Mexican whales and thus only the second locus could be used for determining the sex of the whales. The Workshop noted that whilst there is no single explanation of this, one possibility is that there was a translocation (duplication) of the Y-linked SNP to the X or to an autosome.

Bickham also presented the results of the STRUCTURE analyses for the SNPs. In the cases with locality as a prior and without locality as a prior, $K = 2$ genomes (or populations) was the best solution; the plot with geography as a prior showed better differentiation with one predominating in the east (Mexico) and the other predominated in the west (Sakhalin). All eastern samples showed admixed ancestry (including some with predominantly the "western" genome) but the western samples showed a much higher proportion of admixture including individuals of nearly 'pure' eastern and western genomes. He also presented results for an analytical approach called Landscape and Ecological Associations (LEA)[2]. The LEA analysis also identified K = 2 genomes but with greater separation. In the Sakhalin sample set the western genome still predominated but there were both individuals with pure western and others with pure eastern genomes as well as admixed individuals. The more equal proportions

[1] Not all attendees have had a chance to comment on this final version although much of the report was agreed at the Workshop itself.

[2] http://membres-timc.imag.fr/Olivier.Francois/LEA/tutorial.htm

of western and eastern genomes in the Sakhalin samples was consistent with an Mxy estimate of genetic similarity (the Sakhalin sample set had a notably higher variance for genetic relatedness between paired samples than was observed in the Mexican sample set).

The authors of the working paper concluded that the Sakhalin population might be comprised of two types of individuals representing two breeding stocks (i.e., two different genomes), along with individuals of mixed ancestry (admixture). The proportions of the two genomes are vastly different in the two sample sets.

The Workshop **agreed** that incorporating photo-id data into the genetic results will greatly improve interpretation of stock structure and movements and **recommended** that the genetic dataset should be examined comparing whales seen only once off Sakhalin with those whales seen in multiple years.

Lang gave a brief update of her work on SNPs, using the next-generation sequencing approach ddRAD. She is analysing approximately 200 gray whales representing approximately equal sample sizes of PCFG (Pacific Coast Feeding Group), western gray whales, and Northern Feeding Group whales. She expects to present the results of at the 2019 gray whale *Implementation Review.*

The Workshop **welcomed** news from Bickham that a request to the government of Japan to obtain gray whale samples for genetics studies (including of the possible extant western breeding stock).

It was noted that the extent of mixing of gray whales in the past had probably fluctuated in response to changes in sea ice (glacial versus interglacial periods). Bickham responded that additional genome sequencing was planned and that the reconstruction of the historical demography of western and eastern gray whales is one goal of that study. Analyses may reveal associations with the climate cycles of the Pleistocene.

2.2 Updated information from photo-identification studies including consolidation of WGW catalogues

SC/MP/CMP/02 reviewed the results of long-term photo-identification studies conducted between 2002-2017 off northeast Sakhalin Island by the Joint Monitoring Program of two oil and gas companies[3]. The photo-identification catalogue resulting from this work contains 283 identified individual gray whales, including: (a) 175 whales that use the Sakhalin Island feeding area on a regular annual, (b) 27 occasionally-sighted whales (recorded at intervals greater than 3 years), and (c) 71 individuals that have been recorded only once. Forty-eight of the one-time visitors were recorded as calves, excluding the nine calves first identified in 2017. There are 29 identified mothers and 127 whales first identified as calves in the catalogue. Six mother-calf pairs were identified in 2017, along with three unpaired calves. Whale no. KOGW127 (aka “Agent”), was identified as a calf in 2005 and was first recorded as a mother in 2017 at the age of 12 years. Agent was satellite tagged in 2011 and her winter migration was tracked to the Gulf of Alaska before the transponder stopped working (Mate et al., 2015).

Drone-based photography was incorporated into the joint-programme field program in 2017. In most cases, the drone was used at an average distance of about 800 m from shore with a standard altitude of 8 meters. The range of the drone presently in use is 2.5 km from the shore. With the collection of aerial photographs from drones, a new body aspect (“back”) was added to the photo-identification catalogue. Also, a new supplemental catalogue of drone-collected video was created for 35 individuals.

The catalogues of the ENL-SEIC joint programme and the Russian Gray Whale Programme (previously the Russia-US programme) were last cross-matched using data available through 2011. At that time, the two Sakhalin photo-identification catalogues contained a total of 222 whales, of which 186 were common to both. Seventeen whales were found only in the Russian Gray Whale Programme catalogue and 19 only in the ENL-SEIC catalogue (IUCN, 2013). An updated catalogue comparison, under the auspices of the IWC, is being discussed as is the concept of a common shared catalogue and database.

In discussion, the Workshop **agreed** on the importance of the long-term nature of the research programmes being conducted off Sakhalin. The concept of a common catalogue and database was welcomed and several measures to ensure data compatibility were mentioned, including the important step to standardize reporting of effort and protocols used to designate calves versus yearlings. It was further mentioned that sighting histories of whales photo-identified off Kamchatka should be evaluated to determine patterns of annual occurrence. Finally, the availability of a shared catalogue and regular updating of such was highlighted with respect to the research component of the hunt management plan proposed for the Makah hunt.

2.3 Gray whales off Korea

SC/M18/CMP/04 reported the possible occurrence of a gray whale off Korea in 2015. Video footage of what appears to be a gray whale was uploaded on YouTube in 2015[4]. The whale was swimming near a port facility in

[3] Exxon Neftegas Limited (ENL) and Sakhalin Energy Investment Company (SEIC)

[4] https://www.youtube.com/watch?v=dJ4J7luGgcE

Samcheok, on the east coast of Korea. While the poor quality of the video prevented positive identification to species, some features of the whale suggest that it was a gray whale. Additional information is being sought to confirm the species identification. If this sighting was indeed of a gray whale, it would be the first record from Korea since 1977. The Workshop thanked D. Yasutaka Imai for alerting Kim to the existence of this video.

3. UPDATING SCIENTIFIC ASPECTS OF THE CMP

Donovan reported recent progress on the "Rangewide Review of the Status of North Pacific Gray Whales" and the 'Western Gray Whale Conservation Management Plan' (CMP). Since 2004, the IUCN and IWC have emphasized the need for a comprehensive international CMP to mitigate anthropogenic threats facing gray whales throughout their range in the western North Pacific. This CMP was initiated at an IUCN-convened international workshop in Tokyo in summer 2008 (IUCN 2009). A draft of the CMP was completed in 2010 (Brownell *et al.* 2010) and this was endorsed by both the IWC and IUCN. The first successes of the CMP included completion of a telemetry project conducted off Sakhalin and a Pacific-wide photo-identification catalogue comparison. The results of these projects showed that some of the whales sighted off Sakhalin in the summer migrate east, across the Pacific, reaching portions of the North American coast between British Columbia, Canada and the wintering lagoons off Baja California, Mexico. In light of this new information, the IWC has been engaged in the present rangewide review.

In support of the CMP initiative, in 2014 a 'Memorandum of Cooperation Concerning Conservation Measures for the Western Gray Whale Population' (the MoC), was signed by Japan, Russian Federation and the USA. In 2016, the memorandum was signed by Mexico and the Republic of Korea and Prof. Hidehiro Kato of the Tokyo University of Marine Science and Technology was appointed as coordinator of the memorandum. It is hoped that in time the other remaining range states will also sign the memorandum.

3.1 Review of existing sections

The Workshop noted that the work to complete the computing specifications, especially taking into account the new Makah Management Plan, meant that there was insufficient time to update the CMP sections, also recognising that this could best be completed after the modelling results became available, ideally at SC67b. Attention was drawn to the updated seasonal maps[5] and participants were asked to send any comments or suggestion for modification to Donovan and Reeves.

The Workshop **recommended** that the Scientific Committee considers establishing a small drafting group comprised of at least the national co-ordinators of the MoC, Reeves (IUCN) and Donovan be convened to meet intersessionally (e.g. at IUCN headquarters) to provide an updated version of the plan after SC67b.

3.2 Consideration of future stakeholder workshop

An important component of the CMP effort is the need for a stakeholder workshop (tentatively forecast to occur in 2019) that helps to finalize the CMP and develops a strategy for its implementation (IWC, 2017b). The workshop, which would be co-sponsored by IWC, IUCN and the signatories to the Memorandum of Cooperation, should be broad-based and include representatives of national and local governments, industry (e.g. oil and gas, fishing, shipping and tourism), IGOs and NGOs. Objectives of this meeting should include: (1) review and updating of the CMP taking into account any new scientific results from the rangewide workshops, (2) establish a stakeholder Steering Group to monitor CMP implementation, (3) arrange for a coordinator of the CMP and (4) establish a work plan and consider funding mechanisms to implement the actions of the plan. The IWC has a Voluntary Fund for Conservation, to which donations can be specifically directed towards the gray whale CMP and related work. It is expected, however, that after the first year of CMP implementation, range states will contribute the necessary funds to advance the conservation actions listed in the plan. The Workshop welcomed the support offered by IUCN with respect to organising the stakeholder workshop.

4 UPDATE ON MODELLING FRAMEWORK AND RUNS

4.1 Progress of modelling since SC67a including validation

4.1.1 General progress, including validation

Punt informed the Workshop that code implementing the specifications agreed at the 4th Rangewide Workshop and modified during SC67a had been written and used to condition the reference trials based on stock hypotheses 3a, 3e and 5a, along with the sensitivity tests that implement stock hypotheses 3b and 6b.

[5] https://iwc.int/western-gray-whale-cmp

Brandon summarized progress on validating the code implementing the operating model and the conditioning process. SC/M18/CMP/03 provides an update on code validation, including a brief overview of the code and input files, and a list of verification steps taken to date. The main focus of the validation process has been on the FORTRAN procedures necessary for the conditioning phase. Conditioning the operating model is the first and most computationally expensive phase of the Rangewide modelling effort because this code involves the bulk of calls to numerical methods to estimate parameters given model fits to the data. To this end, the conditioning code has been checked against the mathematical and statistical model specifications, to ensure that the procedures as implemented are consistent with the specifications (see Annex D for the specifications of the Rangewide model). Likewise, diagnostic output from the code has been checked against expected values. No errors in the coding were identified.

4.1.2 Modelling related to the proposed Makah management plan

Punt informed the Workshop that code implementing the Makah Management Plan (Annex X) had been developed and initial results presented to the March 2018 AWMP meeting. However, Brandon has yet to validate this code. The code implementing the Makah Management Plan needs to be validated prior to SC67b.

During the Workshop, the Makah Management Plan was clarified/updated as shown below.

(1) It was clarified that the hunt will be stopped if the PCFG 10-yr strike limit less number of PCFG-designated animals drops below 1 or if the PCFG 10-yr female strike limit less number of PCFG-designated females drops below 1. The initial implementation only stopped the hunt only when these differences were less or equal to zero.

(2) It was agreed to incorporate an 'unknown identity' component for landed whales because it may not be possible to obtain a useable photograph of landed as well as struck and lost whales (although at a lower probability).

(3) It was agreed to allowing for the fact that the amount that unidentified whales count towards the PCFG 10-year strike limit will be updated based on available data rather than always being assumed to be 0.4. The error associated with the estimate of the proportion of PCFG whales in even-year hunts needs to be accounted for (see Item 4.4.1).

4.2 Review of stock hypotheses

The Workshop reviewed how the three baseline stock hypotheses (3a, 3e and 5a) and the two stock hypotheses considered as tests of sensitivity (3b and 6b) had been implemented, noting that some of the 'limited' movements (light arrows in Annex E) had been omitted from the baseline hypotheses, but would be considered in tests of sensitivity (e.g. the PCFG in sub-area BSCS). The omission of the associated links was due to lack of mixing data to allow the links to be modelled. It was also noted that that there are no data (abundance estimates, mixing proportions, catches) for some of the sub-area (e.g. the OS sub-area), which implies that the results will be identical no matter how such regions are treated in the modelling.

The Workshop noted that the current implementation of hypothesis 5a did not include the WBS in the SKNK sub-area. This is because there was currently no basis to specify a mixing proportion for WBS vs WFG animals in the sub-area. Cooke provided abundance estimates by breeding stock / feeding group (see Item 4.3.1), which means that it is no longer necessary to specify mixing proportions for the SKNK sub-area.

The Workshop **agreed** that stock hypotheses 3a and 5a would form the references for the analyses as they appear to be most plausible, while trials would also be conducted for stock hypotheses 3b, 3c, 3e and 6b. Annex E shows the final stock hypotheses considered in the trials graphically, while Annex D, Table 2 shows the resulting mixing matrices. The γ values in Annex D, Table 2 indicate parameters that are estimated during the model fitting process.

4.2.1 Plausibility of stock hypothesis 6b

SC/M18/CMP/01 aimed to reopen discussion on the plausibility of the stock hypotheses previously considered as high priority for modelling, with special emphasis on stock hypothesis 6b. Stock hypothesis 6b assumes that the WBS has no fidelity to wintering ground and uses both wintering grounds in both Asia and Mexico. SC/M18/CMP/01 argued that this hypothesis was elevated to high priority due to discussions regarding the movements of humpback whales and the social aggregating hypothesis of Clapham and Zerbini (2015). This hypothesis involves humpback whales learning of new wintering grounds, likely through hearing other humpback whales, and temporarily immigrating. SC/M18/CMP/01 argued that this hypothesis does not apply well to gray whales because they are much quieter than humpback whales and there is a large distance between the distribution of WBS and eastern breeding stock whales (as portrayed by hypothesis 6b) preventing communication between whales. Furthermore, humpback whales and gray whales have very different breeding behaviour, with humpback whales aggregating on modified leks (Clapham and Zerbini 2015). There does not appear to be a functional benefit for WGW to justify shifting their migration to go to wintering grounds in Mexico instead of Asia given the extra 4,000 km of travel required (Villegas-Amtmann *et al*., 2015). Furthermore, it does not appear likely that the WBS used both wintering grounds without fidelity prior to commercial whaling given that whaling occurred off Japan and Korea during a period when the whales using the Mexican wintering grounds were depleted. Bickham et al. (2013) has also presented arguments based on genetics on why hypothesis 6b has low plausibility. SC/M18/CMP/01 also suggested that hypothesis 3e has low plausibility because it assumes that WBS whales occur in their historical feeding range but do not use the Piltun Lagoon area of Sakhalin Island, which has proved to be an important feeding area since the mid-1980s. It is more likely that if the WBS exists, that this breeding stock would spend at least some time feeding near Piltun Lagoon. SC/M18/CMP/01 concluded the trials based on stock hypotheses other than 3a and 5a should be sensitivity tests.

In discussion, it was noted that gray whales that feed off Sakhalin and traditionally used wintering grounds in the western North Pacific could be driven to occasionally use migratory routes and wintering areas in the Eastern North Pacific. While the Rangewide model does not explicitly account for breeding so does not incorporate information on when or where whales breed, this hypothesis could provide an explanation for the observations of Sakhalin whales in the eastern North Pacific. There is evidence showing that whales from the same feeding groups migrate together; both Sakhalin and PCFG whales have been photographically identified in the same groups and in localized areas while on migratory routes (Weller et al. 2012, Calambokidis and Perez 2017). This could provide a mechanism by which whales that feed together, but have traditionally used different wintering areas, could learn new migratory routes.

Although the possibility that gray whales use multiple wintering grounds could not be ruled out, the Workshop **agreed** that stock hypotheses 6b would be considered as a sensitivity test. It was also **agreed** that stock hypothesis 3e would be considered a sensitivity test.

4.3 Confirm final data sets

4.3.1 Removals (direct and incidental)

IWC (2018) referenced records of gray whale deaths from entanglement/entrapment, ship strike, and unknown causes in Japan from 1982 until the present (Nakamura *et al.*, 2017). A small group (Scordino, Reeves, Brownell) met to confirm and update what had been stated previously on removals in Japan (and elsewhere), recalling that the adult that 'died off Hokkaido in 1996' was killed deliberately (Brownell, 1999).

The Workshop **endorsed** the conclusions of the small group as summarised below.

(1) Of the six gray whales reported as beached in Japan between 1990 and 2016 but with cause of death undetermined, some proportion should be assumed to have died from either entanglement/entrapment or ship strike. The under-reporting factor (usually x4 but with sensitivities of x10 and x20; Annex D, tables 8 and 9) used in the model to convert observed mortality to true mortality in the case of bycatch and ship strike would account for this.

(2) There was no reason to believe there had been any change in fishing effort (e.g. set net fishing) in Japan between 1930 and 1982. Therefore, the removal rate from 1982 to the present should be extended back to 1930 for modelling purposes.

(3) Finally, with respect to commercial set gillnet fishing in California prior to 1981, as noted last year (IWC, 2018), a seabass fishery operated in northern Mexico and southern California prior to the 1980s (e.g. landing 412,000 pounds of black seabass and 873,000 pounds of white seabass in 1953; Marine Fisheries Branch, 1956). In fact, this fishery was active and overall fishing effort 'fairly constant' from before 1930 until the early 1980s (Vojkovich and Reed, 1983). There was no observer effort in this fishery before 1981, nor was an official stranding record of cetaceans maintained in California before that time. However, a coordinated reporting system for stranding was established in the early 1960s under the auspices of the American Society of Mammalogists, and stranded gray whales were regularly reported. For example, 24 dead gray whales were reported as stranded in California between 1960 and 1968, of which seven were confirmed or suspected of having been either entangled in fishing gear or struck by a ship; Brownell, 1971). A gray whale that stranded at Ocean Beach, California, on 19 February 1953 was missing its flukes and bore 'several gashes' on the body – all suggestive of an entanglement death (Robert Orr, pers. comm. to R. Brownell, April 1964).

At last year's workshop, it was assumed that set gillnet fishing effort for halibut in California declined linearly from 1982 to no effort in 1975. To model the effect of this assumption, it was decided to assign all records of gray whales recorded as injured or killed in halibut or other set gillnet fisheries to a single fishery and modelled separately from all other California fisheries. It was also decided to examine both a low case that assigned no deaths to set gillnet fisheries and a high case that considered all bycatch reports related to gillnet, set gillnet, net, and halibut fisheries in California as if they came from a single fishery (IWC, 2018). A recently found publication (Bureau of Commercial Fisheries, 1936) reported that both set gillnets and trammel nets were used in the 1930s in California for halibut and white seabass fishing. Based on this new information, the Workshop **agreed** to drop the assumption that fishing effort declined linearly to zero from 1982 to 1975 and therefore there was no reason to evaluate high and low scenarios as a way of accounting for bycatch in California prior to 1975.

Set gillnetting effort off California changed markedly in 1991 due to regulations passed in November 1990 intended to eliminate gillnet fishing within 3 n.miles of the mainland and within 1 n.mile of any offshore island in southern California by 1994 (Barlow *et al.*, 1994). To address this, a second set gillnet fishery was added to the model starting in 1991 and the set gillnet fishery described in the preceding paragraph was modelled as having ended in 1990.

Table 1

Abundance estimates (1+) for the WFG feeding aggregation and the western breeding stock

Year	Group	Hypothesis	Estimate	SD	CV
1995	WFG	3a/3c/3e/6b	75.1	3.8	0.051
1995	WBS	3b	25.8	7.3	0.282
1995	WFG	3b	75.5	3.3	0.043
1995	WBS	3e	30.0*	15.0	0.500
1995	WBS	5a	26.6	6.9	0.259
1995	WFG	5a	47.8	7.7	0.160
1995	WBS+WFG	5a	74.4	3.9	0.052
1995	WBS/(WBS+WFG)	5a	0.358	0.093	0.259
2015	WFG	3a/3c/3e/6b	199.8	5.4	0.027
2015	WBS	3b	63.8	15.8	0.248
2015	WFG	3b	198.9	5.7	0.029
2015	WBS	3e	30.0*	15.0	0.500
2015	WBS	5a	64.4	14.0	0.218
2015	WFG	5a	135.6	14.1	0.104
2015	WBS+WFG	5a	200.0	5.7	0.029
2015	WBS/(WBS+WFG)	5a	0.322	0.069	0.200

* Guestimate because the WBS cannot be distinguished given the available information.

4.3.2 Abundance estimates

There were no updates to the estimates of abundance for the PCFG or the ENP stock. New abundance estimates for western gray whales had been presented to the last WGWAP meeting (Cooke *et al*., 2017), which will also be presented to the SC67b. Estimates for the WFG were extracted at the Workshop that would correspond to the stock structure hypotheses listed in Annex E (table 1). The larger estimates for the WFG correspond to the hypothesis that all whales visiting SE Kamchatka and/or Sakhalin belong to the WFG, while the smaller ones correspond with the hypothesis that only whales that visit Sakhalin belong to the WFG (regardless of whether these individuals also visit Kamchatka).

For the hypotheses where a proportion of the WFG belongs to the western breeding stock (WBS), this proportion is highly uncertain (and could be zero) even though the estimate for the total WFG is reasonably precise. The estimates of the numbers of WFG animals in each of the two breeding stocks are, therefore, highly negatively correlated. In these cases, the multi-stock model uses as inputs the estimate of the total WFG and the estimated proportion of this that belongs to the WBS.

Table 2

Mixing proportions for use in the trials

Sub-area	Season	Stock / Feeding aggregation	Mixing proportion
EJPJ	All	WBS/NFG	0.33
SEA	Feeding	PCFG	0.57[1]
SEA	Migration	PCFG	0.1[2]
SEA	Migration	WGW	0.002[3]
BCNC	Feeding	PCFG	0.93
BCNC	Feeding	WGW	0
BCNC	Migration	PCFG	0.28
BCNC	Migration	WGW	0.002
CA	Feeding	PCFG	0.60
CA	Feeding	WGW	0
CA	Migration	PCFG	0.1
CA	Migration	WGW	0.002[3]

1: Not used in the conditioning as no bycatch is recorded for the SEA sub-area during the feeding season.
2: Assumed value owing to lack of data to estimate mixing proportions.
3: Set to the value calculated for BCNC by Moore and Weller 2013)

4.3.3 Mixing proportions
Table 2 lists the updated mixing proportions. The mixing proportion for the EJPJ sub-area is unchanged from that specified at the 4th Rangewide Workshop because none of whales encountered recently in this sub-area had adequate photographs to allow for matching (Table 3).

Table 3

Updated information on matches between whales encountered off Japan and those photographed off Sakhalin (D. Weller, SWFSC).

Date	Location and source	Conclusion
April 2016	Shizuoka, beached	no useable photos/no match
February 2017	Kanagawa, sighting	poor quality video only/no match
April 2017	Chiba, sighting	poor quality video only/no match
March 2017	Aogashima, sighting	no useable photos/no match
February 2018	Aogashima, sighting	no useable photos/no match

New mixing proportions were calculated for PCFG whales by sub-area for the winter/spring (migrating) and summer/fall (feeding) seasons (Table 4). The sub-regions of the BCNC region used for the analysis were northern Oregon, southern Washington, and northern Washington because they were thought to have the least chance of bias in calculated mixing proportions. Updated data through 2015 based on matches to the PCFG catalogue were used. There was considerable discussion about how to calculate the mixing rate for the Oregon-Washington outer coast area due to a dramatic change in proportion of PCFG whales in northern Washington from surveys in early April 2015. Those surveys identified a large number of whales in a previously poorly sampled area that had very few PCFG whales. Identifications in spring 2015 (heavily influenced by these April surveys) reduced the overall proportion of PCFG whales based on pooled proportions through 2015 to 24% (it had been 36% based on data through 2014). To provide a value less influenced by these two days of surveys, the proportions of PCFG whales were averaged over sub-region and month to compute an overall average of 28% (an average of the eight values presented in Table 4.

Table 4

Proportion of PCFG whales by region and month for cells with >10 IDs; complete through 2015 for OR-WA Jan to May (no Dec data)

Region	Jan	Feb	Mar	April	May
NWA	0.09		0.09	0.10	0.41
SWA			0.38	0.21	0.33
NOR					0.63

Mean of above cells for OR to WA: **Unweighted = 28%**, Pooled = 24%
Mean of above for just N WA: Unweighted = 17%, Pooled = 20%

The Workshop **agreed to** adopt 28% for the proportion of PCFG whales in the BCNC sub-area during the migrating season for the bulk of the trials, and that sensitivity would be evaluated to 17%. This value is obtained by restricting the analysis of mixing rates of PCFG whales during the winter/spring to just northern Washington where the hunt would occur (based on the unweighted average of the 4 months where there were at least 10 photo-IDs, table 4). Pooling all 622 photo-IDs for December to May would result in a rate of 20%, although this approach weights values towards periods with more photo-IDs.

Considering some of the uncertainty around the estimate for the portion of PCFG whales present in the spring off the Washington-Oregon coast and the variation by location, month, and year, the Workshop **agreed** the current best estimate of 28% to be +-20% (8-48%) for the true PCFG mixing rate. The rationale for the choice is that very different results would be obtained in different areas such as 1) the recently sampled zone north of Tatoosh Island in the early spring where migrating whales appear to gather in some years where recent efforts revealed almost no PCFG whales, compared to 2) areas along the Northern Washington Coast or for example in Barkley Sound that are feeding areas for PCFG whales and where their proportion compared to migrating whales would be highest.

4.4. Confirm final trial structure and conditioning

4.4.1 Changes to the trials specifications, including stock structure
Annex D lists the specifications for the model that will form the basis for drawing final conclusions regarding the implications of alternative stock structure hypotheses and of the implementation of the Makah management plan. The specifications (see also Annex D and Table 5 and 6) reflect changes to how the stock hypotheses are implemented as well as how the abundance estimates for the western Pacific are used in conditioning. The Workshop also agreed that the following additional changes will be made the trials specifications:

(1) the base-case survival rate for animals aged 1 and older would be assumed to be 0.98, which reflects the estimates obtained by Cooke (ref) and Punt and Wade (2012); the values used in previous trials was 0.95;

(2) the SET1 and SET2 fleets (set gillnets off California in the feeding and migration seasons) would be split between 1990 and 1991 given the changes in regulations in the associated fisheries that appear to have changed bycatch rates;
(3) the survey plan for the California counts were updated to reflect the current plan (two surveys in every five-year block); and
(4) the periods used to calculate average bycatch rates to infer bycatch prior to the establish of monitoring networks into the future as generally but the earliest and most recent five years, but a longer period is specification for sub-areas (e.g. EJPJ and SI) with limited data (Annex D, table 3)

Evaluation of the Makah Management Plan requires specification of the probability of photographing a landed or struck and lost whale, as well as the probability of correctly deciding that such a whale is from the PCFG or the WFG. In addition, it is necessary to specify the probability of striking and losing a whale and assigning a sex to an animal for which a match has been made. These probabilities are specified as follows:

(1) *Probability of obtaining a photograph of sufficient quality to allow it to be matched to the catalogue*. For struck and lost whales, this probability is estimated to be a 0.6 for winter/spring and 0.8 for summer/fall (due less favourable light and weather in winter/spring compared to summer/fall). For landed whales, it is estimated to be 0.9 for all seasons.
(2) *Probability of struck and lost*. The review of the Makah whale *SLA* concluded in 2013 was based on a value for this probability of 0.5, which was informed by two strikes that occurred during the Makah 1999 hunt in which one strike resulted in a landing and the other contacted the whale but did not penetrate the skin. The Workshop agreed to retain the assumption of a 50% struck and lost rate for hunts during the winter and spring. It was decided that hunts occurring during the summer and fall were much less likely to have struck and lost due to better weather conditions and more predictive movement behaviours of whales in the normal feeding depths of PCFG whales. The Workshop therefore agreed that the struck and lost rate for summer and fall hunts would be 0.1 and that sensitivity would be explored to a value of 0.5.
(3) *False positive rate for PCFG (i.e. probability of a non-PCFG being identified as from the PCFG given a good quality photograph*). The probability that a non-PCFG whale might be falsely identified as a PCFG whale is estimated to be 0.05. Normally, there is a near 100% confidence for matches that are identified to Cascadia's PCFG catalogue because these are double checked and photographs of poorer quality where there is some ambiguity are treated as Poor Quality and not used. The value of 0.05 is based on the assumption that a slightly different set of circumstances would exist for comparison of a whale struck or landed because there would be pressure to try to match regardless of the quality of the photograph and it would be hard to justify not reporting as a match something where there was a relatively high degree of confidence (i.e. 95% confident of the match to a PCFG whale).
(4) *False negative rate for PCFG* (i.e. *i.e. probability of a PCFG whale not being identified as such given a good quality photograph*). This probability is estimated to be 0.25 for a hunt in the winter/spring, and zero for a hunt in summer since all struck whales are assumed to be of the PCFG. This value of 0.25 accounts for several factors, including whales only seen in fewer in two years in the PCFG because of a combination of being young, not being photographed, and the one year lag in available catalogue. In addition, there could be a matcher error in missing a match due to things like changed markings.
(5) *False positive rate for WFG (i.e. probability of a non-WFG being identified as from the WFG given a good quality photograph*). This probability is estimated to be 0.01 based on the WFG catalogue being smaller and more well-known. Also, it is suspected that the matcher would likely only declare a match when there was a high level of confidence given the infrequent rate of these matches.
(6) *False negative rate for WFG* (i.e. *i.e. probability of a WFG whale not being identified as such given a good quality photograph*). On the assumption that calves and lactating mothers will not be hunted, the proportion of huntable WFG whales that would not be known as WFG whales if taken during the spring northward migration was estimated using the population model fit to the Sakhalin and Kamchatka photo-id data. An animal that has been seen off Sakhalin is assumed to be a WFG animal if seen or taken in the eastern North Pacific. An animal seen off eastern Kamchatka but not Sakhalin is not assumed to be a WFG animal, because it might be an NFG animal. The estimated proportion, averaged across the posterior distribution of the population trajectory, was 4-5% depending on the hypothesis. These estimates used data through 2011 only, that being the last season for which the catalogues were cross-matched. If only a single catalogue were used, the rate would be higher. The values used in the trials are: stock hypotheses 3a, 3c, 3e, and 6b: 0.041; stock hypothesis 3b: 0.040; stock hypothesis 5a: 0.049.
(7) *Probability of not assigning a sex to a struck and lost animal that has been identified to the PCFG.*
    a. This probability is estimated at 19% for the feeding season based on 81% of encounters of PCFG whales from June-Nov through 2015 for the Oregon and Washington outer coast having known sex. For those with known sex in this sample 58% were female and 42% male, but this could be

biased by some directed sampling toward females so the sex ratio should be treated as 50:50 in the management plan.

b. This probability is estimated at 27% for the migrating season based on 73% of encounters of PCFG whales from Dec-May through 2015 for the Oregon and Washington outer coast having known sex. For those with known sex in this sample 46% were female and 54% were male. This male-biased sex ratio is in the opposite direction of the bias from intentionally sampling females, which suggests males are actually more abundant and available in the spring off the Oregon and Washington outer coast likely as a result of females with calves migrating later and being less available in spring. Given the bias for trying to sample known females, it is likely that the sex ratio in spring is likely closer to 60:40 male:female. If hunters avoid taking mothers with calves it would further reduce the chances of taking a female.

Estimates of the proportion of PCFG whales used in the Makah management plan for assigning a struck unidentified whale in the winter/spring hunt are subject to uncertainty due to for example shifting proportions based on sampling differences and these should be considered subject to a bias (which depends on trials) that ranges from -0.1 to 0.1.

Table 5

Factors considered in the model scenarios. The bold values are the base-levels and the values in standard font form the basis for sensitivity analyses.

Factor	Levels
Model fitting related	
Stock hypothesis	**3a,** 3b, 3c, 3e, **5a,** 6b
$MSYR_{1+}$ (western)	As for WFG
$MSYR_{1+}$ (north)	**4.5%**, 5.5%, Estimated (common); estimate (separately)
$MSYR_{1+}$ (WFG)	**4.5%** Estimated (common); estimate (separately)
$MSYR_{1+}$ (PCFG)	2%, **4.5%**, 5.5%, Estimated (common); estimate (separately)
Mixing rate (migration season in BCBC	**0.28**, 0.17, 1.00
Immigration into the PCFG	0, 1, **2**, 4
Bycatches and ship strikes	Numbers dead + M/SI, **dead x 4**; dead x 10; dead x 20
Pulse migrations into the PCFG	10, **20**, 30
Projection-related	
Additional catch off Sakhalin (mature female)	0, 1
Catastrophic events	**None**, once in years 0 – 49, and once in years 50-99
Northern need in final year (from 150 in 2014)	**340**
Struck and lost rate	**(0.1; odd-years; 0.5 even years),** 0.5 all years
Future effort	**Constant**, Increase by 100% over 100 years
Probability of a photo (struck and lost whales)	**0.8; odd-years; 0.6 even years**
Probability of a photo (landed whales)	**0.9**
Probability of false positive rate PCFG	**0.05**, 0.1
Probability of false negative rate PCFG	**0.25**
Probability of false positive rate WFG	**0.01**
Probability of false negative rate WFG	**0.041 (stock hypotheses 3a, 3c, 3e, 6b);** 0.040 (stock hypothesis 3b); **0.049 (stock hypothesis 5a)**
Probability of a sex assignment given a PCFG match	**0.81**

4.4.2 Base-case trials and sensitivity tests

The 4th Rangewide workshop specified a series of trials. However, it had not been possible to implement all of these trials during the intersessional period. The Workshop reviewed the set of trials and made the following changes (trial numbers relate to revised numbering system):

(1) stock hypothesis 3e is now treated as a sensitivity test as it is a variant of stock hypothesis 5a (with no WBS animals in the SI sub-area);

(2) a new sensitivity test (18C) based on stock hypothesis 3c has been added as agreed at the 4th Rangewide workshop (IWC, 2018);

(3) the sensitivity test exploring a higher proportion of WBS whales in sub-area SI (3B) involves increasing the estimates of abundance for the WBS by 50% and correspondingly reducing the estimates of abundance for the WFG;

(4) the trials involving PCFG whales in the BSCS sub-area (12A/B) are based on assuming that all PCFG whales are in the BSCS sub-area. The assumption will be conservative given that most PCFG whales are located elsewhere when the aboriginal hunt off Chukotka occurs;

(5) the trials involving WFG whales in the BSCS sub-area (13A/B) are based on assuming that all WFG whales are in the BSCS sub-area. The assumption will be conservative given that most WFG whales are located elsewhere when the aboriginal hunt off Chukotka occurs;

(6) the trials exploring the sensitivity of how the California set gillnet catches were modelled (trials 14 and 15 in Table 8 of IWC (2018)) were dropped as the approach for modelling the SET1 and SET2 fleets was modified (see Item 4.3.1);

(7) the trials with MSYR estimated and a higher pulse were dropped as these trials are unlikely to be informative (trials 14A/B and 8A/B examine these factors individually);

(8) variants of trials 5A/B and 16A/B (trials 18A/B and 19A/B) that have net immigration of 1 to the PCFG were added because the assumption of zero immigration into the PCFG is unlikely given the results of Lang and Martien (2012);

(9) trials 7A/B and 16A/B exclude the PCFG abundance estimates for 1998-2002 as a low pulse would not allow the model to mimic these data – this change in model specifications mimics the adoption in the trials used to evaluate the *SLA* for a Makah hunt by IWC (2013) of a time-varying survey bias;

(10) trials 22A/B have been added to examine the future consequences of a catastrophic events in the NFG – these events occurs randomly once in the first 50 years and randomly once in the second 50 years, with a magnitude equivalent to that of the mortality event in 1999/2000; and

(11) trials 23A/B and 24A/B have been added to explore sensitivity to the struck and lost rate for a Makah hunt in the feeding season, and the false negative rate for a Makah hunt in summer.

Table 6

Final trial specifications

Trial	Description/stock hypothesis	PCFG or WFG in BSCS	$MSYR_{1+}$			PCFG		Bycatch	Condition?
			North	PCFG	WFG	Imm.	Pulse		
Base-case trials									
0A	Reference 3a	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
0B	Reference 5a	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
Sensitivity tests									
1A	Lower MSYR PCFG 3a	No	**4.50%**	**2%**	**4.50%**	2	20	D x 4	Yes
1B	Lower MSYR PCFG 5a	No	**4.50%**	**2%**	**4.50%**	2	20	D x 4	Yes
2A	Higher MSYR PCFG and North 3a	No	**5.50%**	**5.50%**	**4.50%**	2	20	D x 4	Yes
2B	Higher MSYR PCFG and North 5a	No	**5.50%**	**5.50%**	**4.50%**	2	20	D x 4	Yes
3A	Lower WBS in Sakhalin 5a (Hyp 3e)	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
3B	Higher WBS in Sakhalin 5a	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
4A	PCFG mixing based on Northern WA only 3a	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
4B	PCFG mixing based on Northern WA only 5a	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
5A	No PCFG Immigration 3a	No	4.50%	4.50%	4.50%	**0**	20	D x 4	Yes
5B	No PCFG Immigration 5a	No	4.50%	4.50%	4.50%	**0**	20	D x 4	Yes
6A	Higher PCFG Immigration 3a	No	4.50%	4.50%	4.50%	**4**	20	D x 4	Yes
6B	Higher PCFG Immigration 5a	No	4.50%	4.50%	4.50%	**4**	20	D x 4	Yes
7A	Lower Pulse into PCFG 3a (and no 1998-2002 PCFG data)	No	4.50%	4.50%	4.50%	2	**10**	D x 4	Yes
7B	Lower Pulse into PCFG 5a (and no 1998-2002 PCFG data)	No	4.50%	4.50%	4.50%	2	**10**	D x 4	Yes
8A	Higher pulse into PCFG 3a	No	4.50%	4.50%	4.50%	2	**30**	D x 4	Yes
8B	Higher pulse into PCFG 5a	No	4.50%	4.50%	4.50%	2	**30**	D x 4	Yes
9A	Bycatch=Dead + MSI 3a	No	4.50%	4.50%	4.50%	2	20	**D + MSI**	Yes
9B	Bycatch=Dead + MSI 5a	No	4.50%	4.50%	4.50%	2	20	**D + MSI**	Yes
10A	Bycatch x 10 3a	No	4.50%	4.50%	4.50%	2	20	**D x 10**	Yes
10B	Bycatch x 10 5a	No	4.50%	4.50%	4.50%	2	20	**D x 10**	Yes
11A	Bycatch x 20 3a	No	4.50%	4.50%	4.50%	2	20	**D x 20**	Yes
11B	Bycatch x 20 3e	No	4.50%	4.50%	4.50%	2	20	**D x 20**	Yes
12A	PCFG in BSCS 3a	**PCFG**	4.50%	4.50%	4.50%	2	20	D x 4	Yes
12B	PCFG in BSCS 5a	**PCFG**	4.50%	4.50%	4.50%	2	20	D x 4	Yes
13A	WFG in BSCS 3a	**WFG**	4.50%	4.50%	4.50%	2	20	D x 4	Yes
13B	WFG in BSCS 5a	**WFG**	4.50%	4.50%	4.50%	2	20	D x 4	Yes
14A	MSYR1+ estimated (common) 3a	No		**Estimated**		2	20	D x 4	Yes
14A	MSYR1+ estimated (common) 5a	No		**Estimated**		2	20	D x 4	Yes
15A	MSYR1+ estimated (by FA) 3a	No	**Est**	**Est**	**Est**	2	20	D x 4	Yes
15B	MSYR1+ estimated (by FA) 5a	No	**Est**	**Est**	**Est**	2	20	D x 4	Yes
16A	Lower PCFG immigration and higher bycatch 3a (and no 1998-2002 PCFG data)	No	4.50%	4.50%	4.50%	**0**	20	**D x 10**	Yes

Trial	Description/stock hypothesis	PCFG or WFG in BSCS	MSYR$_{1+}$			PCFG		Bycatch	Condition?
			North	PCFG	WFG	Imm.	Pulse		
16B	Lower PCFG immigration and higher bycatch 5a (and no 1998-2002 PCFG data)	No	4.50%	4.50%	4.50%	**0**	20	**D x 10**	Yes
17A	MSYR estimated and lower pulse 3a	No	**Est**	**Est**	**Est**	2	**10**	D x 4	Yes
17B	MSYR estimated and lower pulse 5a	No	**Est**	**Est**	**Est**	2	**10**	D x 4	Yes
18A	Stock hypothesis 3b	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
18B	Stock hypothesis 6b	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
18C	Stock hypothesis 3c	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
19A	Lower PCFG Immigration 3a	No	4.50%	4.50%	4.50%	**1**	20	D x 4	Yes
19B	Lower PCFG Immigration 5a	No	4.50%	4.50%	4.50%	**1**	20	D x 4	Yes
20A	Lower PCFG immigration and higher bycatch 3a	No	4.50%	4.50%	4.50%	**1**	20	**D x 10**	Yes
20B	Lower PCFG immigration and higher bycatch 5a	No	4.50%	4.50%	4.50%	**1**	20	**D x 10**	Yes
21A	Survival = 0.95; 3a	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
21B	Survival = 0.95; 3a	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
22A	Future catastrophic events (once in each of yrs 1-50 & 51-99) - 3a	No	4.50%	4.50%	4.50%	2	20	D x 4	No, 3a
22B	Future catastrophic events (once in each of yrs 1-50 & 51-99) - 5a	No	4.50%	4.50%	4.50%	2	20	D x 4	No, 5a
23A	Summer S&L rate = 0.5 - 3a	No	4.50%	4.50%	4.50%	2	20	D x 4	No, 3a
23B	Summer S&L rate = 0.5 - 5a	No	4.50%	4.50%	4.50%	2	20	D x 4	No, 5a
24A	PCFG false negative rate = 0.1 - 3a	No	4.50%	4.50%	4.50%	2	20	D x 4	No, 3a
24B	PCFG false negative rate = 0.1 - 5a	No	4.50%	4.50%	4.50%	2	20	D x 4	No, 5a
25A	PCFG mixing based on Northern WA is 100%	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
25B	PCFG mixing based on Northern WA is 100%	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes

4.4.3 Conditioning statistics

The Workshop reviewed the diagnostic plots for evaluating the conditioning developed for the trials specified at the 4th Rangewide Workshop. The Workshop **agreed** that the following plots should be produced for each trial and provided to the Intersessional Steering Group for review:

(1) The estimates of absolute abundance (with 90% sampling intervals) and the median, 50% and 90% intervals for the time-trajectory of the model estimates of 1+ population size.
(2) The time-trajectory of the model estimates of the number of mature females.
(3) The distributions (median, 50% and 90% intervals) for the generated mixing proportions and those for the model-predicted mixing proportions.
(4) The distribution for the net immigration rate from the NFG to the PCFG and the target value (black vertical bar).
(5) The estimates of average bycatch over the period for which reporting is considered adequate [Annex D, table 3] (with 90% sampling intervals) and the median, 50% and 90% intervals for the model-estimate of the average bycatch over the period.
(6) The distributions (median, 50% and 90% intervals) for the generated survival rates for PCFG whales and those for the model-predicted survival rates for PCFG whales.
(7) The time-trajectories of removals, including the recorded removals (adjusted for under-reporting) and the bycatch inferred for the years for which reporting is not considered adequate.

4.4.4 Projection scenarios

Previous projections for the Sakhalin population (J. Cooke in Reeves *et al.*, 2005) considered a scenario in which there is future bycatch of 1.5 mature females off Japan based on inferences from bycatch at that time. The Workshop noted that observed bycatch off Japan has declined since then. The Workshop **agreed** that a projection scenario with 1 mature female taken each year in the EJPJ sub-area should to be conducted.

In addition, the Workshop **agreed** that, if possible, projections should be conducted for the current Makah *SLA*, although it was recognised this may not be feasible to achieve before 67b.

The Workshop noted that care needs to be taken to compare the results from the previous *Implementation Review* with those based on the Rangewide review because the population structure hypotheses have changed and the Rangewide review has more fully accounted for bycatch and its uncertainty.

4.4.5 Performance statistics

4.4.5.1 TIME-TRAJECTORIES OF POPULATIONS

The results of the model fits and the projections will be summarized by time-trajectories of 1+ numbers of breeding stock / feeding group and by sub-area

4.4.5.2 MAKAH MANAGEMENT PLAN

The results of the projections to evaluate the performance of the Makah management plan will be based on the standard statistics used by the Committee to evaluate the performance of Strike Limit Algorithms

(1) D1. Final depletion of 1+ and mature female numbers by breeding stock / feeding group (median, lower 5th and upper 5th percentiles)
(2) D8. Rescaled final depletion: P_T/P_0 (1+ and mature female numbers by breeding stock / feeding group; median, lower 5th and upper 5th percentiles) where P_0 is number of 1+ / mature female animals had there been no future Makah hunts.
(3) D10. Relative increase. The ratio of the 1+ and mature population size after 10 and 100 years to that at the start of the projection period by breeding stock / feeding group (median, lower 5th and upper 5th percentiles)
(4) N9. Need satisfaction. The proportion of the total number of requested strikes that were taken over the first 10 years and the entire 100-year period (median, lower 5th and upper 5th percentiles).

Results are provided for both 10 and 100 years for the D10 and N9 statistics because (a) the Makah management plan current only operates for 10 years, and (b) previous evaluations of the performance of management procedures (RMP and AWMP) have considered performance over 100 years. Population-related statistics should be also be provided for the case there is no future Makah hunt (only bycatch and hunting off Chukotka).

5. WORKPLAN

Before / during 67b

(1) Update the code for the operating model (Punt)
(2) Validate any changes to the historical (conditioning) component of the operating model (Brandon)
(3) Conduct conditioning and distribution of conditioning diagnostics to the Steering Group (Punt)
(4) Review of the conditioning results (Steering Group)
(5) Code the revised Makah management plan and the associated testing code (Punt)
(6) Validate the revised Makah management plan and the associated testing code (Brandon)
(7) Conduct the projections and assemble the projection results (Punt)

After 67b

(1) Complete drafting of the CMP.

6. ADOPTION OF REPORT

The co-chairs thanked Brownell and his colleagues for the excellent and historic facilities provided at the laboratory in the beautiful setting of Granite Canyon (complete with gray whales migrating by). The report was adopted by email.

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Annex A

List of Participants

USA
J. Bickham
R.L. Brownell, Jr.
D. Darm
A. Lang
J. Scordino
D. W. Weller
N. Young

REPUBLIC OF KOREA
H.W. Kim
H. Sohn

INVITED PARTICIPANTS
J. Brandon
A. Burdin
J. Calambokidis
J. Cooke
A.E. Punt
M. Scott
R.R. Reeves

IWC
G.P. Donovan

Annex B

Agenda

1. Introductory items
   - 1.1 Convenor's opening remarks
   - 1.2 Election of Chair
   - 1.3 Appointment of rapporteurs
   - 1.4 Adoption of Agenda
   - 1.5 Documents and data available
2. Progress on 'non-modelling' recommendations and new data
   - 2.1 Updated information from the co-operative genetics studies
   - 2.2 Updated information from photo-identification studies including consolidation of WGW catalogues
   - 2.3 Gray whales off Korea
3. Updating scientific aspects of the CMP
   - 3.1 Review of existing sections
   - 3.2 Consideration of future stakeholder workshop
   - 3.3
4. Update on modelling framework and runs
   - 4.1 Progress on modelling since SC/66b, including validation
     - 4.1.1 General progress, including validation
     - 4.1.2 Modelling related to the proposal Mkah management plan
   - 4.2 Review of stock hypothesis
   - 4.3 Confirm final data sets
     - 4.3.1 Removals (direct and incidental)
     - 4.3.2 Abundance estimates
     - 4.3.3 Mixing proportions
   - 4.4 Confirm final trial structure and conditioning
     - 4.4.1 Changes to the trial specifications, including stock structure
     - 4.4.2 Base-case trials and sensitivity tests
     - 4.4.3 Conditioning statistics
     - 4.4.4 Projection scenarios
     - 4.4.5 Performance statistics
5. Work plan
6. Adoption of Report

Annex C
List of Documents

SC/M18/CMP

1. Scordino, J. and Bickham, J. Plausibility of stock structure hypothesis 6b
2. Tyurneva, O.Y., Takovlev, Y.M., Vertyankin, V.V. van der Wolf, P. and Scott, M.J. Lomg-term photo-identification studies of gray whales (*Eschrichtius robustus*) offshore northeast Salhalin Island, Russia, 2002-2017.
3. Brandon, J. IWC Gray Whale Rangewide Model: Code Validation for the 2018 Workshop.
4. Kim, H.W. and Sohn, H. Possible occurrence of gray whale off Korea in 2015.

Annex D

Terminology Used with Respect to Stock Structure Hypotheses

Breeding stocks. There are up to two extant breeding stocks: Western (WBS) and Eastern (EBS).

*Feeding groups or aggregations**. There are up to three feeding groups or aggregations. There is dispersal between the PCFG and North Feeding Group (NFG), but the Western Feeding Group (WFG) is demographically independent of the other two feeding groups (i.e. there is no permanent movement of animals from the NFG or PCFG to the WFG).

	Feeding groups or aggregations	Abbreviation	Definition (may vary with hypothesis)
1	Western Feeding Group	WFG	Animals that feed regularly (define?) off Sakhalin Island* according to photo-identification data
2	Pacific Coast Feeding Group	PCFG	Animals that feed regularly (define?) in the PCFG area according to photo-identification data
3	North Feeding Group	NFG	Animals found in other feeding areas (and for which there is relatively little information including photo-ID)

* May need revising with regard to Southern Kamchatka animals given Justin's paper.

Sub-areas. The model includes 11 geographical sub-areas that are used to explain the movements of gray whales (breeding stocks and feeding groups) in the North Pacific and two 'latent sub-areas' used to link model predictions to observed indices of abundance.

	Sub-area	Abbreviation
1	Vietnam-South China Sea	VSC
2	Korea and western side of the Sea of Japan	KWJ
3	Eastern side of the Sea of Japan and the Pacific coast of Japan	EJPJ
4	Northeastern Sakhalin Island	SI
5	Southern Kamchatka and Northern Kuril Islands*	SKNK
6	Areas of the Okhotsk Sea not otherwise specified	OS
7	Northern Bering and Chukchi Sea	BSCS
8	Southeast Alaska	SEA
9	British Columbia to Northern California	BCNC
10	California	CA
11	Mexico	M
12	Latent sub-area	Calif-3
13	Latent sub-area	BC-BCA-3

* New at this workshop – replaces the old East Kamchatka and Kuril Islands to recognise the information from telemetry and photo-ID.

Annex E

Specifications of the rangewide model

A. **Basic concepts and stock structure**

The aim of the projections is to explore the population consequences of various scenarios regarding anthropogenic removals of gray whales, with a view to informing future conservation and management. The model distinguishes 'breeding stocks' and 'feeding aggregations'. Breeding stocks are demographically and genetically independent whereas feeding aggregations may be linked through dispersal of individuals[6], though perhaps at very low rates for some combinations of feeding aggregations. Each breeding stock / feeding aggregation is found in a set of sub-areas, each of which may have catches (commercial, aboriginal or incidental), proportions of breeding stock / feeding aggregation mixing[7] in those sub-areas, observed bycatch rates[8], estimates of survival rates, and indices of relative or absolute abundance. Removals may be specified to sets of months during the year for some sub-areas if the various feeding aggregations are not equally vulnerable to catches throughout the year for those sub-areas. The trials capture uncertainty regarding stock structure and MSYR, as well as uncertainty regarding bycatch and immigration.

The region concerned, the North Pacific, is divided into 11 sub-areas (Fig. 1). The model also includes several 'latent' sub-areas used to link model predictions to observed indices of abundance. These are denoted, WFG, WBS, WST, CA-3 and BCNC-3. There are up to two extant *breeding stocks* (Western and Eastern). The Eastern breeding stock consists of up to three *feeding aggregations* depending on the stock structure hypothesis: Western Feeding Group (WFG), Pacific Coast Feeding Group (PCFG) and North Feeding Group (NFG). There is dispersal between the PCFG and the NFG, but the WFG is demographically independent of the other two feeding aggregations (i.e. there is no *permanent* movement of animals from the NFG or PCFG to the WFG or vice-versa).

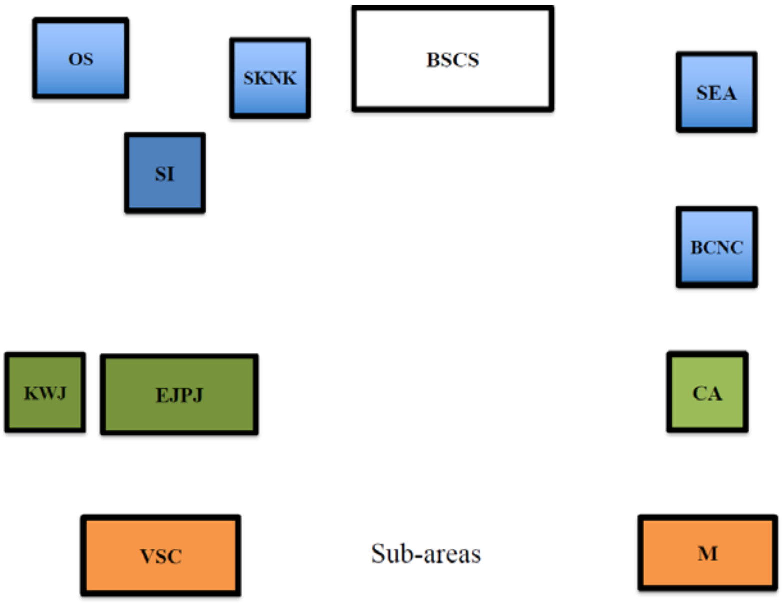

Fig. 1. The sub-areas in the model.

The trials consider five stock structure hypotheses

(1) *Hypothesis 3a.* Although two breeding stocks (Western and Eastern) may once have existed, the Western breeding stock is assumed to have been extirpated. Whales show matrilineal fidelity to feeding grounds, and the Eastern breeding stock includes three feeding aggregations: PCFG, NFG, and WFG.

[6] The term 'dispersal' is used here in the sense of 'effective dispersal', and refers to permanent movement of individuals among feeding aggregations. Such individuals become part of the feeding aggregation to which they move and contribute to future reproduction.

[7] Mixing is defined here as two feeding aggregations that overlap at some time on the feeding grounds, but do not exchange individuals.

[8] Bycatch is understood to include mortality or 'serious' injury from entanglement or entrapment in fishing gear (or debris) and ship strikes.

(2) *Hypothesis 3b*. Identical to hypothesis 3a, except that NFG whales do not feed off SKNK. In addition, a Western breeding stock exists that overwinters in VSC and feeds in the OS (but not SI) and SKNK. Thus, SKNK is used by both the WFG whales and the whales of the Western breeding stock.
(3) *Hypothesis 3c*. Identical to 3a, except that on occasion whales migrating between the Sakhalin feeding region and Mexico travel through the BSCS sub-area
(4) *Hypothesis 3e*. Identical to hypothesis 3a, except that the Western breeding stock is extant and feeds off both coasts of Japan and Korea and in the northern Okhotsk Sea west of the Kamchatka Peninsula. All of the whales feeding off Sakhalin overwinter in the eastern North Pacific
(5) *Hypothesis 5a*. Identical to hypothesis 3e except that the whales feeding off Sakhalin include both whales that are part of the extant Western breeding stock and remain in the western North Pacific year-round, and whales that are part of the Eastern breeding stock and migrate between Sakhalin and the eastern North Pacific
(6) *Hypothesis 6b*. This hypothesis assumes that the WFG does not exist, but that whales feeding in the SI sub-area represent an extant Western breeding stock that utilizes two wintering grounds (VSC and M). This hypothesis differs from hypothesis 5a, in that 1) all removals off China and Japan are assumed to be Western breeding stock animals, and 2) the abundance estimates for Sakhalin are assumed to relate only to the Western breeding stock.

B. **Basic dynamics**

The population dynamics are based on the standard age- and sex-structured model, which has formed the basis for the evaluation of *Strike Limit Algorithms* for eastern North Pacific gray whales, i.e.:

$$\begin{aligned}
N_{t+1,0}^{m/f,i,j} &= 0.5B_{t+1}^{i,j} && a=0\\
N_{t+1,a}^{m/f,i,j} &= (N_{t,a-1}^{m/f,i,j} + I_{t,a-1}^{m/f,i,j} - C_{t,a-1}^{m/f,i,j})\, S_{a-1}\, \tilde{S}_t^{i,j} && 1 \le a \le x-1 \quad \text{(B.1)}\\
N_{t+1,x}^{m/f,i,j} &= ((N_{t,x}^{m/f,i,j} + I_{t,x}^{m/f,i,j} - C_{t,x}^{m/f,i,j})S_x + (N_{t,x-1}^{m/f,i,j} + I_{t,x-1}^{m/f,i,j} - C_{t,x-1}^{m/f,i,j})\, S_{x-1})\, \tilde{S}_t^{i,j} && a=x
\end{aligned}$$

where $N_{t,a}^{m/f,i,f}$ is the number of males / females of age *a* in feeding aggregation *j* of breeding stock *i* at the start of year *t*; $C_{t,a}^{m/f,i,f}$ is the number of anthropogenic removals of males / females of age *a* in feeding aggregation *j* of breeding stock *i* during year *t* (whaling/incidental catches are assumed to take place in a pulse at the start of each year); S_a is the annual survival rate of animals of age *a* in the absence of catastrophic mortality events (assumed to be the same for males and females):

$$S_a = \begin{cases} S_0 & \text{if } a = 0 \\ S_{1+} & \text{if } 1 < a \end{cases} \qquad \text{(B.2)}$$

S_0 is the calf survival rate; S_{1+} is the survival rate for animals aged 1 and older; $\tilde{S}_t^{i,j}$ is the amount of catastrophic mortality (represented in the form of a survival rate) for feeding aggregation *j* of breeding stock *i* during year *t* (catastrophic events are assumed to occur at the end of the year after mortality due to anthropogenic removals, whaling and non-catastrophic natural causes and dispersal; in general $\tilde{S}_t^{i,j}$ =1, i.e. there is no catastrophic mortality); $B_{t+1}^{i,j}$ is the number of births to feeding aggregation *j* of breeding stock *i* during year *t*; $I_{t,a}^{s,m/f}$ is the net dispersal of female/male animals of age *a* into feeding aggregation *j* of breeding stock *i* during year *t*; and *x* is the maximum (lumped) age-class (all animals in this and the *x*-1 class are assumed to be recruited and to have reached the age of first parturition). *x* is taken to be 15.

C. **Births and density-dependence**

Density-dependence is assumed to be a function of numbers of animals aged 1 and older by feeding ground relative to the carrying capacity by feeding ground. The density-dependence component for feeding aggregation *j* of breeding stock *i* is the sum of the density-dependence components by feeding aggregation weighted by the proportion of animals from feeding aggregation *j* of breeding stock *i* that are found on each feeding ground, i.e.:

$$F(i,j,t) = \sum_A \psi^{A,i,j} \left(X^{A,i,j} (N_t^{1+,A} / K^{1+,A})^z \right) / \sum_A \psi^{A,i,j} X^{A,i,j} \qquad \text{(C.1)}$$

where z is the degree of compensation; $\psi^{A,i,j}$ indicates whether sub-area A impacts density-dependence for feeding aggregation j of breeding stock i, N_t^{1+A} is the number of 1+ animals on feeding ground A at the start of year t:

$$N_t^{1+,A} = \sum_i \sum_j X^{A,i,j} \sum_{a=1}^{x} (N_{t,a}^{m,i,j} + N_{t,a}^{f,i,j}) \tag{C.2}$$

K^{1+A} is the carrying capacity for feeding ground A:

$$K^{1+,A} = \sum_i \sum_j X^{A,i,j} \sum_{a=1}^{x} (N_{-\infty,a}^{m,i,j} + N_{-\infty,a}^{f,i,j}) \tag{C.3}$$

$X^{A,i,j}$ is the proportion of animals of feeding aggregation j of breeding stock i that are found in feeding ground A[9] (Tables 1 and 2).

The number of births at the start of year t for feeding aggregation j of breeding stock i, $B_t^{i,j}$, is given by:

$$B_t^{i,j} = b_t^{i,j} \, N_t^{f,i,j} \tag{C.4}$$

where $N_t^{f,i,j}$ is the number of mature females in feeding aggregation j of breeding stock i at the start of year t:

$$N_t^{f,i,j} = \sum_{a=a_m}^{x} N_{t,a}^{f} \tag{C.5}$$

a_m is the age-at-maturity (the convention of referring to the mature population is used here, although this actually refers to females that have reached the age of first parturition); $b_t^{i,j}$ is the probability of birth/calf survival for mature females:

$$b_t^{i,j} = \max(0, b_K\{1 + A^{i,j}(1 - F(I,j,t))\}) \tag{C.6}$$

b_K is the average number of live births per year per mature female at carrying capacity; and $A^{i,j}$ is the resilience parameter for feeding aggregation j of breeding stock i.

D. **Immigration (dispersal)**

The numbers dispersing into feeding aggregation j of breeding stock i, include contributions from pulse migration as well as diffusive dispersal:

$$I_{t,a}^{s,j,i} = I_{t,a}^{1,s,j,a} - I_{t,a}^{2,s,j,a} \tag{D.1a}$$

$$I_{t,a}^{1,s,j,i} = \sum_{k \neq j} \delta^{k,j,i} N_{t,a}^{s,i,k} \left(\frac{N_t^{f,i,k}}{N_{-\infty}^{f,i,k}}\right)^{\tilde{\lambda}} + \sum_{k \neq j} \Omega_y^{k,j,i} \frac{N_{t,a}^{s,i,k}}{\sum_{a=1}^{x} (N_{t,a}^{m,i,k} + N_{t,a}^{f,i,k})} \tag{D.1b}$$

$$I_{t,a}^{2,s,j,i} = \sum_{k \neq j} \delta^{j,k,i} N_{t,a}^{s,i,j} \left(\frac{N_t^{f,i,j}}{N_{-\infty}^{f,i,j}}\right)^{\tilde{\lambda}} + \sum_{k \neq j} \Omega_y^{j,k,i} \frac{N_{t,a}^{s,i,j}}{\sum_{a=1}^{x} (N_{t,a}^{m,i,j} + N_{t,a}^{f,i,j})} \tag{D.1c}$$

[9] It is usually the case that $\sum X^{A,i,j} = 1$. However, for gray whales, this is not necessarily the case because removals can take place in the various sub-areas at different times. What is then important is the relative values of the $X^{A,i,j}$ among feeding aggregations for a given feeding ground.

where $\delta^{k,j,i}$ is the rate of dispersal from feeding aggregation *k* to feeding aggregation *j* of breeding stock *i*; λ is a factor to allow for density-dependence in the dispersal rate (set to 2); and $\Omega_y^{k,j,i}$ is the number of animals that disperse in year *y* from feeding aggregation *k* to feeding aggregation *j* of breeding stock *i* in a pulse.

E. **Anthropogenic removals**

The catch by feeding aggregation, sex and age is the sum of the catch over fleet (see Table 3 for fleet definitions), i.e.:

$$C_{t,a}^{m/f,i,j} = \sum_k C_t^{m/f,k} \frac{\alpha_a^k X^{A_k,i,j} N_{t,a}^{m/f,i,j}}{\sum_{i,j,a} \alpha_a^k X^{A_k,i,j} N_{t,a}^{m/f,i,j}} \tag{E.1}$$

where $C_t^{m/f,k}$ is the catch of males/females by fleet *k* during year *t*; A_k is the sub-area in which fleet *k* operates; and α_a^k is the relative vulnerability of animals of age *a* to harvest by fleet *k*. The values for the catches by fleet and sex are either pre-specified (Table 4[10]) or computed using Equation E.2. for the years for which actual estimates are not available:

$$C_{t,a}^{m/f,k} = \lambda^k E_t^k \sum_{i,j,a,m/f} \alpha_a^k X^{A,i,j} N_{t,a}^{m/f,i,j} \tag{E.2}$$

where E_t^k is a measure of the effort by fleet *k* during year *t* (Table 5) and λ^k is the catchability coefficient for fleet *k*.

F. Initializing the parameter vector

The numbers at age in the pristine population are given by:

$$\begin{aligned} N_{-\infty,a}^{m/f,i,j} &= 0.5\, N_{-\infty,0}^{i,j} \prod_{a'=0}^{a-1} S_{a'} && \text{if } a < x \\ N_{-\infty,x}^{m/f,i,j} &= 0.5\, N_{-\infty,0}^{i,j} \prod_{a'=0}^{x-1} S_{a'} / (1-S_x) && \text{if } a = x \end{aligned} \tag{F.1}$$

The value for $N_{-\infty,0}^{i,j}$ is determined from the value for the pre-exploitation size of the 1+ component of feeding aggregation *j* of breeding stock *i* using the equation:

$$N_{-\infty,0}^{m,i,j} = K^{1+,i,j} / \left(\sum_{a=1}^{x-1} \left(\prod_{a'=0}^{a-1} S_{a'} \right) + \frac{1}{1-S_x} \prod_{a'=0}^{x-1} S_{a'} \right) \tag{F.2}$$

where $K^{1+,i,j}$ is the carrying capacity (in terms of the 1+ population size size) for feeding aggregation *j* of breeding stock *i*:

$$K_t^{1+,i,j} = \sum_{a=1}^{x} (N_{-\infty,a}^{m,i,j} + N_{-\infty,a}^{f,i,j}) \tag{F.3}$$

$N_{-\infty,a}^{m/f,i,j}$ is the number of animals of age *a* that would be in feeding aggregation *j* of breeding stock *i* in the pristine population.

The model is based on the assumption that the age-structure at the start of year τ is stable rather than that the population was at its pre-exploitation equilibrium size at some much earlier year. The determination of the age-structure at the start of year τ involves specifying the effective 'rate of increase', γ, that applies to each age-class. There are two components contributing to γ, one relating to the overall population rate of increase (γ^+) and the other to the exploitation rate due to all forms of anthropogenic removal. Under the assumption of knife-edge recruitment to the fishery at age a_r, only the γ^+ component (assumed to be zero following Punt and Butterworth

[10] The bycatches for 2016 are set equal to those for 2015 as data on bycatch for 2016 are not finalized at present.

[2002]) applies to ages a of a_r or less. The number of animals of age a at the start of year τ relative to the number of calves at that time, $N^*_{\tau,a}$, is therefore given by the equation:

$$N^*_{\tau,a} = \begin{cases} 1 & \text{if } a = 0 \\ N^*_{\tau,a-1}\, S_{a-1} & \text{if } a \le a_r \\ N^*_{\tau,a-1}\, S_{a-1}\,(1-\gamma) & \text{if } a_r < a < x \\ N^*_{\tau,x-1}\, S_{x-1}(1-\gamma)/(1-S_x\,(1-\gamma)) & \text{if } a = x \end{cases} \quad \text{(F.4)}$$

where B_τ is the number of calves in year τ and is derived directly from equations C.1 and C.6.

$$B_\tau = \left(1 - \left[1/(N^f_\tau b_K) - 1\right]/A\right)^{1/z} \frac{K^{1+}}{N^{1+,*}_\tau} \quad \text{(F.5)}$$

The effective rate of increase, γ, is selected so that if the population dynamics model is projected from year τ to a year Ψ, the size of the 1+ component of the population in a reference year Ψ equals a value, P_Ψ.

G. **Conditioning**

The parameters of the model are: (a) the carrying capacity of each stock, (b) the population size for each stock at the start of 1930 (expressed relative to carrying capacity), (c) MSYR by stock, (d) annual survival under 'normal' conditions, (e) maturity as a function of age, (f) the impact of the mortality event in the eastern Pacific in 1999 and 2000, (g) selectivity, (h) the rate of dispersal between the NFG and the PCFG, (i) the parameters of the mixing matrices, (j) the catchability coefficients that determine bycatch by fleet (Eqn E.2), and (k) the extent of additional variation for each abundance index. Some of these parameters are pre-specified:

(1) MSYR (except for trials 14, 15, and 17);
(2) Annual survival under 'normal' conditions (base-case 0.98);
(3) Maturity as a function of age (a logistic function of age, with an age-at-50%-first-parturition of 8 years and a minimum age-age-at-first parturition of 3 years); and
(4) Selectivity (Table 3).

Under the assumption that the estimates of abundance for a sub-area (Table 6) are log-normally distributed, the negative of the logarithm of the likelihood function is given by:

$$-\ell n L = \ell n\sqrt{\mathrm{Det}[V]} + 0.5\sum_k (\ell\,\mathrm{n}\,\underline{N}^{A,obs} - \ell\,\mathrm{n}\,\underline{N}^{A})[V^{-1}](\ell\,\mathrm{n}\,\underline{N}^{A,obs} - \ell\,\mathrm{n}\,\underline{N}^{A})^T \quad \text{(G.1)}$$

where $N_t^{A,\mathrm{obs}}$ is the survey estimate of abundance for sub-area A during year t; and V is the sum of the variance-covariance matrix for the abundance estimates plus an additional variance term (assumed to be independent of year). Note that the abundance estimates for the western areas (Table 6a) depend on the stock hypothesis under consideration.

The data on the proportion of each stock (Tables 6a and 7) in each sub-area are modelled under the assumption that the proportions are normally distributed, i.e.:

$$-\ell n L = \sum_i \sum_A \sum_t \tfrac{1}{2(\tau_t^{i,A})^2}(p_t^{i,A} - p_t^{i,A,\mathrm{obs}})^2 \quad \text{(G.2)}$$

where $p_t^{i,A}$ is the model-estimate of the proportion of the animals in sub-area A that are from feeding aggregation i of the Eastern breeding stock; $p_t^{i,A,\mathrm{obs}}$ is the observed proportion of animals in in sub-area A that are from feeding aggregation i of the Eastern breeding stock; and $\tau_t^{i,A}$ is the standard error of $p_t^{i,A,\mathrm{obs}}$.

The (non-zero) bycatches by sub-area for the first five years for which data are available are assumed to be log-normally distributed, and the model is fitted to the average bycatch by sub-area over a pre-specified set of years (the years for which detection and reporting of entanglements, ship strikes, and strandings in general was relatively good; Table 3), i.e.:

$$-\ell\text{n}L = \sum_A \frac{1}{2\sigma_{BC}^2}\left(\ell\text{n}C^{I,A,\text{obs}} - \ell\text{n}\hat{\hat{C}}^{I,A}\right)^2 \quad \text{(G.3)}$$

where $C^{I,A,\text{obs}}$ is the observed average annual bycatch from sub-area *A* over the pre-specified period, $\hat{\hat{C}}^{I,A}$ is the average over this period of the model-estimate of the bycatch from sub-area *A*, and σ_{BC} is the standard error of the logarithms of the observed bycatches.

A penalty is imposed on the average number of animals moving permanently from the NFG into the PCFG between 2001 and 2008, i.e.:

$$-\ell nL = \frac{1}{2\sigma_I^2}\left(\tilde{I} - \frac{\delta^{\text{m/f,north},West}}{8}\sum_{t=2001}^{2008}\sum_{s=m/f}\sum_{a=1}^{x} I_{t,a}^{s,\text{East,north}}\right)^2 \quad \text{(G.4)}$$

where $\tilde{I}$ is the pre-specified average number of immigrants into the PCFG from the NFG, and σ_I is a weighting factor.

The estimates of survival for PCFG whales (Calambokidis *et al.*, 2017) are assumed to be normally distributed, i.e.:

$$-\ell\text{n}L = \frac{1}{2\sigma_{S,1}^2}(S^{\text{obs},1} - \hat{S}^1)^2 + \frac{1}{2\sigma_{S,2}^2}(S^{\text{obs},2} - \hat{S}^2)^2 \quad \text{(G.5)}$$

where $S^{\text{obs},1} = 0.917$, $\sigma_{L,1} = 0.0142$, $S^{\text{obs},2} = 0.967$, $\sigma_{L,2} = 0.0066$, $\hat{S}_1$ is the estimate of post-first-year survival for whales that entered in 1998 or earlier, and $\hat{S}_2$ is the estimate of post-first-year survival for whales that entered in 1999 or later.

H. **Quantifying uncertainty using bootstrap**

A bootstrap procedure is used to quantify uncertainty for a given model specification. Each bootstrap replicate involves:

(1) Generating pseudo time-series of abundance estimates based on the assumption that the abundance estimates are log-normally distributed with means and variance-covariance matrices given by the observed abundance estimates and the reported variance-covariance matrices.

(2) Generating pseudo mixing proportions from beta distributions with means and CVs given by the observed means and CVs.

(3) Generating pseudo bycatch rates by sub-area from log-normal distributions with means of $C^{I,A,\text{obs}}$ and a log standard error of σ_{BC}.

(4) Generating a pseudo immigration rate from the NFG into the PCFG based on a normal distribution (truncated at zero) with mean $\tilde{I}$ and standard error σ_I.

(5) Generating pseudo survival rates from normal distributions.

I. Generation of Data

The actual historical estimates of absolute abundance (and their associated CVs) provided to the *Strike Limit Algorithms* are listed in Table 6. The future estimates of abundance for sub-areas WFG, WST, BCNC-3 and CA-3 (say sub-area *K*) are generated using the formula:

$$\hat{P} = PYw / P^*\beta^2 Yw \quad \text{(I.1)}$$

where *Y* is a lognormal random variable *Y*=e$^{\varepsilon}$ where $\varepsilon \sim N(0;\sigma_\varepsilon^2)$ and $\sigma_\varepsilon^2 = \ell n(1+\alpha^2)$; *w* is a Poisson random variable with $E(w) = \text{var}(w) = \mu = (P/P^*)/\beta^2$, *Y* and *w* are independent; *P* is the current total (1+) population size in survey area *K*:

$$P = P_t^K = \sum_i\sum_j\sum_g\sum_{a\ge1} N_{t,a}^{g,i,j} \quad \text{(I.2)}$$

P^* is the reference population level, and is equal to the total (1+) population size in the survey area prior to the commencement of exploitation in the sub-area for which an abundance estimate is to be generated. For consistency with the first-stage screening trials for a single stock (IWC, 1991, 1994), the ratio $\alpha^2 : \beta^2 = 0.12 : 0.025$, so that $CV^2(\hat{P}) = \tau(0.12 + 0.025P^* / P)$. If $\overline{CV}$ is the target CV then $\tau = \overline{CV}^2 / (0.12 + 0.025P_{\rm ref} / P^*)$ where $P_{\rm ref}$ is the population size in a reference year.

An estimate of the *CV* is generated for each estimate of abundance:

$$CV(\hat{P})^2_{\rm est} = \sigma^2 \chi^2 / n \qquad \text{(I.3)}$$

where $\sigma^2 = \ell n(1 + \alpha^2 + \beta^2 P^* / \hat{P})$, and χ is a random number from a Chi-square distribution with *n* degrees of freedom (where *n*=10 as used for NP minke trials; IWC, 2004).

J. Trials

The factors included in the trials are listed in Table 8 and the trials in Table 9.

K. Management options

The strike limits for the BSCS sub-area are based on the Gray Whale *SLA* (IWC, 2005). The strike limits for the BCNC sub-area based on the Makah Management Plan (Appendix 1) although sensitivity is explored using variant 1 agreed to in 2012 (IWC, 2013; Appendix 2).

Removals due to bycatch are based on the scenarios regarding future trends in effort. Table 8 lists the factors considered in the projections.

L. Output Statistics

The population-size statistics are produced for each breeding stock / feeding aggregation, while the removal-related statistics are for each sub-area.

I.1 Risk

D1. Final depletion: P_T/K (1+ and mature female numbers by breeding stock / feeding group (median, lower 5th and upper 5th percentiles)).

D2. Lowest depletion: $\min(P_t / K) : t = 0,1,...,T$.

D3. Plots of $\{P_{t[x]} : t = 0,1,..,T\}$ where $P_{t[x]}$ is the *x*th percentile of the distribution of P_i. Results are presented for *x* = 5, 50, and 95.

D8. Rescaled final depletion: P_T/P_0 (1+ and mature female numbers by breeding stock / feeding group; median, lower 5th and upper 5th percentiles) where P_0 is number of 1+ / mature female animals had there been no future Makah hunts.

D10. Relative increase. The ratio of the 1+ and mature population size after 10 and 100 years to that at the start of the projection period by breeding stock / feeding group (median, lower 5th and upper 5th percentiles)

I.2 Removal-related

N9. Need satisfaction. The proportion of the total number of requested strikes that were taken over the first 10 years and the entire 100-year period (median, lower 5th and upper 5th percentiles).

R1. Plots of strikes by year for simulations 1-100.

R2. Plots of landed whales by year for simulations 1-100.

R3. Plots of incidental catches by year for simulations 1-100 (median, lower 5th and upper 5th percentiles by year).

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Table 1
The presence matrices for stock structure hypotheses 3a, 3b, 3c, 3e, 5a and 6b.

[a] Hypothesis 3a (no extant Western breeding stock)

Breeding stock/ Feeding Aggregation	Sub-area													
	VSC	KWJ	EJPJ	OS	SI	SKNK	BSCS	SEA (J-N)	SEA (D-M)	BCNC (J-N)	BCNC (D-M)	CA (J-N)	CA (D-M)	M
Eastern														
WFG			1	1	1	1			1		1		1	1
North			1			1	1	1	1	1	1	1	1	1
PCFG							1[A]	1	1	1	1	1	1	1

A: Sensitivity test (12) only

[b] Hypothesis 3b (extant Western breeding stock)

Breeding stock/ Feeding Aggregation	Sub-area													
	VSC	KWJ	EJPJ	OS	SI	SKNK	BSCS	SEA (J-N)	SEA (D-M)	BCNC (J-N)	BCNC (D-M)	CA (J-N)	CA (D-M)	M
Western	1	1	1	1		1								
Eastern														
WFG				1	1	1			1		1		1	1
North			1				1	1	1	1	1	1	1	1
PCFG								1	1	1	1	1	1	1

[c] Hypothesis 3c (no extant Western breeding stock; WFG in BSCS)

Breeding stock/ Feeding Aggregation	Sub-area													
	VSC	KWJ	EJPJ	OS	SI	SKNK	BSCS	SEA (J-N)	SEA (D-M)	BCNC (J-N)	BCNC (D-M)	CA (J-N)	CA (D-M)	M
Eastern														
WFG			1	1	1	1	1		1		1		1	1
North			1			1	1	1	1	1	1	1	1	1
PCFG								1	1	1	1	1	1	1

[d] Hypothesis 3e (extant Western breeding stock; WFG in EJPJ)

Breeding stock/ Feeding Aggregation	Sub-area													
	VSC	KWJ	EJPJ	OS	SI	SKNK	BSCS	SEA (J-N)	SEA (D-M)	BCNC (J-N)	BCNC (D-M)	CA (J-N)	CA (D-M)	M
Western	1	1	1	1		1								
Eastern														
WFG			1	1	1	1			1		1		1	1
North						1	1	1	1	1	1	1	1	1
PCFG								1	1	1	1	1	1	1

[e] Hypothesis 5a (Western breeding stock in SI)

Breeding stock/ Feeding Aggregation	Sub-area													
	VSC	KWJ	EJPJ	OS	SI	SKNK	BSCS	SEA (J-N)	SEA (D-M)	BCNC (J-N)	BCNC (D-M)	CA (J-N)	CA (D-M)	M
Western	1	1	1	1	1	1								
Eastern														
WFG			1	1	1	1			1		1		1	1
North						1	1	1	1	1	1	1	1	1
PCFG							1[A]	1	1	1	1	1	1	1

A: Sensitivity test (12) only

[f] Hypothesis 6b (no Western feeding group)

Breeding stock/ Feeding Aggregation	Sub-area													
	VSC	KWJ	EJPJ	OS	SI	SKNK	BSCS	SEA (J-N)	SEA (D-M)	BCNC (J-N)	BCNC (D-M)	CA (J-N)	CA (D-M)	M
Western	1	1	1	1	1	1			1		1		1	1
Eastern														
North						1	1	1	1	1	1	1	1	1
PCFG								1	1	1	1	1	1	1

Table 2

The mixing matrices for stock structure hypotheses 3a, 3b, 3e, 5a and 6b. The γs denote the estimable parameters of the catch mixing matrix and the χs denote values that are varied in the tests of sensitivity.

[a] Hypothesis 3a (no extant Western breeding stock)

Breeding stock/ Feeding Aggregation	Sub-area													
	VSC	KWJ	EJPJ	OS	SI	SKNK	BSCS	SEA (J-N)	SEA (D-M)	BCNC (J-N)	BCNC (D-M)	CA (J-N)	CA (D-M)	M
Eastern														
WFG			1	1	1	1			γ_6		γ_3		γ_6	1
North			γ_1			1	1	1	1	1	1	1	1	1
PCFG							1^{A}	γ_8^{B}	γ_7	γ_2	γ_4	γ_5	γ_7	1

A: Sensitivity test (12) only
B: Sensitivity test (9) only

[b] Hypothesis 3b (extant Western breeding stock)

Breeding stock/ Feeding Aggregation	Sub-area													
	VSC	KWJ	EJPJ	OS	SI	SKNK	BSCS	SEA (J-N)	SEA (D-M)	BCNC (J-N)	BCNC (D-M)	CA (J-N)	CA (D-M)	M
Western	1	1	γ_1	1										
Eastern														
WFG				1	1	1			γ_6		γ_3		γ_6	1
North			1			1	1	1	1	1	1	1	1	1
PCFG								1	γ_7	γ_2	γ_4	γ_5	γ_7	1

[c] Hypothesis 3c (extant Western breeding stock; WFG in BSCS)

Breeding stock/ Feeding Aggregation	Sub-area													
	VSC	KWJ	EJPJ	OS	SI	SKNK	BSCS	SEA (J-N)	SEA (D-M)	BCNC (J-N)	BCNC (D-M)	CA (J-N)	CA (D-M)	M
Western	1	1												
Eastern														
			1	1	1	1	1		γ_6		γ_3		γ_6	1
North			γ_1			1	1	1	1	1	1	1	1	1
PCFG								1	γ_7	γ_2	γ_4	γ_5	γ_7	1

[d] Hypothesis 3e (extant Western breeding stock; WFG in EJPJ)

Breeding stock/ Feeding Aggregation	Sub-area													
	VSC	KWJ	EJPJ	OS	SI	SKNK	BSCS	SEA (J-N)	SEA (D-M)	BCNC (J-N)	BCNC (D-M)	CA (J-N)	CA (D-M)	M
Western	1	1	γ_1	1		1								
Eastern														
WFG			1	1	1	1			γ_6		γ_3		γ_6	1
North						1	1	1	1	1	1	1	1	1
PCFG								1	γ_7	γ_2	γ_4	γ_5	γ_7	1

[e] Hypothesis 5a (Western breeding stock in SI)

Breeding stock/ Feeding Aggregation	Sub-area													
	VSC	KWJ	EJPJ	OS	SI	SKNK	BSCS	SEA (J-N)	SEA (D-M)	BCNC (J-N)	BCNC (D-M)	CA (J-N)	CA (D-M)	M
Western	1	1	γ_1	1	1	1								
Eastern														
WFG			1	1	1	1			γ_6		γ_3		γ_6	1
North						1	1	1	1	1	1	1	1	1
PCFG							1^{A}	γ_8^{B}	γ_7	γ_2	γ_4	γ_5	γ_7	1

A: Sensitivity test (12) only
B: Sensitivity test (9) only

[f] Hypothesis 6b (no Western feeding group)

Breeding stock/ Feeding Aggregation	Sub-area													
	VSC	KWJ	EJPJ	OS	SI	SKNK	BSCS	SEA (J-N)	SEA (D-M)	BCNC (J-N)	BCNC (D-M)	CA (J-N)	CA (D-M)	M
Western	1	1	1	1	1	1			γ_6		γ_3		γ_6	1
Eastern														
North						1	1	1	1	1	1	1	1	1
PCFG								1	γ_7	γ_2	γ_4	γ_5	γ_7	1

Table 3

Fleets included in the population dynamics model, the associated selectivity patterns, and the years for which detection and reporting of entanglements, ship strikes, and strandings in general was relatively good. The columns "Years (hindcast)" and "Years (forecast)" denote the ranges of years used to infer bycatch rates respectively before and after the first year for which detection and reporting of entanglements, ship strikes, and strandings in general was relatively good

Fleet	Season	Type	Years	Years (hindcast)	Years (forecast)	Selectivity
Northern Bering and Chukchi Sea (BSCSA)	All	Subsistence	N/A			Uniform 1+
WA U&A (feeding) (WAUAF)	June-Nov	Subsistence	N/A			Uniform 1+
WA U&A (migration) (WAUAM)	Dec-May	Subsistence	N/A			Uniform 1+
CA-scientific (migration)	Dec-May	Scientific	N/A			Uniform 1+
Vietnam-South China Sea (VSC)	All	All removals	No removals			
Korea and western side of the Sea of Japan (KWJ)	All	All removals	No removals			
Eastern side of the Sea of Japan and the Pacific coast of Japan (EJPJ)	All	All removals	1982 – 2015	1982 – 2015	1982 – 2015	Uniform 0-5
Northeastern Sakhalin Island (SI)	All	All removals	1982 – 2015	1982 – 2015	1982 – 2015	Uniform 0-5
Southern Kamchatka and Northern Kuril Islands (SKNK)	All	All removals	No removals			
Areas of the Okhotsk Sea not otherwise specified (OS)	All	All removals	No removals			
Northern Bering and Chukchi Sea (BSCSE)	All	Entanglements	1987 – 2015	1987 – 1991	2011 – 2015	Uniform 0-5
Southeast Alaska (SEA1E)	June-Nov	Entanglements	M/SI only	1987 – 1991	2011 – 2015	Uniform 0-5
Southeast Alaska (SEA2E)	Dec-May	Entanglements	1987 – 2015	1987 – 1991	2011 – 2015	Uniform 0-5
British Columbia to Northern California (BCNC1E)	June-Nov	Entanglements	1990 – 2015	1990 – 1994	2011 – 2015	Uniform 0-5
British Columbia to Northern California (BCNC2E)	Dec-May	Entanglements	1990 – 2015	1990 – 1994	2011 – 2015	Uniform 0-5
California (CA1E)	June-Nov	Entanglements	1982 – 2015	1982 – 1986	2011 – 2015	Uniform 0-5
California (CA2E)	Dec-May	Entanglements	1982 – 2015	1982 – 1986	2011 – 2015	Uniform 0-5
Mexico (MEXE)	All	Entanglements	MS/I only	1982 – 1986	2011 – 2015	Uniform 0-5
Northern Bering and Chukchi Sea (BSCSS)	All	Ship strikes	No ship strikes			
Southeast Alaska (SEA1S)	June-Nov	Ship strikes	No ship strikes			
Southeast Alaska (SEA2S)	Dec-May	Ship strikes	1987 – 2015	1987 - 2015	1987 - 2015	Uniform 0+
British Columbia to Northern California (BCNC1S)	June-Nov	Ship strikes	1990 – 2015	1990 – 2015	1990 – 2015	Uniform 0+
British Columbia to Northern California (BCNC1S)	Dec-May	Ship strikes	1990 – 2015	1990 – 2015	1990 – 2015	Uniform 0+
California (CA1S)	June-Nov	Ship strikes	1982 – 2015	1982 – 2015	1982 – 2015	Uniform 0+
California (CA2S)	Dec-May	Ship strikes	1982 – 2015	1982 – 2015	1982 – 2015	Uniform 0+
Mexico (MEXS)	All	Ship strikes	MS/I only	1982 – 2015	1982 – 2015	Uniform 0+
California (SET1)	June-Nov	Set Gillnet	1982 – 1990	1982 – 1990	None	Uniform 0-5
California (SET2)	Dec-May	Set Gillnet	1982 – 1990	1982 – 1990	None	Uniform 0-5
California (SET3)	June-Nov	Set Gillnet	1991 – 2015	None	1991 – 2015	Uniform 0-5
California (SET4)	Dec-May	Set Gillnet	1991 – 2015	None	1991 – 2015	Uniform 0-5

Table 4a
Non-bycatch removals. The BSCS 'fleet' represents the aboriginal catches, the two WAUA 'fleets' represent Makah hunting in the Makah usual and accustomed area, and the CA migration 'fleet' is the scientific catches off California.

Year	Fleet				Year	Fleet			
	BSCS	WAUA Feeding	WAUA Migration	CA Migration		BSCS	WAUA Feeding	WAUA Migration	CA Migration
1930	47	0	0	0	1974	184	0	0	0
1931	10	0	0	0	1975	171	0	0	0
1932	10	0	0	10	1976	165	0	0	0
1933	15	0	0	60	1977	187	0	0	0
1934	66	0	0	60	1978	184	0	0	0
1935	44	0	0	110	1979	183	0	0	0
1936	112	0	0	86	1980	182	0	0	0
1937	24	0	0	0	1981	136	0	0	0
1938	64	0	0	0	1982	168	0	0	0
1939	39	0	0	0	1983	171	0	0	0
1940	125	0	0	0	1984	169	0	0	0
1941	77	0	0	0	1985	170	0	0	0
1942	121	0	0	0	1986	171	0	0	0
1943	119	0	0	0	1987	159	0	0	0
1944	6	0	0	0	1988	151	0	0	0
1945	58	0	0	0	1989	180	0	0	0
1946	30	0	0	0	1990	162	0	0	0
1947	31	0	0	0	1991	169	0	0	0
1948	19	0	0	0	1992	0	0	0	0
1949	26	0	0	0	1993	0	0	0	0
1950	11	0	0	0	1994	44	0	0	0
1951	13	0	1	0	1995	92	0	0	0
1952	44	0	0	0	1996	43	0	0	0
1953	38	0	10	0	1997	79	0	0	0
1954	39	0	0	0	1998	125	0	0	0
1955	59	0	0	0	1999	123	0	1	0
1956	122	0	0	0	2000	115	0	0	0
1957	96	0	0	0	2001	112	0	0	0
1958	148	0	0	0	2002	131	0	0	0
1959	194	0	0	2	2003	128	0	0	0
1960	156	0	0	0	2004	111	0	0	0
1961	208	0	0	0	2005	124	0	0	0
1962	147	0	0	4	2006	134	0	0	0
1963	180	0	0	0	2007	131	1	0	0
1964	199	0	0	20	2008	130	0	0	0
1965	181	0	0	0	2009	116	0	0	0
1966	194	0	0	26	2010	118	0	0	0
1967	249	0	0	125	2011	130	0	0	0
1968	135	0	0	66	2012	143	0	0	0
1969	140	0	0	74	2013	127	0	0	0
1970	151	0	0	0	2014	124	0	0	0
1971	153	0	0	0	2015	125	0	0	0
1972	182	0	0	0	2016	120	0	0	0
1973	178	0	0	0					

Table 4b.
Bycatches. The bycatches in the remaining areas are: VSC (2 in 2011), EJPJ (1 in 1995; 1 in 1970; 1 in 1996; 5 in 2005; 1 in 2007); and SI (2 in 2014)). Values replaced by the predictions of Eqn E.2 are indicated by dashes.

(a) Deaths

Year	Entanglements								Ship strikes								Entanglements	
	BSCS	SEA	SEA	BCN	BCN	CA	CA	MEX	BSCS	SEA	SEA	BCN	BCN	CA	CA	MEX	SET	SET
		Feeding	Migration	Feeding	Migration	Feeding	Migration			Feeding	Migration	Feeding	Migration	Feeding	Migration		Feeding	Migration
1982	-	-	-	-	-	0	1	0	-	-	-	-	-	0	0	0	0	0
1983	-	--	-	-	-	1	2	0	-	--	-	-	-	0	0	0	0	0
1984	-	-	-	-	-	0	3	0	-	-	-	-	-	0	1	0	0	0
1985	-	-	-	-	-	0	6	0	-	-	-	-	-	0	0	0	1	2
1986	-	-	-	-	-	0	1	0	-	-	-	-	-	0	0	0	0	0
1987	1	0	0	-	-	0	2	0	0	0	0	-	-	0	4	0	0	1
1988	0	0	1	-	-	0	1	0	0	0	0	-	-	0	3	0	0.75	0
1989	0	0	0	-	-	0	1	0	0	0	0	-	-	0	0	0	0	2
1990	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
1991	0	0	0	0	0	0	2	0	0	0	0	0	0	0	3	0	0	0
1992	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
1994	0	0	0	0	2	1	1	0	0	0	0	0	0	0	1	0	0	0
1995	0	0	0	1	1	0	1	0	0	0	0	1	0	0	1	0	0	0
1996	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1
1998	1	0	1	1	0	0	1	0	0	0	0	0	1	0	2	0	0	0
1999	2	0	0	1	0	1	1	0	0	0	0	0	0	0	1	0	0	0
2000	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0
2004	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0.75	0
2005	0	0	0	1	1	0	0	0	0	0	0	0	0	0	2	0	0	0
2006	0	0	0	0	1	0	1	0	0	0	0	0	0	0	2	0	0	0
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0
2010	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
2012	0	0	0	1	1	1	2	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	1	0	4	0	0	0	0	0	1	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0.75	0

(b) Serious Injuries

Year	Entanglements								Ship strikes								Entanglements	
	BSCS	SEA	SEA	BCN	BCN	CA1	CA2	MEX	BSCS	SEA	SEA	BCN	BCN	CA	CA	MEX	SET	SET
		Feeding	Migration	Feeding	Migration	Feeding	Migration			Feeding	Migration	Feeding	Migration	Feeding	Migration		Feeding	Migration
1982	-	-	-	-	-	0	1	0	-	-	-	-	-	0	0	0	0	0
1983	-	--	-	-	-	1	2	0	-	--	-	-	-	0	0	0	0	0
1984	-	-	-	-	-	0	3	0	-	-	-	-	-	0	1	0	0	0.75
1985	-	-	-	-	-	0	10.75	0.75	-	-	-	-	-	0	0.14	0	1	4.5
1986	-	-	-	-	-	0	10.25	0	-	-	-	-	-	0	0	0	0	4.5
1987	1.75	0	0	-	-	1.5	5	0	0	0	0	-	-	0	4	0	0	3.5
1988	0	0	1	-	-	0	6	0	0	0	0	-	-	0	4	0	0.75	0
1989	0	0	0	0	0	0	3.5	0	0	0	0	-	-	0	0	0	0	2.75
1990	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0.52	0	0	3.75
1991	0	0	0	0	0	0.75	2.75	0	0	0	0	0	0	0	3	0	0	0
1992	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
1994	0	0	0	0	0	1	2.75	0	0	0	0	0	0	0	1	0	0	0
1995	0	0	0.75	1	0	0	2.75	0.75	0	0	0	1	0	0	1.72	0	0	0
1996	0	0	0	0	0	0	3.75	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0.75	0.75	0.75	0	0	1	0	1	0	0	0	0	1.75
1998	1.75	0	1	1	0	0.75	2.5	0	0	0	0	0	2	0	3.56	0	0	0
1999	2	0	0	1.375	0	1	2.5	0	0	0	0	0	0.2	0	1.36	0	0	0
2000	0	0	0	0	0	0.75	3.25	0.75	0	0	0	0	0	0	0	0	0	1
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0
2002	0	0	0	1	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	1	0	0	1.75	0.75	0	0	0	0	0	0	1	0	0	0
2004	1	0.75	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0.75	0
2005	0	0	0	1	0	0	1.5	0	0	0	0	0	0	0	2	0	0	0
2006	0	0	0	0	0	0	1.75	0.75	0	0	0	0	0	0	2.56	0	0	0
2007	1	0	0	0	0	1.5	0	0	0	0	0	0	0	1	0	0	0	0
2008	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	1	0	0
2009	0	0	0.75	0.75	0	0	1.5	0	0	0	0	0.52	1	0	3	0	0	0
2010	0	0	0	0	0	1	2.5	0	0	0	0	0	0	0	1.52	0	0	0
2011	0	1	0	0	0	2	0	0	0	0	0	0	0	1	1.28	0	0	0
2012	2.5	0	0	1.75	0	2	7.75	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	1	0	4	2.5	0	0	0	0	1	0	0	0	0	0	0
2014	0	0	0	0	0	2.5	1.5	0	0	0	0	0	0	0	0	0	0	0
2015	1	0	0	0	0	1.5	6	0	0	0	0	0	0	0	1	0	0.75	0

Table 5

Relative effort for the set gillnet fishery off California (J. Carrette, SWFSC, pers commn. Effort is constant at 1 prior to 1981

Year	Effort	Year	Effort	Year	Effort
1981	1.000	1993	1.438	2005	0.428
1982	1.819	1994	0.571	2006	0.365
1983	1.940	1995	0.460	2007	0.401
1984	2.459	1996	0.519	2008	0.384
1985	2.598	1997	0.690	2009	0.304
1986	2.048	1998	0.554	2010	0.358
1987	1.883	1999	0.737	2011	0.370
1988	1.560	2000	0.754	2012	0.324
1989	1.376	2001	0.624	2013	0.278
1990	1.444	2002	0.668	2014	0.265
1991	1.395	2003	0.607	2015	0.419
1992	1.197	2004	0.626		

Table 6a

Abundance estimates (1+) for the WFG feeding aggregation and the western breeding stock (J.G. Cooke, pers. commn)

Year	Group	Stock hypothesis	Estimate	SD	CV
1995	WFG	3a/3c/3e/6b	75.1	3.8	0.051
1995	WBS	3b	25.8	7.3	0.282
1995	WFG	3b	75.5	3.3	0.043
1995	WBS	3e	30.0*	15.0	0.500
1995	WBS	5a	26.6	6.9	0.259
1995	WFG	5a	47.8	7.7	0.160
1995	WBS+WFG	5a	74.4	3.9	0.052
1995	WBS/(WBS+WFG)	5a	0.358	0.093	0.259
2015	WFG	3a/3c/3e/6b	199.8	5.4	0.027
2015	WBS	3b	63.8	15.8	0.248
2015	WFG	3b	198.9	5.7	0.029
2015	WBS	3e	30.0*	15.0	0.500
2015	WBS	5a	64.4	14.0	0.218
2015	WFG	5a	135.6	14.1	0.104
2015	WBS+WFG	5a	200.0	5.7	0.029
2015	WBS/(WBS+WFG)	5a	0.322	0.069	0.200

* Guestimate because the WBS cannot be distinguished given the available information.

Table 6b

Estimates of absolute abundance (with associated standard errors) for the eastern North Pacific stock of gray whales based on shore counts (source: 1967/78-2006/07: Laake *et al*, 2012; 2006/07-2015/16: Durban *et al*, 2013, 2017). These estimates are assumed to pertain to the total number of gray whales.

Year	**Estimate**	**CV**	**Year**	**Estimate**	**CV**
1967/68	13426	0.094	1987/88	26916	0.058
1968/69	14548	0.080	1992/93	15762	0.067
1969/70	14553	0.083	1993/94	20103	0.055
1970/71	12771	0.081	1995/96	20944	0.061
1971/72	11079	0.092	1997/98	21135	0.068
1972/73	17365	0.079	2000/01	16369	0.061
1973/74	17375	0.082	2001/02	16033	0.069
1974/75	15290	0.084	2006/07	19126	0.071
1975/76	17564	0.086	2006/07	20750	0.060
1976/77	18377	0.080	2007/08	17820	0.054
1977/78	19538	0.088	2009/10	21210	0.046
1978/79	15384	0.080	2010/11	20990	0.044
1979/80	19763	0.083	2014/15	28790	0.130
1984/85	23499	0.089	2015/16	26960	0.050
1985/86	22921	0.081			

Table 6c
Estimates of absolute abundance (with associated CVs) for the PCFG feeding aggregation based on mark-recapture analysis (source: Calambokidis et al., 2017).

Year	Estimate	CV	Year	Estimate	CV
1998	126	0.087	2009	208	0.101
1999	145	0.101	2010	200	0.095
2000	146	0.098	2011	205	0.078
2001	178	0.076	2012	217	0.052
2002	197	0.069	2013	235	0.059
2003	207	0.084	2014	238	0.080
2004	216	0.077	2015	243	0.078
2005	215	0.125			
2006	197	0.108			
2007	192	0.136			
2008	210	0.089			

Table 7
Data on mixing proportions (definite and likely matches / non-matches only) to be used when conditioning the models.

Sub-area	Season	Stock / Feeding aggregation	Mixing proportion (assumed SD)
EJPJ	All	WBS/NFG	0.33 (0.1)
SEA	Feeding	PCFG	0.57[1] (0.1)
SEA	Feeding	WFG	0
SEA	Migration	PCFG	0.1[2] (0.1)
SEA	Migration	WFG	0.002[3] (0.05)
BCNC	Feeding	PCFG	0.93 (0.1)
BCNC	Feeding	WFG	0
BCNC	Migration	PCFG	0.28 (0.1)
BCNC	Migration	WFG	0.002 (0.05)
CA	Feeding	PCFG	0.60 (0.1)
CA	Feeding	WFG	0
CA	Migration	PCFG	0.1 (0.05)
CA	Migration	WFG	0.002[3] (0.05)

1: Not used in the conditioning except for the sensitivity test based when the bycatch is based on M/SI as no dead bycatch is recorded for the SEA sub-area during the feeding season.
2: Assumed value owing to lack of data to estimate mixing proportions.
3: Set to the value calculated for BCNC by Moore and Weller (2013)

Table 8
Factors considered in the model scenarios. The bold values are the base-levels and the values in standard font form the basis for sensitivity analyses.

Factor	Levels
Model fitting related	
Stock hypothesis	**3a,** 3b, 3c, 3e, **5a,** 6b
$MSYR_{1+}$ (western)	As for WFG
$MSYR_{1+}$ (north)	**4.5%**, 5.5%, Estimated (common); estimate (separately)
$MSYR_{1+}$ (WFG)	**4.5%** Estimated (common); estimate (separately)
$MSYR_{1+}$ (PCFG)	2%, **4.5%**, 5.5%¸ Estimated (common); estimate (separately)
Mixing rate (migration season in BCBC	**0.28**, 0.17, 1.00
Immigration into the PCFG	0, 1, **2**, 4
Bycatches and ship strikes	Numbers dead + M/SI, **dead x 4**; dead x 10; dead x 20
Pulse migrations into the PCFG	10, **20**, 30
Projection-related	
Additional catch off Sakhalin (mature female)	0, 1
Catastrophic events	**None**, once in years 0 – 49, and once in years 50-99
Northern need in final year (from 150 in 2014)	**340**
Struck and lost rate	**(0.1; odd-years; 0.5 even years),** 0.5 all years
Future effort	**Constant**, Increase by 100% over 100 years
Probability of a photo (struck and lost whales)	**0.8; odd-years; 0.6 even years**
Probability of a photo (landed whales)	**0.9**
Probability of false positive rate PCFG	**0.05**, 0.1
Probability of false negative rate PCFG	**0.25**
Probability of false positive rate WFG	**0.01**
Probability of false negative rate WFG	**0.041 (stock hypotheses 3a, 3c, 3e, 6b);** 0.040 (stock hypothesis 3b); **0.049 (stock hypothesis 5a)**
Probability of a sex assignment given a PCFG match	**0.81**

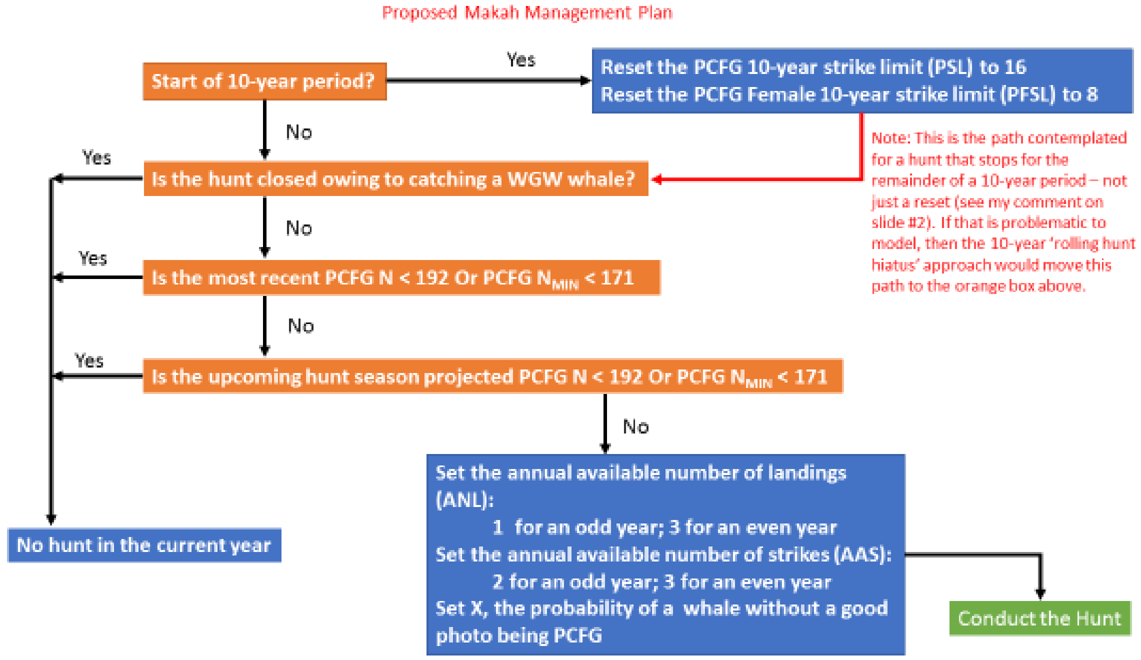
Table 9

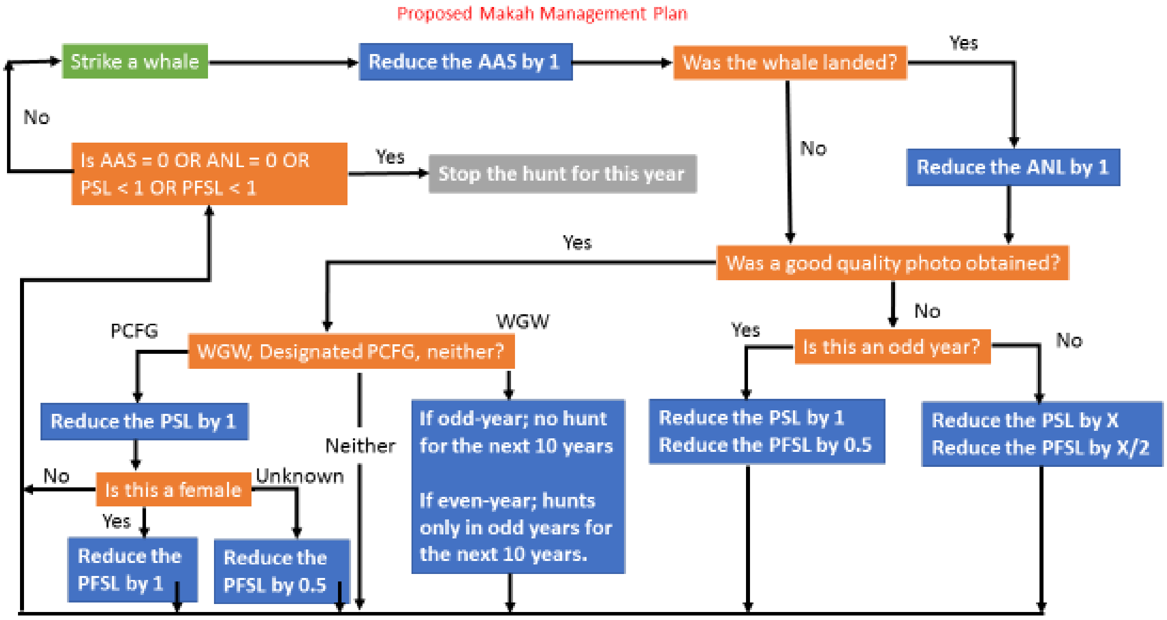
Final trial specifications

Trial	Description/stock hypothesis	PCFG or WFG in BSCS	MSYR$_{1+}$			PCFG		Bycatch	Conditioning
			North	PCFG	WFG	Imm.	Pulse		
Base-case trials									
0A	Reference 3a	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
0B	Reference 5a	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
Sensitivity tests									
1A	Lower MSYR PCFG 3a	No	**4.50%**	**2%**	**4.50%**	2	20	D x 4	Yes
1B	Lower MSYR PCFG 5a	No	**4.50%**	**2%**	**4.50%**	2	20	D x 4	Yes
2A	Higher MSYR PCFG and North 3a	No	**5.50%**	**5.50%**	**4.50%**	2	20	D x 4	Yes
2B	Higher MSYR PCFG and North 5a	No	**5.50%**	**5.50%**	**4.50%**	2	20	D x 4	Yes
3A	Lower WBS in Sakhalin 5a (Hyp 3e)	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
3B	Higher WBS in Sakhalin 5a	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
4A	PCFG mixing based on Northern WA only 3a	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
4B	PCFG mixing based on Northern WA only 5a	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
5A	No PCFG Immigration 3a	No	4.50%	4.50%	4.50%	**0**	20	D x 4	Yes
5B	No PCFG Immigration 5a	No	4.50%	4.50%	4.50%	**0**	20	D x 4	Yes
6A	Higher PCFG Immigration 3a	No	4.50%	4.50%	4.50%	**4**	20	D x 4	Yes
6B	Higher PCFG Immigration 5a	No	4.50%	4.50%	4.50%	**4**	20	D x 4	Yes
7A	Lower Pulse into PCFG 3a (and no 1998-2002 PCFG data)	No	4.50%	4.50%	4.50%	2	**10**	D x 4	Yes
7B	Lower Pulse into PCFG 5a (and no 1998-2002 PCFG data)	No	4.50%	4.50%	4.50%	2	**10**	D x 4	Yes
8A	Higher pulse into PCFG 3a	No	4.50%	4.50%	4.50%	2	**30**	D x 4	Yes
8B	Higher pulse into PCFG 5a	No	4.50%	4.50%	4.50%	2	**30**	D x 4	Yes
9A	Bycatch=Dead + MSI 3a	No	4.50%	4.50%	4.50%	2	20	**D + MSI**	Yes
9B	Bycatch=Dead + MSI 5a	No	4.50%	4.50%	4.50%	2	20	**D + MSI**	Yes
10A	Bycatch x 10 3a	No	4.50%	4.50%	4.50%	2	20	**D x 10**	Yes
10B	Bycatch x 10 5a	No	4.50%	4.50%	4.50%	2	20	**D x 10**	Yes
11A	Bycatch x 20 3a	No	4.50%	4.50%	4.50%	2	20	**D x 20**	Yes
11B	Bycatch x 20 3e	No	4.50%	4.50%	4.50%	2	20	**D x 20**	Yes
12A	PCFG in BSCS 3a	**PCFG**	4.50%	4.50%	4.50%	2	20	D x 4	Yes
12B	PCFG in BSCS 5a	**PCFG**	4.50%	4.50%	4.50%	2	20	D x 4	Yes
13A	WFG in BSCS 3a	**WFG**	4.50%	4.50%	4.50%	2	20	D x 4	Yes
13B	WFG in BSCS 5a	**WFG**	4.50%	4.50%	4.50%	2	20	D x 4	Yes
14A	MSYR1+ estimated (common) 3a	No		**Estimated**		2	20	D x 4	Yes
14A	MSYR1+ estimated (common) 5a	No		**Estimated**		2	20	D x 4	Yes
15A	MSYR1+ estimated (by FA) 3a	No	**Est**	**Est**	**Est**	2	20	D x 4	Yes
15B	MSYR1+ estimated (by FA) 5a	No	**Est**	**Est**	**Est**	2	20	D x 4	Yes
16A	Lower PCFG immigration and higher bycatch 3a (and no 1998-2002 PCFG data)	No	4.50%	4.50%	4.50%	**0**	20	**D x 10**	Yes
16B	Lower PCFG immigration and higher bycatch 5a (and no 1998-2002 PCFG data)	No	4.50%	4.50%	4.50%	**0**	20	**D x 10**	Yes
17A	MSYR estimated and lower pulse 3a	No	**Est**	**Est**	**Est**	2	**10**	D x 4	Yes
17B	MSYR estimated and lower pulse 5a	No	**Est**	**Est**	**Est**	2	**10**	D x 4	Yes

Trial	Description/stock hypothesis	PCFG or WFG in BSCS	MSYR$_{1+}$			PCFG		Bycatch	Conditioning
			North	PCFG	WFG	Imm.	Pulse		
18A	Stock hypothesis 3b	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
18B	Stock hypothesis 6b	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
18C	Stock hypothesis 3c	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
19A	Lower PCFG Immigration 3a	No	4.50%	4.50%	4.50%	**1**	20	D x 4	Yes
19B	Lower PCFG Immigration 5a	No	4.50%	4.50%	4.50%	**1**	20	D x 4	Yes
20A	Lower PCFG immigration and higher bycatch 3a	No	4.50%	4.50%	4.50%	**1**	20	**D x 10**	Yes
20B	Lower PCFG immigration and higher bycatch 5a	No	4.50%	4.50%	4.50%	**1**	20	**D x 10**	Yes
21A	Survival = 0.95; 3a	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
21B	Survival = 0.95; 3a	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
22A	Future catastrophic events (once in each of yrs 1-50 & 51-99) - 3a	No	4.50%	4.50%	4.50%	2	20	D x 4	No, 3a
22B	Future catastrophic events (once in each of yrs 1-50 & 51-99) - 5a	No	4.50%	4.50%	4.50%	2	20	D x 4	No, 5a
23A	Summer S&L rate = 0.5 - 3a	No	4.50%	4.50%	4.50%	2	20	D x 4	No, 3a
23B	Summer S&L rate = 0.5 - 5a	No	4.50%	4.50%	4.50%	2	20	D x 4	No, 5a
24A	PCFG false negative rate = 0.1 - 3a	No	4.50%	4.50%	4.50%	2	20	D x 4	No, 3a
24B	PCFG false negative rate = 0.1 - 5a	No	4.50%	4.50%	4.50%	2	20	D x 4	No, 5a
25A	PCFG mixing based on Northern WA is 100%	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes
25B	PCFG mixing based on Northern WA is 100%	No	4.50%	4.50%	4.50%	2	20	D x 4	Yes

Appendix 1
OUTLINE OF THE MAKAH MANAGEMENT PLAN AND ITS IMPLEMENTATION IN TRIALS





Appendix 2
THE 'RESEARCH WITH VARIANT' (SLA VARIANT 1) OPTION (IWC, 2013).

This option operates as follows:

(1) Update the ABL (Allowable Bycatch Limit of PCFG whales) if this is the start of a new 6-year block as:

$$ABL = N_{MIN} * 0.5 * R_{MAX} * F_R$$

Where:

N_{MIN} is the log-normal 20th percentile of the most recent abundance estimate for the Oregon to Southern Vancouver (OR-SVI) sub-area of the PCFG. The abundance estimates for use in the ABL formula are generated as specified in Section I, except for allowance is made for a bias which differs among simulations but is constant over time between the estimates for OR-V and those for the PCFG, i.e. $\ell n B_A \sim N(-0.335, 0.112^2)$ (IWC, 2012).

R_{MAX} is equal to 0.04;

F_R is equal to 1.0.

(2) Strike an animal

(3) If the total number of struck animals equals the need of 7 stop the hunt.

(4) If the animal is struck-and lost:
   a. if the total number of struck and lost animals is 3, stop the hunt.
   b. go to step (2).

(5) If the animal is landed and is matched against the PCFG catalogue:
   a. add one to the number of whales counted towards the ABL
   b. if the ABL is reached; stop the hunt
   c. if the total number of landed whales equals 5; stop the hunt
   d. if the number of landed whales for the current six-year block equals 24; stop the hunt
   e. go to step (2).

(6) If the animal is landed and does not match any whale in the PCFG catalogue:
   a. if the total number of landed whales equals 5; stop the hunt
   b. if the number of landed whales for the current six-year block equals 24; stop the hunt
   c. go to step (2).

References

IWC. 2012. Report of the Standing Working Group in the Aboriginal Whaling Management Procedure. J. Cetacean Res. Manage. 13 (Suppl.) 130-53.

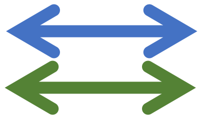
Geographic areas utilized by gray whales are illustrated with colored boxes:

Feeding region

Migratory region

Wintering region

Arrows represent movements between geographic areas, with blue representing movements between feeding regions and green representing migratory movements:

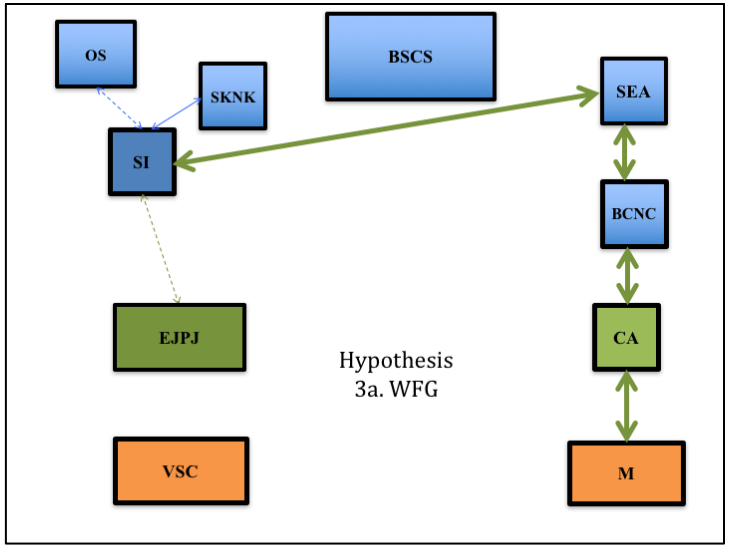


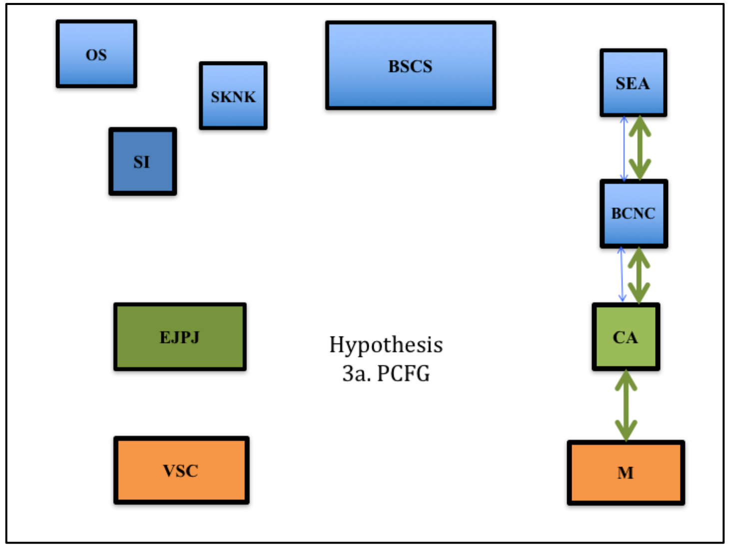
Solid thick lines with arrows denote movements between regions of a significant proportion of individuals using the area

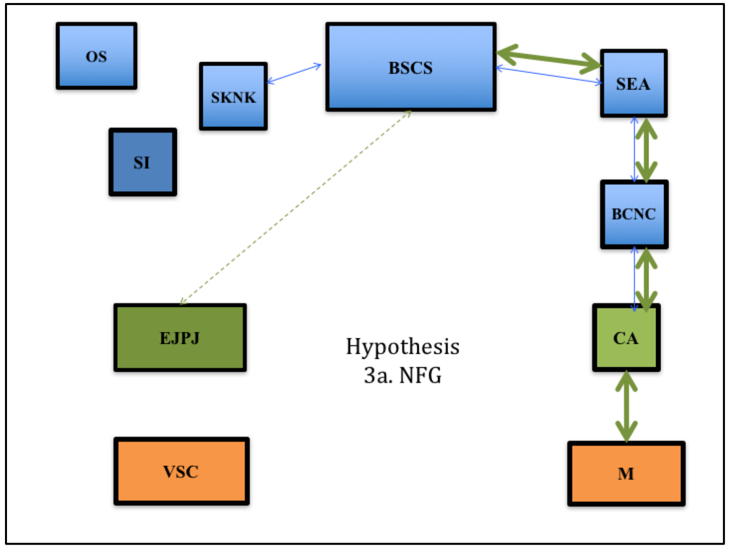
Solid thin lines with arrows denote limited movements between regions

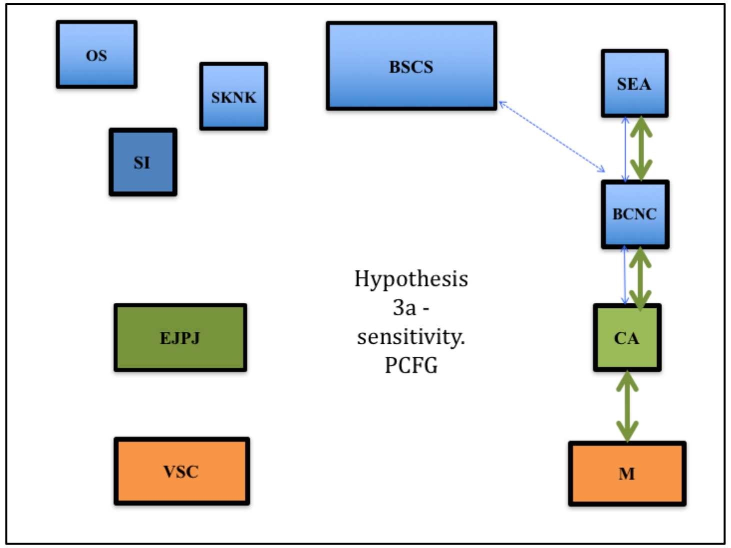
Dashed thin lines with denote occasional movement between regions of small number of individuals

Hypothesis 3a:

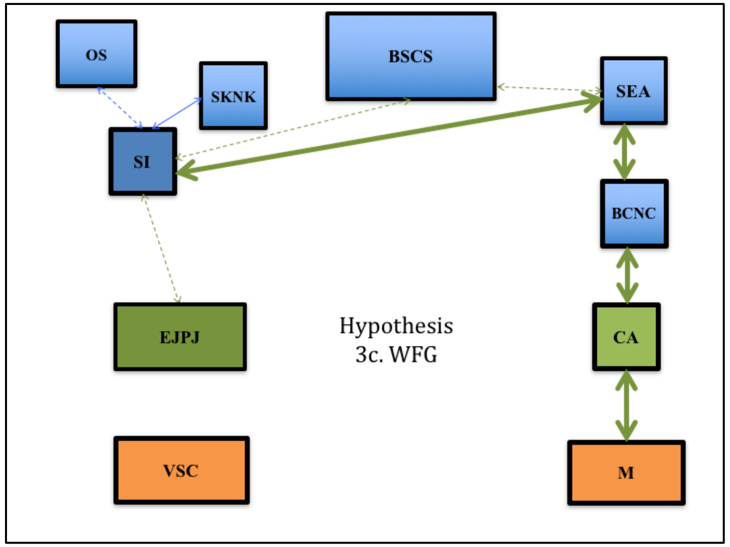


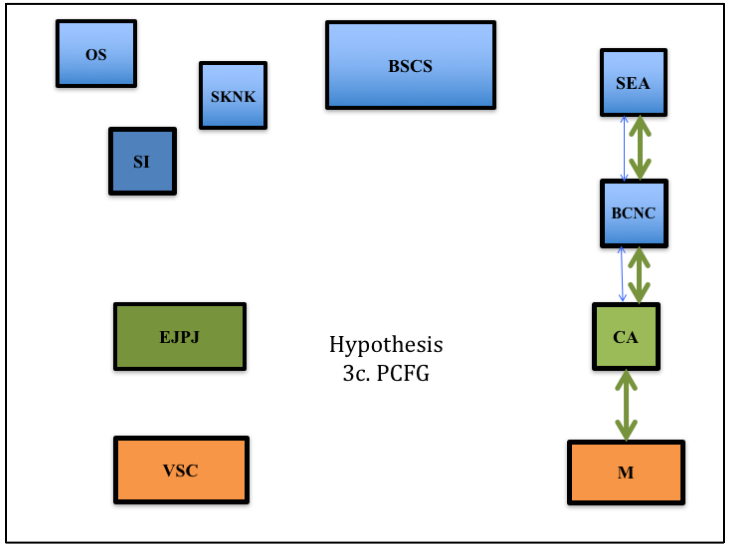


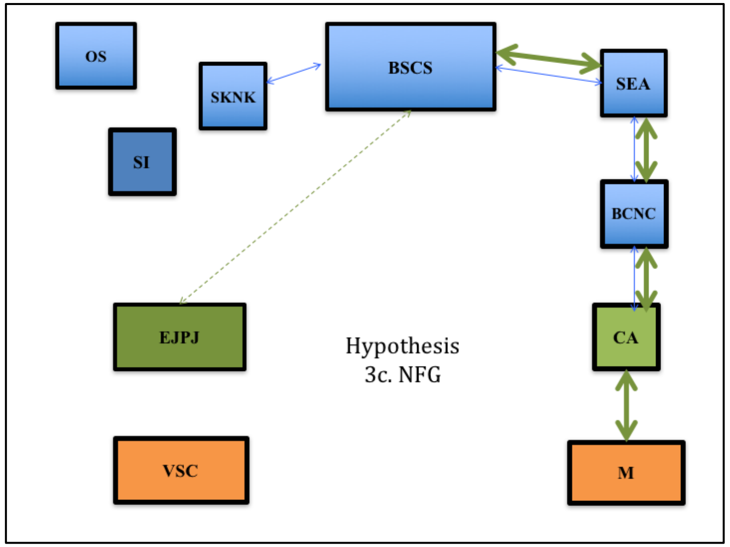




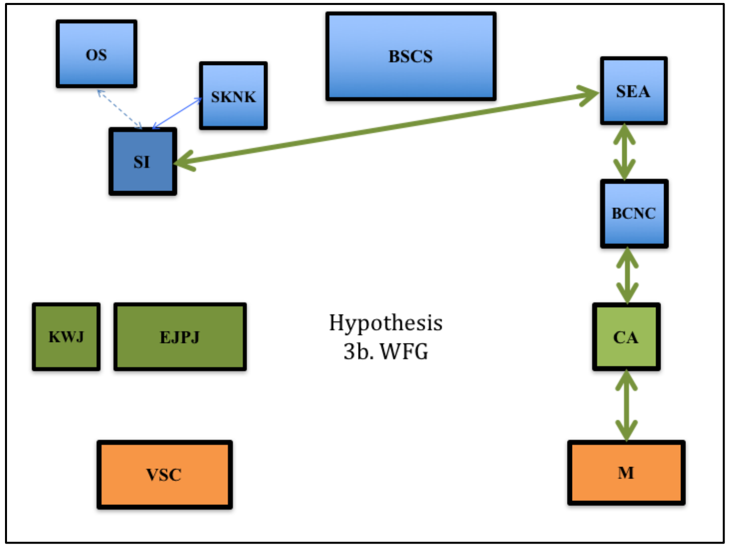
Hypothesis 3c:

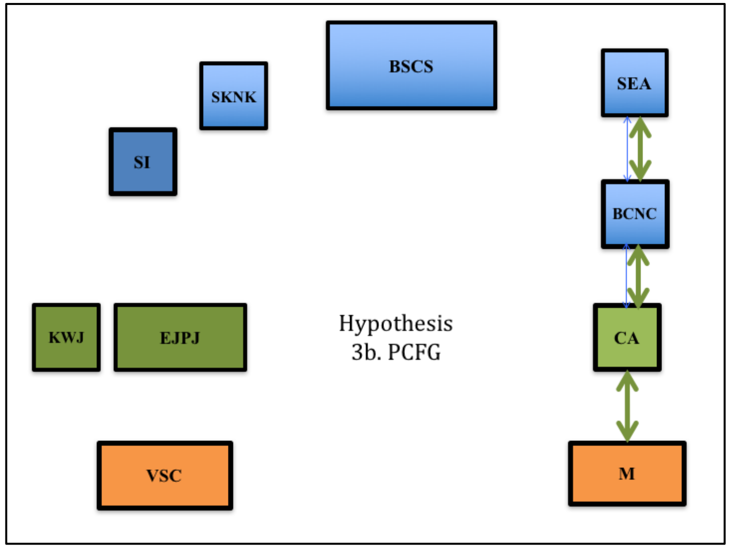


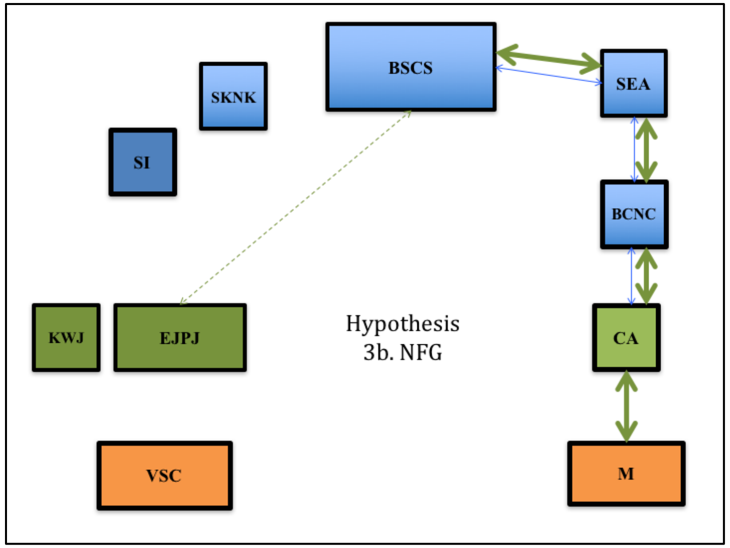


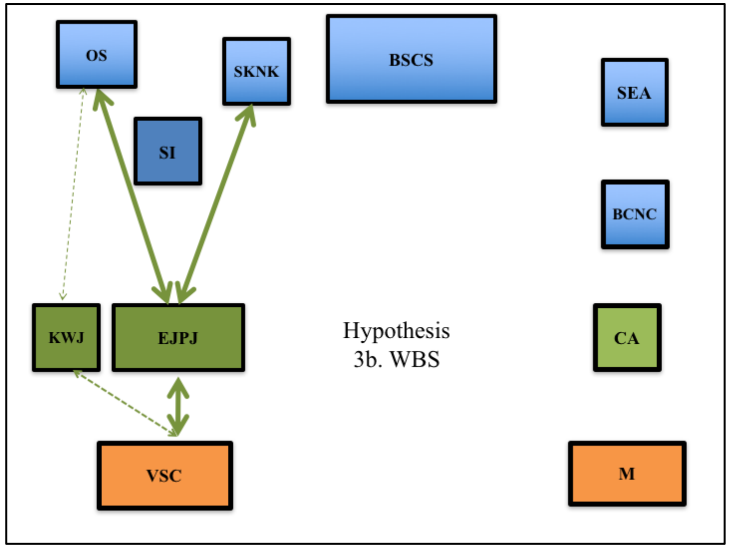


Hypothesis 3b:









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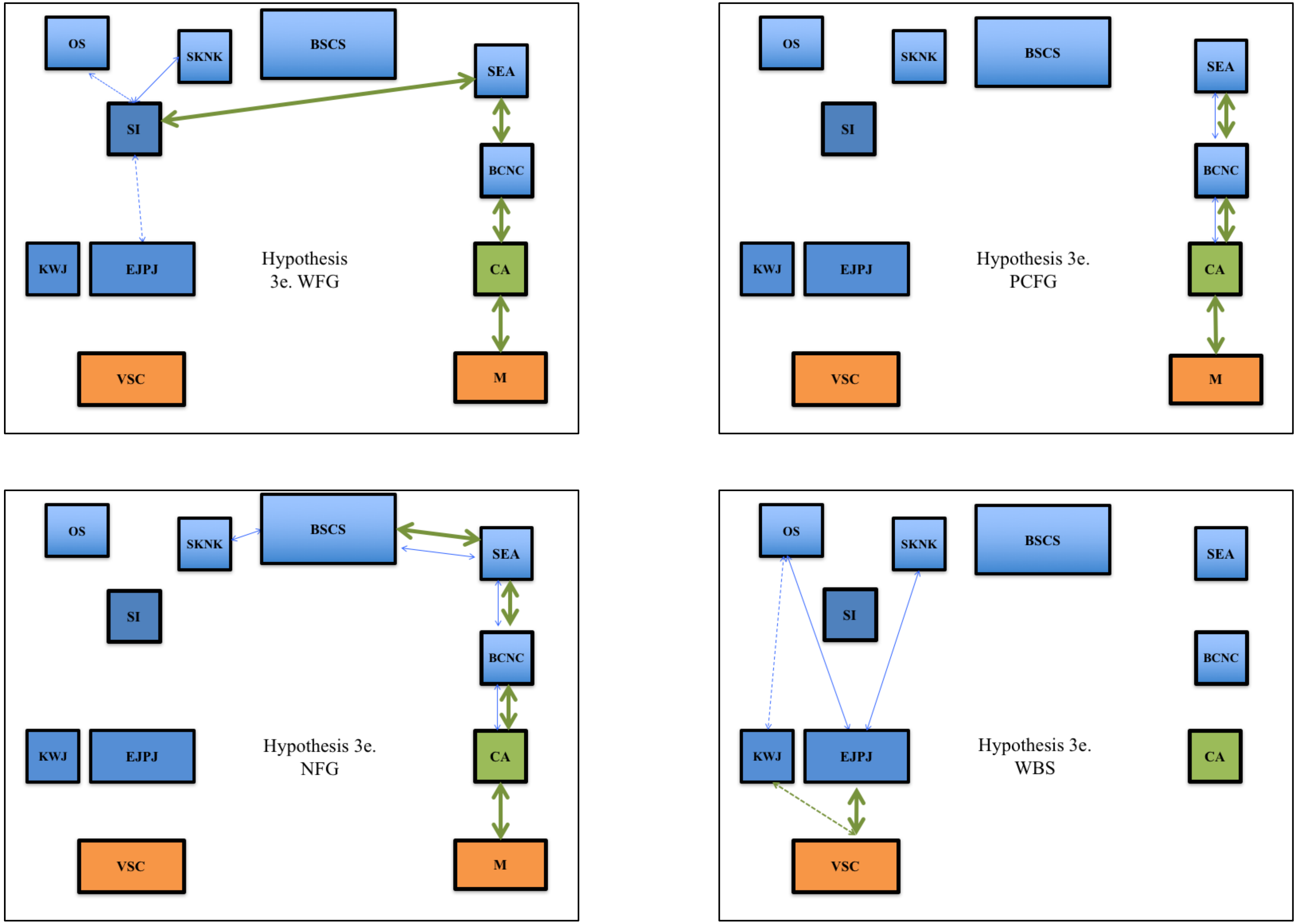

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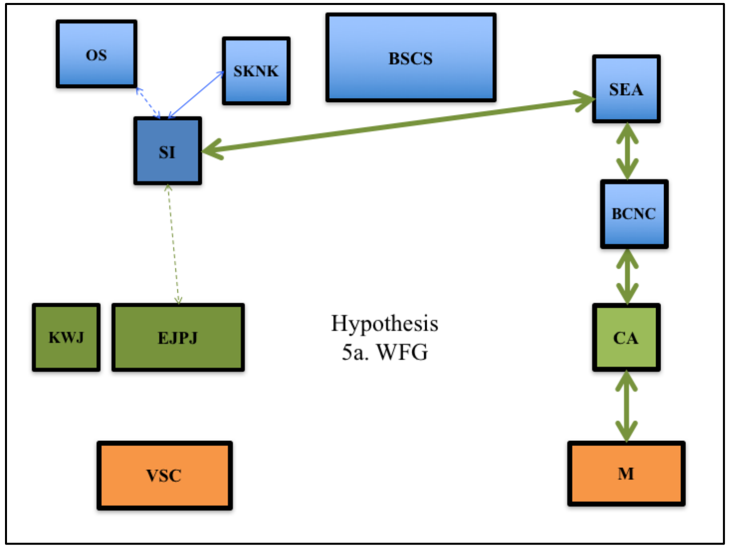

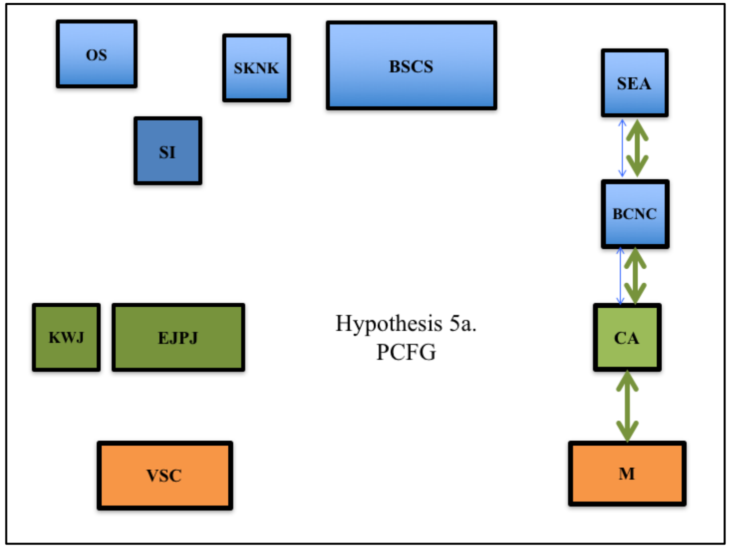

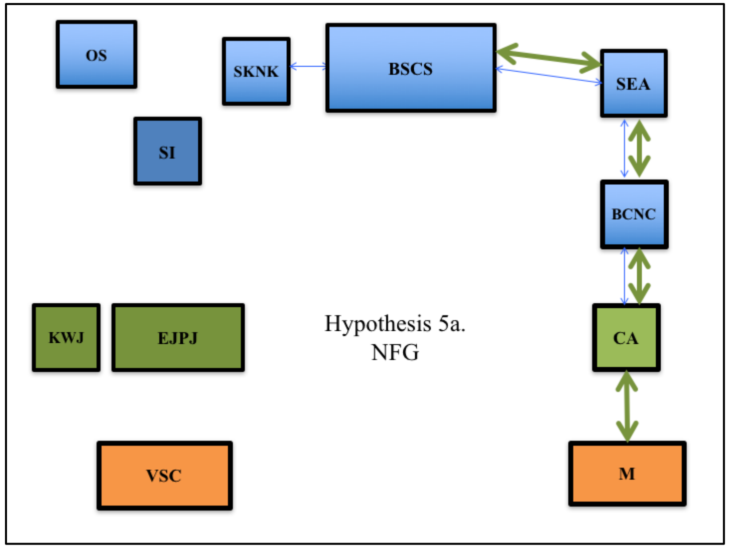

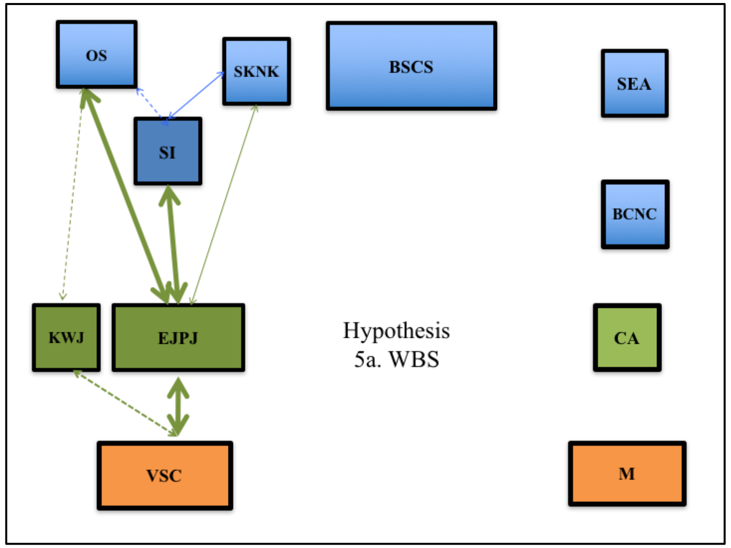

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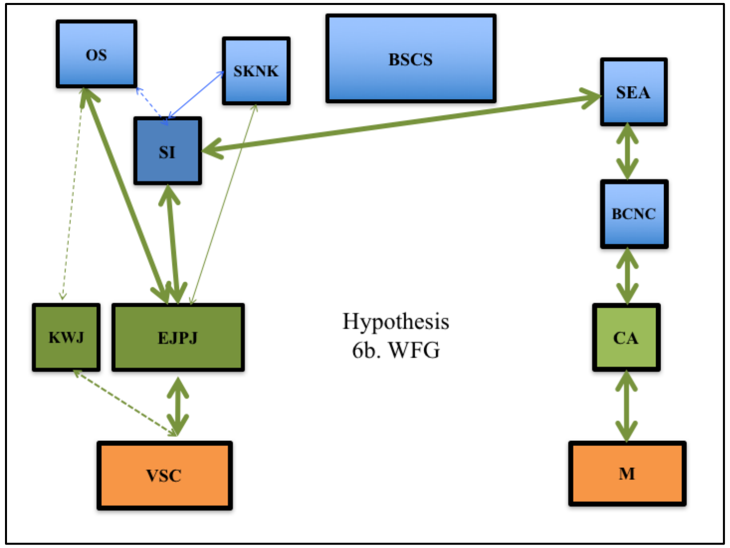

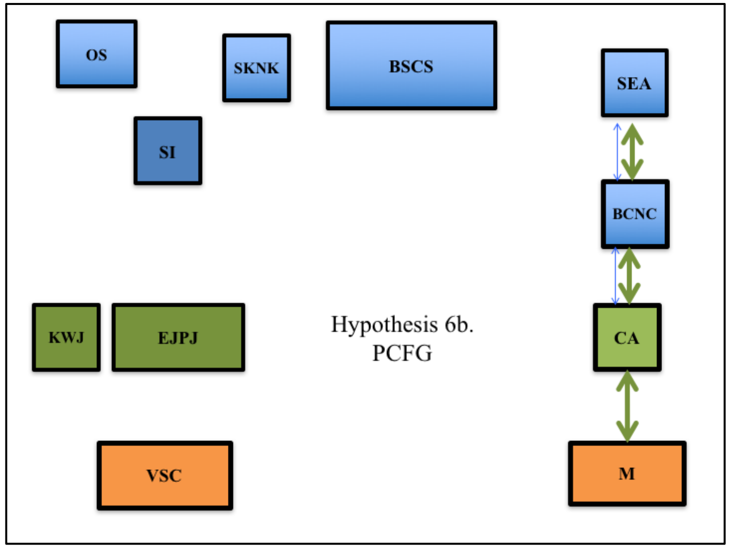

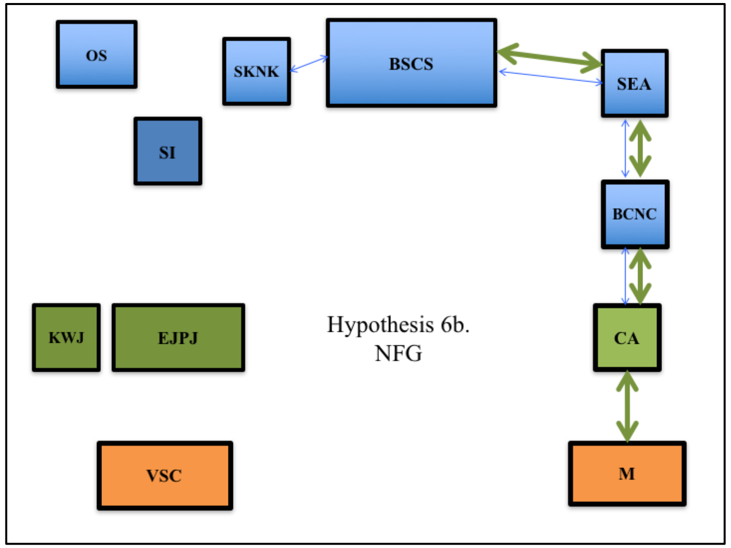

Report of the Scientific Committee

Bled, Slovenia, 24 April-6 May 2018

Annex E

Report of the Standing Working Group on Aboriginal Subsistence Whaling Management Procedures

This report is presented as it was at SC/67b.
There may be further editorial changes (e.g. updated references, tables, figures) made before publication.

International Whaling Commission

Bled, Slovenia, 2018

Annex E

Report of the Standing Working Group on Aboriginal Subsistence Whaling Management Procedures

Members: Donovan (Convenor), Allison, Aoki, Baba, Baird, Bell, Bickham, Brandão, Brandon, Brierley, Brownell, Burkhardt, Butterworth, Cubaynes, De Moor, DeMaster, Doniol-Valcroze, Double, Ferguson, Ferriss, Fortuna, Frey, Gallego, George, Givens, Haug, Hielscher, Holm, Hubbell, Iñíguez, Jaramillo-Legorreta, Johnson, Kitakado, Lang, Litovka, Lundquist, Mallette, Mckinlay, Morishita, Morita, Moronuki, Nelson, Palka, Pastene, Phillips,Punt, Reeves, R., Reeves, S., Ritter, Rodriguez-Fonseca, Rojas Bracho, Safonova, Scordino, Scott, Simmonds, Skaug, Slugina, Smith, Stachowitsch, Stimmelmayr, Suydam, Svoboda, Taylor, Terai, Thomas, Tiedemann, Víkingsson, Wade, Walløe, Walters, Weinrich, Weller, Wilberg, Witting, Zagrebelnyy, Zerbini, Zharikov.

1. INTRODUCTORY ITEMS

1.1 Convenor's opening remarks

Donovan welcomed the participants. The workload this year was immense. Two priority topics are: (1) work towards completion of the remaining *SLA*s for the Greenland hunts; and (2) developing a recommended Aboriginal Whaling Scheme. Both topics have been the subject of intense intersessional work including two workshops in Copenhagen in October 2017 and March 2018, as well as a small technical meeting in December at OSPAR headquarters in London. He stressed that this year, the Commission would be setting new catch/strike limits for all aboriginal subsistence hunts and therefore the third major topic is to provide advice on these. Finally, the SWG will try to complete the *Implementation Review* for Bering-Chukchi-Bering Sea (B-C-B) bowhead whales. He also reminded participants that we will need to provide a two-year workplan and budget.

Donovan noted that Cherry Allison was unable to attend the meeting in person this year and thanked her greatly for all the intersessional work undertaken as well as providing tremendous support from Cambridge. He also thanked Punt, de Moor, Brandão, Witting who have stepped up even more than usual with computing assistance.

He explained that the work of the intersessional Steering Group on developing *SLA*s for the Greenland hunts is ongoing and will continue during this meeting as the report of this group will assist greatly in discussing Item 2. Similarly, the intersessional group on the AWS is continuing and the group's final report will greatly facilitate discussions under Item 3.

1.2 Election of Chair and appointment of rapporteurs

Donovan and Brandon were named co-Chairs. Brandão, Brandon and Givens acted as rapporteurs with the assistance of the Chair.

1.3 Adoption of Agenda

The agenda was adopted. See Appendix 1.

1.4 Documents available

The documents available included SC/67b/AWMP01rev1, SC/67b/AWMP02-08, SC/67b/AWMP10, SC/67b/AWMP12, SC/67b/AWMP13rev1, SC/67b/AWMP14-19, SC/67b/AWMP20rev1, SC/67b/Rep06, and SC/67b/Rep07.

Donovan drew attention to the fact that Canadian scientists had submitted two papers (Frasier *et al.* (2015) [SC/67a/ForInfo31] and Doniol-Valcroze *et al.* (2015) [SC/67b/ForInfo32]) providing abundance estimates for Eastern Canadian-West Greenland bowhead whales. The SWG **greatly appreciated** these contributions.

2. *SLA* DEVELOPMENT

2.1 Fin whales (Greenland)

2.1.1 Review results of intersessional workshops – SC/67b/Rep06

Donovan presented SC/67b/Rep06 and provided an overview of progress made during two intersessional Workshops and the small working group meeting.

He reported that considerable progress was made in relation to the following|:

(a) updated abundance estimates (and see Item 5.6.2);
(b) finalisation of the trial structure;
(c) review and approval of conditioning;
(d) initial consideration of new *SLA*s and results.

2.1.2 Review post-Workshop progress

Most of the work undertaken after the final workshop involved *SLA* development. The final trial specifications are provided as Appendix 2. Table A.XX summarises the main factors considered in the *Evaluation Trials.*

SC/67b/AWMP13 developed a candidate *SLA* for West Greenland fin whales. The new fin whale trials have a large amount of variation in the point estimates of abundance, and the *SLA* takes an inverse variance weighted average of the last three estimates as an estimate of abundance. The strike limit is then calculated as a growth rate fraction of a lower percentile of the abundance measure, conditional on a trend modifier, a snap to need feature, and a protection level. This *SLA* is somewhat simpler than the earlier fin whale *SLA*s developed by Witting. Those fitted a straight line to the abundance estimates in order to obtain a measure of abundance and trend. However, these estimates were unreliable due to the highly variable abundance estimates of the trials. The *SLA* is proposed in three versions, where the D10 statistics for the 5th percentile of the 'Influx' trial F34-1 is tuned to 1.0, 0.9 and 0.8 for the medium (B) need envelope.

SC/67b/AWMP15 presented three potential *SLA*s for West Greenlandic fin whales that are based on a weighted-average interim *SLA* which uses all abundance estimates, but earlier abundance estimates are down-weighted compared to more recent ones. An adjustment to the multiplier of the abundance estimate in the interim *SLA* is applied which depends on the trend of the abundance indices. This approach allows for additional reduction of the *Strike Limit* if the time series of abundances shows a reasonably precise downward trend in abundance. Three candidate *SLA*s are tuned to achieve 1.0, 0.9 and 0.8 for the conservation statistic (D10, relative increase) at the lower 5th percentile for the Influx hypothesis trial GF34-1B with an $MSYR_{1+}$ of 1% and the middle need envelope (B) as suggested at the 2018 Workshop (SC/67b/Rep06). Dropping the D10 statistic to 0.8 for this trial improves need satisfaction by all other trials without sacrificing conservation performance (except for the Influx hypothesis trials at $MSYR_{1+}$= 1%). It was noted that these *SLA*s do not have a snap to need feature.

2.1.3 Review final results and performance

In total, seven potential *SLA*s (which include the 'Interim' *SLA* – a modified version of the *Interim SLA* that has been used to provide advice for the last two blocks) were reviewed. As in previous years, an initial examination of the full set of results was undertaken by a 'winnowing' group with the aim to focus the SWG to those aspects of the performance of the *SLA*s that needed to be discussed further. Initially, the focus was on projections of the lower 5th percentiles and medians for 1+ population abundance and 'Zeh' plots for various performance statistics. Focus was given to the exploration of the univariate performance statistics D1 (final depletion) and D10 at the lower 5th percentile. The desired performance for these statistics is to obtain a value of D10 greater or equal to one and for D1 to be above 0.6 (MSYL). In other words, satisfactory performance on the conservation criteria by an *SLA* is deemed if either the population is not at MSYL but it is increasing or the population is increasing/decreasing but is above MSYL.

Tables which highlighted which *SLA* was performing well or not relative to the 'best' performance amongst all the *SLA*s (including the 'Interim' *SLA*) were also examined to evaluate the performance of the proposed *SLA*s. Plots of depletion where examined as the conservation statistics are based on this rather than on population abundance numbers. Trials for which at least one of the proposed *SLA*s failed either the D1 or the D10 conservation statistics were highlighted for further investigation (5 trials). Looking at results on a single dimension was not helpful because the D10 statistic does not need to be at or above one if the population is above MSYL. Thus, further focus on the performance of the *SLA*s was placed rather on the joint statistic of D1 and D10 for these 5 trials.

The bivariate plots of the D1 and D10 statistics (see Fig. B.1 Appendix 3) were examined for all the proposed *SLA*s, with a focus on the simulation results in the quadrant in which D1 <0.6 and D10 <1. The counts of the simulations for all *SLA*s that fall in this quadrant were examined to see if this could help to distinguish the performance amongst the different *SLA*s. Examination of these plots concluded that for all the trials that had failed on at least one of the univariate conservation statistics, only trial F34-1C (a low MSYR, high need case for the Influx model) showed unacceptable conservation performance.

The SWG **agreed** that the proposed *SLA*s performed satisfactorily on the joint conservation statistics for the A and B (but not for C) need envelopes for all trials, and the selection between *SLA*s was narrowed down to those that had been tuned to obtain D10 of 0.8 for the more difficult Influx hypothesis trial F34-1B (B0.8 and L0.8). The focus on selecting amongst the *SLA*s should be on the *SLA* that meets need satisfaction best and that also achieves stability in the catches. 'Zeh' plots were examined for all trials, concentrating on the need satisfaction statistics, N9(20) the average need satisfaction over the first 20 years, N9(100) the average need satisfaction over the 100 years and N12 the mean downstep statistic, which is a modified average annual variability statistic.

It was noted that because of the present incorporation into the trial structure of the widely different 'Influx' and 'partial' hypotheses to explain the variability of the abundance estimates, the need satisfaction over 20 years is more appropriate to consider than over 100 years as it is likely that future *Implementation Reviews* may be able to remove one or other scenario.

After an examination of the full range of results, there was no obvious 'winner' between the two *SLA*s. Depending on the trials considered, and which statistic was examined, the different *SLA*s performed slightly differently but their performance overall was equivalent.

Following an approach originally adopted during the development of the *Bowhead SLA*, the SWG **agreed** that an *SLA* which sets the strike limit to the average of the values obtained by the two *SLA*s tuned to a D10 of 0.8 for the influx trial F34-1B (B0.8 and L0.8) would be preferable, providing performance was as good or better than either individual *SLA*; no snap to need for the averaged *SLA* has been applied. The results of the 'combined *SLA'* are summarised in Appendix 3.

2.1.4 Conclusions and recommendations
The SWG **agreed** that the *SLA* which sets the strike limit to the average of the values obtained by the two *SLA*s tuned to a D10 of 0.8 for the influx trial F34-1B (B0.8 and L0.8) performed satisfactorily in terms of conservation performance and that it was to be preferred over the individual proposed *SLA*s in terms of need satisfaction. The SWG **agreed** that this '*WG-fin SLA*' be used to provide management advice to the Commission on the subsistence hunt for West Greenland fin whales under need scenarios A and B. For the management advice see Item 5.6.

In conclusion, the SWG expressed its **great thanks** to the developers, Brandão and Witting for the vast amount of work put into the development process. It also expressed similar thanks to Allison and Punt for their extensive work developing the operating models and running the trials. It noted that final validation and archiving would be undertaken by Allison.

The SWG also concurred with the intersessional Workshop (SC/67b/Rep06, item 2.7) that one focus of the next *Implementation Review* would be to examine further stock structure in relation to the two hypotheses being considered at present, and especially the influx model which was developed in the context of low abundance estimates in some years rather than genetic information.

Attention: C-A, SC

The Committee ***draws attention*** *to the extensive work undertaken over recent years to develop an S*LA *for the West Greenland hunt for fin whales. In concluding this work, the Committee:*

(1) ***agrees*** *that the combined* SLA *(which sets the strike limit to the average of the values obtained by the two best SLAs considered) performed satisfactorily in terms of conservation performance and was to be preferred over the individual SLAs in terms of need satisfaction;*
(2) ***recommends*** *that this* 'WG-Fin SLA' *be used to provide management advice to the Commission on the subsistence hunt for West Greenland fin whales (provided the need request falls within need scenarios A and B);*
(3) ***expresses*** *its great thanks to the developers, Brandão and Witting for the vast amount of work put into the development process and to Allison and Punt for their extensive work developing the operating models and running the trials; and*
(4) ***agrees*** *that one focus of the next* Implementation Review *will be to examine further stock structure in relation to the two hypotheses being considered at present, and especially the 'influx' model which was developed in the context of low abundance estimates in some years, rather than being based upon genetic information.*

2.2 Common minke whales (Greenland)
2.2.1 Review results of intersessional workshops - SC/67b/Rep06
Donovan summarised report SC/67b/Rep06 and the intersessional progress made on common minke whales. He noted that enormous effort had been devoted to reviewing the new genetic information that had been provided in response to a recommendation at SC/67a. This had greatly assisted in developing the final stock structure hypotheses and mixing matrices to be considered in the trials. These extensive discussions can be found under items 3.3.1 and 3.3.2 of SC/67b/Rep04.

Finally, the Workshop **agreed** that instead of formally using the RMP to set catch limits by sub-area and year for each simulation, the RMP catch limits would be pre-specified based upon baseline hypothesis 1 trials (M01-1 and M01-4). This allows the trials to run more quickly and focus to be given on *SLA* development – the objective of this work. Details can be found in the full trials specification (Appendix 4).

2.2.2 Review post-Workshop progress
Considerable work was undertaken to finalise the list of trials, to ensure that the mixing matrices were correctly specified and to complete and agree conditioning. The final trial specifications are provided as Appendix 4.

Table 4.XX summarises the factors considered in the *Evaluation Trials.*

2.2.3 Candidate SLAs
SC/67b/AWMP14 developed a candidate *SLA* for common minke whales off West Greenland. It operates, like the fin whale *SLA* in SC/67b/AWMP13, on an inverse variance weighted average of the last three abundance estimates. The strike limit is calculated as a growth rate fraction of a lower percentile of the abundance measure, conditional on a snap to need feature, and a protection level. The *SLA* for common minke whales, however, does not include a trend modifier, as it is almost impossible to detect an underlying trend from the abundance data in West Greenland.

The *SLA* was tuned to have a 5th percentile of D10 of 0.80 for a flat need envelope of 164 on the most difficult *Evaluation Trial* (trial M04-1A, where there are two sub-stocks in the western North Atlantic, where the mixing between the Central and the Western stock, and the mixing between the putative western sub-stocks, are minimal, and where the MSYR is 1%). Conservation performance on all other measures was adequate for all trials with a flat need of 164, and the *SLA* produces an expected average need satisfaction of 99% (with a lower 5th percentile of 89%) for the first 20 years, and 89% (5th percentile of 61%) for the 100-year simulation period.

2.2.4 Consideration of results

The SWG **agreed** that conditioning of the *Evaluation Trials* had been completed satisfactorily. A summary of the results of the *Evaluation Trials* is provided in Appendix 5.

In determining satisfactory conservation and need performance when evaluating *SLA*s, the SWG considers the full range of results across all of the *Evaluation Trials* not simply the worst-case scenarios. The SWG **agreed** that conservation performance was satisfactory in all but one of the trials. This trial was a trial with low MSYR and two W-stocks and had been originally considered in the context of potential problems for the hunt to simulate possible local depletion in the hunting area rather than for conservation reasons. It was noted that genetic stock structure in the entire North Atlantic is subtle such that even a hypothesis of almost complete panmixia is not rejected by most of the analyses. Hence, differentiation among C and W is very low. This is even more true for substructure within the W stock (if there is any. Given that trials are conservative in so far to overrate isolation among stocks and the very subtle differentiation among stocks and sub-stocks in the North Atlantic, a single trial (which implements fully separate W1 and W2 sub-stocks for which evidence is weak) not meeting the D1/D10 criteria is not of conservation concern.

In developing this advice, the SWG noted that given the unforeseen situation with Secretariat computing, there had been insufficient time to consider the results of the *Robustness Trials* in the SWG. Such trials are not needed to determine an *SLA* but are examined to ensure that the selected *SLA* has no unforeseen properties in extreme trials. Given the importance of being able to provide the best management advice to the Commission, the SWG agreed that the Steering Group set up for *SLA* development should take responsibility to review the results of the *Robustness Trials* as soon as they become available and report to the Plenary session[1].

2.2.4 Conclusions and recommendations

Given the overall satisfactory performance in the *Evaluation Trials* with respect to meeting the Commission's conservation and management objectives for need envelope A (i.e. constant need over the simulation period), the SWG **agreed** to recommend this, the '*WG-common minke SLA'* to the Committee as the best way to provide management advice for the West Greenland hunt of common minke whales. The management advice developed using the *WG-common minke SLA* is provided under Item 5.5.

In accordance with the AWS (see Item 3), the first *Implementation Review* is scheduled for 2023. The SWG **agreed** that one focus of that review should be consideration of the results of analyses of genetic data using additional samples from Canada (as well as the additional samples that will become available from West Greenland and Iceland). To this end it **agrees** that planning for the *Implementation Review* should begin two years before the scheduled review. A small group comprising Tiedemann, Doniol-Valcroze, Witting and Víkingsson was established to facilitate issues related to obtaining samples.

In conclusion, the SWG expressed its **great thanks** to the developers, Brandão and Witting for the vast amount of work put into the development process. It also expressed similar **thanks** to Allison and Punt for their extensive work developing the operating models and running the trials. It noted that final validation/archiving would be undertaken by Allison.

Attention: C-A, SC

*The Committee **draws attention** to the extensive work undertaken over recent years to develop an* SLA *for the West Greenland hunt for common minke whales. In concluding this work, the Committee:*

(1) ***agrees*** *that the tested* SLA *which performed satisfactorily in terms of conservation performance;*
(2) ***agrees*** *that this 'WG-Common minke SLA' be used to provide management advice to the Commission on the subsistence hunt for West Greenland common minke whales provided the need request falls within need scenario A (i.e. does not exceed 164 annually);*
(3) ***expresses*** *its great thanks to the developers, Brandão and Witting for the vast amount of work put into the development process and to Allison and Punt for their extensive work developing the operating models and running the trials; and*
(4) ***agrees*** *that one focus of the next* Implementation Review *will be to examine further stock structure in relation to the two hypotheses being considered at present, should be consideration of the results of analyses of genetic data using additional samples from Canada (as well as the additional samples that will become available from West Greenland and Iceland); and*
(5) ***agree****s to establish an intersessional group to facilitate issues relating to samples.*

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[1]Editor's note: this was completed and no problems were detected.

2.3 North Pacific gray whales (Makah whaling)

2.3.1 Management plan proposed by the US for Makah whaling

The Makah Indian Tribe has requested that the US National Marine Fisheries Service (NMFS) authorises a tribal hunt for Eastern North Pacific gray whales in the coastal portion of its 'usual and accustomed fishing area'. The Tribe intends to hunt gray whales from the ENP population, which currently numbers approximately 27,000 animals (Durban *et. al.*, 2017). In the management plan, NMFS has taken measures to restrict the number of PCFG whales that are struck or landed in a given 10-year period and to avoid, to the extent possible, striking or killing a Western North Pacific gray whale. The US government has requested that the Committee test this plan to ensure that it meets IWC conservation objectives. An overview of the hunt management plan and how it was operationalised in the coding of the *SLA* trials is provided in Appendix 1 of SC/67b/Rep/07.

2.3.2 Review intersessional progress including at the Rangewide Workshop - SC/67b/Rep07

Donovan summarised the report of the Fifth Rangewide Workshop on the Status of North Pacific Gray Whales (SC/67b/Rep07rev1). The Workshop was held at the Granite Canyon Laboratory, California of the Southwest Fisheries Science Center from 28-31 March 2018. The primary tasks of the Workshop were to: (a) review the results of the modelling work identified at the Fourth Workshop (IWC, 2018a) and SC/67a (IWC, 2018b); (b) examine the new proposed Makah Management Plan (submitted by the USA – described above and illustrated in the Workshop report under Annex E, Appendix 1) for gray whaling off Washington state; and (c) to update as possible (and develop a workplan for) the scientific components of the Conservation Management Plan (CMP) for western gray whales.

The major focus of the Workshop related to finalising the specifications for modelling to enable results to be available for SC/67b. A new component included the need to incorporate the recently developed Makah Management Plan (SC/67b/Rep07, Annex E, Appendix 1) into the modelling framework; the Plan is somewhat complex and the Workshop focus was on understanding the intended process and ensuring that it was parameterised in an appropriate way. A further key area was finalising the stock structure hypotheses to be given priority. After a review, the Workshop concluded that Hypotheses 3a and 5a would form the reference cases but that sensitivity trials would be conducted for Hypotheses 3b, 3c, 3e and 6b. The full specifications for these hypotheses are provided in SC/67b/Rep07 (Annex E, Appendix 1 and Annex F).

In summary, Hypothesis 3a assumes that whilst two breeding stocks (Western and Eastern) may once have existed, the Western breeding stock (WBS) is extirpated. Whales show matrilineal fidelity to feeding grounds, and the Eastern breeding stock includes three feeding aggregations: PCFG (Pacific Coast Feeding Group), NFG (Northern Feeding Group) and WFG (Western Feeding Group). Hypothesis 5a assumes that both breeding stocks are extant and that the WBS feeds off both coasts of Japan and Korea and in the northern Okhotsk Sea west of the Kamchatka Peninsula. Whales feeding off Sakhalin include both whales that are part of the extant WBS and remain in the western North Pacific year-round, and whales that are part of the Eastern breeding stock and migrate between Sakhalin and the eastern North Pacific (the WFG).

Another important component of the trials relates to bycatch. Considerable effort was put into capturing the uncertainty in past and future estimates of bycatch mortality based upon the available data. The base case for trials was that observed deaths due to bycatch account for only 25% of the true incidental human caused mortality. This fraction was based on a study of bottlenose dolphin stranding data off the coast of California (Carretta *et al*. 2016). Trials were also considered with higher rates of cryptic mortality, including scenarios where observations represent only 5% of true incidental human caused mortality.

Abundance estimates for the eastern North Pacific and the PCFG had been approved by the Committee last year (IWC, 2017). New estimates of abundance for western gray whales were provided by Cooke (SC/67B/ASI/02), and correspond with the various stock structure hypotheses for the western feeding group (WFG), WBS and WST (WFG + WBS). These estimates were reviewed and adopted by the SWG on ASI (Annex Q). Modifications were also made to the mixing matrices in the rangewide model based on the new estimates.

Each stock structure hypothesis was combined with multiple assumptions about other factors (e.g. bycatch rates) and this led to the development of 53 'trials' (see Table 6 of SC/67b/Rep07). Each trial was based on 100 simulations that reflect uncertainty in the estimated parameters of the model. Projections thus lead to a very large amount of model output that needed to be distilled to address questions such as the conservation performance of the new management plan for Makah whaling with respect to the stocks in question (in particular, the PCFG and the WFG). The Rangewide Workshop identified several plots and 'performance statistics' to summarise results from each trial (see Section 4.4.5 of SC/67b/Rep07 and Appendix 4).

Brandon presented an update on the code validation for the model. The first phase of code validation was completed prior to Fifth Rangewide Workshop. That effort focused on the code implementing the operating model and the conditioning process. A summary, including a brief overview of the code and input files was provided to the Workshop (SC/M18/CMP03). Like the first phase, the second phase of code validation involved checking the code against the mathematical and statistical model specifications. The focus of this validation phase was on three aspects of the code: (1) future projections and the updated US management plan concerning strike and landing limits for Makah whaling; (2) input files for the factors considered across conditioning trials and; (3) processing results across simulations into relevant performance statistics. Code validation was completed prior to the presentation of model results to the SWG.

The sub-committee on CMP reviewed and approved the conditioning results in the context of the full rangewide review. The SWG reviewed the model results with a focus on conservation performance of the management plan for Makah whaling. To aid in this evaluation, bivariate plots were generated for the lower 5th percentiles of the D1 and D10 performance statistics. Trials for which the D1 statistic is less the 0.6 after 100 years (i.e. the stock is not above its MSYL) and the D10 statistic after 100 years is not larger than 1 (i.e. the stock is not increasing towards MSYL) represent a scenario under which the management plan would not be expected to meet the conservation objectives for ASW (this is denoted by the gray quadrant in Fig X of Appendix 6). Several trials were identified in this category, but they corresponded with scenarios that were considered to have the low plausibility (e.g. bycatch mortality of ~ 20 PCFG whales per year). The SWG **agreed** that the performance of the management plan for Makah whaling was adequate to meet the Commission's conservation objectives for the PCFG, WFG and northern feeding group gray whales in the context of the proposed Makah hunt.

2.3.3. Conclusions and recommendations

The SWG **agreed** that the newly proposed hunt management plan for the Makah Tribe's gray whale hunt meets the IWC conservation objectives for PCFG, WFG, and ENP gray whales (see Appendix 6). Similar to its recommendations regarding the hunt plan evaluated during the last *Implementation Review* (IWC, 2012; 2013), the new hunt management plan is dependent on photo-identification studies to estimate PCFG abundance and the mixing proportions of PCFG whales available to the hunt (and bycatch in its range). The SWG's conclusions are dependent on the assumption that these studies will continue in the future.

Attention: C-A, SC

The Committee was asked by the USA to review a US Management Plan for a Makah hunt of gray whales off Washington State (the Committee had evaluated a previous plan in 2011 - IWC, 2011; 2012). The Committee conducted this work using the modelling framework developed for its rangewide review of gray whales (SC/67b/Rep07). In conclusion, the Committee:

(1) ***agrees*** *that the performance of the Management Plan was adequate to meet the Commission's conservation objectives for the Pacific Coast Feeding Group, Western Feeding Group and Northern Feeding Group gray whales;*
(2) ***notes*** *that the proposed management plan is dependent on photo-identification studies to estimate PCFG abundance and the mixing proportions of PCFG whales available to the hunt (and to bycatch in its range);*
(3) ***stresses*** *that its conclusions are dependent on the assumption that these studies will continue in the future; and*
(4) ***expresses*** *its great thanks to Punt, Brandon and Allison for their excellent work in developing and validating the testing framework and running the trials.*

2.4 West Greenland bowhead whales

2.4.1 Review results using 400 replicates

Following a previous examination of the precision with which estimates of the 5th percentiles of the performance statistics could be obtained as the number of replicates was increased; an agreement was made that 400 simulations should be used to determine the performance of the selected *SLA* for West Greenland bowhead whales. SC/O17/AWMP03 had showed projection plots for the 5th percentile and the median of the 1+ population for the baseline evaluation trials for this *SLA* based on 400 simulations. For comparison purposes, the projections for the *SLA* under 100 simulations were also shown. These show substantial variability between estimates of the 5th percentile of the distribution of population size.

Wilberg presented an analysis (Appendix 7) based on bootstrapping that was used to determine the effect of the number of simulations on the precision of the estimates of the 5th percentile of several performance measures. Projections for the selected *SLA* for West Greenland bowhead whales showed substantial differences in estimates of the 5th percentile of abundance based on 100 and 400 simulations. With only 100 simulations, the confidence intervals of the 5th percentile were quite wide, but 400 simulations led to a substantial improvement in precision. The investigation concluded that continuing to use 400 trials for the simulations appears to be sufficient to estimate the lower 5th percentile with a reasonable amount of precision.

2.4.2 Testing the Interim Allowance strategy

The SWG noted that the interim relief strategy (see Item 3) has not been examined for this *SLA* yet and **agreed** that this should be added to the workplan.

2.4.3 Conclusions and recommendations

It was agreed that continuing to use 400 replicates for the simulations is sufficient to estimate the lower 5th percentile with adequate precision.

3. ABORIGINAL WHALING MANAGEMENT SCHEME (AWS)

The Scientific Committee's Aboriginal Whaling Management Procedure (AWMP) applies stock-specific *Strike Limit Algorithms* (*SLA*s) to provide advice on aboriginal subsistence whaling (ASW) strike/catch limits.

ASW management (as part of an AWS, the aboriginal whaling scheme) incorporates several components, several of which have a scientific component:

(a) *Strike Limit Algorithms* (case-specific) used to provide advice on safe catch/strike limits;
(b) operational rules (generic to the extent possible) including carryover provisions, block quotas and interim relief allocations;
(c) Guidelines for *Implementation Reviews*; and
(d) Guidelines for data and analysis (e.g. guidelines for surveys, other data needs).

3.1 Review intersessional work
In 2017, the Scientific Committee appointed an intersessional correspondence group (Givens (Chair), Allison, Donovan, George, Scordino, Stachowitsch, Suydam, Tiedemann, Witting) to develop draft text regarding the scientific aspects of an Aboriginal Whaling Scheme. The starting place was a previous version agreed by the Scientific Committee (IWC, 2003). Two key components of a new draft AWS were the interim relief allowance and carryover provisions. The report of this group is SC/67b/AWMP21.

Donovan summarised the results from the intersessional workshops on the AWS. In addition to continuation of discussions on the extensive work of the intersessional group under Givens (see above), the Governments of Denmark and the USA had requested advice on the conservation implications of provisions that:

> '…allow for the carry forward of unused strikes from the previous three blocks, subject to the limitation that the number of such carryover strikes used in any year does not exceed 50% of the annual strike limit'.

This request was tested using the *Bowhead SLA* (applicable to the Bering-Chukchi-Beaufort Seas stock) and the *WG-Humpback SLA* (applicable to West Greenland) and three types of options were examined:

(1) baseline case - all strikes taken annually (i.e. no need for carryover);
(2) 'frontload' case - strikes taken as quickly as possible within block (+50% limit annually until the block limit is reached); and
(3) two alternative scenarios where carryover strikes are accrued for one or three blocks, followed by a period of carryover usage subject to the +50% limit.

The three-block scenario considered in (3) served as a direct test of the provision described in the request of USA and Denmark/Greenland. The Committee agreed that the Commission's conservation objectives were met for both *SLA*s for all of the options above and would also be met for a proposal carrying forward strikes from the previous two blocks.

Attention: CG-A

The Committee received a request from the USA and Denmark/Greenland (SC/67b/Rep06, Annex F, appendix) on the conservation implications of carryover provisions that:

> *'…allow for the carry forward of unused strikes from the previous three blocks, subject to the limitation that the number of such carryover strikes used in any year does not exceed 50% of the annual strike limit'.*

The Committee reviewed the request using its simulation frameworks and the two SLA*s available for stocks hunted by the USA and Greenland available at the time of the Workshop i.e. the* Bowhead SLA *(applicable to the Bering-Chukchi-Beaufort Seas stock) and the* WG-Humpback SLA *(applicable to West Greenland) and*

(1) ***agrees*** *that a carryover provision for up to 3-blocks meets Commission's conservation objectives; and*

(2) ***reiterates*** *its previous advice, applicable for all* SLA*s, that interannual variation of 50% within a block with the same allowance from the last year of one block to the first year of the next is acceptable; and*

(3) ***agrees*** *to evaluate the above request for the other Greenland* SLA*s at the 2019 Committee meeting.*

3.2 Review proposed updates to the AWS
The SWG considered a proposed update to the previous AWS based upon the work of the intersessional correspondence group. It considers carryover, block quotas, interim relief allocation, *Implementation Reviews* and Guidelines for surveys and data. The agreed text can be found as Appendix 8.

3.3 Conclusions and recommendations
The SWG **recommends** the AWS provided in Appendix 8 to the Committee. It notes that the Commission's AWS may include additional, non-scientific provisions.

Attention: C-R

The Committee has been working for some years to update the scientific components of an Aboriginal Whaling Scheme. It has completed this work and recommends the AWS provided in Annex E, appendix 8 to the Commission. It has sections on carryover, block quotas, interim relief allocation (and see Annex E, appendix 7), Implementation Reviews and guidelines for surveys and data. It notes that the Commission's AWS may include additional, non-scientific provisions.

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4. *IMPLEMENTATION REVIEW* OF B-C-B BOWHEAD WHALES

From the Committee's Guidelines (*JCRM* 14 (*Suppl.*): 170-1), the primary objectives of an *Implementation Review* are to:

(1) review the available information (including biological data, abundance estimates and data relevant to stock structure issues) to ascertain whether the present situation is as expected (i.e. within the space tested during the development of a *Strike Limit Algorithm* (*SLA*)) and determine whether new simulation trials are required to ensure that the *SLA* still meets the Commission's objectives; and

(2) to review information required for the *SLA*, i.e. catch data and, when available at the time of the *Review*, new abundance estimates (note that this can also occur outside an *Implementation Review* at an Annual Meeting).

The *Bowhead SLA* was adopted in 2002 (*JCRM* 5 (*Suppl.*): 158) and there was an extensive *Implementation Review* completed in 2007 (*JCRM* 10 (*Suppl.*): 124) with a major focus on stock structure including three intersessional workshops. That included consideration of additional trials investigating management implications of assuming additional population structure even though these were considered of low plausibility. The Committee concluded that the *Bowhead SLA* remained the best tool to provide management advice. The next *Implementation Review* was completed in 2012 (*JCRM* 14 (*Suppl.*): 147); that concluded that there was no need to develop additional trials to those evaluated during the previous *Implementation Review* (IWC, 2008b).

In Committee discussions last year (IWC, 2018), it was agreed that at that time, there was no information that suggested that the situation for this stock was outside the tested parameter space. Given that, the Committee had agreed that it should be possible to complete the *Implementation Review* at the 2018 Annual Meeting. It established a Steering Group (Suydam [Convenor], Donovan, George) to prepare for the *Review* and Donovan confirmed that the Data Availability deadlines were met and that papers on the necessary topics were submitted. Donovan thanked the US colleagues for the extremely hard work that they have put in to providing the SWG with papers to facilitate this review.

Discussions within the SWG benefitted from the discussions within two other sub-committees, SD-DNA (Annex I) and ASI (Annex Q) and, as relevant, conclusions from those groups are briefly summarised under the agenda items below.

4.1 Stock structure: review new information

The Working Group on SD-DNA provided a summary of their discussions relevant to the *Implementation Review*. Genetic analyses (SC/67b/SDDNA01) confirmed that B-C-B bowheads and bowheads in the Sea of Okhotsk constitute two distinct stocks. There may be some weak distinction between B-C-B and EC-WG bowheads, but the majority of the evidence found no significant difference between these two populations. There is one known instance of interchange (from east to west), and one set of overlapping telemetry tracks, although those two whales returned to the populations from which they came. SC/67b/AWMP04 presented data from 64 satellite tagged whales, all but one of which followed the well-known counter-clockwise Bering-Beaufort-Chukchi circuit. The unusual track corresponded to a whale tagged in Utqiaġvik(Barrow) in autumn that migrated to the north coast of Chukotka the following spring, rather than swimming east into the Beaufort Sea. Considering the multiple lines of evidence as a whole, the Working Group on SDDNA had concluded that B-C-B bowheads constituted a single population, with no signs of substructure.

The SWG welcomed this information and thanked the hunters for their skill in making the tagging efforts efficient and successful. It **encouraged** continuation of these tagging studies. The SWG **agreed** that there was no need to consider any new *SLA* trials regarding stock structure, since the trials conducted in 2002 and 2007 already covered all plausible stock structure hypotheses.

Attention: SC

With respect to stock structure, considering the multiple lines of evidence, the Committee:

(1) agrees that BCB bowheads comprise a single population, with no signs of substructure;
(2) agrees that there was no need to consider any new SLA trials regarding stock structure, since the trials conducted in 2002 and 2007 already covered all plausible stock structure hypotheses;
(3) welcomes the telemetry information provided, thanks the hunters involved for their skill and assistance;
(4) encourages additional telemetry efforts; and
(5) agrees with the suggestions for future genetic studies in the Arctic provided under Item 11.

4.2 Abundance estimates: review new information

The Working Group on ASI (Annex Q) received new information about the 2011 B-C-B bowhead abundance from a long-term photo-identification capture-recapture study (SC/67b/AWMP01rev1). The estimated 1+ abundance was 27,133 (CV=0.217; 95% CI from 17,809 to 41,337). They concluded that this estimate could be classified as having been examined in detail and found to be suitable for providing management advice and for use in the *SLA*.

The SWG **welcomed** this information and noted that there was a completely independent 2011 abundance estimate from an ice-based survey (Givens *et al.*, 2016). This estimate is 16,820 (CV=0.052; 95% CI 15,176 to 18,643). It is not surprising that these two estimates differ because - in addition to random variability - the ice-based estimate does not count whales that are spatially or temporally excluded from the survey, whereas the photo-id dataset is more likely to contain false negative matches than false positive matches and this imbalance will tend to inflate the resulting abundance estimate.

There are thus two independent estimates for the same year considered suitable for use in the *SLA* (the ice-based estimate is already used). Discussion on how to consider such circumstances is provided under Items 3 and 5.

The Working Group on ASI (Annex Q) also received two reports on future B-C-B bowhead survey plans (SC/67b/AWMP12 and SC/67b/AWMP16). The first is for an ice-based survey in spring 2019, following methods used in earlier such surveys but not including an acoustic component. The availability of bowhead whales will be estimated from past acoustic data, as has been done with previously accepted estimates. The second survey is an August 2019 aerial line transect survey of unprecedented scope for B-C-B bowheads, covering the eastern edge of the Chukchi Sea and the entire Beaufort Sea (including Canadian waters) with most transects extending to the 200 m isobaths and some to the 2,000m isobaths. Detailed plans for the latter survey were presented in SC/67b/AWMP16, and were thoroughly discussed by the Working Group on ASI (see Annex Q).

The SWG thanked the authors for these papers, noting that their presentation is an accord with the AWS Guidelines (see Item 3) that 'plans for undertaking a survey/census should be submitted to the Scientific Committee in advance of their being carried out, although prior approval by the Committee is not required. This should normally be at the Annual Meeting before the survey/census is carried out'.

The SWG noted that the degree of precision to be achieved by the 2019 aerial survey is unknown and may be lower than for some other recent abundance estimates. The *Bowhead Evaluation and Robustness Trials* mainly specified CVs of 0.25 or less. If the new CV turns out to be higher than this, additional trials may be required at the next *Implementation Review*.

4.3 Biological parameters: review new information

The SWG received new information about length at sexual maturity and pregnancy rate (SC/67b/AWMP07). Studies of bowhead reproduction have been conducted by the North Slope Borough Department of Wildlife Management (Alaska) over the past 35 years, with the co-operation of Alaska Native hunters. Although low calf counts and few pregnant harvested females were a concern at the inception of the programme, the situation has improved markedly since then. For SC/67b/AWMP07, pregnancy rates were estimated from examinations of reproductively mature bowhead whales (*n*=208) landed during the Alaska Native subsistence harvest from 1976-2016. The estimated pregnancy rate was 0.317 (95% CI 0.251 to 0.385). This suggests an inter-birth interval of just over 3 years. Whales harvested in the autumn at Utqiaġvik (Barrow) and Kaktovik comprise the most reliable pregnancy dataset because pregnancies are easier to detect and whales are more carefully examined. From this restricted dataset (*n*=33), the pregnancy rate is estimated to be 0.394 (95% CI 0.211 to 0.553); which the authors considered is at the high end of what is plausible for this species.

Logistic regression was used to estimate length at maturity from a separate dataset (*n*=150) that included whale lengths. Length at maturity was defined, relative to an equally balanced set of mature and immature whales, as the length at which the estimated probability of maturity equals 0.5. Since the actual dataset is neither balanced nor representative, the authors introduced a correction calculation. The resulting length at maturity is estimated to be 13.65m (95% CI 13.29 to 13.94). The authors recognised that their data could be biased by sampling from harvested animals where hunter selectivity occurs and by the approximately 14-month gestation period of bowheads. The estimates are consistent with past investigations and suggest a reproductively robust population. The finding that pregnancy rates are stable or possibly increasing over the past 40 years is also consistent with the increase in population abundance seen over the same time span. Finally, the authors believe that there is no evidence in the reproductive data of density-regulated reproduction or the population approaching carrying capacity.

In discussion, the SWG noted that selectivity patterns in the bowhead harvest make some types of inference from such data difficult. In particular, there are several factors that may affect the determination of pregnancy rate and trends in pregnancy rate. The SWG concluded that it was not possible therefore, to conclude that there had been a long-term increase in pregnancy rate despite the statistically significant positive trend reported in the paper; the authors concurred. However, the SWG noted that the length-at-maturity analysis was specifically corrected for age selectivity in hunting so such concerns do not arise in that analysis.

The SWG welcomed information about the potential use of samples from baleen plates to examine hormone cycles and pregnancy. Since baleen provides up to 20 years of record, it may be possible to correlate reproductive information with other variables such as environmental factors. The SWG **encouraged** future work on this subject.

SC/67b/AWMP03 summarised sightings of bowhead whale calves in the western Beaufort Sea during July-October, 2012-17, from the Aerial Surveys of Arctic Marine Mammals (ASAMM) project. Overall, 76% of the calves recorded were first sighted only after the aircraft broke from the transect line to circle an adult whale sighting. Calves were detected during all months, although more calves were detected in autumn (September-October, 245 calves) than summer (July-August, 160 calves). Total number of calves sighted per year ranged from 22 in 2012 to 155 in 2017. The highest calf ratio (number of calves/number of whales) and sighting rate (number of calves/km of effort) occurred in 2017, although 2013 and 2016 were also high. Preliminary analysis of photo- identification data suggests that it is rare to see an individual calf more than once in a given year.

The SWG welcomed this information, recognising that that it relates to successful pregnancies and, if it can be collected and analysed to provide a calving rate/index representative of the population, can provide valuable information for future *Implementation Reviews*. In discussion, it was also noted that the ASAMM aerial survey data could potentially be useful as an independent index of calf production for comparative purposes with the pregnancy rates presented in SC/67b/AWMP07. The SWG **encouraged** the continuation of the ASAMM surveys and any future collaboration involving life history data from the harvest.

Attention: SC

With respect to biological parameter information, the Committee:

(1) welcomes the extensive information presented;
(2) encourages the continued collection of such data from the hunt;
(3) encourages the work on the baleen plate analyses to examine hormone levels and pregnancy;
(4) encourages continued aerial surveys under the ASAMM surveys and any future collaboration involving life history data from the harvest; and
(5) agrees that the information presented does not suggest the need to consider any new SLA trials regarding stock structure.

4.4 Removals: review new information

The SWG received updated information about the 2017 harvest (SC/67b/AWMP05) and long-term removals (SC/67b/AWMP06). The authors of SC/67b/AWMP05 reported that in 2017, 57 bowhead whales were struck resulting in 50 animals landed. The total landed for the hunt in 2017 was higher than the average over the past 10 years (2007-16 mean of landed=41.7; SD=6.7). Efficiency (no. landed/no. struck) in 2017 was 88%, which was also higher than the average for the past 10 years (mean of efficiency=75.2%; SD=6.5%). Of the landed whales, 28 were females and 22 were males. Based on total length (>13.4m in length) or pregnancy, 13 females were presumed mature. Six of those animals were examined and two were pregnant, one with a term foetus and another with a mid-term foetus, and one female was lactating. The fact that one third of the mature females were pregnant is consistent with past years.

SC/67b/AWMP06 provided a summary of bowhead whale catches in Alaska between 1974 and 2016. The authors pointed to the excellent cooperation and contribution of the whale hunters from the 11 villages that are members of the Alaska Eskimo Whaling Commission (AEWC). In total, 1,373 whales were landed. Over half (700) were landed in Barrow, while Shaktoolik and Little Diomede landed only one and two whales, respectively. Five of the 11 villages hunt only in the spring, two hunt only in the autumn whilst the remaining four have landed bowhead whales in both the spring and autumn/winter. Three of those villages (Gambell, Savoonga, and Wainwright) used to primarily hunt in the spring, but they now also hunt in the autumn or winter because changing ice conditions have made hunting more difficult in the spring. The efficiency of the hunt has improved over time. In the late 1970s, the efficiency averaged about 50% - because of improved hunting gear, communication, training and other factors, the efficiency now averages about 80%. Kaktovik and Nuiqsut hunt in the autumn in open water conditions and rarely have struck and lost whales. Some villages (Gambell, Savoonga, and Wainwright) on average land longer whales than others (Barrow and Point Hope). The length of landed whales within a season is correlated with the timing of the hunt. During spring, shorter whales tend to be landed earlier in the season while larger whales tend to be landed later. The opposite occurs in the autumn when larger whales tend to be landed earlier. The sex ratio of landed whales is even.

From 2013 to 2017, four bowhead whales (2 females and 2 males) were harvested near Chukotka, mainly in Anadyr Bay (SC/67b/AWMP20). The average length was 14.5m (minimum 13.0m, maximum 17.0m). Although the portion of the annual strike limit allocated to Russia under their bilateral agreement with the USA is five animals, the actual annual take is usually only 1-2 whales per year, and this has been the case since at least 2004.

The SWG thanked the authors of the provision of this information; catch and strike data are used in the *SLA* calculations (see Item 5.)

4.5 Other anthropogenic threats and health: review new information

New information about detection of carcasses in the eastern Chukchi and western Beaufort seas from the ASAMM project (2009-17, see summary under Item 3 above) was reported in SC/67b/AWMP02. A total of 27 bowhead whale carcasses (21 in the eastern Chukchi Sea) was detected, most in September but with the highest sighting rate in October. Survey effort does not account for the difference between the eastern Chukchi and western Beaufort study areas. A total of six carcasses, including all three of the calf/yearling carcasses sighted, showed signs of killer whale injuries; knowledge of killer whale behaviour and the location of the injuries on the whales, suggested to the authors that killer whale predation not scavenging was the cause of death. One carcass, with subsistence hunting gear (i.e., a line and float) attached, was observed in late October 2015. There were two struck and lost whales reported from about that same time; one at Barrow in late September and one in Wainwright in mid-October. Both of those whales were reported by the whaling captains to have likely died.

SC/67b/AWMP08 reported that during 2017, around 14% of landed whales carried injuries from line entanglement but none had ship strike injuries (consistent with 1990-2012 baselines). Two whales landed at Utqiaġvik (Barrow) in spring

2017 were carrying line associated with pot gear and had severe entanglement injuries such that veterinarians and the attending hunters thought that they were dying when captured.

The SWG **agreed** that whilst the present level of unintentional human induced mortality is too low to require new *Implementation* trials or incorporation into the *SLA* calculations, the situation should continue to be monitored and evaluated at the next *Implementation Review*. The SWG **welcomed** information that discussions between the AEWC and the Bering Sea Crabbers Association were ongoing, with the goal of limiting or reducing bowhead mortality attributable to their fishing gear.

The SWG **agreed** with the authors that the carcasses with killer whale injuries were probably a result of predation not scavenging. George expressed his opinion that killer whale/bowhead interactions have increased in the NE Chukchi Sea over the past 40 years. While beachcast gray whale calves killed by killer whales are commonly observed in Alaska along the NE Chukchi coast, dead bowhead calves (or subadults) were first seen only three years ago. There has also been an increase in observations of killer whale predation from ASAMM surveys and from hunters. In fact, a bowhead calf, probably killed by killer whales, was recovered by hunters northeast of Barrow; such a recovery has not happened before in the memory of native Alaskan hunters.

SC/67b/AWMP08 provided a comprehensive review of B-C-B bowhead health. The authors first noted that the strong, steady rate of population increase and the recent estimate of survival rate are possibly the best indicators that this population is healthy. A body condition index has shown a significant increase (fatter whales) over the period 1990-2012 but there is some evidence it has slowed or reduced in the last five years. This may reflect a density dependent effect of a population nearing carrying capacity, but further analysis is required. Post-mortem analyses indicate that whales caught in the spring migration are generally not feeding, while most (75-100%) in the autumn are. This is consistent with past findings and suggests that bowhead whale feeding habitat remains viable and productive.

General health information on landed bowhead whales was obtained from several major retrospective screening survey studies and from pathological analysis of 2017 post-mortem examinations. Key findings included: (i) declining body burden trend (blubber and muscle) in organic pollutants; (ii) limited detection of anthropogenic radionuclides (low levels in muscle); (iii) continued absence of major pathogens that could impact health; (iv) interannual variation of *Giardia* spp. with some suggestion of environmental marine contamination with human faeces; and (v) variable presence of marine biotoxins in faeces suggesting complex environmental drivers of harmful algae blooms in the Arctic. Pathological findings in 2017 were consistent with previous years e.g.: (i) low prevalence of fatty benign tumors in livers and gastric nodules associated with anisakis infection; and (ii) presence of kidney worm infection. Further work is underway on species characterisation of kidney worm specimens. The authors suggest that Arctic climate change (e.g., diminishing sea ice, increased sea surface temperature, opening of the Northwest Passage, range overlap with seasonal southern baleen whale migrants known to carry kidney worms, and prey shifts) may be setting the stage for an evolving host-parasite relationship in B-C-B bowhead whale stock.

The SWG **thanked** the authors for this valuable summary and **agreed** that nothing in the health analyses was cause for concern with respect to the continued application of the *Bowhead SLA*.

Attention: SC

With respect to threats and health to the B-C-B bowhead whales, the Committee:

(1) ***welcomes*** *the extensive information presented;*
(2) ***agrees*** *that whilst the present level of unintentional human induced mortality is too low to require new* Implementation *trials or incorporation into the* SLA *calculations, the situation should continue to be monitored and evaluated at the next* Implementation Review*;*
(3) ***agrees*** *that the health analyses give no cause for concern with respect to the continued application of the* Bowhead SLA*; and*
(4) ***encourages*** *that the excellent work on health-related issues continues.*

4.6 Conclusions and recommendations (and, if needed, workplan to complete *Review*)

The SWG **concluded** that no additional work was required to complete the *Implementation Review*. It further **concluded** that the range of hypotheses and parameter space already tested in *Bowhead SLA* trials was sufficient and therefore the *Bowhead SLA* could continue to be **recommended** to the Commission as the best way to provide management advice. This advice is presented under Item 5.3.

Attention: SC

With respect to the Implementation Review *of B-C-B bowhead whales, the Committee* ***concludes*** *that:*

(1) the Implementation Review *has been satisfactorily completed; and*
(2) the range of hypotheses and parameter space already tested in Bowhead SLA *trials was sufficient and therefore the* Bowhead SLA *remains the best way to provide management advice for this stock;*

In addition, it thanks the US scientists for the extremely hard work that they have put into providing comprehensive papers to facilitate this review

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5. STOCKS SUBJECT TO ASW (NEW INFORMATION AND MANAGEMENT ADVICE)

The SWG noted that the Commission will be setting new catch/strike limits for at its 2018 biennial meeting in Brazil. It had received written or verbal requests for limits to be considered for each hunt as discussed below.

In addition, there had been a general request to the intersessional workshop from the USA and Denmark (SC/67b/Rep06, annex F, appendix) for advice on whether there would be a conservation issue if there was a one-time seven-year block followed by a return to six-year blocks to address logistical issues from a Commission perspective. The SWG **agreed** with the intersessional workshop that there are no conservation issues associated with this suggestion (and see the block quota section of the ASW Appendix).

5.1 Eastern Canada/West Greenland bowhead whales

5.1.1 New abundance information

Last year, the SWG had recommended that Canadian scientists attend the Committee to present the results of their work on abundance. It was very pleased that Doniol-Valcroze from Department of Fisheries and Oceans Canada and the primary author of the paper on aerial survey abundance estimate was present at the meeting.

The two relevant papers were first discussed by the Standing Working Group on ASI (see Annex Q for details). Doniol-Valcroze *et al.* (2015) provided a fully corrected estimate from the 2013 aerial survey of 6,446 bowheads (CV=0.26, 95% CI 3,722-11,200). The survey covered the major summering area for the Eastern Canada/West Greenland stock. The Working Group on ASI agreed that this was acceptable for management advice and for use within the AWMP. The other paper (ref) contained a genetic mark-recapture estimate that was considered preliminary at this stage.

The SWG **welcomed** this information and recalled that the *WG-Bowhead SLA* had been developed on the conservative assumption that the abundance estimates for the West Greenland area alone (1,274 whales in 2012 (CV=0.12)) represented the abundance of the whole stock, as it believed that it was not possible to assume that a non-member country would continue with regular surveys. Doniol-Valcroze advised the SWG that the present management strategy of Canada does involve obtaining regular abundance estimates. The SWG noted it would be pleased to receive such estimates from Canada being presented to the Committee in the future.

The SWG **welcomed** this information. It **agreed** that consideration of how to incorporate abundance estimates from Canada should be one focus of the next *Implementation Review.* It noted the regular collaboration of Canadian and Greenlandic scientists on other matters such as genetic sampling (*inter alia* for mark-recapture abundance estimation). It **encouraged** further collaboration between Canada, Greenland and the USA for the study of bowhead whales across their range and the presentation of these results at future Committee meetings.

In this regard, Witting reported that Greenland continues its biopsy sampling programme, with 60 biopsy samples collected in 2017. Bickham noted that many SNPs had been developed for B-C-B bowheads (SC/67b/SDDNA01) and that it would be productive for the same markers to be analysed for the Canadian samples since between-lab calibration is straightforward for SNPs and the increased statistical power would improve stock structure analyses, e.g. the ability to identify individual whales could provide information relevant to mixing proportions between areas.

5.1.2 New catch information

SC/67b/AWMP10 provided an update of recent Canadian takes made in the Inuit subsistence harvest of EC-WG bowhead whales. In the eastern Canadian Arctic, the maximum take is 7 bowhead whales per year according to domestic policy, with no carry-over of unused takes between years. Since 2015, five strikes were taken and four bowhead whales were successfully landed (one in 2015, two in 2016 and one in 2017).

The SWG **thanked** Canada for regularly providing catch information. It noted that the reported number of strikes was within the parameter space that was tested for the *WG-Bowhead SLA* and **encouraged** the continued collection of genetic samples from harvested whales.

Witting reported that West Greenland hunters struck no bowheads in 2017. There was one whale of 14.7m in length that died from entanglement in crab gear.

5.1.3 Management advice

SC/67b/AWMP19 reported Greenland's plans for requesting aboriginal whaling provisions at IWC/67 and no changes were requested for bowhead whales.

The SWG **agreed** that the *WG Bowhead SLA* remains the best available ways for management advice, and noted that this *SLA* had been developed under the conservative assumption that the number of bowhead whales estimated off West Greenland represented the total abundance between West Greenland and Eastern Canada. Based on the agreed 2012 estimate of abundance for West Greenland (1,274, CV=0.12), the catch of one whale in Canada in 2017, and using the agreed *WG-Bowhead SLA*, the SWG **repeated its advice** that an annual strike limit of two whales will not harm the stock and meets the Commissions conservation objectives.

Although the SWG had not yet had time to examine the request from the US/Denmark (SC/67b/Rep06, Annex F, appendix) for this *SLA,* it **agreed,** based on *WG-bowhead SLA* testing thus far, that its previous advice that the interannual variation of 50% within a block with the same allowance from the last year of one block to the first year of the next was acceptable.

Attention: C-A

A general request had been received from the USA and Denmark (SC/67b/Rep06, annex F, appendix) for advice on whether there would be a conservation issue if there was a one-time 7-year block followed by a return to 6-year blocks to address logistical issues related to the Commission.

The Committee ***agrees*** *there are no conservation issues associated with this suggestion (and see the block quota section of the ASW in Annex E, appendix 8).*

Attention: SC

The Committee greatly appreciated the presence of a Canadian scientist at its meeting. The Committee:

(1) ***welcomes*** *the provision of the abundance estimate for the Eastern Canada/West Greenland stock and (see Item 8.1.2) the regular provision of information on catch data by Canada;*
(2) ***welcomes*** *the attendance of Canadian scientists at its meetings;*
(3) ***agrees*** *that consideration of how to incorporate abundance estimates from Canada should be one focus of the next* Implementation Review *for this stock;*
(4) ***notes*** *the regular collaboration of Canadian and Greenlandic scientists on other matters such as genetic sampling (inter alia for mark-recapture abundance estimation); and*
(5) ***encourages*** *further collaboration between Canada, Greenland and the USA for the study of bowhead whales across their range and the presentation of these results at future Committee meetings.*

Attention: C-A
SC/67b/AWMP19 reported Greenland's plans for requesting aboriginal whaling provisions at IWC67 and no changes were requested for bowhead whales. The Committee therefore:
(1) ***agrees*** *that the* WG-Bowhead SLA *remains the best available way to provide management advice for the Greenland hunt;*
(2) ***notes*** *that this SLA had been developed under the conservative assumption that the number of bowhead whales estimated off West Greenland represented the total abundance between West Greenland and Eastern Canada;*
(3) based on the agreed 2012 estimate of abundance for West Greenland (1,274, CV=0.12), the catch of one whale in Canada in 2017, and using the agreed WG-Bowhead SLA*,* ***agrees*** *that an annual strike limit of two whales will not harm the stock and meets the Commissions conservation objectives; and*
(4) although the Committee has not yet had time to examine the request from the US/Denmark (SC/67b/Rep06, annex F, appendix) for the WG-Bowhead SLA*, reiterates its advice, applicable for all SLAs, that interannual variation of 50% within a block with the same allowance from the last year of one block to the first year of the next, is acceptable.*

5.2 North Pacific gray whales
The Russian Federation (SC/67b/AWMP17) had requested advice on the following provision:

> 'For the **seven** years 2019, 2020, 2021, 2022, 2023, 2024 and 2025, the number of gray whales taken in accordance with this sub-paragraph shall not exceed 980 (i.e. 140 per annum on average) provided that the number of gray whales taken in any one of the years 2019, 2020, 2021, 2022, 2023, 2024 and 2025 shall not exceed 140.'

5.2.1 New information (including catch data)
SC/67b/AWMP20 presented a comparison of gray whale catch data off Chukotka during: (i) the Soviet era (i.e. data from the catcher boat *Zvezdny*, from 1969-91); with (ii) recent data from 2013-17. The average length and weight of harvested whales in recent years is smaller than it was during the Soviet era. This discrepancy could be due to a difference in the selectivity patterns between the Soviet era industrial-sized catcher boat and the small boats used by native Chukotkans. The average annual number of whales was also higher during the Soviet era (150 *vs* 123). The annual biomass of removals in recent years is estimated to be one-third of that during the Soviet era. In recent years, most whales have been taken by the eastern and northeastern settlements of the Chukchi Peninsula – in the Bering Strait and east Chukchi Sea. Authors speculated that more mature whales migrate to the Arctic via the Bering Strait compared to those remaining in Anadyr Bay. Whales caught on Chukotka's Arctic coast were found to be statistically larger with a higher fat index than whales harvested on the eastern coast. Considering the 11% rise of native population in Chukotka since 2010 and also considering the drop in acquired whaling products comparing to 1980s-1990s, the authors concluded that the subsistence need of indigenous people is not satisfied.

Zharikov presented results of the 2017 whaling season in Chukotka. A total of 119 gray whales were struck in 2017 (37 males and 82 females). No whales were struck and lost, and no stinky (inedible) gray whales were taken. Similar whaling methods were employed as in recent years and the overall efficiency of the hunt was almost same as in 2016. It was noted that whale products are a large part of the local diet; there is also exchange with inland aborigines and use for non-nutritional purposes. A total of 615 gray whales have been taken in 2013-17 (SC/67b/AWMP17). Therefore only 105 strikes remain for 2018 under the current block quota, while the average annual take in recent years is 123 whales. The *SLA* trials performed in 2017 at the request of the Government of the Russian Federation (IWC, 2018) showed that a take of up to 136 whales per year by indigenous people of Chukotka will not harm the population. He noted that a possible overrun of 2013-18 quota by Chukotka native whalers was within this catch level and believed that such needs should be taken into account in the near future.

SC/67b/AWMP17 presented proposed text by the Russian Federation for amendments to Paragraph 13(b)(2) of the Schedule for gray whales. It was noted that a specific native diet has been documented. The consumption of relatively high amounts of proteins and fats is a necessary component of health and longevity in the native population of Chukotka. The importance of aboriginal whaling to the social, cultural and economic structure of Chukotka's coastal villages was also noted. Under the current block quota, the annual strike limit is 140 per year (including any strikes allocated to the Makah tribe). The proposed amendments would extend the duration of this block quota from six to seven years. Under the proposed seven-year block quota, the total number of strikes would be increased to 980 (140x7yrs). This provision would continue to be reviewed biannually by the Commission in light of the annual advice of the Scientific Committee.

5.2.2 Management advice

The SWG **agreed** that the *Gray Whale SLA* remains the best available way for management advice for this stock. It **advised** that an average annual strike limit of 140 whales will not harm the stock and meets the Commission's conservation objectives. It also noted that its previous advice that the interannual variation of 50% within a block with the same allowance from the last year of one block to the first year of the next was acceptable. It also **advised** that the Makah Management Plan (Item 2.3) is in accord with the Commission's management objectives.

Attention: SC

In reviewing the results of new genetic analyses of gray whales in the North Pacific, the Committee ***agrees*** *that the genetic and photographic data for this species be combined to better assess stock structure-related questions. Given the potential for genomic data to aid in better evaluating the stock structure hypotheses currently under consideration for North Pacific gray whales, the Committee* ***encourages*** *the continuation of work to produce additional genomic data from sampled gray whales.*

Attention: C-A

The Russian Federation (SC/67b/AWMP/17) had requested advice on the following provision:

> *'For the seven years 2019, 2020, 2021, 2022, 2023, 2024 and 2025, the number of gray whales taken in accordance with this sub-paragraph shall not exceed 980 (i.e. 140 per annum on average) provided that the number of gray whales taken in any one of the years 2019, 2020, 2021, 2022, 2023, 2024 and 2025 shall not exceed 140.'*

The Committee therefore:

(1) ***agrees*** *that the* Gray Whale SLA *remains the best available way to provide management advice for the gray whale hunts;*
(2) ***advises*** *that an average annual strike limit of 140 whales will not harm the stock and meets the Commission's conservation objectives;*
(3) ***notes*** *that its previous advice that the interannual variation of 50% within a block with the same allowance from the last year of one block to the first year of the next remains acceptable;*
(4) ***advises*** *that the Makah Management Plan (see Item 2.3) also is in accord with the Commission's management objectives.*

5.3 Bering-Chukchi-Beaufort Seas bowhead whale

5.3.1 New information

New information was considered as part of the *Implementation Review* discussed under Item 4.

The USA had indicated that it was proposing no changes to the present catch/strike limits although it may suggest changes to its carryover request in light of the advice received by the Committee as discussed at the intersessional Workshop (SC/67b/Rep06).

The SWG noted that there are now two independent estimates of abundance for this stock in 2011 (see Item 4). Recognising the need to formally consider the general question of how best to combine estimates in such cases as part of the workplan in the next biennium, the SWG noted that if they are combined as a weighted average by the inverse of their variances, there is little difference (it is slightly higher) between the combined estimate and that from the ice-based census estimate that is the approach used to obtain the other estimates used in the *SLA*. It therefore **agreed** to use the ice-based census estimate for 2011 survey (Givens *et al.*, 2016; 16,820, CV=0.052, 95% CI 15,176 to 18,643) as the most recent estimate of abundance for use in the *Bowhead SLA* this year.

5.3.2 Management advice
The SWG **agreed** that the *Bowhead SLA* remains the best available way for management advice for this stock. It **advised** that a continuation of the present average annual strike limit of 67 whales will not harm the stock and meets the Commission's conservation objectives.

The SWG also **advised** that provisions allowing for the carry forward of unused strikes from the previous three blocks, subject to the limitation that the number of such carryover strikes used in any year does not exceed 50% of the annual strike limit' has no conservation implications (see SC/67b/Rep04).

Attention: C-A

The USA indicated that it requested advice on the existing catch/strike limits. The Committee therefore:

(1) ***agrees*** *that the* Bowhead Whale SLA *remains the best available way to provide management advice for this stock;*
(2) ***advises*** *that a continuation of the present average annual strike limit of 67 whales will not harm the stock and meets the Commission's conservation objectives; and*
(3) ***advises*** *that provisions allowing for the carry forward of unused strikes from the previous three blocks, subject to the limitation that the number of such carryover strikes used in any year does not exceed 50% of the annual strike limit, has no conservation implications (see SC/67b/Rep04).*

5.4 Common minke whales off East Greenland
SC/67b/AWMP19 reported Greenland's plans for requesting aboriginal whaling provisions at IWC/67. It requested advice on an annual take of 20 animals (it had previously been 12).

5.4.1 New information on catches
In the 2017 season, 9 common minke whales were landed in East Greenland, and one was struck and lost. Three of the landed whales were males, 6 were females, and genetic samples were obtained from 8 of the landed whales. One common minke whale died from entanglement in fishing gear. The SWG **encouraged** the continued collection of genetic samples and collaborative studies (see Item 5.1.1).

5.4.2 New information on abundance
The Working Group on ASI endorsed the 2015 aerial survey abundance estimate of 2,762 (CV=0.47; 95%CI 1,160-6,574). This is only a small part of the wider Western and Central stocks.

5.4.2 Management advice
The SWG noted that in the past its advice for the East Greenland hunt had been based upon the fact that the catch was a small proportion of the number of animals in the Central Stock. During the process to develop an *SLA* for common minke whales off West Greenland produced a simulation framework that produces a considerably more rigorous way to provide advice for this hunt, taking into account stock structure issues. In addition, there is for the first time a separate estimate of abundance for common minke whales off East Greenland alone (this is only a small part of the wider western and Central stocks from which the catches can be drawn). The results of the simulation trials that incorporated a continuing catch of 20 whales from East Greenland led to no conservation concerns (see Appendix 4). The SWG noted that a formal *SLA* for this hunt should be developed in the future.

Given the above information, the SWG **advised** that an annual strike limit of 20 whales for the next block will not harm the stock and meets the Commission's conservation objectives.

In response to a request for advice on the length of the season for the common minke whale hunts in SC/67b/AWMP19, the SWG **agreed** that changing the length of the season to 12 months had no conservation implications.

Attention: C-A

SC/67b/AWMP19 reported Greenland's plans for requesting aboriginal whaling provisions at IWC67. It requested advice on an annual take of 20 animals (it had previously been 12). It had also requested advice on any conservation implications of a 12-month hunting season for common minke whales.

The Committee therefore:

(1) ***notes*** *that in the past its advice for the East Greenland hunt had been based upon the fact that the catch was a small proportion of the number of animals in the Central Stock;*
(2) ***notes*** *the process to develop an* SLA *for common minke whales off West Greenland resulted in a simulation framework that produces a considerably more rigorous way to provide advice for this hunt than before, by taking into account stock structure issues;*
(3) ***notes*** *that the results of the simulation trials that incorporated a continuing catch of 20 whales from East Greenland gave rise to no conservation concerns;*
(4) ***notes*** *that the 2015 aerial survey abundance estimate of 2,762 (CV=0.47; 95%CI 1,160-6,574) is only a small part of the wider western and central stocks;*

(5) ***advises** that a continuation of the present average annual strike limit of 20 whales will not harm the stock and meets the Commission's conservation objectives;*
(6) ***advises** that changing the length of the season to 12 months had no conservation implications; and*
(7) ***agrees** that an* SLA *should be developed for this hunt in the future; and*
(8) ***encourages** the continued collection of samples for collaborative genetic analyses (and see Item 7.1.2.3).*

5.5 Common minke whales off West Greenland
SC/67b/AWMP19 reported Greenland's plans for requesting aboriginal whaling provisions at IWC/67. It requested advice on annual strikes of 164 animals (i.e. no change).

5.5.1 New information on catches
In the 2017 season, 129 common minke whales were landed in West Greenland and four were struck and lost. Of the landed whales, there were 95 females, 33 males and one of unknown sex. Genetic samples were obtained from 104 of these common minke whales in 2017, and the SWG was pleased to note that samples were already part of the data used in the genetic analyses of common minke whales in the North Atlantic. The SWG **encouraged** the continued collection of samples and the collaborative approach of the genetic analysis.

5.5.2 New information on abundance
The Working Group on ASI endorsed the 2015 aerial survey abundance estimate of 5,095 (CV=0.46; 95%CI 2,171-11,961) as discussed in Annex Q.

5.5.3 Management advice
The SWG **agreed** that the new *WG-common minke SLA* (Item 2.2) is the best available way to provide management advice for this stock. It **advised** that an annual strike limit of 164 whales will not harm the stock and meets the Commission's conservation objectives. Although the SWG had not yet had time to examine the request from the US/Denmark (SC/67b/Rep06, Annex F, appendix) for this new *SLA*, it **agreed,** based on *WG-common minke SLA* testing thus far, that its previous advice that the interannual variation of 50% within a block with the same allowance from the last year of one block to the first year of the next was acceptable.

In response to a request for advice on the length of the season for the common minke whale hunts in SC/67b/AWMP19, the SWG **agreed** that changing the length of the season to 12 months had no conservation implications.

Attention: C-A

SC/67b/AWMP19 reported Greenland's plans for requesting aboriginal whaling provisions at IWC67. It requested advice on annual strikes of 164 animals (i.e. no change). It had also requested advice on any conservation implications of a 12-month hunting season for common minke whales.

The Committee therefore:

(1) ***agrees** that the WG-Common minke SLA is the best available way to provide management advice for this stock under need scenario A;*
(2) ***advises** that a continuation of the present average annual strike limit of 164 whales will not harm the stock and meets the Commission's conservation objectives;*
(3) *although the Committee has not yet had time to examine the request from the US/Denmark (SC/67b/Rep06, annex F, appendix) for this SLA, reiterates its previous advice, applicable for all SLAs, that interannual variation of 50% within a block with the same allowance from the last year of one block to the first year of the next is acceptable;*
(4) ***advises** that changing the length of the season to 12 months had no conservation implications; and*
(5) ***encourages** the continued collection of samples for collaborative genetic analyses (and see Item 7.1.2.3).*

5.6 Fin whales off West Greenland
SC/67b/AWMP19 reported Greenland's plans for requesting aboriginal whaling provisions at IWC/67. It requested advice on annual strikes of 19 animals (i.e. no change).

5.6.1 New information on the catch
A total of seven fin whales (five females and two males) was landed, and one was struck and lost, off West Greenland during 2017. The SWG was pleased to note that genetic samples were obtained from five of these, and that the genetic samples are analysed together with the genetic samples from the hunt in Iceland. It **encouraged** the continued collection of samples and collaborative work on analyses.

5.6.2 New information on abundance
The Working Group on ASI endorsed the 2015 aerial survey abundance estimate of 2,215 (CV=0.41; 95%CI 1,017-4,823) as discussed in Annex Q.

5.6.3 Management advice

The SWG **agreed** that the new *WG-fin SLA* (Item 2.2) is the best available way to provide management advice for this stock. It **advised** that an annual strike limit of 19 whales will not harm the stock and meets the Commission's conservation objectives.

Although the SWG had not yet had time to examine the request from the US/Denmark (SC/67b/Rep06, Annex F, appendix) for this new *SLA*, it **agreed,** based on *WG-fin SLA* testing thus far, that its previous advice that the interannual variation of 50% within a block with the same allowance from the last year of one block to the first year of the next was acceptable.

In response to a request for advice on length limits for fin whales in SC/67b/AWMP19, the SWG **agreed** that removing the length limits had no conservation implications.

Attention: C-A

SC/67b/AWMP19 reported Greenland's plans for requesting aboriginal whaling provisions at IWC/67. It requested advice on annual strikes of 19 animals (i.e. no change). It also requested advice on whether there were any conservation implications of removing length limits (while retaining the prohibitions relating to calves.

The Committee therefore:

(1) *agrees that the* WG-Fin SLA *is the best available way to provide management advice for this stock;*
(2) *advises that a continuation of the present average annual strike limit of 19 whales will not harm the stock and meets the Commission's conservation objectives;*
(3) *although the Committee has not yet had time to examine the request from the US/Denmark (SC/67b/Rep06, annex F, appendix) for this SLA, reiterates its advice, applicable for all SLAs, that interannual variation of 50% within a block with the same allowance from the last year of one block to the first year of the next is acceptable;*
(4) *advises that removing the length limits had no conservation implications; and*
(5) *encourages the continued collection of samples for collaborative genetic analyses (and see Item 7.1.1.3).*

5.7 Humpback whales off West Greenland

SC/67b/AWMP19 reported Greenland's plans for requesting aboriginal whaling provisions at IWC/67. It requested advice on annual strikes of 10 animals (i.e. no change).

5.7.1 New information on catches

A total of two (two females) humpback whales were landed and none were struck and lost in West Greenland during 2017. The SWG was pleased to learn that genetic samples were obtained from all the landed whales. The SWG again **emphasised** the importance of collecting genetic samples and photographs of the flukes from these whales.

The SWG noted that five humpback whales were observed entangled in fishing gear in West Greenland in 2017. Of these, one died, two became free and one was successfully disentangled by a disentanglement team. The remaining animal was alive and still entangled when it was last sighted.

The SWG noted that some bycaught whales had been included in the scenarios for the development of the *Humpback SLA.* If high levels continued, then this would need to be taken into account in any *Implementation Review.* It noted the IWC efforts with respect to disentanglement and prevention and **welcomed** the news that the Greenland authorities requested IWC disentanglement training that took place in 2016 and that they successfully disentangled one humpback whale.

5.7.2 New information on abundance

The Working Group on ASI endorsed the 2015 aerial survey abundance estimate of 993 (CV=0.46; 95%CI 434-2,272) as discussed in Annex Q.

5.7.3 Management advice

The SWG **agreed** that the *WG humpback SLA* remains the best available tool for management advice for this stock. It **advised** that a continuation of the present average annual strike limit of 10 whales will not harm the stock and meets the Commission's conservation objectives.

The SWG also **advised** that provisions allowing for the carry forward of unused strikes from the previous three blocks, subject to the limitation that the number of such carryover strikes used in any year does not exceed 50% of the annual strike limit' has no conservation implications (see SC/67b/Rep04).

Attention: C-A

SC/67b/AWMP19 reported Greenland's plans for requesting aboriginal whaling provisions at IWC/67. It requested advice on annual strikes of 10 animals (i.e. no change).

The Committee therefore:

(1) ***agrees** that the* WG-Humpback SLA *is the best available way to provide management advice for this stock;*

(2) ***advises*** *that a continuation of the present average annual strike limit of 10 whales will not harm the stock and meets the Commission's conservation objectives;*
(3) ***advises*** *that that provisions allowing for the carry forward of unused strikes from the previous three blocks, subject to the limitation that the number of such carryover strikes used in any year does not exceed 50% of the annual strike limit' has no conservation implications (see SC/67b/Rep04); and*
(4) ***encourages*** *the continued collection of samples and photographs for collaborative analyses.*

5.8 Humpback whales off St Vincent and The Grenadines

The alternate Commissioner for St Vincent and The Grenadines advised that no change to the present limits were envisaged.

5.8.1 New information on catch

It was reported that one humpback whale was struck and landed in 2017 by St Vincent and The Grenadines.

5.8.2 New information on abundance

Last year, the Committee had requested that the USA provide a new abundance estimate for the western North Atlantic based upon the available NOAA data (IWC, 2018). Clapham and Wade provided a progress report on this work with a focus on information on abundance estimates generated by the MONAH study, conducted in 2004 and 2005 on Silver Bank (a breeding ground in the West Indies) and in the Gulf of Maine feeding ground. The best estimate was judged to be a genotype-based two-year pooled feeding-to-breeding male-only Chapman estimate. This estimate was 6,156 (95% CI 4,344, 7,977), which when doubled (to account for females) equals 12,312. This was slightly higher than, although not significantly different from, the best estimate from the YONAH project from 1992/93, which was 10,400 (8,000, 13,600). The lack of strong population growth was unexpected given information on rates of increase from some other areas of the North Atlantic, and may reflect either a true rate of increase, unidentified sampling bias, and/or the idea that Silver Bank as a habitat has reached a maximum capacity. Given this, it was not clear whether the MONAH estimate is representative of the entire population, nor whether it can be applied to the southeastern Caribbean in the context of the St Vincent hunt. Four animals from the southeastern Caribbean have been linked to animals seen in the Gulf of Maine (one was caught in the hunt).

The SWG also noted the recent new abundance estimates of humpback whales in the North Atlantic including 993 (95% CI: 434-2,272) in West Greenland in 2015, 4,223 (95% CI: 1,845-9,666) in East Greenland in 2015 and Iceland-Faroes with 12,879 (95% CI 5,074; 26455) estimated from the 2007 ship survey

It has now been nearly two decades since the IWC has undertaken an In-Depth Assessment on North Atlantic humpback whales. The SWG **agreed** that it would be a valuable exercise to perform a North Atlantic Rangewide review of humpback whales, similar in scope to the Rangewide Review for North Pacific gray whales and taking into account recent work on stock structure including that of Stevick *et al.* (2018).

5.8.3 Management advice

The SWG noted that it did not have an approved abundance estimate for western North Atlantic since that in 1992. In accord with the advice provided in the AWS (see Appendix 8), it therefore considered the available evidence to see if was sufficient to provide safe management advice. Given the information above on recent abundance in the North Atlantic and the size of the requested catch/strikes (an average of four annually), the SWG **advised** that continuation of the present limits will not harm the stock.

The SWG also **repeats** its earlier advice that:

(1) the status and disposition of genetic samples collected from past harvested whales be determined and reported next year;
(2) photographs for photo-id (where possible) and genetic samples are collected from all whales landed in future hunts; and that
(3) the USA (NOAA, NMFS) provides an abundance estimate from the MONAH data as soon as possible for the Committee.

Attention: C-A

The alternate Commissioner for St Vincent and The Grenadines advised that no change to the present limits were envisaged. The Committee therefore:

(1) ***notes*** *that is does not have an approved abundance estimate for western North Atlantic since that in 1992;*
(2) ***notes*** *that in accord with the advice provided in the AWS (see Annex E, Appendix 8), it therefore considered the available evidence to see if was sufficient to provide safe management advice;*
(3) ***advises*** *that, given the information above on recent abundance in the North Atlantic combined with the size of the requested catch/strikes (an average of four annually), continuation of the present limits will not harm the stock;*

*The Committee also **reiterates** its previous advice that:*

(1) *the status and disposition of genetic samples collected from past harvested whales be determined and reported next year;*
(2) *photographs for photo-id (where possible) and genetic samples are collected from all whales landed in future hunts; and that*
(3) *the USA (NOAA, NMFS) provides an abundance estimate from the MONAH data as soon as possible for the Committee.*

6. WORKPLAN 2019-20 (INCLUDING WORKSHOPS AND INTERSESSIONAL GROUPS)

Table 1 summarises the work plan for work related to aboriginal subsistence whaling.

Simulation testing of interim relief allowances has been conducted for B-C-B bowheads and WG humpbacks (Appendix 8 under Item 3). Interim relief will be tested for eastern NP gray whales at the next *Implementation Review* for that stock. Testing for the remaining ASW stocks will be added to the future workplan of the Committee.

Table 1

Work plan for matters related to aboriginal subsistence whaling.

Topic	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting
(1) Annual review of catch/strike limits		Carry out		Carry out
(2) *Implementation Review*		Gray whales based upon rangewide review		West Greenland humpback whales
(3) *SLA*s		Consider development of an *SLA* for the hunt of common minke whales off East Greenland based on operational models developed for the West Greenland hunt		Adopt *SLA* if it is decided one is necessary
(5) Interim relief allowance testing	Run trials for gray whale hunts	Review results	Run trials for West Greenland common minke whales and fin whales	Review results
(6) Carryover (US/Denmark request)	Run trials for remaining Greenland hunts (West Greenland common minke whales, bowhead whales and fin whales	Review results		

7. BUDGETARY ITEMS 2019-20

The SWG has no budget requests for the next biennium.

8. ADOPTION OF REPORT

The Chair noted that this meeting represented the end of a long journey – with the adoption of the two new *SLA*s, the SWG had completed the development tasks it had been assigned by the Commission. He thanked all of the people who have made such a wonderful contribution over the years – the SWG has, in his view, achieved ground-breaking work over the last two decades in a spirit of great collaboration and co-operation, even when there were disagreements as inevitably there were. At this meeting, he thanked the rapporteurs, and especially John Brandon for their hard work. Primarily, though thanks were due to André Punt, Lars Witting and Anabela Brandão for their herculean efforts in developing and running trials and developing *SLA*s. However, greatest praise should go to Cherry Allison who under extremely difficult circumstances provided superb support from Cambridge. The whole SWG sends their thanks, support and best wishes.

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Appendix 1

AGENDA

1. INTRODUCTORY ITEMS
    - 1.1 Convenor's opening remarks
    - 1.2 Election of Chair and appointment of rapporteurs
    - 1.3 Adoption of Agenda
    - 1.4 Documents available
2. *SLA* DEVELOPMENT
    - 2.1 Fin whales (Greenland)
        - 2.1.1 Review results of intersessional Workshops
        - 2.1.2 Review post-Workshop progress
        - 2.1.3 Review final results and performance
        - 2.1.4 Conclusions and recommendations
    - 2.2 Common minke whales (Greenland)
        - 2.2.1 Review results of intersessional Workshops
        - 2.2.2 Review post-Workshop progress
        - 2.2.3 Review description of and results for candidate *SLA*s
        - 2.2.4 Conclusions and recommendations
    - 2.3 North Pacific gray whales (Makah management plan)
        - 2.3.1 Summarise the plan
        - 2.3.2 Review intersessional progress including at the Rangewide Workshop
        - 2.3.3. Conclusions and recommendations
    - 2.4 WG-bowhead whales
        - 2.4.1 Review results using 400 replicates
        - 2.3.2 Testing the Interim Allowance strategy
        - 2.3.3 Conclusions and recommendations
3. ABORIGINAL WHALING MANAGEMENT SCHEME (AWS)
    - 3.1 Review results of intersessional Workshops
    - 3.2 Review proposed updates to the AWS
    - 3.2 Conclusions and recommendations
4. IMPLEMENTATION REVIEW OF B-C-B BOWHEAD WHALES
    - 4.1 Stock structure: review new information (including advice from SD)
    - 4.2 Abundance estimates: review new information (including advice from ASI)
    - 4.3 Biological parameters: review new information
    - 4.4 Removals: review new information
    - 4.5 Other anthropogenic threats and health: review new information
    - 4.6 Conclusions and recommendations (and, if needed, workplan to complete *Review*)
5. STOCKS SUBJECT TO ASW (NEW INFORMATION AND MANAGEMENT ADVICE)
    - 5.1 Eastern Canada/West Greenland bowhead whales
    - 5.2 North Pacific gray whales
    - 5.3 Bering-Chukchi-Beaufort Seas bowhead whale
    - 5.4 Common minke whales off East Greenland
    - 5.5 Common minke whales off West Greenland
    - 5.6 Fin whales off West Greenland
    - 5.7 Humpback whales off West Greenland
    - 5.8 Humpback whales off St Vincent and The Grenadines
6. WORKPLAN 2019-20 (INCLUDING WORKSHOPS AND INTERSESSIONAL GROUPS)
7. BUDGETARY ITEMS 2019-20
8. ADOPTION OF REPORT

Appendix 2

SPECIFICATIONS FOR THE TESTING OF THE WEST GREENLAND FIN WHALE *SLA*

[To come]

Appendix 3

WEST GREENLAND FIN WHALE *SLA* PERFORMANCE STATISTICS

[To come]

[Place holder figure from AWMP WP 15: Insert additional 'Wilberg-Brandao' plots from LARS / Bela / Andre re: D1:D10 across simulation replicates etc]

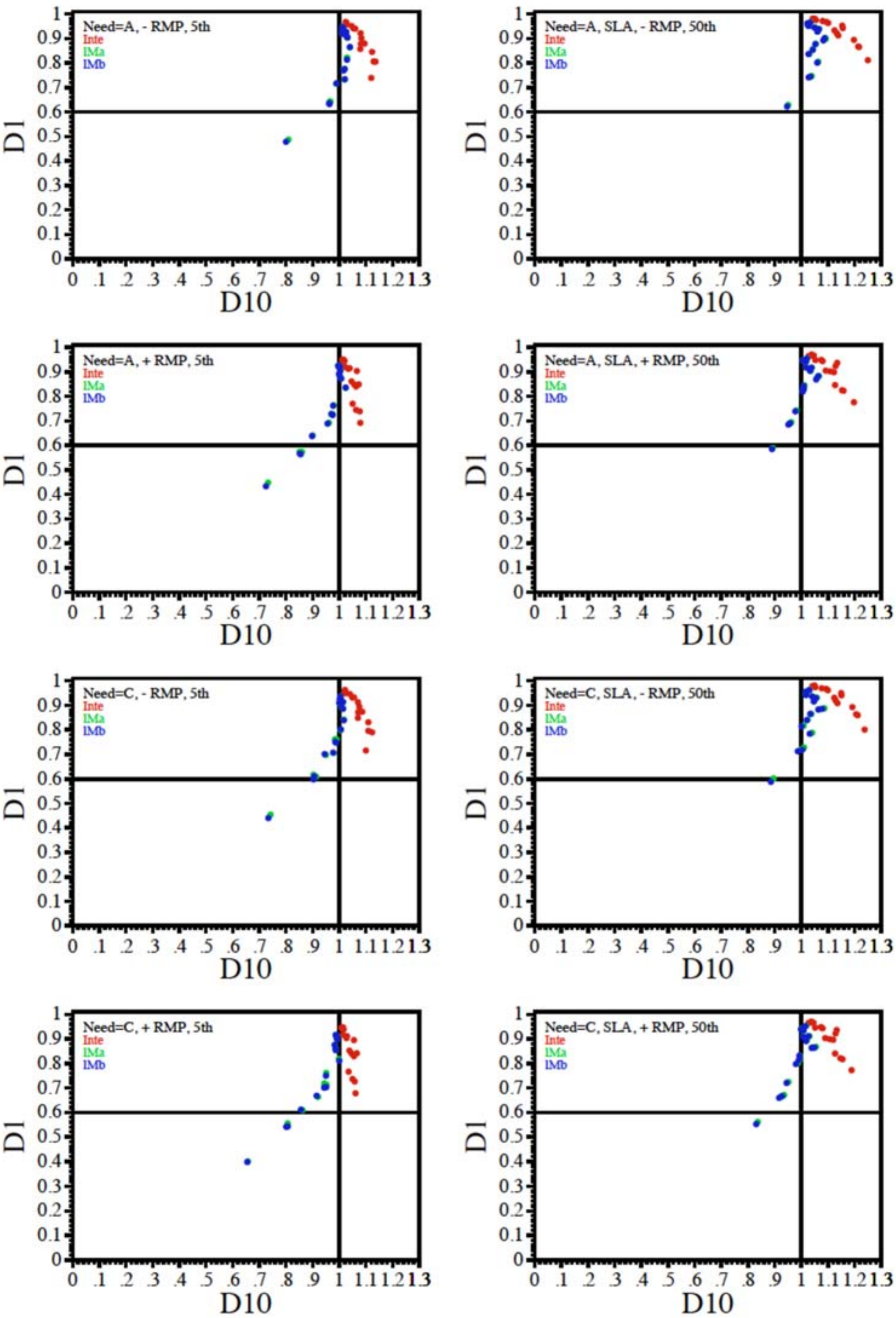


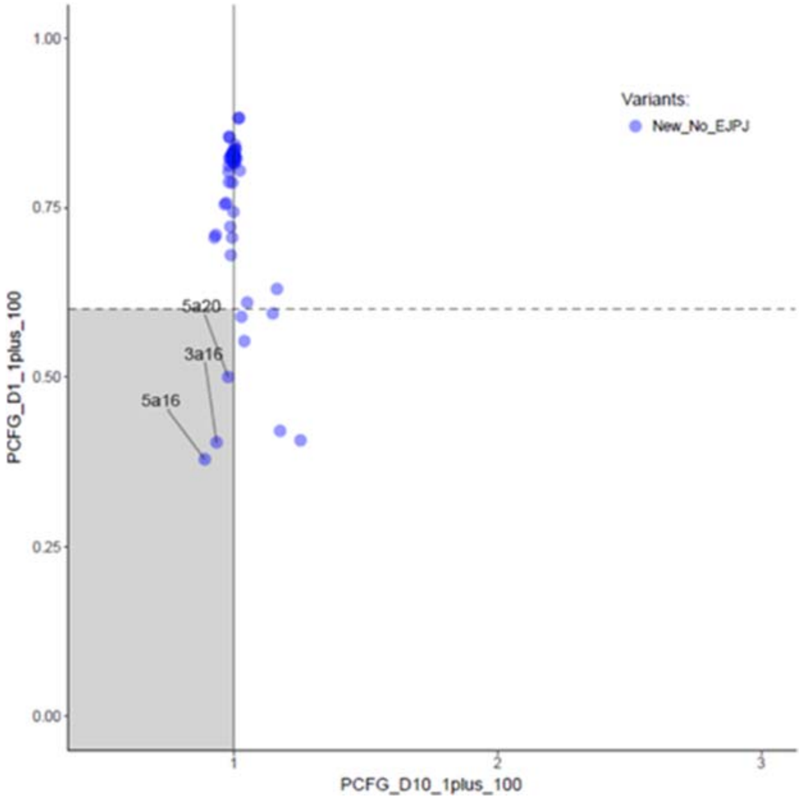
Fig A.1. Points in the lower left quadrant are of interest

Appendix 4

SPECIFICATIONS FOR THE TESTING OF THE WEST GREENLAND COMMON MINKE WHALE *SLA*

[To come]

Appendix 5
SELECTION OF RESULTS FOR THE MAKAH MANAGEMENT PLAN
[Trials list to come]



Appendix 6

[to come]

Appendix 7

INTERIM RELIEF SCENARIOS

Appendix 8 specifies an interim relief provision for the Aboriginal Whaling Scheme. Under this provision, a survey is required at least every 10 years. If no survey is available after that time and third quota block has begun, the Committee has **endorsed** the use of an 'interim relief', namely a 'grace period' strike limit equal to the limit produced by the applicable Strike Limit Algorithm, without reduction, for a single block.

The 10-year survey interval requirement is complicated by the fact that there will usually be a delay between when the survey is conducted and when the resulting abundance estimate is agreed by the Committee, and because surveys, estimates and quota blocks need not be synchronised, as recognised in IWC (2003). For the sake of counting years, a survey is not considered to have occurred until the resulting abundance estimate is agreed. At that point, the 10-year time window is deemed to have begun in the year during which the survey was conducted. Then, ideally, the next survey would be conducted and the estimate approved within 10 years of the previous survey. However, other scenarios might occur. For example, the next survey might have occurred eight years after the previous one, but the corresponding abundance estimate not agreed until 13 years after the previous survey was conducted ('the 13th year'). In this case, a survey would be considered overdue during the 11th and 12th years. If the start of a new block occurred during that time, the grace period would be triggered and an interim relief provided. Otherwise, when the abundance estimate is agreed in the 13th year after the last survey was conducted, the fact that the survey actually took place eight years after the last agreed estimate would reset the clock so that the next deadline would be the 18th year, and a grace period would have been averted.

Tables 1 and 2 illustrate several scenarios about how strike limits might evolve with varying survey intervals and grace periods. In these tables, it is assumed for simplicity that the *Strike Limit Algorithm* would output a six-year block strike limit (SL) each time. For the sake of simplicity, carryover is ignored in these tables.

Five different scenarios (A-E) are shown in Tables 1 and 2. These tables cover more than four quota blocks (boxes), with surveys (Surv), abundance estimates (Est) and the establishment of block strike limits (SL) scheduled by year (Yr), The 'Clock' counts the number of years remaining before a survey will thereafter be overdue. Thus, when the clock set by the most recent estimate is negative, a survey is overdue and when a grace period quota is required an interim relief strike limit (IASL) is set.

Scenario A in Table 1 illustrates a situation with regular 8-year survey intervals and estimates two years later. Each strike limit is set using a timely survey; no surveys are overdue and no grace periods are required. Note that in year 13, a block strike limit is set using the survey from year 4. Although the more recent survey (year 12) has occurred, the corresponding abundance estimate has not yet been computed. Scenario B represents an unproblematic case with 10-year survey intervals.

Scenarios C and D illustrate cases where the grace period is invoked in year 13. In Scenario C, immediate revision of the interim relief strike limit (IASL) is assumed and an updated strike limit (USL) is computed. Scenario D presents the same schedule of surveys and estimates, but when the grace period is invoked, the IASL is retained for the entire block, with the year 12 survey first being used in year 19.

Scenario E illustrates that it is possible that surveys could be more than 10 years apart (in this case, 13 years) without triggering the grace period.

Tables 1 and 2

Example schedules of surveys, block strike limits and so forth. See the text for a detailed explanation.

Yr	A	Clock		B	Clock	
1	SL			SL		
2						
3						
4	Surv	10				
5		9				
6	Est	8		Surv	10	
7	SL	7		Est/SL	9	
8		6			8	
9		5			7	
10		4			6	
11		3			5	
12	Surv	2	10		4	
13	SL	1	9	SL	3	
14	Est	0	8		2	
15			7		1	
16			6	Surv	0	10
17			5	Est	-1	9
18			4			8
19	SL		3	SL		7
20	Surv	10	2			6
21		9	1			5
22	Est	8	0			4
23		7				3
24		6				2
25	SL	5		SL		1
26		4		Surv	10	0

Yr	C	Clock		D	Clock		E	Clock	
1	SL			SL			SL		
2	Surv	10		Surv	10				
3		9			9				
4		8			8		Surv	10	
5	Est	7		Est	7			9	
6		6			6		Est	8	
7	SL	5		SL	5		SL	7	
8		4			4			6	
9		3			3			5	
10		2			2			4	
11		1			1			3	
12	Surv	0	10	Surv	0	10		2	
13	IASL	-1	9	IASL	-1	9	SL	1	
14		-2	8		-2	8		0	
15	Est/USL	-3	7	Est	-3	7		-1	
16			6			6		-2	
17			5			5	Surv	-3	10
18			4			4	Est	-4	9
19	SL		3	SL		3	SL		8
20	Surv	10	2	Surv	10	2			7
21		9	1		9	1			6
22	Est	8	0	Est	8	0			5
23		7			7				4
24		6			6				3
25	SL	5		SL	5		SL		2
26		4			4				1

Appendix 8

SCIENTIFIC ASPECTS OF AN ABORIGINAL WHALING SCHEME

The Scientific Committee's Aboriginal Whaling Management Procedure (AWMP) applies stock-specific *Strike Limit Algorithms* (*SLA*s) to provide advice on aboriginal subsistence whaling (ASW) strike/catch limits.

ASW management (as part of an AWS, the aboriginal whaling scheme) incorporates several components, several of which have a scientific component:

(a) *Strike Limit Algorithms* (case-specific) used to provide advice on safe catch/strike limits;
(b) operational rules (generic to the extent possible) including carryover provisions, block quotas and interim relief allocations;
(c) Guidelines for *Implementation Reviews*; and
(d) Guidelines for data and analysis (e.g. guidelines for surveys, other data needs)

The scientific components are considered below.

1. CARRYOVER

Carryover is a provision to enable (some) strikes not used in one year to be used in a subsequent year or years, in order to allow for the inevitable fluctuations in the success of hunts (e.g. due to environmental conditions and/or whale availability). Whilst providing flexibility, carryover does not allow hunts to take more than the total number of strikes agreed by the Commission. This flexibility may produce additional benefits for the local management of the hunt. The concept is not new and *ad hoc* provisions incorporating carryover have been included in the Schedule for many years (see the summary provided in *J. Cetacean Res. Manage* 19 (Suppl.), pp. 169-72). As general guidance, the Commission has (in 2001 and 2016), approved examination by the Committee of scenarios incorporating a 50% interannual variation within blocks and 50% allowance to the next block, noting that this did not imply any commitment by the Commission that these values would be used in the Schedule.

1.1 The Committee's role

The Scientific Committee's role is not to recommend a particular carryover approach (there are many possibilities e.g. see IWC *In Press*) but rather to provide advice on the conservation and need performance of carryover options when asked by the Commission or ASW countries. Formal evaluation of the performance of options (see Item 1.2) by the Committee will allow a more consistent approach to carryover across hunts. The Committee's evaluation began in the year 2000 as the Committee began to develop its first recommended components of an AWS (IWC, 2001).

1.2 Examining conservation performance

The Committee examines the conservation performance of options using the same simulation testing approach used to develop *SLA*s. This allows the Committee to provide guidance as to the acceptable limits within which carryover provisions can be developed. In requesting guidance on carryover provisions, at least the following information should be provided by ASW countries or the Commission:

(a) an initial start date for the provision (e.g. 2003, start of new block);
(b) an expiration period (unused strikes cannot be carried over indefinitely); and
(c) limits on use (e.g. the maximum number of strikes allowed in any one year).

1.3 Additional provision

The Committee's *Implementation Review* process (see section 4 below) includes the monitoring of carryover provisions. Should new information (e.g. abundance data) lead an *SLA* to indicate a severe decrease in the quota then this will trigger an appropriate review of the existing carryover provisions and any implications for conservation performance. If necessary, the review may lead the Committee to recommend changes in carryover provisions that may, for example, result in a 'reset' of the starting year or other amendments to carryover provisions.

1.4 Schedule language

The Committee advises that the incorporation of carryover provisions in the Schedule should avoid ambiguity. Rather than try to encode general provisions in the Schedule, the Committee offers to assist the Commission in by providing the actual numbers for each hunt in a new quota block, based upon agreed general provisions.

1.5 Example

An example of a response to a request for advice on a carryover option is given in (IWC, *In press*). The request from the USA and Denmark/Greenland was to

> '…allow for the carry forward of unused strikes from the previous three blocks, subject to the limitation that the number of such carryover strikes used in any year does not exceed 50% of the annual strike limit'.

This request was tested using the *Bowhead SLA* (applicable to the Bering-Chukchi-Beaufort Seas stock) and the *WG-Humpback SLA* (applicable to West Greenland) and three types of options were examined:

(1) baseline case - all strikes taken annually (i.e. no need for carryover);
(2) 'frontload' case - strikes taken as quickly as possible within block (+50% limit annually until the block limit is reached); and
(3) two alternative scenarios where carryover strikes are accrued for one or three blocks, followed by a period of carryover usage subject to the +50% limit.

The three-block scenario considered in (3) served as a direct test of the provision described in the request of USA and Denmark/Greenland. The Committee agreed that the Commission's conservation objectives were met for both *SLA*s for all of the options above and would also be met for a proposal carrying forward strikes from the previous two blocks.

2. BLOCK QUOTAS

The Committee has advised the Commission (in the context of moving to biennial meetings) that block quotas of up to 8 years are acceptable (IWC, 2013, p. 22), noting the requirement for abundance estimates every ten years (see Item 3).

3. INTERIM RELIEF

A variety of factors, including environmental conditions, beyond the control of the hunters may prevent the completion of a successful whale population abundance estimate. While recognizing such difficulties, the Committee notes that uncurtailed aboriginal whaling quotas cannot be continued indefinitely in the long-term absence of data. Therefore, the AWS must address what should be done in the event that efforts to obtain an agreed abundance estimate are unsuccessful after some time limit. For the purposes of applying AWMP *Strike Limit Algorithms*, the Committee has agreed that this limit is 10 years (IWC 2003; IWC, 2016a).

A third quota block begun after the 10-year limit has expired is termed a 'grace period' and the Committee has endorsed the use of an 'interim allowance', namely a grace period strike limit equal to the limit produced by the applicable *Strike Limit Algorithm*, without reduction, for a single block. This approach has been simulation tested for B-C-B bowheads and WG humpbacks to confirm that it meets the conservation and need satisfaction goals of the Commission (IWC, 2016a, pp.190-193; 2016b, pp. 471-484; IWC, 2017, p. 498) and the results are summarized in IWC (2017b; 2018 p. 159). It will be tested for eastern NP gray whales at the next *Implementation Review* for that stock. Testing for the remaining ASW stocks will be added to the future workplan of the Committee.

The 10-year survey interval requirement is complicated by the fact that (a) there will usually be a delay between when a survey is conducted and when the resulting abundance estimate is agreed by the Committee and (b) because surveys, estimates and quota blocks need not be synchronised, as recognised in IWC (2003). For the sake of counting years between surveys, a survey is not considered to have occurred until the resulting abundance estimate is agreed. At that point, the 10-year time window is deemed to have begun in the year during which the survey was conducted. Further details and examples are given in IWC (In press [SC 67b Annex E]).

The Committee recommends (IWC, 2003; 2006) that, during the grace period, a new strike limit is established immediately a new abundance estimate is agreed. this approach. However, it notes that if the Commission refrains from updating the strike limit until the grace period expires, this would not pose a conservation risk. If the strike limit is updated during a grace period block, the number of strikes taken to that point of the grace period should be subtracted from the updated quota, with the remainder being the strike limit for the rest of the grace period. Carryover is not affected.

The Committee emphasises that the interim allowance approach is intended to be applied only in the event that exceptional unforeseen circumstances had delayed obtaining an agreed abundance estimate beyond the end of the second quota block. It should not be interpreted as a routine approach for extending quotas for a third block without a concerted effort to obtain a successful survey prior to that time. Furthermore, the Committee would not recommend two consecutive interim allowances.

It is important to consider a scenario in which no acceptable abundance estimate is obtained by the end of the grace period. *SLA*s are not designed or intended to be applied if new abundance data are not forthcoming after such a long period. Given good faith efforts to obtain an abundance estimate, such a situation would probably have arisen from profound and unexpected environmental change (e.g. related to climate or a disaster such as a massive oil spill). Under such circumstances, an immediate *Implementation Review* (see Item 4.1.2) would probably have been initiated, irrespective of the timing of (un)successful surveys and quota blocks. As soon as it becomes apparent that an abundance estimate may not be obtained in time, researchers should immediately begin to develop alternative approaches to obtaining abundance estimates (or at least indices of abundance) that do not depend on the problematic circumstances. Nevertheless, if no abundance estimate is available the year before the end of the grace period, the Scientific Committee should immediately initiate an *Implementation Review*. The approach of the Committee in the absence of positive alternative evidence would be that the Committee could not provide advice on the quota using the *SLA* and the Commission should exercise great caution when agreeing any further strike limits. The level of caution will depend on the specifics of the situation.

4. *IMPLEMENTATION REVIEWS*

The concept of an *Implementation Review* is central to the functioning of the AWMP. The primary objectives of an *Implementation Review* are to:

(1) review the available information (including biological data, abundance estimates and data relevant to stock structure issues) to ascertain whether the present situation is as expected (i.e. within the space tested during the development of a *Strike Limit Algorithm* (*SLA*)) and determine whether new simulation trials are required to ensure that the *SLA* still meets the Commission's objectives; and

(2) to review information required for the *SLA*, i.e. catch data and, when available at the time of the *Review*, new abundance estimates (note that this can also occur outside an *Implementation Review* at an Annual Meeting).

4.1 Timing of *Implementation Reviews*

4.1.1 Regular Implementation Reviews

Implementation Reviews are undertaken regularly, normally every five to six years. This does not have to coincide with the renewal of catch/strike limits in the Commission. For logistical and resource reasons, only one major *Implementation Review* shall be undertaken at a time. The Committee shall begin planning for the *Review* at the Annual Meeting at least two years before the Annual Meeting at which the *Review* is expected to be finished. This is to enable the Committee to schedule additional work or Workshops if it believes that new information or analyses are likely to be presented that will necessitate the development of new simulation trials. Early planning will enhance the likelihood that the Committee will complete an *Implementation Review* on schedule. It is not expected that every *Implementation Review* will entail a large amount of work.

4.1.2 Special Implementation Reviews

In addition to regular *Implementation Reviews*, under exceptional circumstances the Committee may decide to call for special *Implementation Reviews,* should information be presented to suggest that this is necessary and especially if there is a possibility that the Commission's conservation objectives may not be met.

Calling such a *Review* does not necessarily mean revising the Committee's advice to the Commission, although it may do so. The Committee has not tried to compile a formal comprehensive list of what factors might trigger' such an early review, which implies unexpected/unpredictable factors. However, the following list is provided to give examples of some possible factors.

(1) Major mortality events (e.g. suggested by large numbers of stranded animals).
(2) Major changes in whale habitat (e.g. the occurrence of natural or anthropogenic disasters or changes, an oil spill, dramatic change in sea-ice, development of a major oil/gas field, etc.).
(3) Major ecological changes resulting in major long-term changes in habitat or biological parameters.
(4) A dramatically lower abundance estimate (although the SLA has been tested and found to be robust to large sudden drops in abundance, the Committee would review the potential causes of unexpected very low estimates).
(5) Information from the harvest and hunters (this might include very poor harvest results, reports of low abundance despite good conditions, reports of large numbers of unhealthy animals).
(6) Changes in biological parameters that may result in changes to management advice (e.g. reproduction, survivorship).
(7) If there are cases when need is not being satisfied, strong information that might narrow the plausibility range and allow an increase in block limits.

4.1.3 Outcomes of Implementation Reviews

There are a number of possible conclusions of *Implementation Reviews*:

(1) there is no need to run additional trials and that the existing *SLA* is acceptable;
(2) the results from the additional trials developed and run reveal that the existing *SLA* is acceptable;
(3) there is no need for any immediate additional trials or changes to management advice but work is identified that is required for consideration at the next *Implementation Review*; or
(4) the results of the additional trials require the development of a new (or modified and then retested) *SLA* in which case management advice will have to be reconsidered until that work is complete.

4.1.4 Data availability

Implementation Reviews fall under the Committee's Data Availability Agreement Procedure A (IWC, 2004). By the time of the Annual Meeting prior to that at which the *Implementation Review* is expected to be completed, the scientists from the country or countries undertaking the hunts, or others intending to submit relevant analyses, shall develop a document or documents that explains the data that will/could be used for the *Implementation Review*. Such a document will:

(a) outline the data that will be available, including by broad data type (e.g. sighting data, catch data, biological data): the years for which the data are available; the fields within the database; and the sample sizes;
(b) provide references to data collection and validation protocols and any associated information needed to understand the datasets or to explain gaps or limitations; and
(c) where available, provide references to documents and publications of previous analyses undertaken of data.

The data themselves shall be available in electronic format one month after the close of that Annual Meeting.

In the case of complex *Implementation Reviews* that may last more than one year and involve one or more workshops, new data can be submitted, provided that the data are described and made available at least nine months before the Annual Meeting at which the *Implementation Review* is expected to be completed.

4.1.5 Computer programs
Programs used in analyses submitted to the *Implementation Review* may be requested by the Committee, who may decide that the programmes need independent validation in accordance with its guidelines at the time. All *SLA* simulation testing and evaluation software shall be undertaken by the Secretariat using validated programmes.

5. GUIDELINES FOR SURVEYS

The Committee's general advice on surveys is applicable. Some more specific considerations are given below.

5.1 Survey/census methodology and design

Plans for undertaking a survey/census should be submitted to the Scientific Committee in advance of their being carried out, although prior approval by the Committee is not required. This should normally be at the Annual Meeting before the survey/census is carried out. Sufficient detail should be provided to allow the Committee to review the field and estimation methodology. Considerably more detail would be expected if novel methods are planned.

5.2 Committee oversight

Should it desire, the Scientific Committee may nominate one of its members to observe the survey/census to assess the scientific integrity of the process.

5.3 Data analysis and availability

Data to be used in the estimation of abundance will be made available to the Committee in accordance with Procedure A of the Data Availability Agreement (IWC, 2004). If new estimation methods are used in the data analysis, the Committee may require that computer programs (including documentation to allow such programs to be validated) be provided to the Secretariat for eventual validation.

5.4 Estimates to use in the *SLA*

The most recent estimate(s) accepted by the Committee for any year(s) should be incorporated in the *SLA* calculations. If there is more than one accepted estimate for a given year and the Committee agrees that the estimates are based on sufficiently independent data, then both estimates should be incorporated in the *SLA* calculations. If a revised estimate is obtained for a particular year, then the old one should be replaced before the *SLA* is next used.

6. GUIDELINES FOR DATA/SAMPLE COLLECTION

The Schedule states that data from each harvested animal should be collected and made available to the IWC. The following information should normally be provided for each harvest or individual whale as appropriate:

(1) species;
(2) number of animals;
(3) sex;
(4) season;
(5) location of catch (at least to the nearest village); and
(6) length of catch (to 0.1m).

The Committee recognises the importance of additional information, especially in the context of *Implementation Reviews* e.g. on reproductive status and health. It highlights the importance of collecting tissue samples for genetic studies in accordance with guidance provided by the Committee (e.g. *https://iwc.int/index.php?cID=60&cType=document*), especially in the context of stock structure issues. It notes that photo-identification data can be valuable for estimating biological parameters, assessing anthropogenic injuries, and encourages such research where possible. The value of traditional knowledge is also noted, and such information can also provide valuable input to conducting *Implementation Reviews*.

6.1 Revisions to the AWS

Revisions or additions to this AWS may be recommended by the Committee at any time, including during *Special Implementation Reviews*.

REFERENCES

International Whaling Commission. 2016a. Report of the Scientific Committee. Annex E. Report of the Standing Working Group on the Aboriginal Whaling Management Procedure (AWMP). Appendix 6. Trial structure for proposed testing of some AWS provisions for the Bowhead SLA. J. Cetacean Res. Manage. (Suppl.) 17:201-03.

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Report of the Scientific Committee

Bled, Slovenia, 24 April-6 May 2018

**This report is presented as it was at SC/67b.
There may be further editorial changes (e.g. updated references, tables, figures) made before publication.**

International Whaling Commission
Bled, Slovenia, 2018

Report of the Scientific Committee
Bled, Slovenia, 24 April - 6 May 2018

The meeting (SC/67b) was held at the Rikli Balance Hotel, Bled, Slovenia, from 24 April-06 May 2018 and was chaired by Caterina Fortuna. The next meeting of the Commission (IWC/67) will take place 4-14 September 2018. The list of participants is given as Annex A (about one-third of the Contracting Governments were represented by delegates).

1. INTRODUCTORY ITEMS

1.1 Chair's welcome and opening remarks

Fortuna welcomed the participants to the meeting. Although the meeting was not officially hosted by the Slovenian Government, she thanked it for welcoming them back and noted how pleased the Scientific Committee was to be once again in such a beautiful place. She thanked the IWC Secretariat staff for their hard work during the intersessional period, particularly Mark Tandy for organising the meeting under time pressure Stella Duff and Andrea Cooke for their assistance with meeting documents and Greg Donovan for all his support intersessionally. She thanked Sava Hotels for providing the meeting facilities and her Slovenian colleagues for helping meeting arrangements run smoothly. Fortuna also thanked the vice-Chair Robert Suydam, the Convenors (including those of intersessional groups) and Committee members for all their hard work since the last meeting.

Rebecca Lent, the new IWC Executive Secretary, welcomed participants to the meeting She noted this was her first IWC meeting, but already knew of its excellent global reputation and looked forward to attending many sessions. She noted her pleasure at joining the IWC at such an exciting time, with a busy year of meetings and several new initiatives. Two new coordinators have joined the Secretariat as part of the IWC work programmes endorsed by the Commission in 2016: Marguerite Tarzia as bycatch coordinator; and Karen Stockin as strandings coordinator. They will lead the Commission's work in these areas and will provide valuable input into the Scientific Committee's work.

Lent noted that the external "The IWC review – final report" (https://archive.iwc.int/?r=6890) undertaken as part of the IWC's Governance Review has recently become available and she noted that the Commission would welcome comments on it from the Scientific Committee, and that in particular, the Commission's Operational Effectiveness Working Group will take into consideration the comments from the Scientific Committee in making its recommendations to the Finance and Administration Committee; that Committee will then make recommendations to the Commission, which will determine the next steps in the governance review. Budget Management has become more challenging in recent years and there is much work to do to make sure the workplan of the Commission and all its subsidiary bodies is affordable going forward and into the long term. Finally, she thanked Scientific Committee members for their scientific input over the next two weeks and wished everyone a successful meeting.

The Committee was saddened to learn of the death of four scientists connected with the Scientific Committee:

(1) Greg Kaufman, a member of the Committee since 2006 and an active member of the sub-committee on whale watching and the Whale watching Working Group of the Conservation Committee;

(2) Doug Coughran, who although he did not attend Scientific Committee meetings, was a participant in numerous IWC workshops on entanglement and stranding response and was a charter member of both the IWC's entanglement and stranding expert (advisory) groups;

(3) Dale Rice, who although he has not attended IWC meetings in recent years, first represented the USA on the Scientific Committee as far back as 1960; and

(4) John Reynolds, who although not a member of the Scientific Committee, was a mentor to many Committee members.

The Committee paused in silence and respect for these scientists who had contributed directly and indirectly to the Committee's work and to whale conservation and management. Short obituaries can be found in Annex AA.

1.2 Appointment of rapporteurs

Donovan was appointed rapporteur with assistance from various members of the Committee as appropriate. Chairs of sub-committees and Working Groups appointed rapporteurs for their individual meetings.

1.3 Meeting procedures and time schedule

The Committee agreed to the meeting procedures and time schedule outlined by the Chair.

1.4 Establishment of sub-committees and Working Groups

The following pre-meetings were held:

(1) the Standing Working Group on Environmental Concerns held a pre-meeting on 'Cumulative Effects' from 22-23 April; and
(2) the sub-committee on Whale Watching held a pre-meeting on the IWC's 'Five Year Strategic Plan for Whale Watching' from 22-23 April.

Several sub-committees and Working Groups were established. Their reports were either made Annexes (see below) or subsumed into this report.

Annex D – Sub-Committee on the Revised Management Procedure;

Annex E – Standing Working Group on an Aboriginal Whaling Management Procedure;

Annex F – Sub-Committee on In-Depth Assessments;

Annex G – Sub-Committee on Other Northern Hemisphere Whale Stocks

Annex H – Sub-Committee on Other Southern Hemisphere Whale Stocks;

Annex I – Working Group on Stock Definition and DNA testing;

Annex J – Sub-Committee on Non-Deliberate Human-Induced Mortality of Cetaceans;

Annex K – Sub-Committee on Environmental Concerns;

Annex L – Standing Working Group on Ecosystem Modelling;

Annex M – Sub-Committee on Small Cetaceans;

Annex N – Sub-Committee on Whale Watching;

Annex O – Sub-Committee on Conservation Management Plans;

Annex P – Revised ‘Annex P’;

Annex Q – Standing Working Group on Abundance Estimates, Stock Status and International Cruises;

Annex R – *Ad hoc* working Group on Sanctuaries;

Annex S – *Ad hoc* Working Group on Photo-ID;

Annex T – Ad hoc Group on Global databases and repositories

Annex U – Statements on Special Permit discussions

Annex V – IWC-SORP – Southern Ocean Research Partnership

Annex W – Updated Rules of Procedure

Annex X – Comments on the ‘Governance Review’

Annex Y – Intersessional groups

Annex Z – Minority Statements on the Agenda

1.5 Computing arrangements
Donovan outlined the computing and printing facilities available for delegate use.

2. ADOPTION OF AGENDA

The adopted Agenda is given as Annex B. Statements on the Agenda are given as Annex Z.

3. REVIEW OF AVAILABLE DATA, DOCUMENTS AND REPORTS

3.1 Documents submitted
The documents available are listed in Annex C. As agreed at the 2012 Annual Meeting, primary papers were only available at the meeting in electronic format (IWC, 2013a, pp 78-79).

3.2 National Progress Reports on research
The National Progress Reports have their origin in Article VIII, Paragraph 3 of the Convention. All member nations are urged by the Commission to provide Progress Reports to the Scientific Committee following the most recent guidelines developed by the Scientific Committee and adopted by the Commission. The report is intended to provide (1) a concise summary of information available in member countries and (2) advice on where to find more detailed information if required. In addition, the IWC holds several specialist databases (including, catches, sightings, ship strikes, images – see Item 23).

As agreed at the 2013 Annual Meeting (IWC, 2014), all National Progress Reports were submitted electronically through the IWC National Progress Reports data portal. Encouragingly, 18 countries (Argentina, Australia, Brazil, Croatia, Denmark, France, Germany, Iceland, Italy, Japan, Korea, Mexico, New Zealand, Netherlands, Norway, Spain, UK and USA) submitted reports this year compared to 12 last year. Information was provided on bycatch, entanglement, ship strikes, direct and indirect takes, sampling, sightings and tracking studies.

Nearly all the recommendations identified by the Committee in 2017 (IWC, 2018c) have been implemented although further guidance is required on the appropriate level of aggregation for some records (e.g. strandings) to simplify and accelerate data entry without losing valuable resolution.

Although data entry this year was hampered due to problems with the IWC server, this generic issue has already been resolved by the IWC Secretariat. Several suggestions for improvements, including the removal of default values, can be See Annex T for full details.

Attention: C, CG, S, SC

Despite the technical issues of the portal, the eighteen Progress Reports submitted to SC67b was an improvement on the twelve submitted to SC67a. Nevertheless, this represents a small proportion of IWC member nations. The Committee ***reiterates*** *that National Progress Reports are required under the Convention and they represent a useful tool and* ***recommends*** *that Contracting Governments to submit them annually through the IWC data portal (http://portal.iwc.int).*

National Progress Reports include records of reported bycatch and ship strikes. The Committee ***agrees*** *that the data collected in these reports are not intended to replace in-depth studies and they should be considered and used with great caution. However, it also* ***agrees*** *the reports have value because much of these data would not otherwise be available and the reporting process can assist in supporting national compilation of cetacean data.*

To address in part several of the issues and challenges described above the Committee ***agrees*** *to:*

(1) develop a strategy with the Scientific Committee Chair and Secretariat to raise awareness of National Progress Reports and promote reporting by member nations;
(2) produce a short summary explaining the utility of National Progress Reports and suggest including this text in the circular to member nations calling for data submission;
(3) request the Secretariat to issue the first call for data submission in February and repeat the call a few weeks prior to the start of the SC meeting;
(4) develop text acknowledging the likely limitations of the reported data (subsequently this text will be included in all reports and data downloads;
(5) further explore approaches (using R markdown) to produce PDF- formatted national reports.

This work will be conducted by the GDR Steering Group intersessionally (see Annex Y).

3.3 Data collection, storage and manipulation

3.3.1 Catch data and other statistical material

Table 1 lists data received by the Secretariat since the 2017 meeting.

Table 1
List of data and programs received by the IWC Secretariat since the 2017 meeting.

Date	From	IWC ref.	Details
18/05/2017	St Vincent&G: J. Cruickshank-Howard	E128 Cat2016	Information from St Vincent and the Grenadines aboriginal hunt 2016-17
3-10 7/2017	S. Kromann and Y. Ivashchenko	E127 C	Individual catch data for Taiyo Gyogyo, Japan in 1943-44. Copy of data held at NMML Seattle
16/08/2017	Y. Ivashchenko	E127	Extra details of N. Pacific sei whale catches by the USSR 1963-71
16/02/2018	Japan: K. Matsuoka	CD103	2017 POWER sightings cruise data (except photographs)
16/02/2018	Japan: K. Matsuoka	CD104	2017 ICR North Pacific dedicated sighting survey data.
04/04/2018	Canada: S. Reinhart	E130 Cat2017	Details of the Canadian bowhead harvest for the 2015-7 seasons and some information on the 2018 quota
11/04/2018	Japan: K. Matsuoka	E131	Data from the 2017-18 NEWREP-A dedicated sighting survey
18/04/2018	Iceland: G. Vikingsson	E130 Cat2017	Individual records of minke whales caught by Iceland 2017 [there was no fin whale catch]
18/04/2018	Norway: N. Øien	E130 Cat2017	Individual minke records from the Norwegian 2017 commercial catch. Access restricted (specified 14-11-00).
19/04/2018	USA: R. Suydam	E130 Cat2017	Individual records from USA Alaska aboriginal bowhead hunt 2017
20/04/2018	Japan: H.Morita	E130 Cat2017	Individual data for Japan’s catch in 2017 in the N. Pacific (JARPN II) & 2017/8 in the Antarctic. (pdf format)

3.3.2 Progress of data coding projects and computing tasks

On behalf of Allison, Donovan reported that the 2017 catches and Japan coastal records in 1943-44 (data from NMML Seattle) have been added to the database. The changes agreed at the 2017 meeting, in particular to split out the catches taken *en route* to and from the Antarctic whaling grounds, have been implemented. Work on computing tasks with respect to work on the AWMP, RMP and in-depth assessments is reported under the relevant agenda items.

4. COOPERATION WITH OTHER ORGANISATIONS

Attention: C-A

The Committee ***stresses*** *the value of cooperation with other organisations when addressing the range of issues affecting cetacean conservation and management. In addition to the summaries below, co-operation is also discussed where relevant elsewhere in the agenda.*

4.1 African States Bordering the Atlantic Ocean (ATLAFCO)
There was no meeting of the Ministerial Conference of ATLAFCO during the intersessional period.

4.2 Arctic Council
4.2.1 PAME (Protection of the Arctic Marine Environment)
The PAME II-2017 meeting was held in Helsinki, Finland from 18-20 September 2017. No IWC observer attended the meeting. The Committee agrees that if possible an IWC observer should attend the next meeting of PAME.

4.3 Convention on Biological Diversity (CBD)
There was no meeting of the Conference of Parties during the intersessional period. The next meeting will take place 10-22 November 2018. The Committee agrees that if possible an IWC observer should attend the next meeting of CBD.

4.4 Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR)
The 36th Meeting of the CCAMLR Scientific Committee was held 16 - 20 Oct 2017 October 2016 in Hobart, Australia. Although no IWC observer attended the meeting, co-operation with CCAMLR remains an important component of the IWC's work and is discussed further under Item 16.1.

4.5 Convention on the Conservation of Migratory Species (CMS)
4.5.1 Scientific Council
The Second Meeting of the Sessional Committee of the Scientific Council was held 10- 13 July 2017 in Bonn, Germany. No IWC observer attended the meeting.

4.5.2 Conference of Parties
The Conference of Parties met 23-28 October 2017 in Manila, Philippines. No IWC observer attended the meeting.

4.5.3 Agreement on Small Cetaceans of the Baltic and North Seas (ASCOBANS)
The report of the observer to ASCOBANS is given as SC/67b/COMM01E. The following key activities have occurred since the last IWC Scientific Committee meeting:

(1) first Joint Meeting of the 13th Meeting of the Jastarnia Group (Baltic Sea harbour porpoises) and the 6th Meeting of the North Sea Group;
(2) best-practice workshop on 'Fostering Inter-regional Cooperation on Underwater Noise Monitoring and Impact Assessments in waters around Europe, within the context of the European Marine Strategy Framework Directive';
(3) 23rd Meeting of the Advisory Committee; and
(4) 14th Meeting of the Jastarnia Group.

The key ongoing ASCOBANS activities are:

(1) work on the three harbour porpoise Action Plans (Baltic, Belt and North Seas)- in place since February 2018;
(2) web-accessed database on marine mammal stranding and necropsy in preparation (ZSL/IOZ leading), 2018-2020;
(3) preparation of an action plan for common dolphins; and
(4) implementing a change in the national reporting cycle from annual (on all topics) to a four-year cycle (selected topics each year) - the intention is that all the key ASCOBANS working groups and meetings align their agendas to home in on these issues in the respective years of reporting (e.g. covering 2017 in 2018).

The Action Points at the last Advisory Committee meeting included:

(1) preparing a discussion on prey depletion and changes in prey quality on the agenda of the 24th Meeting of the Advisory Committee;
(2) co-organisation of a workshop with ACCOBAMS on strandings and marine debris (the report has been made to the Scientific Committee);
(3) future focuses will include the white-beaked dolphin and the white-sided dolphin.
(4) a draft Action Plan for the Common Dolphin is due to be presented at the 24th Advisory Committee Meeting.

The Committee thanked Simmonds for his report and **agrees** that he should represent the Committee as an observer at the next ASCOBANS meeting.

4.5.4 Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS)

MEETING OF PARTIES

There was no Meeting of the Parties (MoP) to ACCOBAMS during the intersessional period. Donovan will represent the Committee as an observer at the next ACCOBAMS MoP.

SCIENTIFIC COMMITTEE

There was no meeting of the ACCOBAMS Scientific Committee during the intersessional period. Donovan will represent the Committee at the next ACCOBAMS Scientific Committee meeting.

4.6 Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)

No relevant meetings of CITES have taken place during the intersessional period.

4.7 Food and Agriculture Organisation of the United Nations (FAO)

There was no meeting of The Committee on Fisheries (COFI) during the intersessional period. The next meeting will take place in Rome, Italy 9-13 July 2018.

4.8 Inter-American Tropical Tuna Commission (IATTC)

The 92nd meeting of the Inter-American Tropical Tuna Commission (IATTC) was held in Mexico City, Mexico 24-28 July 2017. No observer attended IATTC meetings in the intersessional period.

4.8.1 Agreement on the International Dolphin Conservation Program (AIDCP)

No observer attended IADCP meetings in the intersessional period.

4.9 International Committee on Marine Mammal Protected Areas (ICMMPA)

There was no meeting of ICMMPA task force during the intersessional period. The 5th International Conference will be held from 8- 12 April 2019 in Greece. It will evaluate progress in meeting the ICMMPA's long-standing goal of bringing the MMPA community closer together. A primary goal is to focus on the challenges ahead towards achieving effective place-based protection and management for marine mammals. It will build on previous initiatives to advance our understanding of science, management, and effective biodiversity conservation in protected areas. It will also provide updates on plans for the worldwide Important Marine Mammal Area (IMMA) initiative (*marinemammalhabitat.org*). Rojas-Bracho will represent the Committee at this meeting.

4.10 International Council for the Exploration of the Sea (ICES)

The report of the IWC observer documenting the 2017 activities of ICES is given as SC/67b/COMM01A. The ICES Working Group on Marine Mammal Ecology (WGMME) reported on recent information on status of, and threats to, marine mammal populations and briefly reviewed current knowledge of effects of plastics and underwater noise. Criteria for assessment of abundance trends in offshore cetaceans in the context of the Marine Strategy Framework Directive (MSFD) were reviewed, modifying the proposed indicator (previously based solely on the rate of decline) to make specific reference to baseline values. The group also considered the outcomes of the 2016 SCANS III survey[1]. All three SCANS surveys have arisen from individual projects. WGMME recommended that the surveys be co-organised and coordinated by Member States as part of their routine monitoring and that the frequency is increased to once every six years to match the MSFD reporting cycle.

A Workshop on Predator-prey Interactions between Grey Seals and other marine mammals (WKPIGS) focused on predatory behaviour of grey seals towards other grey seals, harbour seals and harbour porpoises in European waters. The workshop aimed to consolidate pathological indicators of grey seal predation events, collate data on the prevalence and distribution and discuss methods to aid in detection of predation events and potential population level consequences of reported incidences. Cases of predation on harbour porpoises peaked in spring months. Reported incidence has increased over the last decade although it is not known if this represents a true increase in prevalence, an increase in seal numbers or an increase in effort/reporting.

Highlights from the 2017 ICES Working Group on Bycatch of Protected Species (WGBYC) included: review of ongoing bycatch mitigation research projects; presentations on interdisciplinary bycatch monitoring programs in the US Northwest Atlantic northeast region; collaborations with other ICES working groups; positive advancements on WGBYC database development working jointly with the ICES Data Centre; and progress on summarising bycatch for the Baltic Sea and Bay of Biscay/Iberia fisheries overviews.

Four cetacean species were reported as bycatch from the 2015 member state reports (common dolphins, white-beaked dolphin, bottlenose dolphin, and harbour porpoise). The WGBYC continues to highlight the inconsistent submission and content of annual reports provided by some member states and the shortcomings to accurately reflect the full magnitude of cetacean bycatch in European fisheries. WGBYC is preparing for the transition away from regular member state reports as the primary source of data on bycatch of cetaceans over to data coming through the ICES regional database.

[1] https://synergy.st-andrews.ac.uk/scans3/

The 2017 ICES Annual Science Conference (ASC) had no sessions devoted entirely to marine mammals. Nevertheless, some sessions had marine mammals included as an integral part - the most relevant sessions were: 'microbes to mammals: metabarcoding of the marine pelagic assemblage' and 'from iconic to overlooked species: how (electronic) tags improve our understanding of marine ecosystems and their inhabitants'.

More information is available from the ICES website *www.ices.dk.*

The Committee thanked Haug for his report and **agrees** that he should represent the Committee as an observer at the next ICES meeting.

4.11 International Maritime Organisation (IMO)

The report of the observer is given as SC/67b/COMM01D. At IWC66, the Commission endorsed recommendations of the IWC Conservation and Scientific Committees for continued engagement with the IMO, including submission of a paper to the IMO Marine Environment Protection Committee (MEPC) providing an update of recent information related to the extent and impacts of underwater noise from shipping. This paper was written by an intersessional group appointed at SC67a and submitted to the IMO MEPC 72 meeting 9-13 April 2018 (MEPC 72/Inf.9).

The ship strike section of the IWC website now contains a list of the measures that have been put in place globally through IMO or national regulations, to reduce ship strike risks to whales. These include Traffic Separation Schemes, Areas to be Avoided, Recommended Routes, voluntary and mandatory speed restrictions. New measures relevant to ship strikes include three recommendatory areas to be avoided (ATBA) encompassing King Island, Nunivak Island, and St. Lawrence Island in the Bering Sea proposed by the United States (NCSR 5/3/8). The proposal noted that King Island is a biologically important site to the gray whale, while St. Lawrence Island's ATBA would provide protection to bowhead whales, gray whales, and humpback whales. These areas were recommended for adoption (with a reduced size for the St. Lawrence ATBA) by the IMO Navigation, Communications and Search and Rescue sub-committee NCSR 5 in February 2018.

Members of the IWC Scientific Committee have attended IMO meetings in order to discuss how best to provide information on populations of marine mammals relevant to the marine mammal avoidance provisions of the IMO Polar Code. This is discussed further under Item 14.3.

The Committee thanked Ferris and Leaper for their report and **agrees** that they should represent the Committee at the next IMO meeting.

4.12 International Union for the Conservation of Nature (IUCN)

The report of the observers to IUCN is given as SC/67b/COMM01G. The IUCN Marine Mammal Protected Areas Task Force (*https://www.marinemammalhabitat.org*) held its 3rd regional workshop in Malaysia in March 2018 to identify, describe and map candidate areas for inclusion in the Important Marine Mammal Area (IMMA) e-Atlas (*marinemammalhabitat.org/imma-eatlas*). The 46 candidate IMMAs proposed by the workshop are currently undergoing independent review.

Cetaceans entries on the Red List are in the process of being updated. The first batch of updates covering 19 taxa was published on *redlist.org* in December 2017 and is summarised at *iucn-csg.org/index.php/page/3*. Most of the remaining mysticete species assessments and some subpopulation assessments, as well as around 10 more new assessments of small and medium-sized odontocetes, have been submitted for publication in the next Red List update in June 2018. Most of the remaining taxa are in the pipeline for publication in late 2018.

IUCN continues to convene the Western Gray Whale Advisory Panel (WGWAP), which provides advice to Sakhalin Energy Investment Company (SEIC) and other parties, especially on the mitigation of industrial and other impacts on the gray whales that feed each summer off Sakhalin Island, Russia. Details of the Panel's recent work are given in Annex O, Appendix 3.

Regular news items on activities by members of the IUCN SSC Cetacean Specialist Group are posted on the CSG website, *www.iucn-csg.org*.

4.13 North Atlantic Marine Mammal Commission (NAMMCO)

Scientific Committee

The report of the IWC observer at the 24th meeting of the NAMMCO Scientific Committee (NAMMCO-SC) is given as SC/67b/COMM01B. The NAMMCO-SC discussed a current joint project, 'Exploring marine mammal consumption relative to fisheries removal in the Nordic and the Barents Seas'. Preliminary results suggest that marine mammal consume around 15 million tons ± 50% of prey per year, predominantly targeting low and mid trophic level species (zooplankton and small pelagic fish). Fisheries remove around 4.3 million tons per year, targeting mid and top trophic levels (small pelagic fish and larger demersal and pelagic fish).

The NAMMCO By-Catch Working Group (BYCWG) met in May 2017. Methods used for collection of data and by-catch estimation were reviewed, and both the WG and the SC recommended methodological improvements to be implemented both in the data collection and the analysis before the bycatch estimates could be endorsed. Greenland is an atypical case because marine mammals that are caught, either directly or indirectly, are assumed to be reported as direct catch (with large whales being the exception where bycatch is reported as such). The primary concern is to ensure that any bycatch is included in the total number of removals to be used in population assessments.

The NAMMCO SC noted and appreciated that the IWC *Implementation Reviews* for North Atlantic fin whales and North Atlantic common minke whales are completed. The NAMMCO SC provided advice on sustainable catch levels fro these species in Icelandic waters (from 2018-2025) based upon application of the RMP. The NAMMCO SC also recommended that the *SLAs* that are developed in the IWC SC be used for advice for large whales in Greenland and provided advice on strike limits for West Greenland humpback whales for the 2019-24.

The NAMMCO SC received the results from an updated global review of monodontids and provided updated assessments and advice for white whales and narwhals in Greenland and Canada. It also received a new abundance estimate for bottlenose whales from the Faroese component of the 2007 T-NASS survey that was analysed together with data on deep diving species from the SCANS-II and CODA surveys. Sightings were mainly from the Faroese survey block.

Increased research on harbour porpoises in Norway is being driven by the concerns regarding bycatch. Bycaught harbour porpoises were collected in 2016 and 2017 by Norway for biological sampling, and a food-web model is being developed for the Vestfjord area close to Lofoten to study the role of the species in this area. An abundance estimate is now available from the SCANS-III survey which was extended from 62°N to include Vestfjorden, an area with high bycatch. Preliminary investigations using this new abundance estimate suggest that bycatch levels are within PBR.

NAMMCO's whale sighting surveys in the Northeast Atlantic in 2015 (NASS2015) included an intensive survey with the purpose of estimating the abundance of pilot whales around the Faroe Isles, an aerial survey of the coastal waters in East Greenland and a ship-based survey around Jan Mayen following methods developed for the Norwegian minke whale surveys. The next NASS survey should be in 2022-23. The NAMMCO SC strongly recommended that an attempt be made to conduct again a trans-Atlantic coordinated survey and charged the NAMMCO Secretariat to explore what are the present plans and how much flexibility they encompass.

Council
The report of the IWC observer at the 26th Annual Council meeting of NAMMCO held in Tromsø, Norway 7-8 March 2018 is given as SC/67b/COMM01C. Relevant items discussed at the Council meeting include the following:

(1) A newly established working group on bycatch, entanglements and live strandings has started its work and will gather information on the matter from other organisations and develop recommendations for NAMMCO. The focus is animal welfare associated to non-hunting related activities, and how NAMMCO can best contribute to addressing significant adverse impacts of by-catch, entanglement and live strandings on marine mammals; and

(2) The report of the Global Review of Monodontids (white whales and narwhals) reviewed the conservation status, threats, and data gaps for all stocks globally. The last review was in 1999.

The Committee thanked Moronuki for his report.

4.14 North Pacific Marine Science Organisation (PICES)
The report of the IWC observer at 2017 annual meeting of PICES is given as SC/67b/COMM01F.

The marine birds and mammals section (S-MBM) focussed on 'seasonal and climatic influences on prey consumption by marine birds, mammals and predatory fishes' Presentations were made on (1) significance of seasonal changes in prey consumption on energy budgets and ecosystem dynamics; (2) effects of changes in water temperature and other climatic variables on food requirements; (3) relationships between dietary shifts and population trends; (4) limits of plasticity in prey selection; and (5) how prey consumption of birds, mammals and predatory fishes is affected by the recent extreme climatic events. Overall, the collection of presented studies in this session contributed to the efforts of the S-MBM to estimate prey consumption of birds and mammals. They provided new methods to estimate prey consumption of marine mammals and gave insights into the existing databases of diets and population estimates that can be used to further this effort.

For 2018, the S-MBM will focus on 'diets, consumption and abundance of marine birds and mammals in the North Pacific'. Since the 2016 workshop, work on the agreed upon databases to estimate prey consumption has been initiated and will continue to be added to over the coming 12 months in anticipation of the 2018 workshop, when invited experts will review the compiled information. This process should result in near-complete databases of diets, abundances and energy requirements of marine birds and mammals in the North Pacific.

The 2018 annual meeting of the PICES will be held in Yokohama, Japan 25 October-4 November 2018. The Committee thanked Tamura for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next PICES meeting.

4.15 Protocol on Specially Protected Areas and Wildlife (SPAW) of the Cartagena Convention for the Wider Caribbean
No observer attended SPAW meetings in the intersessional period.

4.16 Pacific Region Environment Programme (SPREP)
No observer attended SPREP meetings in the intersessional period.

5. GENERAL ASSESSMENT ISSUES WITH A FOCUS ON THOSE RELATED TO THE REVISED MANAGEMENT PROCEDURE (RMP)

Several assessment topics apply not only to the Revised Management Procedure (RMP), but to the work of the Scientific Committee as whole. This item focuses on general assessment issues, such as: (1) the relationship between $MSYR_{mat}$ and $MSYR_{1+}$; (2) implications of RMP and AWMP simulation trials for consideration of 'status'; and (3) matters of relevance to special permits that involve RMP considerations including effects of catches upon stocks.

5.1 Evaluate the energetics-based model and the relationship between $MSYR_{1+}$ and $MSYR_{mat}$

MSYR is a key parameter in the *Implementation Simulation Trials* used to evaluate the conservation and catch performance of alternative RMP variants for specific species and regions. In recent years, the Committee has been reviewing progress on an individual based energetics model (IBEM) to provide insights into the relationship between $MSYR_{1+}$ and $MSYR_{mat}$. Two papers on the IBEM were reviewed by the Committee in SC/67b.

SC/67b/EM07 outlined enhancements to the IBEM since the last meeting. This included the ability to explicitly model the effects of feeding while on migration, which can have effects on the yield curve as well as MSYR and MSYL. The Committee discussed (Annex D, Item 2.1) several ways in which this model can potentially enhance understanding of the relationship between biological processes and MSYR.

SC/67/RMP01 reported on trials using the IBEM within the standard RMP testing framework. The results were consistent with the behaviour of the RMP *CLA* observed in less complex population models and will also provide a point of comparison for the emulator model for the IBEM currently under development. The Committee has previously agreed that a fully-developed emulator model could form the basis for future *Implementation Simulation Trials*.

Attention: SC

The Committee ***agrees*** *that work continue to develop an emulator model; assess whether it is possible to represent the trajectories from the IBEM using an emulator model; compare the yield curves from the IBEM with those from the emulator model; and develop guidelines for how to use an emulator model as the basis for a multi-stock, multi-area population dynamics model and how such a model could be conditioned given available data.*

5.2 Implications of ISTs for consideration of species' and populations' status

Last year, the Committee recommended that a set of *Implementation Simulation Trials* should be summarised using three statistics to provide information on status (IWC, 2018d). The Committee was advised that intersessional tasks toward that goal could not be completed prior to SC/67b due to computing workloads.

Attention: SC

The Committee ***agrees*** *that Allison should modify the control programs used for* Implementation Simulation Trials *to report the three measures of status agreed last year (IWC, 2018d). The RMP sub-committee, in conjunction with the Working Group on ASI, will review outcomes of the analyses at SC/68a. Punt and Donovan will develop draft updates to the Guidelines for* Implementations *and* Implementation Reviews *to reflect decisions on evaluation status of stocks for consideration at SC68a.*

5.3 General consideration of how to evaluate the effect of special permit catches on stocks and levels of information needed to show improved management performance

5.3.1 General issues

The Committee developed general guidelines on the levels of information needed to show improved management improvement, for proposals that identify this as an objective (Annex D; appendix 2). The guidelines are intended to assist proponents in proposal preparation and to facilitate the review process. It was stressed that these were guidelines not requirements. Proponents might request the establishment of an Advisory Group to provide comment on intersessional work, but this is not mandatory. An Advisory Group may most benefit nations which have not previously developed proposals or may be lacking analysts familiar with the modelling approaches commonly applied at the IWC.

Attention: SC

The Committee ***agrees*** *that the general guidelines on the levels of information needed to show improved management improvement, for proposals that identify this as an objective (Annex D; appendix 2), should be included as an Appendix to the Scientific Committee handbook.*

5.3.2 Specific issues
SC/67b/RMP03 provided draft specifications for RMP/IST type simulations to evaluate management procedures based on modified *CLA*s that use information on recruitment inferred from age data from Antarctic minke whales. This work originally arose from discussions of NEWREP-A and Recommendation 1 of the Panel Review of that proposal (and see Item 19). The Committee noted that SC/67b/RMP03 was a work-in-progress, and that several features of the operating models would need to be extended before final conclusions could be drawn. The author of SC/67b/RMP03 plans to continue this work and received several suggestions from the Committee to carry those efforts forward (Annex D, Item 2.3).

5.4 Work plan 2019-20
Details of work to be undertaken both before and during the 2019 Annual Meeting are given in Table 2.

Table 2

Work plan for general assessment matters with a focus on the RMP

Topic	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting
Item 5.1: Conduct work to evaluate the energetics-based model and hence the relationship between MSYR1+ and MSYRmat	(a) Continue to assess whether it is possible to represent the trajectories from the IBEM using the emulator model (Annex Y); (b) Compare the yield curves from the IBEM with those from the emulator model (Annex Y); and (c) Develop guidelines for how to use an emulator model as the basis for a multi-stock, multi-area population dynamics model and how such a model could be conditioned given available data (Annex Y).	Continue to work to evaluate the energetics-based model and hence the relationship between $MSYR_{1+}$ and $MSYR_{mat}$	Conduct follow-up analyses	Continue to work to evaluate the energetics-based model and hence the relationship between MSYR1+ and MSYRmat
Item 5.2: Implications of ISTs, for consideration of status	(a) Modify the control programs used for *Implementation Simulation Trials* to report the three measures of status (Allison) (b) Draft updates to the Guidelines for *Implementations* and *Implementation Reviews* to reflect decisions on evaluation status of stocks (Punt and Donovan)	Review the results of the projections Review the draft guidelines		
Item 5.3: levels of information needed to show improved management performance		Review progress implementing the suggested changes to the specifications of the model in SC/67b/RMP03 and any results.		

6. RMP – *IMPLEMENTATION*-RELATED MATTERS (RMP)

This agenda item includes the details of ongoing *Implementation Reviews* and preparation for new *Implementation Reviews*. For discussions related to the stock structure and abundance of these stocks, see also Items 11 and 12.

6.1 Completion of the *Implementation Review* of western North Pacific Bryde's whales
6.1.1 Report of the intersessional Workshop
The second intersessional Workshop on western North Pacific Bryde's whales was held in Tokyo from 14-16 February 2018 (SC/67b/Rep02). The objective was to facilitate completion of the *Implementation Review*. Much of the Workshop focussed on completing the final trial specifications, especially confirming the mixing matrices, updating the abundance estimates for the new sub-areas and confirming future sighting survey plans and whaling options. The Workshop reviewed preliminary conditioning results and agreed that they were satisfactory. It developed a workplan to try to ensure completion of the *Review* at SC/67b.

The Committee noted that the intersessional workshop had led to considerable progress towards completing the *Implementation Review*. It thanked Donovan for chairing the meeting, the Government of Japan for providing excellent facilities and all the participants for their contributions to the development of trial specifications and workplan.

The code and specifications for *Implementation Simulation Trials* were updated following the intersessional Workshop.

Attention: SC

The Committee ***agrees*** *to the updated trial specifications for the* Implementation Review *of western North Pacific Bryde's whales. These specifications are provided in Annex D, Appendix 3. It also* ***agrees*** *that conditioning has been achieved satisfactorily.*

6.1.2 Conclusions and recommendations

Once the trial specifications and conditioning had been agreed, the next step was to conduct projections under alternative RMP variants and survey plans. There was insufficient time during the meeting to complete all of the required projections and to check the associated calculations. Consequently, the remaining work will be completed intersessionally and reviewed and summarised by a Steering Group (Annex Y). This will occur well before SC/68a so that Japan has sufficient time to consider the results (e.g. with regard to its preferred survey options), prior to final conclusions being drawn. The Committee expects that this work can be completed before the end of 2018, but if complications arise conducting the projections, an extra day should be added to the 'First Intersessional Workshop for the western North Pacific minke whales' (see Item 6.2) to address outstanding issues.

Attention: SC

The Committee ***agrees*** *that the* Implementation Review *of western North Pacific Bryde's whales will be completed at SC/68a. Outstanding tasks will be completed intersessionally and the results reviewed and summarised by a Steering Group (Annex Y). This will occur well prior to SC/68a, and if complications arise then an extra day should be added to the First Intersessional Workshop for the western North Pacific minke whales (see Item 6.2) to address those issues.*

6.2 Start of the *Implementation Review* of western North Pacific common minke whales

6.2.1 Report of the intersessional Workshop

Donovan summarised the report of the preparatory Workshop for the Western North Pacific common minke whale *Implementation Review* (SC/67b/Rep05). Last year, the Committee recognised that the most difficult aspect of the last *Implementation Review* had been selecting, modelling and assigning plausibility to stock structure hypotheses. The objective of this Workshop was to begin to review work undertaken since the last *Implementation Review* and to develop, if necessary and possible, consensus advice on further analyses that will assist in the forthcoming *Implementation Review*. Stock structure discussions on common minke whales are detailed in Annex I, item 4.2.

This past lack of agreement with respect to the plausibility of existing stock structure hypotheses has, in part, revolved around how genetic analyses can be used to assign whales as part of the 'J' versus 'O' stocks. While some whales assign strongly to one of the two groups based on genetic data, the assignment of others is dependent on the assignment probability deemed sufficient to assign stock affinity. At the intersessional workshop (SC/67b/Rep05), the results of new stock structure-related analyses were reviewed by an advisory panel, and two recommendations were made with regard to additional genetic analyses needed to better understand stock structure. One of the recommended analyses involved evaluating the consistency of individual assignment probabilities when additional loci were genotyped. Progress with respect to that recommendation is discussed below.

The Workshop was also provided with an update to SC/67a/SCSP/13 that used information on the trend over time in the J:O stock ratio for common minke whale bycatches around Japan to draw various inferences, in particular about the value of the MSYR. The Workshop agreed that J:O stock ratios in bycatch will require attention when formulating stock distribution assumptions for the process of conditioning *IST*s in the coming *Implementation Review* and made some recommendations on how this could be achieved.

The Committee noted that the intersessional Workshop was held in an excellent spirit of co-operation among the participants and led to identification of additional data sets and analyses that should be taken forward. The Committee thanked Donovan for chairing the meeting, the Government of Japan for providing excellent facilities and all the participants for their contributions to progress the *Implementation Review*.

6.2.2 Progress since the intersessional Workshop

SC67b/SDDNA06 presented the results of the recommended analysis from the Workshop (see Item 6.2.1) and the Committee confirmed that the workshop's recommendation for this analysis had been properly completed.

Attention: SC

The Committee reviewed new results of genetic analyses that were recommended at the intersessional workshop (SC/67b/Rep05) to better evaluate the use of genetic data to assign stock affinity in North Pacific common minke whales. The Committee:

(1) ***agrees*** *that future analyses should incorporate a range of assignment thresholds to encompass uncertainty;*
(2) ***supports*** *the additional genetic analyses described in Annex I Appendix 5 relating to the second recommendation of the intersessional workshop and agrees that they should be performed prior to the next intersessional workshop; and*
(3) ***encourages*** *the inclusion of non-genetic biological data to inform stock structure where possible.*

SC/67b/RMP/02 aimed at suggesting a plausible range for $MSYR_{1+}$ for the western North Pacific common minke whales, and the relative plausibility of two stock structure hypotheses. The Committee thanked Kitakado for the updated analysis, which implemented some of the recommendations from the intersessional Workshop. Details of this paper and associated discussion can be found in Appendix D, Item 3.2.2. The Committee also discussed the analysis of genetic data conducted since the intersessional workshop (Annex I, Item 4.5).

Attention: SC, CG-A

The Committee ***agrees*** *that:*

(a) it is necessary to update the mixing matrices in the trial specifications to be more consistent with observed genetic and bycatch data, also taking into account sensitivity to alternative methods of genetic assignment to stock;
(b) whether it is possible to use the bycatch data to assign plausibility ranks to $MSYR_{1+}$ values and stock structure hypotheses depends on assumptions regarding trends in fishing effort spatially and temporally; and
(c) trials would need to consider different assumptions regarding the use of J:O bycatch ratios, including that these data do not provide information on $MSYR_{1+}$ and the plausibility of stock structure hypotheses because of possible differential distributional changes by stock.

The Committee therefore ***agrees*** *that scientists from Japan and Korea should provide data on the amount, location and timing (seasonal and annual) of fishing effort and bycatch to the First Intersessional Workshop (see item 6.2.3).*

6.2.3 Preparation for the First Intersessional Workshop

The Committee began preparations for the First Intersessional Workshop on the *Implementation Review* of western North Pacific common minke whales. It re-established the Steering Group (Annex Y) to organise this Workshop.

In accordance with the Committee's *'Requirements and Guidelines for Implementations and Implementation Reviews'* (IWC, 2012b), the primary objectives of the First Intersessional Workshop will be to: (a) consider plausible hypotheses and eliminate any hypotheses that are inconsistent with the data); (b) examine more detailed information in expected whaling operations, including options or suggested modifications to the pattern of those operations; (c) review the small geographical areas ('sub-areas') that will be used in specifying the stock structure hypotheses and operational pattern; and (d) specify the data and methods for conditioning the trials that will be carried out before the next annual meeting. An initial annotated agenda for the Workshop, highlighting the associated data and analysis requirements can be found in Annex D, appendix 5.

6.3 Workplan 2019-20

Details of work to be undertaken both before and during the 2019 Annual Meeting are given in Table 3.

Table 3

Work plan for RMP (*Implementation*-related matters)

Topic	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting
Item 6.1: Western North Pacific Bryde's whales	Finalise the projections and the application of the criteria for evaluating which RMP variants are acceptable, borderline, and unacceptable	Complete the *Implementation Review*		
Item 6.2: Western North Pacific minke whales	(a) conduct the First Intersessional Workshop; (b) code the resulting trials and condition the trials	Conduct the work required for the First Annual Meeting	Conduct the Second Intersessional Workshop	Conduct the work required for the Second Annual Meeting

7. ABORIGINAL SUBSISTENCE WHALING MANAGEMENT PROCEDURE (AWMP)

This item continues to be discussed as a result of Resolution 1994-4 of the Commission (IWC, 1995), which has been strengthened by Resolution 2014-1 (IWC, 2016a). The report of the Standing Working Group (SWG) on the development of an aboriginal whaling management procedure (AWMP) is given as Annex E. The Committee's deliberations, as reported below, are largely a summary of that Annex, and the interested reader is referred to it for a more detailed discussion. The primary issues at this year's meeting comprised: (1) finalising the development of *SLA*s (*Strike Limit Algorithms*) for Greenlandic hunts, with a focus on fin and common minke whales; (2) finalising the work on the scientific components of the AWS (Aboriginal Subsistence Whaling Management Scheme); (4) completion of the *Implementation Review* for Bering-Chukchi-Beaufort Seas stock of bowhead whales; and (3) providing management advice for aboriginal hunts (see Item 8).

Considerable progress on items (1) and (2) was made because of intense intersessional work including two workshops in Copenhagen in October 2017 and March 2018, as well as a small technical meeting in December 2018 at OSPAR headquarters in London.

7.1. *SLA* development for the Greenland hunts

7.1.1 Fin whales

SC/67b/Rep06 incorporated the discussions of the two intersessional Workshops and the small working group meeting. Considerable progress was made in relation to (a) updated abundance estimates; (b) finalisation of the trial structure; (c) review and approval of conditioning; and (d) initial consideration of new *Strike Limit Algorithms* (*SLA*s) and results.

The Committee thanked Donovan, the Workshop chair and the participants for the excellent progress made.

The final trial specifications for the West Greenland fin whales are provided in Annex E (Appendix 2).

Table 4 below summarises the main factors considered in the *Evaluation Trials.* The most influential involve different stock structure hypotheses, different productivity rates (MSYR) and different 'need' envelopes (need envelopes incorporate scenarios where need remains constant at the present level for 100 years (termed A), where it increases linearly to twice the present level over the 100-year simulation period (termed B) and where it increases linearly to three times the present level over the 100-year period (termed C).

Table 4

Summary of the key factors considered in the fin whale trials

Factor
Stock structure hypotheses
Mixing matrices
MSYR rate
Survey bias
Need envelope

7.1.1.1 CANDIDATE *SLA*S

The Committee received two papers with candidate *SLA*s, SC/67b/AWMP13 and SC/67b/AWMP15. The general properties of the three *SLA*s presented in SC/67b/AWMP13 involve taking an inverse variance weighted average of the last three estimates as an estimate of abundance and calculating the strike limit as a growth rate fraction of a lower percentile of the abundance (conditional on a trend modifier), a snap to need feature and a protection level. The three variants relate to how they are 'tuned' (the trade-off balance between conservation and need).

The three *SLA*s presented in SC/67b/AWMP15 are based on a weighted-average interim *SLA* which uses all abundance estimates, but where the earlier ones are down-weighted. An adjustment to the multiplier of the abundance estimate in the interim *SLA* is applied which depends on the trend of the abundance indices. The three variants relate to how they are 'tuned' (the trade-off balance between conservation and need).

7.1.1.2 REVIEW FINAL RESULTS AND PERFORMANCE

In total, seven potential *SLA*s (which include the 'Interim' *SLA* – a modified version of the *Interim SLA* used to provide advice previously by the Committee until the final *SLA*s had been developed) were considered. The full range of conservation and need statistics were reviewed for the *Evaluation Trials*[2], noting that the initial focus is on meeting the Commission's conservation objectives. Those candidate *SLA*s that meet these are then evaluated on their ability to meet need satisfaction. In summary, conservation performance is deemed satisfactory if either the population is not at MSYL but it is increasing towards it or the population is above MSYL (in which case it may be increasing or decreasing towards MSYL). These concepts are captured in the 'D1' and 'D10' statistics (defined fully in Annex E, table 2) and can be visualised in bivariate plots given in Annex E.

The Committee agreed that the proposed *SLA*s had performed satisfactorily on the joint conservation statistics for the A and B (but not for the C) need envelopes for all trials. The focus was then to evaluate the need satisfaction performance over 20 and 100 years and consider stability in catch levels. This performance was captured by examining three statistics:

[2] The Committee also examines the results of *Robustness Trials* to ensure that the *SLA* does not exhibit unusual behaviour in more extreme trials.

N9(20) the average need satisfaction over the first 20 years, N9(100) the average need satisfaction over the 100 years and N12 the mean down step statistic (these are also defined fully in Annex E, table 2). They can be visualised in 'Zeh' plots (e.g. see Annex E).

Given the present incorporation into the trial structure of two widely different stock structure hypotheses ('influx' and 'partial'- see Annex E, appendix 2) to explain the variability of the abundance estimates, the need satisfaction over 20 years was given more weight in the evaluation as it is likely that future *Implementation Reviews* may be able to remove one or other scenario.

After an examination of the full range of results, there was no obvious 'winner' between two of the *SLA*s (one from each developer). Depending on the trials considered, and which statistic was examined, they performed slightly differently but their performance overall was equivalent.

Following an approach originally adopted during the development of the *Bowhead SLA*, it was decided that an *SLA* which sets the strike limit to the average of the values obtained by the two *SLA*s[3] would be preferable, providing performance was as good or better than either individual *SLA*; no 'snap to need' for the averaged *SLA* has been applied. The results of the 'combined *SLA'* are summarised in Annex E, appendix 3[4].

7.1.1.3 CONCLUSIONS AND RECOMMENDATIONS

The management advice developed using this *SLA* is given under Item 8. 6.

Attention: C-A, SC

The Committee ***draws attention*** *to the extensive work undertaken over recent years to develop an* SLA *for the West Greenland hunt for fin whales. In concluding this work, the Committee:*

(1) ***agrees*** *that the combined* SLA *(which sets the strike limit to the average of the values obtained by the two best* SLAs *considered) performed satisfactorily in terms of conservation performance and was to be preferred over the individual SLAs in terms of need satisfaction;*
(2) ***recommends*** *that this* 'WG-Fin SLA' *be used to provide management advice to the Commission on the subsistence hunt for West Greenland fin whales (provided the need request falls within need scenarios A and B);*
(3) ***expresses*** *its great thanks to the developers, Brandão and Witting for the vast amount of work put into the development process and to Allison and Punt for their extensive work developing the operating models and running the trials; and*
(4) ***agrees*** *that one focus of the next* Implementation Review *will be to examine further stock structure in relation to the two hypotheses being considered at present, and especially the 'influx' model which was developed in the context of low abundance estimates in some years, rather than being based upon genetic information.*

7.1.2 Common minke whales (Greenland)

SC/67b/Rep06 incorporated the discussions of the two intersessional Workshops and a small working group meeting. Considerable progress was made in relation to (a) updated abundance estimates; (b) finalisation of the trial structure; (c) conditioning; and (d) initial consideration of new *Strike Limit Algorithms* (*SLA*s) and results.

The Committee thanked Donovan, the Workshop chair and the participants for the excellent progress made.

The final trial specifications for the West Greenland common minke whales are provided in Annex E (appendix 4).

Table 5 below summarises the main factors considered in the *Evaluation Trials* for common minke whales. The most influential involve different stock structure hypotheses, different productivity rates (MSYR) and different 'need' envelopes (see discussion under Item 7.1.1), where it increases linearly to twice the present level over the 100-year simulation period (termed B) and where it increases linearly to three times the present level over the 100-year period (termed C).

Considerable work was undertaken to finalise the list of trials, to ensure that the mixing matrices were correctly specified and to complete and agree conditioning. The final trial specifications are provided in Annex E, Appendix 4.

Table 5

Summary of the key factors considered in the common minke whale trials

Factor
Stock structure hypotheses
Mixing matrices
MSYR rate
Survey bias
Need envelope

[3] tuned to a D10 of 0.8 for the influx trial F34-1B

[4] Final validation and archiving of results will be undertaken by Allison in Cambridge.

7.1.2.1 CANDIDATE *SLAS*
SC/67b/AWMP14 developed a candidate *SLA* for common minke whales off West Greenland similar to that used for fin whales in SC/67b/AWMP13. It operates on an inverse variance weighed average of the last three abundance estimates. The strike limit is calculated as a growth rate fraction of a lower percentile of the abundance measure, conditional on a 'snap to need' feature, and a protection level. It does not include a trend modifier.

It was tuned to have a 5th percentile of D10 of 0.80 for need envelope A for the most difficult *Evaluation Trial* (trial M04-1A – see Annex E, appendix 4), where there are two sub-stocks in the western North Atlantic in which the mixing between the Central and the Western stock, and mixing between the putative western sub-stocks, is minimal, and where the MSYR is 1%).

7.1.2.2 CONSIDERATION OF RESULTS
Conditioning of the *Evaluation Trials* was completed satisfactorily and a summary of the results of the is provided in Annex E (appendix 5[5]). Annex E, fig. 3 provides the bivariate plot.

In determining satisfactory conservation and need performance when evaluating *SLA*s, the Committee considers the full range of results across all the *Evaluation Trials*, not simply the worst-case scenarios. Conservation performance was satisfactory for all but the most extreme trial (trial M04-1A) where it was slightly below for the lower 5th percentile. This trial had low MSYR and two W-stocks; it had been originally considered in the context of investigating potential problems for the hunt to simulate possible local depletion in the hunting area rather than for conservation reasons. Genetic stock structure in the entire North Atlantic is subtle such that even an hypothesis of almost complete panmixia is not rejected by most of the analyses and thus differentiation among 'C' and 'W' is very low. This is even more true for substructure within the W stock (if, indeed, there is any). Given that trials are conservative in so far as they overrate isolation among stocks, and the very subtle differentiation among stocks and sub-stocks in the North Atlantic, a single trial (which implements two fully separate W sub-stocks, for which there is little evidence) not meeting the D1/D10 criteria is not of conservation concern.

The SWG (Annex E, item 2.2.3) had noted that given the unforeseen situation with Secretariat computing, there had been insufficient time for it to consider the results of the *Robustness Trials* during its meeting. Such trials are not needed to determine an *SLA* but are examined to ensure that the selected *SLA* has no unforeseen properties in extreme trials. These were subsequently run prior to the plenary discussions and the results showed no unexpected properties.

7.1.2.3 CONCLUSIONS AND RECOMMENDATIONS
The management advice developed using the *WG-common minke SLA* is provided under Item 8.5.

Attention: C-A, SC

The Committee ***draws attention*** *to the extensive work undertaken over recent years to develop an* SLA *for the West Greenland hunt for common minke whales. In concluding this work, the Committee:*

(1) ***agrees*** *that the tested* SLA *which performed satisfactorily in terms of conservation performance;*
(2) ***agrees*** *that this 'WG-Common minke SLA' be used to provide management advice to the Commission on the subsistence hunt for West Greenland common minke whales provided the need request falls within need scenario A (i.e. does not exceed 164 annually);*
(3) ***expresses*** *its great thanks to the developers, Brandão and Witting for the vast amount of work put into the development process and to Allison and Punt for their extensive work developing the operating models and running the trials; and*
(4) ***agrees*** *that one focus of the next* Implementation Review *will be to examine further stock structure in relation to the two hypotheses being considered at present, should be consideration of the results of analyses of genetic data using additional samples from Canada (as well as the additional samples that will become available from West Greenland and Iceland); and*
(5) ***agree****s to establish an intersessional advisory group (Annex Y) to facilitate issues relating to samples.*

7.1.3 North Pacific gray whales (Makah whaling)
7.1.3.1 MANAGEMENT PLAN PROPOSED BY THE U.S. FOR MAKAH WHALING
The Makah Indian Tribe has requested that the U.S. National Marine Fisheries Service (NMFS) authorise a tribal hunt for Eastern North Pacific (ENP) gray whales in the coastal portion of its 'usual and accustomed fishing area' in Washington State. The Tribe intends to hunt gray whales from the ENP population, which currently numbers approximately 27,000 animals (Durban *et al.*, 2017). However, at certain times of the year there is a possibility that the hunt may take animals from the PCFG (Pacific Coast Feeding Group) and/or the WNFG (Western North Pacific Feeding Group). In an updated management plan – known as the Makah Management Plan (the Committee had approved an earlier plan for this hunt in 2012 (IWC, 2013), NMFS has taken measures to restrict the number of PCFG whales that are struck or landed in a given 10-year period and to avoid, to the extent possible, striking or killing a WNFG gray whale. The Government of the USA requested the Committee to test this plan to ensure that it meets IWC conservation objectives.

[5] Final validation and archiving of results will be undertaken by Allison in Cambridge.

This task was begun at the Fifth Rangewide Workshop on the Status of North Pacific Gray Whales (SC/67b/Rep07) from 28-31 March 2018. The major focus of the Workshop related to finalising the specifications for modelling, to enable results to be available for SC67b including incorporation of the Makah Management Plan (SC/67b/Rep07, Annex E, appendix 1) into the modelling framework. The factors taken into account in the trials are given in Table 6.

Table 6

Summary of the main factors considered in the Makah gray whale trials

Factor	
Model fitting related	Projection-related
Stock hypothesis	Additional catch off Sakhalin
MSYR	Catastrophic events
Mixing rate	Northern need in final year
Immigration into the PCFG	Struck and lost rate
Bycatches and ship strikes	Future effort
Pulse migrations into the PCFG	Factors related to obtaining and matching photographs

At the present meeting, the focus was on the conservation performance of the Makah Management Plan. Performance was evaluated in the same manner as described for the evaluation of the *SLA*s for West Greenland fin and common minke whales (see Items 6.1 and 6.2). The results can be found in Annex E (appendix 6). The only scenarios under which the plan might not perform adequately were considered to have low plausibility (e.g. a bycatch mortality of ~ 20 PCFG whales per year). Annex E, fig. 4 shows the bivariate plot.

7.1.3.2 CONCLUSIONS AND RECOMMENDATIONS

The management advice relating to the Makah Management Plan is provided under Item 8.2.

Attention: C-A, SC

The Committee reviewed a US Management Plan for a Makah hunt of gray whales off Washington State (the Committee had evaluated a previous plan in 2011 - IWC, 2011; 2012), using the modelling framework developed for its rangewide review of gray whales (SC/67b/Rep07). In conclusion, the Committee:

(1) ***agrees*** *that the performance of the Management Plan was adequate to meet the Commission's conservation objectives for the Pacific Coast Feeding Group, Western Feeding Group and Northern Feeding Group gray whales;*
(2) ***notes*** *that the proposed management plan is dependent on photo-identification studies to estimate PCFG abundance and the mixing proportions of PCFG whales available to the hunt (and to bycatch in its range);*
(3) ***stresses*** *that its conclusions are dependent on the assumption that these studies will continue in the future; and*
(4) ***expresses*** *its* ***great thanks*** *to Punt, Brandon and Allison for their excellent work in developing and validating the testing framework and running the trials.*

7.1.4 Conclusions on AWMP work

The Chair of the SWG on the AWMP, Donovan, noted that this meeting represented the end of a long journey – with the adoption of the two new *SLA*s, the SWG and the Committee has completed the development tasks it had been assigned by the Commission, originally in Resolution 1994-1. It was an immense task but a great pleasure to work with such dedicated and talented people. He thanked all of the scientists who have made such a wonderful contribution to this work over the years and especially Geof Givens, Kjartan Magnússon (sadly no longer with us), Eva Dereksdóttir, Lars Witting, Anabela Brandão, Doug Butterworth, Cherry Allison and André Punt – the SWG has, in his view, achieved ground-breaking work over the last two decades in a spirit of great collaboration and co-operation, even when there were disagreements, as inevitably there were. He also thanked the hunters and their representatives who had made major contributions in terms of not only data provision but also advice on the AWS (see Item 7.2). The Committee **concurred** that this was an excellent example of what the Scientific Committee could achieve with international collaboration. Finally, they **thanked** Donovan for his dedicated, good humoured and impartial leading of such a major piece of complex work over such a long period - this work has been central to the Committee's role in providing the best scientific advice to the Commission on aboriginal subsistence whaling hunts, bringing together conservation needs and the needs of the hunters.

7.2 Aboriginal Whaling Scheme (AWS)

7.2.1 Introduction

The Scientific Committee's Aboriginal Whaling Management Procedure (AWMP) applies stock-specific *Strike Limit Algorithms* (*SLA*s) to provide advice on aboriginal subsistence whaling (ASW) strike/catch limits.

ASW management (as part of an AWS, the aboriginal whaling scheme) incorporates several components, several of which have a scientific component:

(1) *Strike Limit Algorithms* (case-specific) used to provide advice on safe catch/strike limits;

(2) operational rules (generic to the extent possible) including carryover provisions, block quotas and interim relief allocations;
(3) Guidelines for *Implementation Reviews*; and
(4) Guidelines for data and analysis (e.g. guidelines for surveys, other data needs).

Considerable work on updating the AWS since the version presented (but not accepted by) to the Commission in 2002 (IWC, 2003) was undertaken by an intersessional correspondence group (SC/67b/AWMP 21) and at the intersessional workshops (SC/67b/Rep04).

7.2.2 Carryover request from the Governments of USA and Denmark/Greenland
The Governments of USA and Denmark/Greenland (SC/67b/Rep06, Annex F, appendix) had requested advice at the March intersessional Workshop on the conservation implications of carryover provisions allowed for a carryover provision that allowed use of unused strikes from the previous three blocks, provided that the number used in any year did not exceed 50% of the annual strike limit.

This request was tested on the two *SLA*s available for stocks hunted by the USA and Greenland at the time of the Workshop i.e. the *Bowhead SLA* (applicable to the Bering-Chukchi-Beaufort Seas stock) and the *WG-Humpback SLA* (applicable to West Greenland).

Three types of options were examined:

(1) baseline case - all strikes taken annually (i.e. no need for carryover);
(2) 'frontload' case - strikes taken as quickly as possible within block (+50% limit annually until the block limit is reached); and
(3) Two alternative scenarios where carryover strikes are accrued for one or three blocks, followed by a period of carryover usage subject to the +50% limit.

The three-block scenario considered in (3) served as a direct test of the provision described in the request of USA and Denmark/Greenland.

Attention: CG-A

The Committee received a request from the USA and Denmark/Greenland (SC/67b/Rep06, Annex F, appendix) on the conservation implications of carryover provisions that
'…allow for the carry forward of unused strikes from the previous three blocks, subject to the limitation that the number of such carryover strikes used in any year does not exceed 50% of the annual strike limit'.
The Committee reviewed the request using its simulation frameworks and the two SLA*s available for stocks hunted by the USA and Greenland available at the time of the Workshop i.e. the* Bowhead SLA *(applicable to the Bering-Chukchi-Beaufort Seas stock) and the* WG-Humpback SLA *(applicable to West Greenland) and*

(1) ***agrees*** *that a carryover provision for up to 3-blocks meets Commission's conservation objectives; and*
(2) ***reiterates*** *its previous advice, applicable for all* SLA*s, that interannual variation of 50% within a block with the same allowance from the last year of one block to the first year of the next is acceptable; and*
(3) ***agrees*** *to evaluate the above request for the other Greenland* SLA*s at the 2019 Committee meeting.*

7.2.3 Review proposed updates to the AWS
The proposed update to the previous AWS is provided in Annex E, appendix 8. It has sections on carryover, block quotas, interim relief allocation (and see Annex E, appendix 7), *Implementation Reviews* and guidelines for surveys and data.

7.2.4 Conclusions and recommendations

Attention: C-R

The Committee has been working for some years to update the scientific components of an Aboriginal Whaling Scheme. It has completed this work and ***recommends*** *the AWS provided in Annex E, appendix 8 to the Commission. It has sections on carryover, block quotas, interim relief allocation (and see Annex E, appendix 7), Implementation Reviews and guidelines for surveys and data. It* ***notes*** *that the Commission's AWS may include additional, non-scientific provisions.*

7.3 *Implementation Review* of BCB bowhead whales
According to the Committee's guidelines, the primary objectives of an *Implementation Review* are to:

(1) review the available information (including biological data, abundance estimates and data relevant to stock structure issues) to ascertain whether the present situation is as expected (i.e. within the space tested during the development of a *Strike Limit Algorithm* (*SLA*)) and determine whether new simulation trials are required to ensure that the *SLA* still meets the Commission's objectives; and
(2) to review information required for the *SLA*, i.e. catch data and, when available at the time of the *Review*, new abundance estimates (note that this can also occur outside an *Implementation Review* at an Annual Meeting).

The *Bowhead SLA* was adopted in 2002 (IWC, 2003, p.158) and there was an extensive *Implementation Review* completed in 2007 (IWC, 2008a, p.124) with a major focus on stock structure including three intersessional workshops. That included consideration of additional trials investigating management implications of assuming additional population structure even though these were considered of low plausibility. The Committee concluded that the *Bowhead SLA* remained the best tool to provide management advice. The next *Implementation Review* was completed in 2012 (IWC, 2013b, p.147); that concluded that there was no need to develop additional trials to those evaluated during the previous *Implementation Review* (IWC, 2008c).

The primary review was undertaken by the SWG on the AWMP (Annex E, Item 4) but the review benefitted from discussions within two other groups, SD-DNA (Annex I, Item X) and ASI (Annex Q, Item Y).

7.3.1 Stock structure: review new information
A full discussion of the work on stock structure can be found in Annex E (item 4.1) and Annex I. New information considered included genetic analyses (SC/67b/SDDNA 01) and telemetry results (SC/67b/AWMP04). SC67b/SDDNA01provided information on genetic analyses using samples from the BCB, Canadian and Okhotsk Sea stocks of bowhead whales. Within the BCB stock, no significant differences were identified in temporal or spatial comparisons, and age-related structure was not detected in comparisons between groups of large (old) versus small (young) whales. While comparisons of the BCB stock with the Okhotsk Sea stock revealed significant differences, there were only small, and in most cases statistically insignificant, differences between BCB and Canadian stocks. While this pattern could be related to historical connectivity between the two stocks, it could also, or additionally, be driven by some degree of contemporary gene flow.

Attention: SC

With respect to stock structure, considering the multiple lines of evidence, the Committee:

(1) ***agrees*** *that BCB bowheads comprise a single population, with no signs of substructure;*
(2) ***agrees*** *that there was no need to consider any new SLA trials regarding stock structure, since the trials conducted in 2002 and 2007 already covered all plausible stock structure hypotheses;*
(3) ***welcomes*** *the telemetry information provided, thanks the hunters involved for their skill and assistance;*
(4) ***encourages*** *additional telemetry efforts; and*
(5) ***agrees*** *with the suggestions for future genetic studies in the Arctic provided under Item 11.*

7.3.2 Abundance estimates: review new information
A new abundance estimate (SC/67b/AWMP) has been accepted for the year 2011 from a long-term photo-id capture-recapture study (27,133, CV=0.217; 95% CI from 17,809 to 41,337) that it has been agreed is suitable for providing management advice and for use in the *SLA* (Annex Q). The previously accepted, completely independent, 2011 abundance estimate from the ice-based survey (Givens *et al.*, 2016) is also acceptable for use in the *SLA* and has already been used in that regard (16,820, CV=0.052; 95% CI 15,176 to 18,643).

There are thus two independent estimates for the same year considered suitable for use in the *SLA* and this is considered under Item 8.3.

The Committee also discussed plans for future surveys (SC/67b/AWMP 12 and AWMP 16) in Annex Q (item 3.1.1.1). These plans are in accord with the AWS Guidelines that 'plans for undertaking a survey/census should be submitted to the Scientific Committee in advance of their being carried out, although prior approval by the Committee is not required.

7.3.3 Biological parameters: review new information
New and extensive information on biological parameters was received as discussed Annex E (item 4.3). These covered such matters: length at sexual maturity and pregnancy rate from hunted animals (SC/67b/AWMP 07); the potential use of samples from baleen plates to examine hormone cycles and pregnancy; and information on calves from aerial surveys (SC/67b/AWMP03).

Attention: SC

With respect to biological parameter information, the Committee:
(1) ***welcomes*** *the extensive information presented;*
(2) ***encourages*** *the continued collection of such data from the hunt;*
(3) ***encourages*** *the work on the baleen plate analyses to examine hormone levels and pregnancy;*
(4) ***encourages*** *continued aerial surveys under the ASAMM surveys and any future collaboration involving life history data from the harvest; and*
(5) ***agrees*** *that the information presented does not suggest the need to consider any new SLA trials regarding stock structure.*

7.3.4 Removals: review new information
The Committee received updated information about the 2017 harvest (SC/67b/AWMP 05) and long-term removals (SC/67b/AWMP 06). In 2017, 57 bowhead whales were struck resulting in 50 animals landed. The total landed for the hunt in 2017 was higher than the average over the past 10 years (2007-2016 mean of landed =41.7; SD=6.7). Efficiency (number landed / number struck) in 2017 was 88%, which was also higher than the average for the past 10 years (mean of efficiency=75.2%; SD=6.5%).

The Committee also received SC/67b/AWMP06 that provided a summary of bowhead whale catches in Alaska between 1974 and 2016. The authors pointed to the excellent cooperation and contribution of the whale hunters from the 11 villages that are members of the Alaska Eskimo Whaling Commission (AEWC). This information is discussed in Annex E (item 4.4).

From 2013 to 2017, four bowhead whales (2 females and 2 males) were harvested near Chukotka, mainly in Anadyr Bay (SC/67b/AWMP20). The average length was 14.5m (minimum 13.0m, maximum 17.0m). Although the portion of the annual strike limit allocated to Russia under their bilateral agreement with the USA is 5 animals, the actual annual take is usually only 1-2 whales per year, and this has been the case since at least 2004.

The Committee thanked the authors of the provision of this information, noting that catch and strike data are used in the *SLA* calculations (see Item 8.3).

7.3.5 Other anthropogenic threats and health: review new information
The Committee received extensive information related to threats and health ranging from entanglement, predation and health (body condition, pathology and parasite loads). The discussion of this can be found in Annex E (item 4.5).

Attention: SC

With respect to threats and health to the BCB bowhead whales, the Committee:
(1) ***welcomes*** *the extensive information presented;*
(2) ***agrees*** *that whilst the present level of unintentional human induced mortality is too low to require new Implementation trials or incorporation into the SLA calculations, the situation should continue to be monitored and evaluated at the next Implementation Review;*
(3) ***agrees*** *that the health analyses give no cause for concern with respect to the continued application of the Bowhead SLA; and*
(4) ***encourages*** *that the excellent work on health-related issues continues.*

7.3.6 Conclusions and recommendations (and, if needed, workplan to complete Review)

Attention: SC

With respect to the Implementation review of BCB bowhead whales, the Committee ***concludes*** *that:*
(1) the Implementation Review has been satisfactorily completed; and
(2) the range of hypotheses and parameter space already tested in Bowhead SLA trials was sufficient and therefore the Bowhead SLA remains the best way to provide management advice for this stock;
In addition, it ***thanks*** *the US scientists for the extremely hard work that they have put into providing comprehensive papers to facilitate this review.*

8. STOCKS SUBJECT TO ABORIGINAL SUBSISTENCE WHALING (NEW INFORMATION AND MANAGEMENT ADVICE)

The Committee noted that the Commission will be setting new catch/strike limits for at its 2018 biennial meeting in Brazil. It had received written or verbal requests for limits to be considered for each hunt as discussed below.

Attention: C-A

A general request had been received from the USA and Denmark (SC/67b/Rep06, annex F, appendix) for advice on whether there would be a conservation issue if there was a one-time 7-year block followed by a return to 6-year blocks to address logistical issues related to the Commission.

The Committee ***agrees*** *there are no conservation issues associated with this suggestion (and see the block quota section of the ASW in Annex E, appendix 8).*

8.1 Eastern Canada/West Greenland bowhead whales

8.1.1 New abundance information

Last year, the Committee had recommended that Canadian scientists attend the Committee to present the results of their work on abundance. It was very pleased that Doniol-Valcroze from Department of Fisheries and Oceans Canada, and the primary author of the paper on the 2013 aerial survey abundance estimate, was present at the meeting.

The Committee accepted, for the provision of management advice and use in an *SLA* (see Annex Q for details), the fully corrected abundance estimate (Doniol-Valcroze *et al.*, 2015) from a 2013 aerial survey of 6,446 bowheads (CV=0.26, 95% CI 3,722-11,200). The survey covered the major summering area for the Eastern Canada/West Greenland (EC/WG) stock.

The Committee recalled that the *WG-Bowhead SLA* had been developed on the conservative assumption that the abundance estimates for the West Greenland area alone (1,274 whales in 2012 (CV=0.12)) represented the abundance of the whole stock, as it believed that it was not possible to assume that a non-member country would continue with regular surveys. Doniol-Valcroze advised the Committee that the present management strategy of Canada does involves obtaining regular abundance estimates. The Committee noted it would be pleased to receive such estimates from Canada being presented to the Committee in the future.

Attention: SC

The Committee greatly appreciated the presence of a Canadian scientist at its meeting. The Committee:
(1) ***welcomes*** *the provision of the abundance estimate for the Eastern Canada/West Greenland stock and (see Item 8.1.2) the regular provision of information on catch data by Canada;*
(2) ***welcomes*** *the attendance of Canadian scientists at its meetings;*
(3) ***agrees*** *that consideration of how to incorporate abundance estimates from Canada should be one focus of the next Implementation Review for this stock;*
(4) ***notes*** *the regular collaboration of Canadian and Greenlandic scientists on other matters such as genetic sampling (inter alia for mark-recapture abundance estimation); and*
(5) ***encourages*** *further collaboration between Canada, Greenland and the USA for the study of bowhead whales across their range and the presentation of these results at future Committee meetings.*

8.1.2 New catch information

SC/67B/AWMP/10 provided an update of recent Canadian takes made in the Inuit subsistence harvest of the EC-WG bowhead whale stock. In the eastern Canadian Arctic, the maximum allowed take is 7 bowhead whales per year according to domestic policy, with no carry-over of unused takes between years. Since 2015, 5 strikes were taken and 4 bowhead whales were successfully landed (1 in 2015, 2 in 2016 and 1 in 2017). Witting reported that West Greenland hunters struck no bowheads in 2017. There was one 14.7m whale that died from entanglement in crab gear.

The Committee notes that the reported number of strikes was within the parameter space that was tested for the *WG-Bowhead SLA*, and encourages the continued collection of genetic samples from harvested whales.

8.1.3 Management advice

Attention: C-A

SC/67b/AWMP19 reported Greenland's plans for requesting aboriginal whaling provisions at IWC67 and no changes were requested for bowhead whales. The Committee therefore:

(1) ***agrees*** *that the WG-Bowhead SLA remains the best available way to provide management advice for the Greenland hunt;*
(2) ***notes*** *that this SLA had been developed under the conservative assumption that the number of bowhead whales estimated off West Greenland represented the total abundance between West Greenland and Eastern Canada;*
(3) based on the agreed 2012 estimate of abundance for West Greenland (1,274, CV=0.12), the catch of one whale in Canada in 2017, and using the agreed WG-Bowhead SLA, ***agrees*** *that an annual strike limit of two whales will not harm the stock and meets the Commissions conservation objectives; and*
(4) although the Committee has not yet had time to examine the request from the US/Denmark (SC/67b/Rep06, annex F, appendix) for the WG-Bowhead SLA, ***reiterates*** *its advice, applicable for all SLAs, that interannual variation of 50% within a block with the same allowance from the last year of one block to the first year of the next, is acceptable.*

8.2 North Pacific gray whales

8.2.1 New information (including catch data)

The Committee received considerable new information on the hunt off Chukotka as discussed in Annex E (item 5.2). In 2017, a total of 119 gray whales were struck in 2017 (37 males and 82 females). No whales were struck and lost, and no stinky (inedible) gray whales were taken. Similar whaling methods were employed as in recent years and the overall efficiency of the hunt was almost same as in 2016.

In advance of the gray whale *Implementation Review* that is scheduled to begin in 2019, the Committee reviewed new information regarding the stock structure of gray whales in the North Pacific (SC67b/SDDNA02 and SC67b/SDDNA03) – for details see Annex I. The results were based on whole genome sequence data from three individuals (one sampled off Barrow, Alaska and two sampled off Sakhalin Island, Russia) and SNP genotype data generated from larger sample sets representing whales sampled off Sakhalin and in the Mexican lagoons.

Attention: SC

In reviewing the results of new genetic analyses of gray whales in the North Pacific, the Committee ***agrees*** *that the genetic and photographic data for this species be combined to better assess stock structure-related questions. Given the potential for genomic data to aid in better evaluating the stock structure hypotheses currently under consideration for North Pacific gray whales, the Committee* ***encourages*** *the continuation of work to produce additional genomic data from sampled gray whales.*

8.2.2 Management advice

Attention: C-A

The Russian Federation (SC/67b/AWMP/17) had requested advice on the following provision:

'For the seven years 2019, 2020, 2021, 2022, 2023, 2024 and 2025, the number of gray whales taken in accordance with this sub-paragraph shall not exceed 980 (i.e. 140 per annum on average) provided that the number of gray whales taken in any one of the years 2019, 2020, 2021, 2022, 2023, 2024 and 2025 shall not exceed 140.'

The Committee therefore:
(1) ***agrees*** *that the* Gray Whale SLA *remains the best available way to provide management advice for the gray whale hunts;*
(2) ***advises*** *that an average annual strike limit of 140 whales will not harm the stock and meets the Commission's conservation objectives;*
(3) ***notes*** *that its previous advice that the interannual variation of 50% within a block with the same allowance from the last year of one block to the first year of the next remains acceptable;*
(4) ***advises*** *that the Makah Management Plan (see Item 2.3) also is in accord with the Commission's management objectives.*

8.3 Bering-Chukchi-Beaufort Seas bowhead whales

8.3.1 New information

New information (on abundance and catches) was considered as part of the *Implementation Review* discussed under Item 7.3.

The USA had indicated that it was proposing no changes to the present catch/strike limits although it may suggest changes to its carryover request in light of the advice received by the Committee as discussed at the intersessional workshop (SC/67b/Rep06).

The Committee noted that there are now two independent estimates of abundance for this stock in 2011 (see Item 7.3.1). Recognising the need to formally consider the general question of how best to combine estimates in such cases as part of the workplan in the next biennium, the Committee noted that if they are combined as a weighted average by the inverse of their variances, there is little difference (it is slightly higher) between the combined estimate and that from the ice-based census estimate; the ice-based approach has been the method used for the other estimates used in the *SLA*. Therefore, the ice-based census estimate for 2011 (16,820, CV=0.052; 95% CI 15,176 to 18,643) is considered the most recent estimate of abundance for use in the *Bowhead SLA* this year.

8.3.2 Management advice

Attention: C-A

The USA indicated that it requested advice on the existing catch/strike limits. The Committee therefore:

(1) ***agrees*** *that the* Bowhead Whale SLA *remains the best available way to provide management advice for this stock;*
(2) ***advises*** *that a continuation of the present average annual strike limit of 67 whales will not harm the stock and meets the Commission's conservation objectives; and*
(3) ***advises*** *that provisions allowing for the carry forward of unused strikes from the previous three blocks, subject to the limitation that the number of such carryover strikes used in any year does not exceed 50% of the annual strike limit, has no conservation implications (see SC/67b/Rep04).*

8.4 Common minke whales off East Greenland

8.4.1 New information on catches

In the 2017 season, nine common minke whales (3 males and 6 females) were landed in East Greenland, and one was struck and lost. Genetic samples were obtained from 8 of the landed whales. One common minke whale died from entanglement in fishing gear.

8.4.1 New information on abundance
The Committee endorsed the 2015 aerial survey abundance estimate of 2,762 (CV=0.47; 95%CI 1,160-6,574). This is only a small part of the wider Western and Central stocks from which catches may occur.

8.4.2 Management advice

Attention: C-A

SC/67b/AWMP19 reported Greenland's plans for requesting aboriginal whaling provisions at IWC67. It requested advice on an annual take of 20 animals (it had previously been 12). It had also requested advice on any conservation implications of a 12-month hunting season for common minke whales.

The Committee therefore:

*(1) **notes** that in the past its advice for the East Greenland hunt had been based upon the fact that the catch was a small proportion of the number of animals in the Central Stock;*
*(2) **notes** the process to develop an* SLA *for common minke whales off West Greenland resulted in a simulation framework that produces a considerably more rigorous way to provide advice for this hunt than before, by taking into account stock structure issues;*
*(3) **notes** that the results of the simulation trials that incorporated a continuing catch of 20 whales from East Greenland gave rise to no conservation concerns;*
*(4) **notes** that the 2015 aerial survey abundance estimate of 2,762 (CV=0.47; 95%CI 1,160-6,574) is only a small part of the wider western and central stocks;*
*(5) **advises** that a continuation of the present average annual strike limit of 20 whales will not harm the stock and meets the Commission's conservation objectives;*
*(6) **advises** that changing the length of the season to 12 months had no conservation implications; and*
*(7) **agrees** that an* SLA *should be developed for this hunt in the future; and*
*(8) **encourages** the continued collection of samples fro collaborative genetic analyses (and see Item 7.1.2.3).*

8.5 Common minke whales off West Greenland
8.5.1 New information on catches
In the 2017 season, 129 common minke whales were landed in West Greenland and four were struck and lost. Of the landed whales, there were 95 females, 33 males and one of unknown sex. Genetic samples were obtained from 104 whales, and the Committee was pleased to note that samples were already part of the data used in the genetic analyses of common minke whales in the North Atlantic. The Committee **encourages** the continued collection of samples and the collaborative approach of the genetic analysis.

8.5.2 New information on abundance
The Committee endorsed the 2015 aerial survey abundance estimate of 5,095 (CV0.46; 95%CI 2,171-11,961) as discussed in Annex Q.

8.5.3 Management advice

Attention: C-A

SC/67b/AWMP19 reported Greenland's plans for requesting aboriginal whaling provisions at IWC67. It requested advice on annual strikes of 164 animals (i.e. no change). It had also requested advice on any conservation implications of a 12-month hunting season for common minke whales.
The Committee therefore:

*(1) **agrees** that the WG-Common minke SLA is the best available way to provide management advice for this stock under need scenario A;*
*(2) **advises** that a continuation of the present average annual strike limit of 164 whales will not harm the stock and meets the Commission's conservation objectives;*
*(3) although the Committee has not yet had time to examine the request from the US/Denmark (SC/67b/Rep06, annex F, appendix) for this SLA, **reiterates** its previous advice**,** applicable for all SLAs, that interannual variation of 50% within a block with the same allowance from the last year of one block to the first year of the next is acceptable;*
*(4) **advises** that changing the length of the season to 12 months had no conservation implications; and*
*(5) **encourages** the continued collection of samples for collaborative genetic analyses (and see Item 7.1.2.3).*

8.6 Fin whales off West Greenland
SC/67b/AWMP19 reported Greenland's plans for requesting aboriginal whaling provisions at IWC67. It requested advice on annual strikes of 19 animals (i.e. no change).

8.6.1 New information on the catch
A total of seven fin whales (5 females and 2 males) was landed, and one was struck and lost, off West Greenland during 2017. The Committee was pleased to note that genetic samples were obtained from five of these, and that the genetic samples are analysed together with the genetic samples from the hunt in Iceland.

8.6.2 New information on abundance
The Committee endorsed the 2015 aerial survey abundance estimate of 2,215 (CV=0.41; 95%CI 1,017-4,823) for use in providing management advice and in the *SLA* as discussed in Annex Q (Item Y).

8.6.3 Management advice

Attention: C-A

SC/67b/AWMP19 reported Greenland's plans for requesting aboriginal whaling provisions at IWC67. It requested advice on annual strikes of 19 animals (i.e. no change). It also requested advice on whether there were any conservation implications of removing length limits (while retaining the prohibitions relating to calves.
The Committee therefore:

(1) ***agrees*** *that the WG-Fin SLA is the best available way to provide management advice for this stock;*
(2) ***advises*** *that a continuation of the present average annual strike limit of 19 whales will not harm the stock and meets the Commission's conservation objectives; and*
(3) although the Committee has not yet had time to examine the request from the US/Denmark (SC/67b/Rep06, annex F, appendix) for this SLA, ***reiterates*** *its advice, applicable for all SLAs, that interannual variation of 50% within a block with the same allowance from the last year of one block to the first year of the next is acceptable;*
(4) ***advises*** *that removing the length limits had no conservation implications; and*
(5) ***encourages*** *the continued collection of samples for collaborative genetic analyses (and see Item 7.1.1.3).*

8.7 Humpback whales off West Greenland
8.7.1 New information on catches
A total of two (both female) humpback whales were landed and none were struck and lost in West Greenland during 2017. Genetic samples were obtained from all the landed whales. The importance of collecting genetic samples and photographs of the flukes from these whales is emphasised.

Five humpback whales were observed entangled in fishing gear in West Greenland in 2017. Of these, one died, two became free and one was successfully disentangled by a disentanglement team. The remaining animal was alive and still entangled when it was last sighted.

Inclusion of bycaught whales had been incorporated into the scenarios for the development of the *Humpback SLA*. If high levels continued, then this will need to be taken into account in any *Implementation Review*. The Committee noted the IWC efforts with respect to disentanglement and prevention and welcomed the news that the Greenland authorities requested IWC disentanglement training that took place in 2016 and that they successfully disentangled one humpback whale.

8.7.2 New information on abundance
The Committee endorsed the 2015 aerial survey abundance estimate of 993 (CV=0.46; 95%CI 434-2,272) as discussed in Annex Q (Item Y) for use in the provision of management advice and in the SLA.

8.7.3 Management advice

Attention: C-A

SC/67b/AWMP19 reported Greenland's plans for requesting aboriginal whaling provisions at IWC67. It requested advice on annual strikes of 10 animals (i.e. no change).
The Committee therefore:
(1) ***agrees*** *that the* WG-Humpback SLA *is the best available way to provide management advice for this stock;*
(2) ***advises*** *that a continuation of the present average annual strike limit of 10 whales will not harm the stock and meets the Commission's conservation objectives;*
(3) ***advises*** *that that provisions allowing for the carry forward of unused strikes from the previous three blocks, subject to the limitation that the number of such carryover strikes used in any year does not exceed 50% of the annual strike limit' has no conservation implications (see SC/67b/Rep04); and*
(4) ***encourages*** *the continued collection of samples and photographs for collaborative analyses.*

8.8 Humpback whales off St. Vincent and The Grenadines
The alternate Commissioner for St Vincent and the Grenadines advised that no change to the present limits were envisaged.

8.8.1 New information on catch
It was reported that one humpback whale was struck and landed in 2017 by St. Vincent and The Grenadines.

8.8.2 New information on abundance

Last year, the Committee had requested that the USA provide a new abundance estimate for the western North Atlantic based upon the available NOAA data. A progress report on this work was provided with a focus on information on abundance estimates generated by the MONAH study, conducted in 2004 and 2005 on Silver Bank (a breeding ground in the West Indies) and in the Gulf of Maine feeding ground. The best estimate around 12,300, similar to the Committee endorsed best estimate from the YONAH project from 1992/93, which was 10,400 (8,000, 13,600). The lack of strong population growth was unexpected given information on rates of increase from some other areas of the North Atlantic, and may reflect either a true rate of increase, unidentified sampling bias, and/or the idea that Silver Bank as a habitat has reached maximum capacity. It is not clear whether the MONAH estimate is representative of the entire population, nor the extent to which the full estimate can be applied to the southeastern Caribbean in the context of the St Vincent hunt. However, four animals from the Gulf of Maine have been linked to animals seen in the southeastern Caribbean (including one that was caught in the hunt).

The Committee also noted several endorsed recent abundance estimates of humpback whales in parts of the North Atlantic including: 993 (95% CI: 434-2,272) in West Greenland in 2015; 4,223 (95% CI: 1,845-9,666) in East Greenland in 2015; and 12,879 (95% CI 5,074; 26,455) in the Iceland-Faroes region in 2007.

It has now been nearly two decades since the IWC has done an In-Depth Assessment on North Atlantic humpback whales. The Committee **agrees** that it would be a valuable exercise to perform a North Atlantic Rangewide review of humpback whales, similar in scope to the Rangewide Review for North Pacific gray whales and taking into account recent work on stock structure including that of Stevick *et al.* (2018).

8.8.3 Management advice

Attention: C-A

The alternate Commissioner for St Vincent and the Grenadines advised that no change to the present limits were envisaged. The Committee therefore:

*(1) **notes** that is does not have an approved abundance estimate for western North Atlantic since that in 1992;*
*(2) **notes** that in accord with the advice provided in the AWS (see Annex E, Appendix 8), it therefore considered the available evidence to see if was sufficient to provide safe management advice;*
*(3) **advises** that, given the information above on recent abundance in the North Atlantic combined with the size of the requested catch/strikes (an average of four annually), continuation of the present limits will not harm the stock;*

*The Committee also **reiterates** its previous advice that:*

(1) the status and disposition of genetic samples collected from past harvested whales be determined and reported next year;
(2) photographs for photo-id (where possible) and genetic samples are collected from all whales landed in future hunts; and that
(3) the USA (NOAA, NMFS) provides an abundance estimate from the MONAH data as soon as possible for the Committee.

8.9 Workplan 2019-20

Table 7 summarises the work plan for work related to aboriginal subsistence whaling. The Committee also established an Intersessional Correspondence Group to work on ASW related issues (Annex Y).

Table 7

Work plan for matters related to aboriginal subsistence whaling

Topic	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting
(1) Annual review of catch/strike limits		Carry out		Carry out
(2) *Implementation Review*		Gray whales based upon rangewide review		West Greenland humpback whales
(3) *SLA*s		Consider development of an *SLA* for the hunt of common minke whales off East Greenland based on operational models developed for the West Greenland hunt		Adopt *SLA* if it is decided one is necessary
(5) Interim relief allowance testing	Run trials for gray whale hunts	Review results	Run trials for West Greenland common minke whales and fin whales	Review results
(6) Carryover (US/Denmark request)	Run trials for remaining Greenland hunts (West Greenland common minke whales, bowhead whales and fin whales	Review results		

9. WHALE STOCKS NOT SUBJECT TO DIRECTED TAKES

9.1 In-depth Assessments

Donovan gave a presentation explaining a streamlined procedure hereby the Committee, via its sub-groups, can undertake Comprehensive Assessment (traditionally the first time an assessment is undertaken for a particular species/ocean basin) or an in-depth assessment (assessments subsequent to a comprehensive assessment). This can be found as SC/67B/GEN04 and is summarised in Fig. 1. The objective is to provide a consistent approach (including methods) that initially focusses on ensuring that sufficient data are available to undertake an assessment (the pre-assessment approach that will normally be undertaken at annual meetings) and then follows this with a concentrated effort (ideally two workshops and two annual meetings, with no new data) to complete the assessment. The objective is to provide Commission with robust information on present status. This involves identifying:

(1) if populations are recovering, recovered or if there is cause for concern;

(2) factors that may be or are affecting status so that conservation and management needs can be determined; and

(3) information gaps and ways to address these in order to reduce uncertainty at the next assessment.

9.1.1 Comprehensive Assessment of North Pacific humpback whales

Work towards a Comprehensive Assessment of North Pacific humpback whales began in 2016, and included an intersessional workshop held in April 2017 (IWC, 2018b). After the 2017 Committee meeting, an intersessional steering group continued preparing the input data and assessment model (IA/67b/IA03). The assessment model is a simplified age-aggregated model of the breeding and feeding grounds. The development of the input data (stock structure, abundance, catches, and life history parameters) continued during the year but given the slower than initially expected progress, particularly with respect to narrowing down the number of stock structure hypotheses, the steering group had agreed that it was premature to hold the anticipated workshop prior to SC67b.

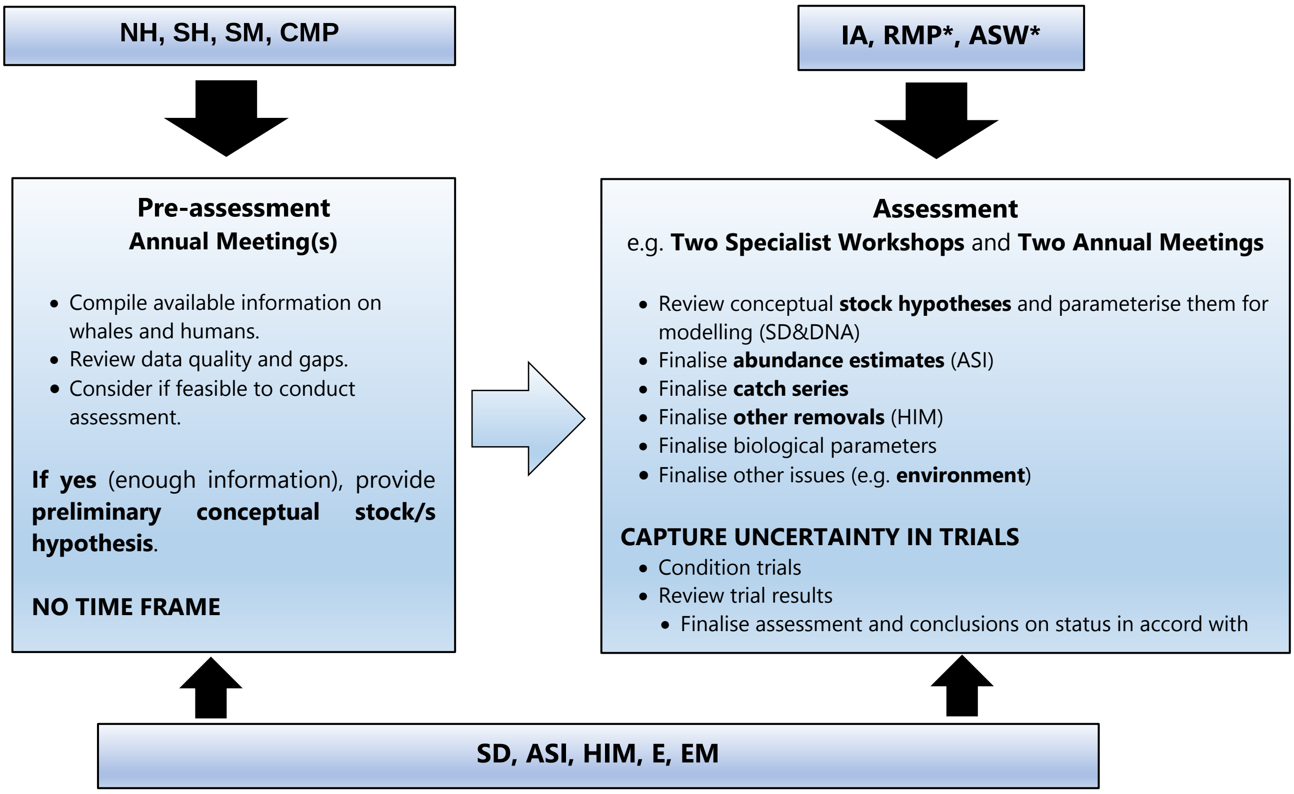

Fig. 1. Schematic of the approach to conduct assessments within the Scientific Committee. Acronyms refer to sub-groups. Normally the final assessment will take place in the sub-committee on in-depth assessments but for stocks subject to direct catches it may occur in the context of the RMP or AWMP sub-groups as appropriate.

Work continued at this meeting and the detailed discussions can be found in Annex F (item 4). The subdivisions of the North Pacific humpback whale feeding and breeding grounds in Annex F (fig. 1) are broadly consistent with existing data; identified uncertainties will be addressed in the assessment by evaluating four scenarios with different numbers of feeding and breeding grounds. This work will be greatly assisted by undertaking comparisons of humpback whale photographs from the Pacific obtained after the conclusion of the photographic component of the SPLASH (Structure of Populations, Levels of Abundance and Status of Humpback Whales) programme in 2005 (e.g. see Calambokidis *et al.*, 2008).

The general underlying structure of the assessment model has been developed but before the model can be run the input data (e.g. catches and abundance estimates) need to be updated and allocated for each stock structure hypotheses and mixing matrices developed and parameterised.

Attention: SC, G

The Committee is undertaking a Comprehensive Assessment of North Pacific humpback whales. To complete this assessment the Committee ***agrees*** *that:*

(1) a large-scale matching effort of post-2005 photo-identifications should be undertaken (see Annex F, item 4 for methods); and
(2) this matching effort will (a) help clarify the connections among the feeding/breeding areas within the North Pacific; and (b) assist in developing updated abundance estimates where appropriate.
The Committee ***stresses*** *that to obtain the most robust assessment and thus conservation advice, all available data should be included in the matching effort. Therefore, the Committee* ***strongly encourages*** *all catalogue holders to participate in this exercise, after the appropriate data sharing agreements are made.*

The Committee also ***welcomes*** *the provision of new abundance estimates (e.g. those from the IWC-POWER surveys and from local areas in Japan), noting that they will also need to be adjusted for the various stock structure hypotheses.*

The Committee ***agrees*** *that the next assessment workshop should take place at a time prior to SC68b when the intersessional Steering Group (Annex Y) decides sufficient progress has been made.*

9.1.2 Comprehensive Assessment of North Pacific sei whales
The Committee began what was called an in-depth assessment of North Pacific sei whales in 2015 (IWC, 2016c) but, in keeping with the discussion under Item 9.1 will now be termed a Comprehensive Assessment for consistency. Work has focussed since then on finalising the stock structure hypotheses (two have been agreed for use in the assessment - a single-stock hypothesis and a five-stock hypothesis), developing an appropriate population model and finalising the model inputs in accordance with these hypotheses (including catches, mark-recovery locations, abundance estimates, estimates of mixing between sub-areas, and life history parameters).

Considerable progress was made with this work intersessionally and at this meeting as discussed in Annex H, item 3.

Attention SC, G

The Scientific Committee intends to complete the Comprehensive Assessment of North Pacific sei whales within the next biennial period. It notes the progress made at this meeting with respect to stock structure, abundance estimates, marking data, catch history, life history parameters and the assessment model. To complete this work, the Committee ***agrees*** *to:*

(a) the work undertaken to finalise input data for the assessment (Annex F, appendices 2-7);
(b) support the modelling work identified in Annex F; and
(c) re-establish the intersessional steering group to oversee the assessment.

In addition, the Committee ***encourages*** *telemetry work in waters outside the 'pelagic' sub-area to assist in quantifying the movement patterns of animals.*

9.1.3 In-depth Assessment of Indo-Pacific Antarctic minke whales
An intersessional correspondence group under Murase completed its task to finalise a document synthesising the results of the 2001 - 2014 in-depth assessment of an eastern Indian stock (I-stock) and a western South Pacific stock (P-stock) of Antarctic minke whales distributed between 35°E and 145°W.

The Committee **commends** the authors for completing this paper and submitting it to the *Journal of Cetacean Research and Management.* As the paper has just entered the review process, the intersessional correspondence group (Annex X) has been re-established to see the paper through to publication.

9.1.4 Workplan 2019-20
The work plan for Comprehensive and in-depth assessments for the next biennium is provided in Table 8.

Table 8

Work plan for in-depth assessments

Topic	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting (SC/68b)
In-depth Assessment of Indo-Pacific Antarctic minke whales	Complete review of paper submitted for publication	-	-	-
Comprehensive Assessment of North Pacific sei whales	Re-establish the ISG (Annex Y) to further data preparation and development of the assessment model	Review progress of intersessional work and continue the assessment	Finalise preparation of assessment	Review progress of intersessional work and finalise the assessment
Comprehensive Assessment of North Pacific humpback whales	Re-establish the ISG (Annex Y) to further data preparation, development of the assessment model and hold a Workshop	Review progress of intersessional work and continue the assessment	Finalise /continue preparation of assessment	Review progress of intersessional work and continue/finalise the assessment

9.2 Evaluation for potential new Comprehensive or In-Depth Assessments

9.2.1 North Pacific blue whales

The Committee welcomed the report of an intersessional group that had been determining the data that are available on items required to carry out a Comprehensive Assessment of blue whales in the North Pacific. The status of the eastern North Pacific population is well known and a stock assessment was reviewed and accepted by the Committee in 2016 (Monnahan and Branch, 2015). However, information from the central and western North Pacific is sparser. Information presented at this meeting concerned stock structure, catch history, biological parameters, photo-identification, Discovery marks and sighting surveys. Details can be found in Annex G (item 6.1).

Several papers and datasets were discussed including: the use of blue whale sounds to identify stocks; morphological data; genetic data; sightings data (SC/67b/IA02; SC/67b/SCSP06; SC/67b/SCSP07; SC/67b/NH08).

Attention: SC

*The Committee **agrees** the following priorities to progress the pre-assessment:*

(1) obtain abundance estimates from the IWC-POWER surveys;
(2) obtain abundance estimates from the JARPN and JARPNII surveys;
(3) analyse and compare genetic samples from ENP, IWC-POWER and ICR biopsy samples to determine stock structure throughout the North Pacific;
(4) compare photo-identification data from POWER, JARPN/JARPNII and other ENP catalogues;
(5) Review new acoustic locations and information and conduct fine-scale analysis of song features for central Pacific blue whale calls, with particular focus on calls around Japan;
(6) Obtain better life history parameters (especially age at sexual maturity and calving interval) from the Cascadia Research Collective, the Mingan Island Cetacean Study Research Station and the CICIMAR-IPN photo-ID dataset;

*With respect to (3), the Committee **requests** the collection of about 20 biopsy samples if possible during the NEWREP-NP surveys in the western North Pacific to improve the power to evaluate stock structure and **encourages** genetic analysis of the existing Japanese samples.*

*With respect to (5), the Committee **requests** a reanalysis of recordings from the Northern Mariana Islands (Saipan and Tinian) collected by the Pacific Islands Fisheries Science Center to look for the presence or absence of the new song type recorded from Japan. It also **encourages** passive acoustic data collection during surveys (e.g. IWC-POWER, university/training cruises) from the region of high blue whale density southeast of the Kamchatka Peninsula to determine the song type produced by animals in that region.*

*The Committee **agrees** that the intersessional correspondence group continue to review data needed for an assessment of North Pacific blue whales be reappointed under Branch (Annex Y).*

9.2.2 Non-Antarctic Southern Hemisphere blue whales

9.2.2.1 SOUTHERN HEMISPHERE POPULATION STRUCTURE

The Committee is currently preparing for a Comprehensive Assessment of pygmy blue whales. For this reason, it continues to gather information on population structure (see Item 3.1, IWC, 2018a). This year, the web-based pygmy blue whale song library funded by the IWC will be launched (SC/67b/SH12). This will enable researchers to compare their acoustic recordings with validated song archetypes and greatly assist the determination of Southern Hemisphere blue whale distribution patterns and stock structure. Photo-ID and genetic evidence support the idea that each distinct pygmy blue whale song represents a geographically and genetically distinct population of pygmy blue whales around the Southern Hemisphere. A full description of the discussion of the use of songs in this pre-assessment is given in Annex H (item 3.1), including comparison with genetic and photo-identification data. The Committee also received information from whale bones and notes that further analysis of blue whale bones from old whaling land stations will be helpful to establish the past distribution of these stocks.

Assessments require catches to be allocated to populations and in 2016 the Committee funded an examination of regional catches to assign them to each putative population (Item 5.1, IWC, 2017a). The results of this work are provided in SC/67b/SH23 and discussed in Annex H (item 3.1). Total pygmy blue whale catches were estimated at 12,184 with totals for each population of 1,228 (Northern Indian Ocean), 6,889 (South West Indian Ocean), 3,646 (South East Indian Ocean) and 421 (South West Pacific Ocean).

The Committee also discussed an intersessional effort to identify and standardise genetic markers used in Southern Hemisphere blue whale research (only four loci were common across all research laboratories) and received a progress report (SC/67b/PH04) on matching within the Southern Hemisphere Blue Whale Catalogue, which has been supported by funding from the Committee (Item 10.2.2, IWC, 2017a). This helps understanding of blue whale movements between regions, and allows estimation of regional abundance. The catalogue is currently being migrated to IWC servers (and see Item 23.2.3.2).

Attention: SC, G

In order to progress its work towards an assessment of pygmy blue whales, the Committee:

(1) ***agrees*** *that further work is needed to identify high and base case catch scenarios for pygmy blue whales;*
(2) ***encourages*** *deployment of more acoustic recorders in the southern Indian Ocean;*
(3) ***agrees*** *that further population modelling is needed to assess pygmy blue whale populations;*
(4) ***strongly encourages*** *blue whale research groups to publish the metadata associated with their sequences in order that levels of sample overlap can be established and datasets compared;*
(5) ***agrees*** *that the Southern Hemisphere Blue Whale Catalogue should be continued to help understand blue whale movements, with a priority focus on matching photographs within regions to measure regional abundance of pygmy blue whales.*

9.2.2.2 INDONESIA/AUSTRALIA BLUE WHALES

The Australian blue whale photo-ID catalogue data have now nearly all been uploaded and matched within the Southern Hemisphere Blue Whale Catalogue, at which point quality control analysis can begin. This will allow the potential for using these data for mark recapture abundance estimation to be assessed. The Scientific Committee was informed that mark-resighting data from the Perth Canyon (Australia) will be analysed intersessionally, to provide a new estimate of Australian blue whale abundance which assist in a future assessment of this population.

Attention: SC, G

The Committee ***encourages*** *analysis to provide an estimate of Australian blue whale abundance using mark-resighting data.*

9.2.2.3 MADAGASCAR BLUE WHALES

The Committee was informed that passive acoustic monitoring of blue whales in the Mozambique Channel detected both South West Indian Ocean (SWIO) and Antarctic blue whale song types, as well as fin and Antarctic minke whales (SC/67b/SH14). In addition, SC/67b/SH24 reported an unidentified blue whale song off Oman. A full discussion of the results of these papers can be found in Annex I (item 3.3.2).

This new information means that the blue whale catch allocations for the Indian Ocean, currently only ascribed to a single ‘NIO’ population in the Northern Indian Ocean, will need revision to take this new acoustic pattern into account.

Attention: SC, G

The Committee notes that the distribution and population isolation of blue whales is poorly understood in the northern and western Indian Ocean. The Committee therefore:

(1) ***strongly encourages*** *further acoustic work in the western Indian Ocean and Arabian sea to better understand the distribution, seasonality and overlap of blue whale calls;*
(2) ***strongly encourages*** *the collection and analysis of available tissue samples for analysis of genetic population structure in this region to assist with characterising these populations; and*
(3) ***agrees*** *that catch allocations of blue whales be revised to include the new blue whale song in the northwest Indian Ocean as a potential distinct ‘stock’.*

9.2.2.4 NEW ZEALAND BLUE WHALES

Three papers were presented on blue whales off New Zealand (see Annex H, item 3.3.4 for a full discussion).

SC/67b/SH09 reported a recent study of blue whale movement and habitat use in the Taranaki region of New Zealand in which two animals were tagged. However, due to the small sample size and La Niña conditions, it is uncertain how representative these movements are for blue whales in New Zealand waters.

SC/67b/SH05 summarised a multi-disciplinary study included acoustics, genetics and photo-identification in the same area, and provided a conservative estimate of blue whale population abundance (see Annex Q, item 3.1.1.9), to consider if this estimate can be used in the upcoming regional assessments of pygmy blue whales. SC/67b/SH04 reported projects underway to assist regional conservation management, including a description of fine-scale habitat use during summer months in the South Taranaki Bight, and response to local acoustic disturbance.

Attention: SC, G

With respect to information on blue whales off New Zealand, the Committee:

(1) ***welcomes*** *the work being undertaken to understand abundance and connectivity, which will contribute towards the pygmy blue whale population assessments; and*
(2) ***agrees*** *that New Zealand photo-identifications should be combined with others within the Southern Hemisphere Blue Whale Catalogue to provide the fullest possible assessment of regional abundance and connectivity*

9.2.2.5 SOUTHEAST PACIFIC BLUE WHALES
The Committee received two papers relevant to blue whales off Chile and the full discussion can be found in Annex H (item 3.3.1). SC/67b/SH03 presented a morphometric analysis of Chilean blue whales which reinforces the argument that Chilean blue whales should be considered a separate sub-species from the Antarctic and pygmy forms. (Bedrinana-Romano *et al.*, 2018) reported distribution modelling of blue whales using Chilean Northern Patagonia waters. Preliminary delimitations of possible blue whale conservation areas in this region overlap with highly used vessel navigation routes and areas allocated for aquaculture. The Committee was also informed that predictions of southeast Pacific blue whale habitat following Redfern *et al.,* (2017) will be completed intersessionally.

Attention: SC, G

In view of the recent identification of movements of Chilean blue whales into the South Atlantic and ongoing questions about the distribution of this population, the Committee:

(1) ***encourages*** *further satellite tracking and surveys (including collection of photo-ID and genetic data) to assess the population limits, habitat use and abundance and sub-species identity of blue whales in Chile;*
(2) ***encourages*** *compilation of morphometric data available for northeast Pacific blue whales and comparison with Chilean data, to assess morphological differentiation of these whales in the eastern Pacific and evaluate sub-species identity; and*
(3) ***welcomes*** *plans for further photo-ID catalogue matching within this region to assist with regional abundance estimation.*

9.2.2.6 WORK PLAN
The work plan for all Southern Hemisphere blue whales is given in Table 9.

9.2.3 Antarctic blue whales (Areas III and IV)
Undertaking a regional population assessment of Antarctic blue whales is challenging due to the scarcity of whales and logistical challenges. The Committee received new information this year on sightings, abundance and genetic studies.

SC/67b/SH08 presents a preliminary estimate of abundance (the first using photo-ID data) and this is discussed in Annex Q (see item 3.1.19) where suggestions were made to refine the analyses. Reports from two 2017/18 NEWREP-A summer cruises included sightings of blue whales and information on biopsy sampling (SC/67b/SP08 and SC/67b/ASI07). An IWC-SORP Southern Ocean blue whale-focussed cruise is planned for January to March 2019 (140°E-175°W), which intends to describe krill swarms in relation to blue whale density and distribution (SC/67b/SH07).

With respect to genetic work, IWC-SORP funded work on blue whale bones to compare past and current genetic diversity levels is reported in SC/67b/SH02 and discussed in Annex I (item 4.4.2). The Committee was also updated about ongoing work to analyse a collection of 1,626 baleen plates (roughly 50:50 blue and fin whales) from the Japanese whaling in the 1940s and held at the Smithsonian Natural History Museum, USA. A pilot study has established that mitochondrial DNA can be sequenced from these plates. Further analyses including of stable isotope and hormone levels are planned for these samples.

Attention: SC, G

The Committee ***welcomes*** *the progress being made towards being able to undertake am in-depth assessment of Antarctic blue whales. The Committee:*

(1) ***encourages*** *further work to update the abundance estimate for Antarctic blue whales following Committee recommendations;*

*(2) **strongly encourages** continued opportunistic photo-ID data collection in the Antarctic to assist with developing estimates of population abundance for this subspecies; and*
*(3) **encourages** continued collection and analysis of bone and baleen from historical Antarctic commercial whaling samples and sites to evaluate loss of genetic diversity and shifts in population structure.*

9.2.3.1 WORK PLAN

The work plan for all Southern Hemisphere blue whales is given in Table 9.

Table 9.

Workplan for Southern Hemisphere Antarctic and pygmy blue whales

Topic	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting
Antarctic blue whales				
Catalogue matching	Catalogue matching of photo-IDs (Annex Y)	Report	Catalogue matching (opportunistically collected photos)	Report
Abundance estimation	Mark recapture modelling work to update SC/67b/SH08 Annex Y	Report		
Photo-ID outreach material	Create photo-ID information booklets for distribution via IAATO operators	Report		
SH non-Antarctic blue whales				
Population assessment	Improve catch separation model, explore alternative catch allocation models (Annex Y)	Report	Population assessment. Analyse minimum and extrapolated recovery status of all populations for which abundance is available	Report
Catalogue matching	Catalogue matching of photo-IDs within southeast and central east Pacific (Annex Y)	Report	Catalogue matching (opportunistic photos from citizen scientists and collaborators) if funds are available	Report
Blue whale song library	Finish implementation of blue whale song library (Annex Y)	Report		
Australian abundance estimate	Analyse Perth Canyon abundance using mark recapture data (Annex Y)	Report		

9.2.4 Southern Hemisphere fin whales

9.2.4.1 POPULATION STRUCTURE

As part of its pre-assessment work, the Committee is gathering information on Southern Hemisphere fin whales in order to: (1) clarify the subspecies status of these whales (currently two Southern Hemisphere subspecies are recognized, Committee on Taxonomy, 2017); and (2) measure population differentiation around the Southern Hemisphere to establish whether any distinct populations exist.

A summary of available data on Southern Hemisphere fin whale structure was presented in SC/67b/SH15 and is discussed in detail in Annex H (item 4.1). The only evidence for any structure comes from acoustics. A genetic study from the southeast Pacific (SC/67b/SH13) found high local diversity in Chile, with no significant differentiation from the other Southern Hemisphere datasets. The Committee noted however that genetic differentiation can be difficult to detect when diversity levels are high and genetic differentiation is low (see Annex H, item 4.1).

Attention: SC, G, S

Knowledge of population structure is essential to future efforts to assess Southern Hemisphere fin whales. To determine the differentiation and potential sub-species structure among fin whales the Committee:

*(1) **agrees** that analysis of concurrently collected acoustic recordings of fin whales, to assess song variation around the Southern Hemisphere, is a priority;*
*(2) **agrees** that a review of all Discovery mark data published on fin whales to assess population connectivity patterns should be carried out; and*

(3) ***requests*** *that the Secretariat provide a letter of support for a study examining the evidence for* B. physalus patachonica*, which requires access to the holotype for this species from the Bernardino Rivadavia Natural Sciences Museum in Buenos Aires***.**

The Committee also ***encourages:***

(1) *analysis of fin whale distribution and geographic aggregations using all available catches;*
(2) *strategic biopsy sampling and analysis to measure the genetic differentiation of fin whales around the Southern Hemisphere;*
(3) *further biopsy sampling and sequencing of multiple nuclear loci to establish Chilean fin whale differentiation patterns, with co-collection of photo-IDs and body length measurements to establish population identity;*
(4) *satellite telemetry to discern seasonal movements; and*
(5) *photo-identification to understand site fidelity and residency patterns and linkages between high- and low-latitude grounds.*

9.2.4.2 DISTRIBUTION AND ABUNDANCE

The Committee welcomed a review of the available metadata on Southern Hemisphere fin whales (SC/67b/SH19), compiling data from dedicated and opportunistic surveys, moored acoustic recorders, sonobuoy surveys, photo-identifications, satellite tagging and biopsy sampling. The Committee also welcomed a summary of recent work by the Brazilian Antarctic Program to conduct dedicated fin whale research using sighting surveys, photo-ID, biopsy sampling and telemetry.

Reports from two 2017/18 NEWREP-A summer cruises included sightings of fin whales and information on biopsy sampling (SC/67b/SP08 and SC/67b/ASI07). A new abundance estimate for fin whales using sightings data from the third IDCR-SOWER circumpolar survey is expected to be available for review at next year's meeting.

SC/67b/14 provided information on the presence of fin whales in the Mozambique Channel and a new lower-latitude song. Details of the discussions can be found in Annex H (item 4.2).

The Committee was also informed that an analysis has suggested that Antarctic fin whales are sufficiently well marked to enable to use in photo-ID projects (SC/67b/PH01) and this is discussed in Annex S (item 4.1).

Attention: SC, G, CG-A

With respect to obtaining information on the distribution, movements and abundance of Southern Hemisphere fin whales for use in a future assessment, the Committee:

(1) ***encourages*** *a meta-analysis of the Antarctic Peninsula and Scotia Sea sightings data, to measure recent fin whale distribution, density and habitat use;*
(2) ***strongly encourages*** *continued work by the Brazilian Antarctic Program towards the understanding of fin whale population structure, movements and habitat use*
(3) ***agrees*** *that a new abundance estimate for fin whales from the IWC IDCR/SOWER programme should be presented for review at next year's meeting,*
(4) ***welcomes*** *news that fin whales can be used in photo-ID studies, and* ***encourages*** *further photo-ID data collection at high latitudes.*

9.2.4.3 WORK PLAN

The work plan for Southern Hemisphere fin whales is given in Table 10.

Table 10

Work plan for Southern Hemisphere fin whales

Topic	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting
Fin whale acoustic structure	Review fin whale call patterns across Southern Hemisphere, investigate call variation (Annex Y)	Report	Complete review of fin whale call patterns (Annex Y)	Report
Discovery marks	Review available Discovery mark data on fin whales (Pastene and Jackson)	Report		
Catch maps	Update fin whale catch model to include Soviet catch data (de la Mare)	Report		

9.2.5 North Atlantic sei whales

The Committee welcomed information on two separate habitat-based density modelling efforts, using visual survey data to produce seasonal abundance estimates for sei whales from the purported 'Nova Scotia' stock, ranging from Nova Scotia to the southeastern USA (SC/67b/NH07). There was also some consideration of passive acoustic and strandings data from the US eastern seaboard. No new data are available from around Iceland or Norway, partially due to difference in timing between surveys and species' arrival in regional waters. This information was discussed in Annex G (item 6.2). An intersessional correspondence group (Annex Y) will compile additional information this species in the North Atlantic and the Committee looks forward to a further update on reanalysis of historical data, particularly related to stock structure and strandings, next year.

9.2.6 North Atlantic right whales

Since 2016, the Committee has recommended a comprehensive update on North Atlantic right whales. SC/67b/NH05 summarised the information on the status of the North Atlantic right whale. This population has been slowly declining since 2010 and the abundance at the end of 2015 was estimated to be around 460 individuals (Pace *et al.*, 2017[6]). Of particular concern is the lower annual survival rate of females than males and poor recent calving (five in 2016/17 and none so far in the 2017/18 calving season). The observed number of dead whales in 2017 was 17 whales, several showing signs of death from fishing gear or blunt force trauma. These clearly represent minimum numbers and there was some discussion as to whether it was possible to scale minimum observed mortalities to an overall estimate but several confounding factors preventing this were identified (see Annex F, item 6.3 and Annex J, item 2.1.2).

Due to the increased 2017 Canadian interactions in the Gulf of St. Lawrence, on 19 April 2018 the Government of Canada implemented mitigation measures to reduce future interactions (DFO, 2018), including: closing a large part of the Gulf of St. Lawrence snow crab fishery on 30 June; creating a dynamic 15-day fishing closure; introducing a 10 knot speed restriction when any single right whale sighting in any area is detected; putting in place mandatory gear marking and reporting of any lost gear; minimising the allowable amount of floating line at surface; and using vessel monitoring systems that reports the boats position every 5 minutes.

A substantial increase in collaboration and data sharing between the US and Canada has occurred as a result of these mortalities.

Attention: C-A, CC

The Committee reiterates its serious concern over the status of the western North Atlantic stock of right whales as it is probably the only viable population of this species, for which entanglements and ship strikes have long been identified as key threats.

This year, the Committee:
(1) ***recognises*** *that entanglements have now replaced ship strikes as the primary cause of deaths (Kraus et al. 2016);*
(2) ***reiterates*** *its recommendation for the USA to submit a comprehensive update on the status of North Atlantic right whales (IWC, 2017:40) including an update of the Pace* et al. *abundance estimate, prior to the 2019 meeting;*
(3) ***stresses*** *that this update will allow time for explanations or additional analyses to be undertaken before the proposed 2019 Workshop on the Comparative Biology, Health, Status and Future of North Atlantic Right Whales: Insights from Comparative with other Balaenid Populations (including bowheads);*
(4) ***encourages*** *updates from the US Large Whale Take Reduction Team (ALWTRT) on progress of the Whale Safe Rope and Gear Marking Feasibility Subgroups; and*
(5) ***requests*** *that the Commission asks the IWC Executive Secretary to write to the U.S. National Marine Fisheries Service (NMFS) and the Canadian Department of Fisheries and Oceans, informing them of the Committee's serious concerns over the declining population trend of this species, and stressing that,* ***as a matter of absolute urgency****, every effort be made to reduce human induced mortality in the population to zero.*

9.2.7 North Pacific right whales

The Committee received a report of a dead right whale caught in a set net off Izu, Japan in 2018 (SC/67b/NH06) – the first in a set net since one in Korea in 2015 (Kim *et al.*, 2015).

The Committee welcomed information on a single sighting off Hokkaido (and a biopsy sample) from a Japanese national cruise (SC/67b/ASI10). It also welcomed information on North Pacific right whales from the visual, acoustic and biopsy sampling components of the 2017 IWC-POWER cruise in the eastern part of the Bering Sea. A total of 9 schools and 18 individuals (including 2 duplicate schools of 3 individuals) of right whales were sighted with photo-identification of 12 individuals and biopsy samples from 3 individuals. Discussion of these sightings can be found in Annex G (item 6.4).

In response to a recommendation made last year (IWC, 2018c), US and Japanese scientists presented the results of new genetic analyses of right whales in the North Pacific. Comparison of whales sampled in the eastern and western North Pacific revealed statistically significant differentiation based on mtDNA data, supporting presumed separation of the two stocks based on gaps in the spatial distribution of sightings (and also see discussion in Annex I, item 4.3).

[6] Any revised estimate from the Pace *et al.* 2017 paper will be reviewed by the ASI sub-committee during SC68a.

Attention: SC

The results of new genetic analyses support the recognition of separate stocks of right whales in the eastern and western North Pacific. Given the importance of this work and the precarious situation of this species, especially in the eastern North Pacific, the Committee ***encourages*** *the publication of this information as soon as possible.*

9.2.8 Workplan 2019-20
The Committee agreed to the two-year workplan in Table 11.

9. 3 New information and workplan for other northern stocks *(NH)*

9.3.1 North Pacific fin whales
The Committee received new information on studies of North Pacific fin whales. New sightings of fin whales were reported in the papers (SC/67b/ASI12, SC/67b/ASI10, SC/67b/SCSP06) during the POWER cruise in the Bering Sea and the two surveys in the western North Pacific (Areas 7, 8 & 9). Over 260 schools found, many individuals were photo-identified and biopsy samples were obtained from 28 whales.

9.3.2 Omura's whale
The Committee welcomed the new information on this species (SC/67b/NH09) from the west coast of Madagascar, supporting the current understanding that the population is resident and non-migratory with strong site fidelity. Likely threats to the Madagascar population include entanglement in local fisheries, impacts from oil and gas exploration, and most imminent the risk of coastal water contamination from a recently initiated mining operation for Rare Earth Elements. Future work should include a long-term latitudinal study that incorporates multiple methodologies to investigate all aspects of the species biology and conservation threats to the population.

Kim and colleagues reported on the first confirmed documentation of Omura's whale in the waters of South Korea. Two of six large baleen whales bycaught were confirmed by genetic analysis to be Omura's whale. This bycatch reinforces the concept that this coastal species is vulnerable to anthropogenic impacts, especially entanglement in fishing gear.

Attention: SC, G

The Committee notes that little information is available to assess the status of Omura's whale. The Committee:

(1) ***recognises*** *the significant contribution the research efforts off Madagascar have made to the understanding of this species and* ***encourages*** *this work to be continued and expanded into the future; and*
(2) ***encourages*** *identification of study sites that are suitable for long-term comparative study on Omura's whales in other parts of its range (e.g. New Caledonia, Komodo Islands, Indonesia, and the Bohol Sea, Philippines).*

Table 11

Workplan for other Northern Hemisphere stocks

Topic	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting
North Pacific blue whales	Data collection and review with focus on catches and stock structure	Review especially stock structure	Develop proposal for stock structure	Agree stock structure hypotheses
North Atlantic sei whales	Review distribution, strandings, sightings and stock structure	Review new information for assessment	Develop proposal for stock structure	Agree stock structure hypotheses
North Atlantic right whales		Review status and mortality data		Review status and mortality data
North Pacific right whales		Review new information for assessment		Review new information for assessment
North Atlantic humpback whales		Consider information for new assessment		Develop plans for new assesssment
Gulf of Mexico Bryde's whale		Review new information on mortality		Review new information on mortality
All other stocks		Review new information		

9.3.3 North Atlantic Bryde's whales
SC/67b/ASI01 presented sightings collected during recent coastal surveys off Guinea, Sierra Leone and Liberia in March 2018. During this survey, two groups of five individual Bryde's whales were observed.

The Committee welcomed this information and **encourages** future surveys in this region.

9.3.4 North Atlantic blue whales
The Committee welcomed new information from the USA on blue whales in the North Atlantic including recent sightings, serious injuries or mortalities, seasonal occurrence based on acoustics. Lesage *et al.* (2018) provides an extensive summary of recent data collected in Canadian waters. This is discussed in Annex G (item 7.6) where it was noted that multiple new datasets (including from passive acoustic monitoring) have been recently collected and may provide more information on blue whale distribution in North Atlantic waters

Attention: SC, G

The Committee notes that there has been a recent increase in information available on North Atlantic blue whales. The Committee:

(1) ***draws attention to*** *the lack of data on interchange between blue whales in the eastern and western North Atlantic and* ***recommends*** *that U.S., Canadian and Icelandic colleagues conduct a new comparison of blue whale photo-identification catalogues and present this information at SC/68a; and*
(2) ***encourages*** *Canadian colleagues to generate a new population abundance estimate as soon as feasible, and looks forward to updates on new passive acoustic and visual sightings data SC/68a.*

9.3.5 North Atlantic humpback whales
The Committee received new information (NOAA, 2018b) on humpback mortalities along the US coast (vessel strikes and entanglements were noted as the primary causes of anthropogenic mortality). An 'Unusual Mortality Event' was declared by the USA for humpback whales in April 2017. This is discussed further in Annex G (item 7.7. New abundance estimates for parts of the North Atlantic are discussed in Annex Q (item 3.1.1.3) and presented in Item 12.1. Consideration of the need for a new in-depth assessment of North Pacific humpback whales is given in Annex E (item 5.8.2) and Item 8.7.3.

9.3.6 North Atlantic bowhead whales not subject to aboriginal subsistence whaling
No new information was available to the Committee.

9.3.7 North Pacific bowhead whales not subject to aboriginal subsistence whaling
No new information was available to the Committee.

9.3.8 North Pacific sperm whales
Three papers (SC/67b/ASI10,12 and SC/67b/SCSP06) provided new information of sperm whale occurrence and distribution was collected during 2017 in the western North Pacific, eastern Bering Sea. An intersessional correspondence group to examine possible ways to assess sperm whales has been reappointed (Annex Y)

9.3.9 Gulf of Mexico Bryde's whales
9.3.9.1 NEW INFORMATION
The Committee received an update on activities related to monitoring and new research plans for the critically endangered Gulf of Mexico sub-species of Bryde's whale. The Southeast Fisheries Science Center undertook a shipboard survey in the northern Gulf of Mexico in 2017, including known habitat of the Gulf of Mexico Bryde's whale. Passive acoustic data were collected in historic habitat of the central and western Gulf from June 2016 to June 2017. The In the USA, there is legislation that provides funds to restore and protect ecosystems of the Gulf of Mexico following the Deepwater Horizon oil spill (2010); this work will include research on the Gulf of Mexico Bryde's whale.

Attention: SC, G

The Committee ***agrees*** *that the NOAA scientists working with this sub-species should present results from shipboard and acoustic data analyses to the IWC at the 2019 Scientific Committee meeting and looks forward to receiving a report from the Workshop held in conjunction with the initiation of research associated with funds to restore and protect ecosystems of the Gulf of Mexico following the Deepwater Horizon oil spill.*

The Committee also ***encourages*** *U.S. and Mexican scientists to collaborate in efforts to determine whether any of these whales occur in Mexican waters (e.g. Bay of Campeche) where a major oil spill of three million barrels occurred in 1979. This should include consideration of the use o9f passive acoustics as well as visual surveys focusing on areas of habitat similar to that found in the core known range in the north-eastern Gulf. It was further noted that passive acoustic data or specimen records from the northern coast of Cuba would be useful to determine potential occurrence of this subspecies in that region.*

9.3.9.2 CONSERVATION ADVICE

Attention: CG-R, S
The small population size, known human related mortality, restricted range and low genetic diversity place the Gulf of Mexico sub-species of Bryde's whale (added to the Critically Endangered category of the IUCN Red List in 2017) at significant risk of extinction. The Committee ***reiterates*** *its previous* ***recommendations*** *that US authorities:*

(1) make full and immediate use of available legal and regulatory instruments to provide the greatest possible level of protection to these whales and their habitat;
ensure that seismic surveys and associated activities that degrade acoustic habitat are excluded from the region of the eastern Gulf of Mexico inhabited by these whales, including an appropriate geographic buffer against acoustic impacts from activities in the Central Planning Area and active leases in the Eastern Planning Area;
(2) characterise the degree of overlap between the whales' currently known preferred habitat and ship traffic, and immediately implement appropriate measures to reduce the risk of ship strikes (e.g. re-routing, speed restrictions);
(3) based on the known distribution of these whales and overlap with certain fisheries, improve understanding of potential for interaction with fishing gear, and expand and implement appropriate measures, such as area closures, to reduce the risk of entanglement throughout their range;
(4) develop and implement restoration projects (with funds from the Deepwater Horizon oil spill settlement) for these whales and their habitat as a priority and ensure that a robust monitoring and adaptive management plan is in place to evaluate the effectiveness of all restoration efforts;
(5) design and conduct research programmes (sighting surveys, acoustic monitoring, genetic mark-recapture, photoidentification if feasible, satellite tagging if feasible, health studies if feasible) to further investigate these whales' distribution, movements, habitat use, health, survival and fecundity - this should include efforts to better document the whales' total geographic range and to document causes of mortality through necropsies when carcasses are reported; and
(6) *ensure that information about core known habitat and movements in the Gulf of Mexico is transmitted to the U.S. Coast Guard, shipping industry trade organizations, and Gulf of Mexico port authorities (e.g. in Tampa, Florida) for their consideration to mitigate ship-strike risk.*

In addition, the Committee ***reiterates*** *its recommendation that the IWC Secretariat (i) communicate the above concerns and recommendations to range state authorities and (b) specifically explore in collaboration with the International Maritime Organization the feasibility of providing internationally recognized forms of protection to these whales (e.g. designation of an Area to be Avoided) that would reduce the risk of ship strike and help mitigate degradation of acoustic habitat by ship noise.*

9.3.10 Other stocks - Northern Indian Ocean sperm whales
No new information was available to the Committee.

9.3.11 Workplan 2019-20
The Committee agreed to the two-year workplan in Table 11.

9.4 New information and workplan for other Southern stocks
9.4.1 Southern Hemisphere humpback whales
9.4.2.1 BREEDING STOCK D
The assessment of the Breeding Stocks D (West Australia), E1 (East Australia) and Oceania was completed in 2014 (IWC, 2015a), but there were substantial associated problems in obtaining a reliable estimate of absolute abundance for Breeding Stock D. See Annex H (IWC, 2017a; 2018a) for a detailed discussion of these issues. Last year (IWC, 2018c), the Committee had agreed that efforts should focus on designing and implementing a new 'survey' (perhaps using new approaches such as drones), and recommended that prior to implementation, an assessment of the feasibility of such a 'survey', focusing in particular on the study conducted by du Fresne *et al.*, (2014), is conducted.

Attention: SC, G, CG-R

The Committee ***agrees*** *that obtaining a reliable estimate of absolute abundance for humpback whale Breeding Stock D (west Australia) is a priority for any future in-depth assessment. The Committee* ***reiterates*** *its recommendation that an evaluation of abundance survey feasibility be carried out for this population, focusing in particular on the study conducted by du Fresne et al. (2014), with a view to implementing a new survey of this population in the future.*

9.4.2.2 WORK PLAN
The work plan for Southern Hemisphere humpback whales is given in Table 12.

Table 12.
Work plan for Southern Hemisphere humpback whales

Topic	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting
Survey feasibility	Reanalyse pilot study to assess feasibility of future West Australia surveys (Kelly)	Receive report		

9.4.3 Southern Hemisphere right whales not the subject of CMPs

The Committee would like to progress regional population assessments for southern right whales (Item 10.8.1.5, IWC, 2017b) This requires a good understanding of population structure, abundance, trend and past exploitation levels. It was agreed that Australia should be the highest priority region for the next assessment (Item 9, IWC, 2018a).

9.4.3.1 SOUTH AFRICA

SC/67a/SH01 provided the results of the 2017 survey of southern right whales flown along the coast of South Africa, part of a long-term monitoring programme since 1979. Since 2015 there has been a marked decline in the presence of unaccompanied adults and cow-calf pairs for unknown reasons (see discussion in Annex S, item 5.1.3). Photo-ID analyses indicated an increasing occurrence of apparent 4- and 5-year calving intervals since 2014. SC/67b/SH22 applied a life history model to photo-ID data collected from 1979 to 2017. They showed that a model variant which allows the probability of a resting female remaining in the resting phase (rather than having a calf) to vary through time provided a better fit to the data than a time-invariant model. They calculate an annual population growth rate of 6.5% and measure first year survival at 0.852, with subsequent annual survival of 0.988.

Attention: SC, G, C-A, CG-A

*The Committee is **concerned** that the future of the exemplary long-term monitoring programme of right whales in South African waters remains uncertain. The Committee therefore **reiterates** that it:*

*(1) **strongly recommends** continuation of the survey;*
*(2) **requests** the Commission to urge South Africa to do all it can to ensure the long-term future of this vital monitoring programme; and*
*(3) **encourages** South African scientists to investigate the offshore movements and locations of southern right whales with future surveys.*

9.4.3.2 AUSTRALIA

The Committee was informed about the latest of a series of aerial surveys conducted in South and West Australia in 2017. The 2017 counts were the highest yet in the series and an exponential increase of ~6% per year remains a good description of the data. Funding has been obtained for the next three years of surveys. The Committee was also informed about: (a) a 26-year cliff-top study conducted at the Head of the Great Australian Bight (south Australia) on right whale population trends and identifications (Charlton *et al.*, In prep); and (b) an aerial survey in southeast Australia where small numbers of whales have been sighted (Watson *et al.*, 2015). Right whales in southeast Australia are genetically and geographically distinct from the large population in south/southwest Australia (e.g., Carroll *et al.*, In press).

The Committee was advised that the Australian Government has recently allocated funds towards a two-year project that will provide an abundance estimate for Australia's two southern right whale populations. It will investigate life history characteristics as well as connectivity between breeding areas on the eastern, southern and western coasts of Australia.

Attention: SC, G, CC, CG-A

*The Committee **recognises** the value of the Australian long-term right whale monitoring programmes to understand right whale population trends and dynamics, and **recommends** that this monitoring continues.*
*In regard to right whales in southeast Australia, the Committee **reiterates** concerns expressed in 2017 that abundance remains low despite this area having been a significant historic calving ground. The Committee therefore:*

(1) recommends an assessment of the likely effects of fish farms and other developments in hindering population recovery in this region; and
(2) encourages further work to estimate the abundance of the southeast Australia population.

9.4.3.3 NEW ZEALAND

The Committee welcomed information that surveys will be conducted in the Auckland Islands in 2020/21 to estimate abundance (updating the last estimate from 2009), to assess trend and population age structure, as well as changes in genetic diversity of right whales using this calving ground.

9.4.3.4 FEEDING GROUNDS

The Committee welcomed the results of a visual and acoustic survey of southern right whales off South Georgia/Islas (SC/67b/SH20). SC/67b/SH06 used genotypic markers to assess re-sight rates and sex ratios from biopsy samples (*n*=157) collected during 14 summer surveys in Antarctic Area IV. A preliminary abundance estimate was calculated using these data and further mark recapture analyses will be conducted intersessionally to provide an abundance estimate for review at next year's meeting. To further investigate linkages it was suggested that these high latitude data be compared the western Australia stock to investigate what population component is using this high latitude area.

Attention: SC

The Committee ***encourages*** *further mark recapture analysis of the genotype data of the 14-year dataset collected in the high latitudes of Area IV, to estimate the abundance of southern right whales in this feeding area and* ***agrees*** *that this will be considered at next year's meeting.*

9.4.3.5 PROGRESS TOWARDS POPULATION ASSESSMENT

This year, the Committee reviewed newly available information on population structuring of southern right whales around the Southern Hemisphere (Carroll *et al.*, In press) which further confirms the genetic differentiation of regional calving grounds off Argentina, South Africa, New Zealand and Australia, showing limited migratory movements between these areas (see Annex H, item 5.1,).

The Committee was provided with updates on trends and distribution for calving grounds off South Africa and off south and southwest Australia. Recent published data on population size and trend for calving grounds across the Southern Hemisphere were summarised in Annex H (table 2); this will be reviewed at next year's meeting. Given the trends in abundance and calving rates reported this year (Items 9.4.3.1 and 9.4.3.2), integration of these analyses in a common modelling framework was suggested as a useful way to evaluate common patterns and changes in demography and investigate the relative importance of environmental drivers in determining these patterns.

Another important aspect of population assessment is to update the pre-modern catch series for southern right whales, to better reflect patterns of regional exploitation. The Committee was informed that substantial new data are available on offshore whaling patterns and extent, particularly from American and British voyage logbooks (see Annex H, item 5.2,), which are likely to increase regional catch estimates and provide revised estimates of the numbers of whales struck but lost at sea by the different fisheries.

Attention: SC, G

To better understand patterns of right whale population dynamics around the Southern Hemisphere, and further the work on updated assessments, the Committee:

(1) ***agrees*** *that analysis of three southern right whale calving grounds (Head of the Bight and southwest Australia, southwest Atlantic and south Africa) should be undertaken using the same life-history model, to estimate regional demographic parameters and investigate commonalities in the population dynamics of these populations; and*
(2) ***supports*** *the compilation of new data on pre-modern right whale catches, and the organisation of a workshop to investigate regional right whale catches and rates of whales struck but lost by fisheries, in order to proceed toward regional population assessments.*

9.4.3.6 WORK PLAN AND BUDGET REQUESTS FOR 2019-2020

The work plan for southern right whales not the subject of a CMP is given in Table 13.

Table 13.

Workplan for southern right whales that are not the subject of a CMP

Topic	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting
Southern right whales	Examine southern right whale demographic parameters across multiple calving grounds using a common modelling framework	Review progress		Complete comparison
Southern right whales	Plan right whale catch series workshop	Progress update	Organise catch series workshop	Workshop report

10. STOCKS THAT ARE OR HAVE BEEN SUGGESTED TO BE THE SUBJECT OF CONSERVATION MANAGEMENT PLANS (CMPs)

10.1 Stocks with existing CMPs

This item covers stocks (with a focus on progress with scientific work and information) that are either: (1) the subject of existing CMPs; or (2) are high priority candidates for a CMP. It also considers stocks that have previously been considered as potential CMPs, recognising that the Commission has stressed the need for Range States to support any IWC CMPs.

10.1.1 SE Pacific southern right whales

10.1.1.1 NEW INFORMATION

The Committee received information on advances with respect to sightings (SC/67b/CMP20) and acoustic monitoring (SC/67b/CMP08; SC/67b/CMP18) of the critically endangered population of SE Pacific southern right whales. This information is discussed in detail in Annex O (item 2.1.1). Four confirmed observations were made off Chile in 2017 (three opportunistic sightings and one entangled carcass) and there was another, as yet unconfirmed sighting involving adults and calves. Analysis to date of acoustic data collected off the southwestern tip of Isla de Chiloe in 2012 has provided valuable new information about call parameters and patterns.

10.1.1.2 PROGRESS WITH THE CMP

The Committee received information on progress in implementing priority actions of the CMP (SC/67b/CMP20) as discussed in Annex O (item 2.1.1.2).

This progress includes:

(1) deployment of Passive Acoustic Monitoring (PAM) devices along the coast of Chile and Peru (SC/67b/CMP18) in two locations that will also be used as the focus of educational and capacity-building activities in communities near the monitoring sites;
(2) additional capacity-building and awareness efforts (including posters, press releases and social media) including advice on how fishermen and the public can provide information to the national sighting network; and
(3) additional training towards increasing the capacity of range states to respond to entanglements.

Attention: SC, CC

The Committee ***reiterates*** *the importance of the CMP for the conservation of this critically endangered population of southern right whales in the southeastern Pacific,* ***welcomes*** *the progress being made in its implementation by Chile and Peru. It therefore:*

(1) ***commends*** *the scientific work and international co-operation being undertaken for the PAM project and looks forward to receiving the results of the acoustic studies such that future sighting surveys will be more informed and baseline information on the location of breeding grounds will be available; and*

(2) ***advises*** *that satellite imagery be explored as an additional means to inform the design of sighting surveys because it is likely that line-transect surveys would not successfully identify whales in some areas even if they were present.*

10.1.2 Southwestern Atlantic southern right whales

10.1.2.1 NEW INFORMATION

The Committee was pleased to receive a considerable amount of new information on the southwest Atlantic population of southern right whales; this is fully discussed in Annex O (item 2.1.2.1).

With respect to abundance, SC/67b/CMP/05 suggested that although the population has continued to increase, the rate may have been slowing, perhaps as a consequence of changes in distribution due to density-dependence processes (SC/67b/CMP02).

The Committee has for some time been focussing on the die off at Peninsula Valdes (e.g. IWC, 2011; 2015) and the excellent work of the Southern Right Whale Health Monitoring Program. New and updated information was presented this year on strandings and investigations related to health including examination of levels of stress hormones in baleen and kelp gull attacks (SC/67b/CMP04) and nutritional condition (SC/67b/CMP03). This work is ongoing.

Information was received on telemetry studies (one animal in 2016 and 8 in 2017) as part of an ongoing long-term study to understand the migratory routes and destinations of southern right whales wintering off the coast of Argentina (SC/67b/CMP17. Tracks reveal that these animals are found across a vast extent of the South Atlantic and each season visit multiple potential feeding areas.

The Committee also received the report of a land-based survey of whales near Miramar on the southwest coast of the Buenos Aires Province, Argentina, where there has been a recent expansion of right whales into the region where they have been seen from May to October with peaks in August and September (SC/67b/CMP21).

Attention: SC, G

The Committee ***reiterates*** *the importance of continued monitoring of the southwestern Atlantic population of southern right whales and research into threats that it may face. The Committee therefore:*

(1) ***commends*** *the work being undertaken on understanding the mortality events and* ***encourages*** *its continuation;*
(2) ***encourages*** *the researchers working on stress hormones in baleen to increase their sample size, consider suggestions for additional studies provided in Annex O (item 2.1.2.1) and present a full report to the Committee when it becomes available;*
(3) ***commends*** *the telemetry work,* ***encourages*** *its expansion and draws attention to additional analyses that could be addressed using the telemetry data suggested in Annex O (item 2.1.2.1).*

10.1.2.2 PROGRESS WITH THE CMP

The overall objective of the southern right whale CMP is to protect their habitat and minimise anthropogenic threats to maximise the likelihood that the population will recover to healthy levels and recolonise its historical range. The Committee was pleased to receive information on progress with the actions of the CMP from Argentina (SC/67b/CMP14), including the work described under Item 10.1.2.2, and Brazil (Annex O, appendix 2). Work in Brazil includes long-term monitoring via sightings and strandings networks, mitigation of entanglements and the development of a management plan for whalewatching (see Annex O, item 2.1.2.2).

Attention: SC, CC

The Committee ***reiterates*** *the importance of the CMP for the conservation of the southwestern Atlantic population of southern right whales. The Committee therefore:*

(1) ***welcomes*** *the progress being made in the implementation of the CMP reported by Argentina and Brazil and supports its continuation;*
(2) ***encourages*** *the continued co-operation and collaboration amongst range states towards implementing the CMP and addressing mortality evens in this population; and*
(3) recognising the report of a ship-struck southwestern Atlantic southern right whale in the range of the southeastern Pacific (Estrecho de Magallanes), ***encourages*** *co-operation with those involved in the southeastern Pacific CMP to facilitate a regional assessment; and*
(4) ***encourages*** *the research work identified under Item 10.1.2.1.*

10.1.3 North Pacific gray whales

10.1.3.1 RANGEWIDE ASSESSMENT

Donovan summarised the report of the Fifth Rangewide Workshop on the Status of North Pacific Gray Whales (SC/67b/Rep07) held at the Granite Canyon Laboratory, California of the Southwest Fisheries Science Center from 28-31 March 2018. The primary tasks of the workshop were to (a) review the results of the modelling work identified at the fourth rangewide workshop (IWC, 2018a) and the 2017 Scientific Committee meeting (IWC, 2018b), (b) examine the new proposed Makah Management Plan (submitted by the USA – given as Annex E, Appendix 1) for gray whaling off Washington state and (c) to update as possible, and develop a workplan for, updating the scientific components of the Conservation Management Plan (CMP) for western gray whales.

A full discussion of the workshop can be found in Annex O (item 2.1.3.1). The Workshop finalised its work on (a) prioritising stock structure hypotheses, (b) finalising inputs for the modelling work especially related to bycatch; and (c) incorporating the Makah Management Plan (SC/67b/Rep07, Annex E, Appendix 1) into the modelling framework.

Two stock structure hypotheses (3a and 5a) were given priority whilst others were used in sensitivity tests. In summary, Hypothesis 3a assumes that whilst two breeding stocks (Western and Eastern) may once have existed, the Western breeding stock is extirpated. Whales show matrilineal fidelity to feeding grounds, and the Eastern breeding stock includes three feeding aggregations: Pacific Coast Feeding Group (PCFG), Northern Feeding Group (NFG), and the Western Feeding Group. Hypothesis 5a assumes that both breeding stocks are extant and that the Western breeding stock feeds off both coasts of Japan and Korea and in the northern Okhotsk Sea west of the Kamchatka Peninsula. Whales feeding off Sakhalin include both whales that are part of the extant Western breeding stock and remain in the western North Pacific year-round, and whales that are part of the Eastern breeding stock and migrate between Sakhalin and the eastern North Pacific.

In discussion of the report and intersessional progress, the Committee thanked Donovan, Punt and the participants for the progress made, approved the conditioning results developed after the workshop, noted the preliminary results from the modelling and agreed a strategy for obtaining conservation advice (see recommendation below under Item 10.3). The management implications of the results for the Makah Management Plan are found under Item 7.1.3.

10.1.3.2 REGIONAL STUDIES

The Committee was pleased to receive recent information from long-term studies in the breeding lagoons of Mexico (SC/67b/CMP09) as discussed in Annex O (item 2.1.3.1.1).

The Committee received several updates on work undertaken in the Russian Federation (see Annex O, item 2.1.3.2). It welcomed the annual update of activities from the IUCN Western Gray Whale Advisory Panel (see Annex O, appendix 3) which highlighted work to develop a monitoring and mitigation plan for a 2018 seismic survey being undertaken near the feeding grounds off Sakhalin Island, Russia and issues related to fishing gear. SC/67b/CMP07 updated findings from the long-term monitoring programme carried out by the Russian Gray Whale Project off Sakhalin Island, Russia. The research programme run in the same area by two oil companies was presented in SC/67b/ASI04 and discussed in Annex S (item 4.2).

The recent status of conservation and research on gray whales in Japan was reported in SC/67b/CMP12. During May 2017-April 2018, no anthropogenic mortalities were reported from the adjacent waters off Japan, while two opportunistic sightings of gray whales were made near Aogashima Island in May 2017 and February 2018.

Finally, SC/67b/CMP11 reported on the possible occurrence of a gray whale off the east coast of Korea; work is continuing to try to confirm the species identification; if confirmed it will be the first record in these waters in over 40 years.

Attention: CG-R, SC, G

The Committee ***reiterates*** *the importance of long-term monitoring of gray whales,* ***recommends*** *that range states support such work and* ***welcomes*** *the information provided this year. In particular, the Committee:*

(1) ***commends*** *the work in the breeding lagoons and urges its continuation;*
(2) ***encourages*** *an additional calf-count survey for Punta Banda to address apparent differences in numbers of calves observed in the lagoons with counts from California;*
(3) ***reiterates its concern*** *at the risk of whales becoming entangled in gear placed by the salmon trap-net fishery off Sakhalin Island, recognises that disentanglement training has occurred but* ***recommends*** *that measures to be taken to reduce risk;*
(4) ***encourages*** *continued genetic analyses to assist in stock structure discussions especially related to a western breeding stock;*
(5) ***welcomes*** *the continued provision of information from Japan and* ***encourages*** *researchers to continue to collect as much information on sightings as possible, including, if feasible, attempting to obtain biopsy samples; and*
(6) ***welcomes*** *the information from Korea and the willingness of researchers to investigate sightings from social media as a form of 'citizen science', which can be especially valuable for areas where occurrence is very rare animals in areas with little to no information on critically endangered species.*

10.1.3.3 PROGRESS WITH THE CMP

As noted above, one of the objectives of the fifth rangewide workshop was to progress work with updating the scientific components of the original IWC/IUCN CMP in the light of the results of the rangewide review. Although some work was undertaken, there was insufficient time at the workshop to complete this although a workplan to achieve it was suggested (see SC/67b/Rep07). The Committee concurred with this view and this is incorporated into the workplan below.

Another important component of the CMP effort is the need for a stakeholder workshop (tentatively forecast to occur in 2019) to finalise the CMP and develops a strategy for its implementation. The plan is for a workshop, co-sponsored by IWC, IUCN and the signatories to the Memorandum of Cooperation, to: (1) review and updating of the CMP; (2) establishing a stakeholder Steering Group to monitor CMP implementation, (3) arrange for a coordinator of the CMP and (4) establish a work plan and consider funding mechanisms to implement the actions of the plan.

Attention: C-A, CG-R, CC, SC

The Committee ***reiterates*** *the importance of the CMP for the conservation of western gray whales. The Committee therefore:*

(1) ***recognises*** *the tremendous work undertaken in the rangewide assessment and the value of the modelling framework developed;*
(2) ***agrees*** *that the next part of the process is to develop conservation-related questions and to use the framework to address these with a view to examining results at SC68a;*
(3) ***agrees*** *that a small group meeting (see Item 27) attended by at least the national co-ordinators of the Memorandum of Co-operation on gray whales, Reeves, Punt and Donovan be held to: (a) draft an update to the CMP; and (b) identify conservation-related questions to be addressed by the modelling framework and to present results at SC68a;*
(4) ***requests*** *those signatories to the Memorandum of Co-operation on western gray whales who have not yet named a national co-ordinator to do so promptly; and*
(5) ***supports*** *the holding of a stakeholder workshop in 2019 co-sponsored by the IWC, IUCN and the states that have signed the Memorandum of Co-operation and* ***welcomes*** *the valuable assistance of IUCN in organising the workshop.*

10.1.4 Franciscana

10.1.4.1 NEW INFORMATION

The Committee received valuable new information on franciscana at this meeting related to fisheries and bycatch from five localities in North Espírito Santo State, Brazil (SC/67b/SM30) – bycatches of Guiana dolphins was also reported. Additional information was presented assessing fisheries that operate in Fisheries Management Area (FMA) Ib for their compliance with Brazilian ordinance (IN) 12 (e.g. with respect to gill-net regulations and no-take zones) and risk of bycatch (SC/67b/SM05) – compliance was limited and enforcement poor. Both projects were funded by the IWC Small Cetacean Fund and the Government of Italy. This information is discussed in Annex O (item 2.1.4.1) and a related recommendation is given under Item 10.4.2.2.

10.1.4.2 PROGRESS WITH THE CMP

The overall objective of the CMP, submitted by Argentina, Brazil and Uruguay (IWC/66/CC11) and adopted in 2016, is to protect franciscana habitat and minimise anthropogenic threats, especially bycatch. It includes seven high priority actions, ranging from public awareness and capacity building through research to mitigation. Coordination with Uruguay to implement the CMP in this area will be initiated during a workshop that will take place in May 2018 with the main stakeholders (SC/67b/CMP16). The CMP is funded by the IWC CMP Voluntary Funds and the World Wildlife Fund.

Attention: CG-R

The Committee ***emphasises*** *the importance of the CMP for the conservation of franciscana in the waters of Argentina, Uruguay and Brazil. The Committee therefore:*

(1) ***stresses*** *the value of the actions included in the CMP towards future assessments of the status of franciscana, which is imperative for determining the effectiveness of conservation efforts;*
(2) ***recommends*** *that research be undertaken to estimate the abundance of franciscana dolphin off Buenos Aires province, Argentina; and*
(3) ***recommends*** *that additional research be undertaken to determine the effectiveness of management measures, such as that described in SC/67b/SM05 for other ports (e.g. Macaé, Tamoios (Cabo Frio) and Armação dos Búzios – the fishery in Tamoios coincides with a high diversity of marine megafauna).*

The Committee established an intersessional correspondence group that will help co-ordinate the presentation of CMP projects for this species across sub-committees at SC/68a (Annex Y).

10.2 Progress with identified priorities

10.2.1 Humpback whales in the northern Indian Ocean including the Arabian Sea

10.2.1.1 NEW INFORMATION

The Committee received several papers that improved knowledge of Arabian Sea humpback whales and a full discussion can be found in Annex O (item 2.2.1). It welcomed the information on the progress of work being undertaken by the Arabian Sea Whale Network (ASWN) formed in 2015 (SC/67b/CMP10). The ASWN is an informal collaboration of researchers, consultants and conservation and governmental organisations interested in the conservation of whales in the Northern Indian Ocean. A primary goal of the ASWN is to promote and foster research and collaboration in previously unsurveyed parts of the Arabian Sea humpback whales' suspected range, as well as in Oman where surveys have been conducted since 2000. Work has focused on collecting data on whale distribution and status (including through increased awareness and an observer programme – described in SC/67b/CMP15)), the introduction and implementation of a regional online data platform (SC/67b/PH03) and providing updates on research activities in Oman, India, Pakistan and Sri Lanka (SC/67b/INFO07). Two marine protected areas have been established in Pakistan (Astola Island and Indus Canyon).

Madhusudhana *et al.* (2018) reported on and compared humpback whale songs recorded off India, Oman, Reunion Island and Comoros Islands in the southwest Indian Ocean. The results highlighted (a) the distinct nature of the Arabian Sea population and (b) that SW Indian Ocean whales may move into the Arabian Sea more commonly than previously thought.

SC/67b/CMP13 reported on a humpback whale tagged off Oman that moved to the southern tip of India and back again - the first recorded movement of a whale across the Arabian Sea. Four additional satellite tags were deployed where the whales remained over the continental shelf of central and southern Oman.

Attention: G, SC

The Committee ***welcomes*** *the new information from the region on this critically endangered population and* ***commends*** *the researchers for their initiatives and collaborative efforts. In light of the information presented, the Committee:*

(1) ***encourages*** *the collection of genetic information which would be helpful for identifying stock structures within the area;*
(2) ***recommends*** *future use of unoccupied aerial systems to (i) measure whale health, (ii) develop long-term health metrics, (iii) compare body condition to stock C in the Southern Hemisphere, which is the presumed 'source' population for whales in the Arabian Sea and (iv) assess for evidence of anthropogenic threats;*
(3) ***commends*** *the use of fishing crew as observers and* ***advises*** *that the crew-based observer programme continue, recognising that it is not clear if the timing of the sightings reflects the seasonal distribution of whales or the seasonal nature of fishing effort and* ***encourages*** *future research to tease apart timing of the distributions using targeted surveys;*
(4) ***advises*** *that capacity building for local scientists be continued such that surveys can be deployed in suspected areas of humpback whale distribution and data can be gathered for future assessments;*
(5) ***advises*** *the continuation of monitoring songs of Arabian Sea humpback whales and that additional data sets be acquired comparison purposes, particularly from the southwest Indian Ocean, if they exist, to further (i) detect the movement of southwestern Indian Ocean animals in Boreal winter, (ii) document potential diffusion of southwestern Indian Ocean song, (iii) provide a long-term data set for the comparison of songs across Oman, Pakistan and India to assess continuity of whales in the Arabian Sea and (iv) evaluate the unprecedented temporal stasis of song in the Arabian Sea; and*
(6) ***agrees*** *that an intersessional correspondence group (Annex Y) be formed to review the methods used for the preliminary estimates of abundance, in order to increase their robustness by taking into account the non-random survey approach that violates some key assumptions of mark-recapture models.*

10.2.1.2 PROGRESS WITH INTERNATIONAL CO-OPERATION AND REGIONAL MEASURES SUCH AS CMPS

A Concerted Action for Arabian Sea humpback whales under the Convention on Migratory Species (CMS; SC/67b/INFO06) was drafted and passed with wide support from Arabian Sea range states at the CMS COP in October 2017. It is hoped that this Concerted Action can be implemented in conjunction with a CMP as a means to translate current research and conservation efforts and plans into concrete, government-supported conservation measures in Arabian Sea humpback whale range states.

Attention: *C-A, S*

The Committee ***reiterates*** *its serious concern about the status of the endangered Arabian Sea humpback whale population and the anthropogenic threats it faces. It therefore:*

(1) ***commends*** *efforts to develop the Concerted Action under the CMS, noting that it covers many of the elements required for a CMP;*
(2) ***stresses*** *the value of regional initiatives and* ***encourages*** *range states to explore future sources of collaboration; and*
(3) ***encourages*** *continued efforts between range states and Secretariats to work toward a joint CMS-IWC CMP.*

10.2.2 Mediterranean fin whales

The ACCOBAMS Meeting of Parties has endorsed the development of a CMP, ideally jointly with the IWC, for fin whales in the Mediterranean Sea. A small group will meet in the summer of 2018 to draft an outline for a CMP that can be presented at SC/68a. ACCOBAMS is also considering the development of CMPs for other species in the region.

10.2.3 South American River Dolphins

Advice was sought regarding the development of a CMP for South American river dolphins, which currently have several actions plans endorsed by various range states.

Attention: CG-A

The Committee ***advises*** *that the applicable range states work towards developing a draft CMP for presentation at SC/68a.*

10.3 Workplan 2019-20

The workplan on matters related to stocks that are or might be the subject of CMPs is given as Table 14.

Table 14

Summary of the work plan on conservation management plans.

Topic	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting
Southeast Pacific right whales	.	Review progress with scientific aspects of the CMP		Review progress with scientific aspects of the CMP
Southwestern Atlantic right whales		Review progress with scientific aspects of the CMP		Review progress with scientific aspects of the CMP
Gray whales	Hold workshop on scientific aspects of CMP and use of modelling framework.	Review results and provide advice on scientific aspects of CMP	Stakeholder workshop	Review scientific aspects of results of stakeholder workshop
Franciscana		Pre-assessment for in-depth review		Continue pre-assessment and develop plan for in-depth assessment
Humpback whales in Northern Indian Ocean	Intersessional email group (Annex Y) on abundance estimates	Review new information and progress towards CMP		Review new information and progress towards CMP
Mediterranean fin whales	Develop outline draft	Review draft and progress towards CMP		Review progress towards CMP
South American river dolphins		Review new information and progress towards CMP		Review new information and progress towards CMP

11. STOCK DEFINITION AND DNA TESTING

This agenda item merges two previously separate sub-groups, the Working Group on Stock Definition and the Working Group on DNA. During SC67b, the Stock Definition and DNA Testing Working Group assessed genetic methods used for species, stock and individual identification, including matters associated with the maintenance of DNA registers (see 11.1); continued to develop and update guidelines for preparation and analysis of genetic data within the IWC context (see 11.2); and provided the Committee with feedback and recommendations concerning stock structure related methods and analyses (see 11.4), including those relevant to other sub-committees (see 11.3). The Report of the Working Group is given as Annex I.

11.1 DNA testing

This item has been considered since 2000 in response to a Commission Resolution (IWC, 2000).

11.1.1 Genetic methods for species, stocks and individual identification

The Committee received two papers relating to the use of genetic methods for species, stock and individual identification. The first paper (Carroll *et al.*, 2018) provided a review of how technological advances, particularly those associated with the development of high throughput sequencing (HTS) technology, can aid in genetic monitoring. Of particular interest to the Committee was discussion of targeted capture approaches that allow for microsatellite genotyping via HTS (e.g. De Barba *et al.*, 2017). Much of the past genetic work has relied on generating microsatellite datasets, including the work to maintain DNA registries of bycaught or direct catches (see Items 11.1.2 and 11.1.3). These 'legacy' datasets may include microsatellite genotypes for thousands of individuals. While technical challenges exist, microsatellite genotyping via HTS could 'bridge the gap' by maintaining the utility of these legacy datasets while also taking advantage of the newer HTS approaches.

The second paper (Baker *et al.*, In press) presented the results of a study confirming the potential to detect environmental DNA (eDNA) in seawater collected from the wake of killer whales. This is a new approach for detecting and identifying cetacean species, including those that may be elusive to study using other methods. Although eDNA has been more broadly used to detect the occurrence of species in an area (i.e. DNA barcoding), it could provide sequence data useful for stock-level identifications of cetaceans under certain circumstances (e.g., when a single animal is present). It was noted, however, that its utility in addressing questions requiring individual identification via multi-locus genotyping is, at least currently, limited for scenarios in which the water sample could contain DNA from multiple individuals.

Attention: SC

The Committee ***welcomes*** *the opportunity to review papers that take advantage of technological advances to improve the ability to detect and identify species, stocks, and individual cetaceans. It* ***encourages*** *the submission of similar papers in the future and recognises the relevance of these techniques to the Committee's work.*

11.1.2 'Amendments' of sequences deposited in GenBank

While *GenBank*[7] is an important scientific resource, it is an uncurated database of DNA sequences and thus contains sequences that are misidentified or have other annotation problems. While retaining the 'raw data' represented in *GenBank* is valuable, less-experienced users may be unaware that additional sequence validation may be needed when incorporating *GenBank* sequences into a study. The Committee has agreed (IWC, 2018c, p. 228) that its revised DNA quality guidelines will contain a section discussing the precautions that should be taken when including GenBank sequences in a study. This text has been drafted and will be incorporated into the revised guidelines (see Item 11.2).

11.1.3 Collection and archiving of tissue samples from catches and bycatches and
11.1.4 Reference databases and standards for diagnostic DNA registries

The Committee previously endorsed a new standard format for the updates of national DNA registers to assist with the review of such updates (IWC, 2012a, p. 53), and the new format has worked well in recent years. This year, the update of the DNA registers by Japan, Norway and Iceland were based again on this new format. Details are given in Annex I (appendices 2-4) for each country, covering the period up to and including 2017. Almost all samples in the three registries have been analysed for microsatellites, and work on unanalysed samples is continuing. Almost all samples in the registries of Japan and Iceland have also been analysed for mtDNA.

During last year's discussion of the Norwegian minke whale DNA register (IWC, 2018c, p. 228-229), the Committee was informed that mtDNA analysis on Norwegian samples had been discontinued and that microsatellite typing would eventually be replaced by SNP analysis. The Committee had expressed concern regarding the comparability of the DNA registers in the future. This year, the Committee noted that Norway had discontinued mtDNA typing of samples and substituted it with SNP genotyping.

Attention: CG-A

The Committee ***expresses appreciation*** *to Japan, Norway and Iceland for providing updates to their DNA registries using the standard format agreed in 2011 and providing the detailed information contained in their DNA registries.*

11.2 Guidelines and methods for genetic studies and DNA data quality

Two sets of guidelines have been developed for reference in the Committee's discussions of stock structure. The most recent version of the guidelines for genetic data analyses are in press with the Commission's *Journal of Cetacean*

[7] https://www.ncbi.nlm.nih.gov/genbank/

Research & Management. The DNA data quality guidelines address DNA validation and systematic quality control in genetic studies, and are currently available as a 'living document' on the IWC website[8]. In recent years, it has become common for the Committee to review papers using data derived from Next Generation Sequencing (NGS) approaches, including SNPs, to address stock structure questions (see Item 11.3).

Attention: SC

The Committee ***emphasises*** *the importance of keeping its guidelines related to genetic data quality and analyses up to date. It therefore:*

(1) ***reiterates*** *the need to update these guidelines to incorporate the discussion of data quality measures used for Next Generation Sequencing data; and*
(2) ***agrees*** *to continue the intersessional correspondence group (Annex Y) to review revised sections of the DNA data quality guidelines that apply to data generated from next generation sequencing platforms, including SNPs and whole genome sequencing, with the goal of posting an updated version of the guidelines on the website next year.*

11.3 Provide advice on stock structure to other sub-groups
The Working Group on Stock Definition and DNA also has the task of discussing high-priority stock related papers from other sub-committees and working groups to provide them with stock structure related feedback and recommendations. These discussions often refer to the genetic analysis guidelines and genetic data quality documents.

The discussions (see Annex I for details) are summarised under the relevant stock agenda items in this report. Two, more general issues arose from discussions of Southern Hemisphere stocks and North Atlantic common minke whales. These are considered below.

11.3.1. Southern Hemisphere whale stocks and use of samples
The Committee reviewed the results of genetic analyses of Southern Hemisphere whale stocks, including Southern Hemisphere blue, fin, right and sei whales. These results highlighted the value of existing collections of tissue samples to address stock structure questions.

Attention: SC

In reviewing the results of stock structure analyses of Southern Hemisphere whale stocks, the Committee expresses ***concern*** *regarding the depletion of tissue samples in existing collections (including those collected during the IWC SOWER surveys, although the Steering Group does take this into account when reviewing requests). Given recent advances in high throughput sequencing technology, the Committee* ***agrees*** *that an intersessional correspondence group (Annex Y) should be formed to provide recommendations on genomic approaches to maximise the utility of these samples for future studies.*

11.3.2. North Atlantic common minke whales
The Committee reviewed the results of genetic analyses pertaining to the stock structure of North Atlantic minke whales (SC/67b/Rep06). The analyses presented involved the use of a new approach to evaluate stock mixing proportions by (1) identifying a 'reference' year in which mixing of stocks was considered low based on a lack of heterogeneity in genetic characteristics estimated for each area, and (2) using principal component analysis of the genetic data to assign stock affinities in the non-reference years based on proximity to mean values in the reference year.

Attention: SC, C-A

The Committee reviewed the use of a new approach that used ordination analyses of genetic data to assign stock mixing proportions. Recognising that this new approach requires making certain assumptions about the data, the Committee:

(1) ***agrees*** *that the inference of mixing rates was informative for AWMP/RMP simulation trials in the absence of empirical data; and*
(2) ***encourages*** *the attempt to use genetic data to estimate mixing rates in the context of other IWC-related tasks.*

11.4 New statistical and genetic issues relating to stock definition
11.4.1. Simulation tools for spatial structuring
TOSSM was developed with the intent of testing the performance of genetic analytical methods in a management context using simulated genetic datasets (Martien *et al.*, 2009), and more recently the TOSSM dataset generation model has been used to create simulated datasets to allow the plausibility of different stock structure hypotheses to be tested (Archer *et al.*, 2010; Lang and Martien, 2012). The Working Group noted that while TOSSM has been particularly valuable in

[8] http://iwc.int/scientific-committee-handbook#ten

informing the interpretation of results of stock structure related analyses, it has not been broadly used within the IWC Scientific Committee for this purpose.

In recent years, a wide-range of software packages have become available for producing simulated datasets that can be used for statistical inference and/or validating statistical methods (Hoban, 2014, and see ; IWC, 2017c p.44), and in 2016 the Committee agreed to expand this item (formerly specific to TOSSM) to include a broader range of tools (IWC, 2016c p.44).

Attention: SC

*The Committee noted that while simulation-based approaches have been particularly valuable in informing the interpretation of results of stock structure-related analyses, they have not been broadly utilized within the Committee for this purpose. The Committee **agrees**:*

(1) to continue an intersessional review via an email correspondence group (Annex Y) of the available simulation tools and their potential utility to the Committee; and
(2) to consider bringing in invited expertise to present an overview of the applicability of such approaches in order to expedite progress on this agenda item.

11.4.2. Terminology
Defining and standardising the terminology used to discuss 'stock issues' remains a long-standing objective of the Working Group, in order to help the Committee report on these issues according to a common reference of terms (IWC, 2014 p.287-8). At SC67b, the status of the existing draft glossary on key terms related to stock definition was revisited.

Attention: SC

*The Committee **agrees** to establish an intersessional correspondence group (Annex Y) to revisit terminology with specific reference to the implications of inferred stock structure in other sub-committees, particularly those that deal with large whale assessments, and suggest revisions where appropriate for consideration at SC68a.*

11.4.3. Close-kin mark-recapture
An overview of the close-kin mark-recapture (CKMR) approach (Bravington *et al.*, 2016) was presented to the Committee last year (IWC, 2018c p.40). CKMR uses multi-locus genotyping to find close relatives among tissue samples from dead and/or live animals; the number of kin-pairs found, and their pattern in time and space, can be embedded in a statistical mark-recapture framework to infer absolute abundance, parameters like survival rate, and stock structure. No papers applying the CKMR approach were reviewed by Committee this year, although the value of integrating data from epigenetic aging (see 11.4.4) into CKMR was noted.

Attention: SC, G

*Given that close-kin mark-recapture has multiple applications that fall within the Committee's scope of work, the Committee **encourages** the submission of papers using this approach in the future.*

11.4.4. Epigenetic ageing
Information on estimated age of individuals can be used in many aspects of the Committee's work, including (1) discriminating between the parent and offspring among genetically identified parent-offspring pairs, which can inform both assessment of stock structure as well as genetic mark-recapture estimates of abundance (e.g. CKMR); and (2) integrating age information into the population modelling exercises integral to assessment work (e.g. on RMP implementation). Recently, epigenetic (DNA-methylation) ageing has been successfully used to estimate age in humpback whales (Polanowski *et al.*, 2014). This year, the Committee invited Jarman, the lead scientist on the humpback whale work, to give an overview presentation to the Committee. This session was organised as a special evening session in order to enable participation across sub-committees and Working Groups. He covered issues specific to age estimation in cetaceans, including how DNA methylation-based age estimation are likely to perform in cetaceans and what current and near-future prospects there are for this class of methods (see Annex I, item 5.5).

The Committee also reviewed the results of a study to evaluate the feasibility of using the DNA-methylation technique to estimate age in Antarctic minke whales (SC/67b/SDDNA04). This study was initiated in response to a recommendation made during the Expert Panel review of the NEWREP-A proposal (SC66A/REP06, p17). DNA-methylation rates were examined for seven methylation sites (CpG sites) within three genes, and regressions of each CpG methylation site against age determined by earplug were conducted. When all sites were incorporated, the assay predicted age from skin samples with a standard deviation of about 8.9 years. While some sites showed age-related effects, others did not show such correlation. Thus, using only those loci that appear to have an age-related effect might reveal a stronger relationship between methylation rates and age.

During the discussion (Annex I, item 5.5) it was noted that the humpback whale age assay, which used the same sites, reports a precision of 2.99 years, measured as the average of the absolute values of the differences between known and estimated ages (Polanowski *et al.*, 2014). During the presentation, the precision as measured by the standard deviation for absolute age prediction was reported as 4.8 years. That was a preliminary study demonstrating the fundamental feasibility of this approach, and is not as accurate or precise as tests developed for humans and mice based on analysis of many more CpG sites. While precision is expected to improve with the inclusion of more CpG sites, the maximum precision possible for any DNA methylation-based age estimator is likely limited by the imperfect relationship between chronological age and biological age. To date, that precision has ranged from 3.9% in humpback whales (Polanowski *et al.*, 2014 assuming a 95-year lifespan), to 3.2% of lifespan in humans (e.g. Horvath, 2013) and 1.7% of lifespan in mice (Stubbs *et al.*, 2017). These observations indicate that the SD and 95% CI for age estimation described in Polanowski *et al.* (2014) and in SC67b/SDDNA04 could be substantially improved before an inherent limit is reached. These precision estimates adhere to age determination in individual specimens. Hence, averaged age estimates over cohort will improve over larger sample sizes and may be more precise.

The Committee noted that the implications of this upper limit on precision in estimating age for individuals would need to be evaluated in the context of the specific application for which the age data were being used. For example, although additional precision is helpful, CKMR studies may be informed by relatively crude estimates of age allowing the parent to be discriminated from the offspring (i.e. ordinal age).

Attention: SC

The Committee welcomed the results of the study to evaluate the feasibility of using epigenetic techniques to estimate age in Antarctic minke whales and ***agrees****:*

(1) that the current set of loci did not provide sufficient precision for use in the population dynamics modelling exercise recommended for NEWREP-A; and
(2) that identification of additional sites with an age-related DNA-methylation pattern is encouraged, as it would likely allow more precise estimates of age to be made in the future; and
(3) given that there is an upper limit to the degree of precision that can be achieved using this technique, the utility of epigenetic age estimation to the Committee should be further evaluated by the sub-committees concerned with regard to the degree of precision needed for the specific application of interest.

11.5 Workplan 2019-20

The details of the workplan are given in Table 15.

Table 15

Workplan on topics related to genetics.

Topic	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting
3.1 DNA quality guidelines	Intersessional group (Annex Y) to review recent revisions to the DNA quality guidelines that pertain to data produced using NGS approaches.	Report and finalise updated guidelines		
4.4.2 Recommendations to avoid sample depletion	Intersessional email group to provide recommendations on genomic approaches to maximize the utility of tissue samples that are in danger of becoming depleted in the future.	Report and provide advice		
4.5 North Pacific minke whale stock structure	Perform genetic analyses detailed in Appendix 5; report results at intersessional workshop on the North Pacific minke whale IR.	Review results and provide advice		
5.1 Simulations	Intersessional email group to review software packages and evaluate utility to the Committee.	Report	Continue as needed	Report (if needed)
5.3 Terminology	Intersessional email group to continue discussions of the use of stock structure-related terms within the Committee.	Report	Continue as needed	Report (if needed)

12. CETACEAN ABUNDANCE ESTIMATES, STOCK STATUS

The Committee received new information from the Standing Working Group on Abundance Estimates, Status and International Cruises (ASI) that had been established (IWC, 2017c, p. 94) to formally review and agree on the status of the abundance estimates submitted to the Scientific Committee across all of the Committee's sub-committees and working groups. It also assists the Committee and the Secretariat in developing a biennial document reporting to the Commission on the abundance and status of whale stocks.

12.1 Summary of abundance estimates and update of IWC consolidated table

Appendix 3 of Annex Q provides detailed information about abundance estimates agreed by the Committee, including estimates received prior to and during 2017, as well as ones evaluated this year. The Secretariat maintains a consolidated table.

Broadly, cetacean abundance estimates are usually obtained in one of three ways. Line transect surveys require observers on ships or aircraft to detect animals while the observers are traveling on paths traversing the survey area. Statistical methods are used to estimate how many animals were not seen, usually by evaluating how detection deteriorates as sighting distance increases and by extrapolating to survey areas beyond visual detection distance. Mark-recapture studies require multiple attempts to 'capture' individuals that are mixing between attempts. For cetaceans, individual animals are usually identified - and hence 'captured'- on the basis of matching photographs of whale markings, or by genetic analysis of biopsy samples of live animals. Statistical methods are used to estimate how many animals were never captured, based on information about the probability of capture, which is inferred from instances when the animal was sometimes captured and sometimes not. Population model based abundance estimates use information from a variety of sources to build a mathematical model of how a population changes over time. Important data and parameters in such models include survival rates, productivity rates, and previous abundance estimates. By fitting (and possibly projecting) this model, an estimate of current abundance is achieved.

Many sophisticated abundance estimation methods are hybrids or extensions of these basic approaches.

This year, the Committee **endorses** the following:

(1) a photo-id mark-recapture estimate of 2011 abundance for Bering-Chukchi-Beaufort Seas bowhead whales;
(2) an aerial line transect estimate of 2013 abundance of East Canada / West Greenland bowhead whales;
(3) aerial line transect estimates of 2015 abundance of East Greenland and West Greenland North Atlantic humpback whales;
(4) ship-based line transect abundance estimates of North Atlantic humpback whales in Iceland/Faroe Islands in 2007 and 2015;
(5) aerial line transect abundance estimates of East Greenland (2015) and West Greenland (2007 and 2015) North Atlantic minke whales;
(6) ship-based line transect abundance estimates of North Pacific Bryde's whales for several areas and time periods;
(7) aerial line transect abundance estimates of East Greenland (2015) and West Greenland (2005, 2007 and 2015) North Atlantic fin whales; and
(8) genetic mark-recapture abundance estimates for Maui's dolphins in New Zealand for several years.

Table 16 summarises key information about the **agreed** abundance estimates. Full details are given in Annex Q (item 3 and appendix 3).

Attention: SC, S, C-A

Abundance estimates are a key parameter in determining status. The Committee:

(1) ***endorses*** the new abundance estimates *presented in Annex Q, Appendix 3 for inclusion in the IWC Table of Accepted Abundance Estimates;*
(2) ***agrees*** *that they should be incorporated into that table and uploaded to the IWC website; and*
(3) ***agrees*** *that the table should continue to be updated intersessionally by the Steering Group (Annex Y).*

12.2 Process to review abundance estimates

Abundance estimates are needed to assess the status of cetacean populations and are used extensively by the Committee, including for providing management advice. These estimates are often computed by standard, but technically advanced methods. In addition, because of the high scientific standards found within the Committee's work, it is not uncommon for the Committee to receive estimates of abundance computed using novel methods and non-standard software/code. The review of these estimates can be complex and time consuming. At last year's meeting, the Committee noted that adequate time is needed to review abundance estimates and agreed that a process to facilitate the review of these estimates be developed (IWC, 2018c). In addition, the Committee noted that reviews would benefit if minimum requirements for the presentation of abundance estimates are established.

Table 16

Abundance estimates, CVs and 95% confidence intervals for estimates agreed at the 2018 meeting.

Whale and Region	Year	Estimate	CV	95% Confidence Interval
North Pacific Bryde's whales				
Area 1W	1995	12,149	0.41	5,579-26,454
	2000	6,894	0.47	2,872-16,549
	2011	25,158	0.38	12,202-51,872
Area 1E	1995	15,695	0.42	7,079-34,801
	2000	19,200	0.56	6,929-53,204
	2011	9,315	0.33	4,957-17-505
Area 2	1995	4,340	0.45	1,876-10,039
	2000	6,083	0.61	2,030-18,229
	2014	6,491	0.36	3,254-12,950
North Atlantic common minke whales				
East Greenland	2015	2,762	0.47	1,160-6,574
West Greenland	2007	9,066	0.39	4,333-18,973
	2015	5,095	0.46	2,171-11,961
North Atlantic fin whales				
East Greenland	2015	6,440	0.26	3,901-10,632
West Greenland	2005	9,800	0.62	3,228-29,751
	2007	15,957	0.72	4,531-56,202
	2015	2,215	0.41	1,017-4,823
North Atlantic humpback whales				
East Greenland	2015	4,223	0.44	1,845-9,666
West Greenland	2015	993	0.44	434-2272
Iceland/Faroe Islands	2007	18,105	0.43	7,226-45,360
	2015	10,031	0.36	4,962-20,278
Bowhead whales				
Bering-Chukchi-Beaufort Seas	2011	27,133	0.22	17,809-41,377
East Canada / West Greenland	2013	6,446	0.26	3,722-11,200
Gray whales				
Western North Pacific	1995	74	0.05	66-81
	2015	200	0.03	187-211
Maui's dolphin				
North Island, New Zealand	2016	57	n/a	44-75

This year, the Committee developed a process to improve the review of abundance estimates, including a prioritisation of the estimates according to the timeline they need to be used by the Committee. This process is described in detail in Annex Q, item 2.1. In addition, minimum requirements to present abundance estimates for review by the Committee were established. Details are given in item 2.2 of Annex Q.

The Committee noted that validation may be needed before estimates computed using novel methods and non-standard software are used to provide management advice (Annex Q, item 2.3). The Committee also noted the need to consider how estimates of abundance from population models are reviewed before they are included in the Table of Accepted Abundance Estimates (Annex Q, item 2.4).

Attention: SC, S

The Committee ***reiterates*** *the importance of using high quality, fully reviewed abundance estimates for its work. To achieve this the Committee* ***agrees****:*

(1) to adopt the process to improve the review of abundance estimates given in Annex Q (item 2.1);
(2) the minimum requirements for the presentation of estimates for review by the Committee given in Annex Q (item 2.2);
(3) to host a pre-meeting before next year's meeting (SC68a) to develop (a) a process to validate abundance estimates computed with non-standard methods, noting the value of simulated datasets in this process; (b) a process to review estimates of abundance computed with population models is needed.

12.3 Methodological issues

12.3.1 Model-based abundance estimates (and amendments to RMP guidelines)

The Committee noted that there was a need for RMP guidelines to be modified in order to incorporate spatial modelling approaches to estimate abundance.

Attention: SC

The Committee noted that whilst much progress has been made with respect to considering model-based estimates (IWC, 2016c), the 'Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme' need to be modified. The Committee ***agrees*** *that an intersessional steering group (Annex Y) will develop instructions and select a candidate to modify the Guidelines.*

12.3.2 Review new survey techniques/equipment

The Committee received information on the use of unmanned aircraft vehicles (UAVs) to improve estimation of abundance of river dolphins in the Amazon. Details are provided in Annex Q, item 5.

Attention: SC, G

*The Committee **looks forward** to receiving information on new survey technologies used to improve estimates of abundance of cetaceans.*

12.4 Consideration of the status of stocks

The Committee noted that further consideration on how to report status of cetacean stocks is needed.

Attention: SC

*The Committee **recognises** the need to further consider how to report status of stocks to the Commission in a consistent manner and **agrees** to address this topic at a pre-meeting to be held prior to next year's SC meeting (SC68A).*

12.5 Workplan 2019-20

The Committee **agrees** to the workplan given in Table 167

Table 17

Workplan on abundance estimates and status.

Topic	Intersessional 2018-19	SC68a	Intersessional 2019-20	SC68b
Review of Abundance Estimates	Review estimates identified at SC67B (New Zealand Blue Whales, Arabian Sea humpback whales) – Annex Y	Review intersessional progress and estimates available at SC68A	Review estimates identified at SC68A	Review intersessional progress and estimates available at SC68A
Upload the estimates accepted at the annual meeting to the IWC website and continue to update the IWC Abundance Table	Update the table with estimates accepted at SC67B (Annex Y)		Update the table with estimates accepted at SC67B	
Review and provide advice on plans for future surveys		Receive, review and provide feedback to research plans to conduct abundance estimates		Receive, review and provide feedback to research plans to conduct abundance estimates
Pre-meeting to consider: (a) validation of non-standard software and methods, (b) estimates of abundance computed from population models and (c) Status of populations	Meeting Preparation	Review of progress		
Amend the RMP Guidelines to consider abundance estimates computed with model-based methods.	Identify a candidate to update the RMP Guidelines (Annex Y)	Review an updated document of the Guidelines		
Develop simulation software to evaluate methods for abundance estimates		Review Progress		

13. BYCATCH AND ENTANGLEMENTS

13.1 Review new estimates of entanglement rates, risks and mortality (large whales)

The Committee received three papers relating to the bycatch of large whales. SC/67b/HIM03 provided information on stranded humpback whales stranded along the southeastern coast of Brazil in 2016 and 2017 including records of entanglements over the São Paulo coast. SC/67b/HIM09 focussed on ten baleen whale populations for which bycatch appears to be a component of substantial conservation problems and the authors categorised priorities for action. SC/67b/AWMP08 provided information on Bering-Chukchi-Beaufort Seas stock of bowhead whales. Discussion can be found in Annex J (item 2.1).

13.2 Reporting of entanglements and bycatch in National progress reports

Reports of large whale bycatch are summarised in Annex J (item 2.4) and the issue of partial reporting discussed. Issues related to reporting and progress reports is given under Item 3.2.

13.3 Mitigation measures for preventing large whale entanglement

Mattila, the IWC's technical advisor for reducing unintended human impacts, reported on relevant activities under the entanglement initiative. Details can be found in Annex J (item 2.5). Since last year's meeting, IWC entanglement trainings have been conducted in Sakhalin (Russia), Arica (Chile), Sortland (Norway) and Bahía Solan (Colombia). This brings the total number of trainees in this initiative to 1,130 from 27 countries. In addition, two apprentices were hosted this year, one from Chile and one from Oman. Mattila also presented the IWC's work with entanglement in two workshops at the Society for Marine Mammalogy Biennial conference (2017). The Committee thanked Mattila for his exemplary work in coordinating the Global Whale Entanglement Response Network.

13.4 Review proposal for global entanglement database

The Committee considered progress with the development of a dedicated entanglement database. This will be considered further at the June 2018 meeting of the Global Whale Entanglement Response Network (see Annex J, item 2.3).

13.5 Estimation of rates of bycatch, risks of, and mortality for small cetaceans

13.5.1 Small cetacean bycatches in Peru

The Committee received a report (SC/67b/HIM01) summarising monitoring efforts of beach-cast cetaceans in 11 locations along the Peruvian coast from 2000-2017. Full discussion can be found in Annex J (item 2.1.2) that showed clear evidence of continued high bycatch rates and some intentional takes. Burmeister's porpoises accounted for 66% of the specimens and the low proportion (25%) of dusky dolphins contrasted with 1985-1990 statistics, when dusky dolphins accounted for three quarters of all cetacean captures. This reiterated prior concerns (Van Waerebeek, 1994) about a persistent long-term trend of a significant decline in prevalence of Peruvian dusky dolphin in catch and stranding records.

The observed high mortality levels in Burmeister's porpoise are a serious concern, and action is needed to avoid the same critical situation as with the closely related vaquita. Burmeister's porpoise is already included in a preliminary list for potential Conservation Management Plan development (Genov *et al.*, 2015), and dusky dolphin could potentially also be included. The Committee reiterated recommendations from 2008 regarding bycatch monitoring programmes and mitigation efforts in these fisheries (IWC, 2009, p. 323).

Attention: C-A, CC

*The Committee **draws the attention** of the Commission to its **serious concern** over the high mortality levels from bycatches in Peru and especially those of the Burmeister's porpoise and dusky dolphin. It **stresses** that action is needed to avoid the same critical situation for Burmeister's porpoise as with the closely related vaquita. In this regard the Committee:*

*(1) **reiterates** its advice (IWC, 2009, p. 323) on bycatch monitoring and mitigation in these fisheries;*
*(2) **reiterates** that the Burmeister's porpoise is a potential candidate for a Conservation Management plan;*
*(3) **highlights** opportunities to focus on the bycatch of small cetaceans in Peru through the new IWC Bycatch Mitigation Initiative and **recommends** that they are considered as a potential pilot project; and*
*(4) **offers its assistance** to the Government of Peru; and*
*(5) **requests** that the Commission, through the Secretariat, transmits the Committee's concern and offer of assistance to the Government of Peru.*

13.5.2 Franciscana bycatch in Brazil

Considerable information was provided on the Santos Basin Beach Monitoring Project required by the Brazilian authorities for licensing oil and gas production and transport (see Annex J, item 2.1.2). This provided information *inter alia* on stranded franciscana. From October 2015 to September 2017, 1,123 carcasses were recorded stranded in the area and interactions with fishing gear was reported for over 85% of necropsied individuals with signs of human activities.

Attention: CG-A

*The Committee **draws attention** to the fact that the franciscana remains under strong pressure from human activities, especially bycatch, in Brazilian waters despite fishing net regulations established by the government. The Committee:*

*(1) **advises** that the existing regulation on gillnets, implemented in 2012, is either not being effectively enforced or is not effective in reducing bycatch; and therefore*
*(2) **recommends** the need for this to be investigated further by the Brazilian authorities.*

13.5.3 Estimating bycatch from strandings data

Estimates of common dolphin mortality in the Bay of Biscay based on strandings data (Peltier *et al.*, 2016) had been discussed at SC67a. SC/67B/HIM/05 and SC/67B/HIM/08 provided further analyses related to using stranding data to make inferences about small cetacean mortality. An intersessional group was established at SC67a to provide advice on consistent ways to estimate bycatch across both large and small cetaceans, and specifically, to review the methods applied in Peltier *et al.* (2016) focused on small cetaceans. Discussion of the report of the intersessional group and some additional related papers (SC/67b/ HIM05 and SC/67b/HIM08) can be found in Annex J (item 2.1.2).

In discussion of other ways to estimate bycatch, the Committee noted that Bartholomew *et al.* (2018) had concluded that Remote Electronic Monitoring can provide a time- and cost-effective method to monitor target catch in small-scale fisheries and can be used to overcome some of the challenges of observer coverage. This requires consideration by the Committee.

Attention: CG-A, SC, G

With respect to methods for obtaining bycatch estimates the Committee:

*(1) **agrees** with the recommendations of its intersessional group regarding (a) uncertainties in bycatch estimates derived from strandings; (b) the use of bycatch estimates derived from strandings; and (c) assessing whether strandings can identify gaps in observer coverage;*
*(2) **notes** the importance of observer programmes, including electronic monitoring, and the limitations of stranding information for determining the type of fishing gear implicated in a bycatch event, or in determining reliable bycatch estimates;*
*(3) **recognises** that in small scale fisheries (a) observer programmes are particularly complicated, given the small size of vessels and (b) electronic monitoring may not capture the animals falling from the net during hauling*
*(4) **advises** that a robust evaluation of the effectiveness of bycatch mitigation measures requires a combination of monitoring measures, including well-designed and effectively implemented observer programmes, electronic monitoring and stranding programmes;*
*(5) **advises** that the above advice is relevant to the situation of the franciscana in Brazil; and*
*(6) **agrees** that given the increased use of Remote Electronic Monitoring techniques and the rapid development of camera and associated electronic technology, these techniques should be a focus topic at SC68a.*

13.6 Scientific aspects of mitigation measures

13.6.1 The IWC Bycatch Mitigation Initiative

The Committee considered the outcomes of an assessment on the potential work areas for the new IWC Bycatch Mitigation Initiative (SC/67b/HIM12). This resulted in several recommendations for the Committee in relation to potential work areas, including:

(1) identification of priority fisheries/sites/species/populations to be considered for pilot projects based on conservation need and the establishment of bycatch baselines for relevant cetacean populations where mitigation is to be trialled;
(2) leading in communicating the need for increased research on mitigation measures/management approaches for cetaceans to the broader scientific community;
(3) annually reviewing mitigation measure tables;
(4) providing technical assistance to the coordinator and the expert panel in the development of scientific trials/monitoring programmes to evaluate mitigation measures; and
(5) collaborating with researchers identifying fishing effort using vessel monitoring and tracking systems and assessing bycatch risk, with a focus on small scale fisheries.

With respect to the identification of priorities, five criteria for the selection of pilot projects were identified:

(1) urgency of conservation situation driven by bycatch or concern over situations with little or no data on bycatch, but suspected overlap between high risk fishing gears and vulnerable cetacean species;
(2) enabling conditions necessary for success;
(3) scope for IWC to contribute (e.g. enhanced international cooperation);
(4) ability to monitor effectiveness of mitigation actions; and
(5) potential for the project to contribute to mitigation of bycatch in other areas.

A list of information sources (including SOCER) was created at the meeting to assist Tarzia, the new BMI coordinator, to identify potential projects, after which she will consult with the expert panel to apply the above criteria, including contact with any of the governments involved, to select the projects for review by the initiative's Standing Working Group which can be presented to the Commission. The Committee suggested that identified fisheries in the Republic of Congo, Peru, Ecuador, Pakistan and India appear to fulfil many of the criteria and are locations where past or present IWC work is being carried out which is relevant to bycatch.

Attention: C-R, SC, CC

The Committee discussed the strategic assessment of the Bycatch Mitigation Initiative (BMI) and the role of the Committee. The Committee:

(1) ***welcomes*** *the progress made thus far under the BMI, including the Strategic Assessment;*
(2) ***thanks*** *Tarzia for the excellent work she has carried out since her appointment as co-ordinator;*
(3) ***agrees*** *to incorporate in its workplan the five work areas listed in its report under Item 13.6.1 and also consideration of 'rapid bycatch and risk assessment' tools;*
(4) ***agrees*** *to the criteria listed in its report under Item 13.6.1 when identifying priority fisheries/sites/species/populations; and*
(5) ***recommends*** *to the Commission that the BMI continues and is supported, including the provision of ongoing support for the BMI coordinator.*

13.6.2 Collaboration with FAO

FAO held an Expert Workshop on Means and Methods for Reducing Marine Mammal Mortality in Fishing and Aquaculture Operations in March 2018 which had been attended by several members of the Committee. The workshop report contained a review of mitigation measures and a decision tree providing guidance on choosing a bycatch mitigation pathway. The IWC Executive Secretary and BMI Coordinator will attend the FAO Committee on Fisheries (COFI) meeting in July 2018 where the report will be reviewed.

Attention: C-R, S

The Committee ***welcomes*** *the efforts of the FAO to consider cetacean bycatch and* ***recommends*** *that the IWC Secretariat continues to collaborate with the FAO on this issue.*

13.7 New information on cetacean bycatch in the Western, Central and Northern Indian Ocean

Last year (IWC, 2018c, p. 46), the Committee had recommended that in light of the scope and scale of cetacean bycatch in the Western, Central and Northern Indian Ocean and the considerable data gaps associated with intensive and extensive gillnet fisheries, the topic be included in the work plan for this meeting and the Secretariat establish communications on the issue with the Indian Ocean Tuna Commission (IOTC). SC/67B/HIM/07 provided updated information on this topic, as discussed in Annex J (item 2.7). The IWC's Executive Secretary provided an update on engagement with the IOTC, including a recent teleconference with the IOTC Executive Secretary.

Attention: C-A, CC, SC

With respect to bycatches of cetaceans in the Indian Ocean, the Committee:

(1) ***reiterates*** *its willingness to collaborate with the IOTC on this issue; and*
(2) ***encourages*** *the Secretariat to continue to work with the IOTC Secretariat.*

13.8 Workplan 2019-20

The Committee's workplan on bycatch and entanglement is given in Table 18.

14. SHIP STRIKES

14.1 Review estimates of rates of ship strikes, risk of ship strikes and mortality

The Committee received information on a pilot study to better characterise ship strikes in Southeastern Alaska (see Annex J, item 3.1) and looks forward to further updates on this work.

14.1.1 Review progress on ship strike database

The IWC continues to develop a global database of ship strike incidents as discussed in Annex J (item 3.1.1). The primary task is ongoing review of previously reported records by two data coordinators in conjunction with a data review group (SC/67b/HIM11). It is expected that the review process for all historical records will be completed in the next biennium.

Attention: C-R, S

The Committee ***reiterates*** *the importance of the global ship strikes database to its work. It therefore:*

(1) ***welcomes*** *the work undertaken thus far;*
(2) ***recommends*** *the continuation of this work including (a) that of the co-ordinators and Data Review Group on the review of historical records and (b) the Secretariat on upload tools.*

Table 18

Workplan on bycatch and entanglement related issues.

Topic	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting
Bycatch Mitigation Initiative		Review aspects relevant to Committee and respond to requests for advice		Review aspects relevant to Committee and respond to requests for advice
Rates and risks		Review new estimates of entanglement rates, risks and mortality		Review new estimates of entanglement rates, risks and mortality
Mitigation		Review new information on mitigation		
Inferences from strandings	Consider new information and issues that need to be addressed at SC68a	Review new information		
Rapid risk assessment		Consideration of 'rapid risk assessment' tools and outputs		
Electronic monitoring		Consideration of remote electronic monitoring and vessel tracking		
Mitigation measures tables		Develop table of mitigation measures for small cetaceans and update table for large whales from 2017 if needed.		
Global disentanglement database	Discussion at GWERN workshop	Review Progress	Advance database development if considered feasible	Review Progress
Collaboration with FAO	Secretariat attend COFI meeting	Review FAO outputs on bycatch	Continue collaboration	Continue to review
Encouraging innovative research on mitigation	BMI through existing networks, at conferences, workshops and with students – all members of Committee with relevant expertise	Review progress		

14.2 Mitigation of ship strikes in high risk areas

The Pelagos Sanctuary in the Mediterranean is a recognised high risk area for ship strikes to fin and sperm whales. In France, the REPCET reporting system became mandatory on 1 July 2017 for French passenger, cargo vessels (SC/67b/HIM04). As discussed in Annex J (item 3.2.1), 'alerting' systems such as REPCET require a trained observer and a subsequent avoidance action of some sort by the vessel in order to be a considered as a mitigation tool.

The Committee had previously agreed that the available data supported a proposal to IMO to move the shipping lanes off the southern coast of Sri Lanka to reduce the risks of ship strikes to Northern Indian Ocean blue whales. In 2017, major shipping organisations represented at IMO also wrote to the Sri Lankan government requesting the routing change to reduce ship strike risks and improve maritime safety. So far, there has been no response from Sri Lanka.

The Hellenic Trench west of Greece is also an identified high risk area for sperm whales and in 2015 (IWC, 2016d), the Committee recommended that interested parties (including Greece, ACCOBAMS and the shipping industry) move forward with Greece in order to develop a proposal for routing measures.

The IUCN Marine Mammal Protected Areas Task Force process for identifying Important Marine Mammal Areas (IMMAs) may assist in identifying high risk areas for ship strikes. The Committee and the IWC's Ship Strike Standing Working Group have previously encouraged cooperation on this between the IUCN Task Force and the IWC.

Attention: C-A, CC, SC, G

The Committee has continued its work on identifying high risk areas for ship strikes and potential mitigation measures. In this regard the Committee:

(1) ***recommends*** *continued work to develop and evaluate mitigation measures, such as speed restrictions, that might be associated with the designation of a Particularly Sensitive Sea Area (PSSA) in the Pelagos Sanctuary area;*
(2) ***reiterates*** *its previous recommendations on the importance of evaluating the efficacy of the REPCET system for reducing the risk of ship strikes;*
(3) ***requests*** *the Commission, via the Secretariat, to remind the authorities in Sri Lanka of its previous offer of assistance from the IWC on this issue;*
(4) ***requests*** *the Commission via the Secretariat, to follow up on previous correspondence on the ship strike risks to sperm whales off Greece;*
(5) ***agrees*** *to support a workshop to evaluate how the data and process used to identify IMMAs can assist the IWC to identify areas of high risk for ship strikes; and*
(6) ***agrees*** *to continue ongoing IWC engagement with the process to identify IMMAs, including consideration of their utility to address other threats.*

14.3 Co-operation with IMO Secretariat and relevant IMO committees
The Committee has long recognised the importance of co-operation with IMO on matters related to shipping including ship strikes.

Attention: C-R, S

*The Scientific Committee **reiterates** the importance of cooperation with IMO and:*

*(1) **welcomes** the ongoing co-operation the Secretariat has maintained with IMO and its Secretariat on ship strike issues, including meetings during IMO MEPC 72; and*
*(2) **recommends** that this dialogue continue.*

14.4 Work Plan
The Committee's work plan on matters related to ship strikes is given as Table 19.

Table 19

Workplan on matters related to ship strikes

Topic	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting
Rates and risks		Review estimates of rates of ship strikes, risk of ship strikes and mortality		Review estimates of rates of ship strikes, risk of ship strikes and mortality
Mitigation		Review new information on mitigation		
Advice on routing measures related to ship strike risk	Provide advice as required (Annex Y)	Review advice	Provide advice as required (Annex Y)	Review advice
Follow up on previous contacts offering IWC assistance regarding high risk areas	Secretariat to contact Sri Lankan and Greek authorities	Review progress on identified high risk areas in IWC Ship Strike Strategic Plan		
Continued co-operation with IMO	Secretariat to maintain dialogue with IMO Secretariat. Attend relevant IMO meetings.	Review cooperation		
Ship strike database	Continue ongoing data entry into Ship Strike Database and validation of records	Review progress against specific deliverables and time line	Continue ongoing data entry into Ship Strike Database and validation of records	Review progress against specific deliverables and time line
Provision of AIS data	Secretariat to develop MOU with Marine Traffic for provision of data	Consider best way to handle requests for data through the MOU		
Use of IMMAs to identify high risk areas for ship strikes	Hold workshop to evaluate how the data and process used to identify IMMAs can assist the IWC to identify areas of high risk for ship strikes.	Review workshop report		

15. ENVIRONMENTAL CONCERNS
The Commission and the Scientific Committee have increasingly taken an interest in the environmental threats to cetaceans. In 1993, the Commission adopted a resolution on research on the environment and whale stocks and on the preservation of the marine environment, IWC Resolution 1993-12 (e.g. IWC, 1996; 1997; 1998; 1999; 2010). As a result, the Committee formalised its work by establishing a Standing Working Group that has met every year subsequently. This year, it has been established as a sub-committee and its report can be found in Annex K.

15.1 Pollution 2020
15.1.1 Review on intersessional progress on the Pollution 2020 initiative
The individual based model to investigate the effects of pollutants on cetacean populations (SPOC) has been finalised. A peer-reviewed paper detailing the model and applying it to a number of case studies has been published in *Environmental Pollution* (Hall *et al.*, 2018) and the model's R code is available through the repository associated with the paper. The web-based, user-friendly version is now available through the Sea Mammal Research Unit, University of St Andrews server (*http://www.smru.st-andrews.ac.uk/reports/*) and a link will be added to the IWC webpages on the Chemical Pollution page. There are new data on the combined effects of persistent organic pollutants (POPs) on the immune system of killer whales (Desforges *et al.*, 2017) and this will be integrated into the model in the next year.

As noted in Annex K (item 2.1), the contaminant mapping tool will be completed next year, with the inclusion of the data on the concentrations of mercury in cetacean tissues by time and region. This online resource that will be made available through the IWC website and will be updated with new information identified in the SOCER annual reviews.

Research to estimate how long it is likely to take for POPs in the blubber of cetaceans to observably decline, following a reduction in environmental levels, will be completed next year.

Attention: SC

The Committee ***agrees*** *that the Pollution 2020 initiative should be completed and presented at SC/68a. It also* ***encourages*** *a paper to be presented at SC/68a summarising the potential mitigation measures for reducing exposure of cetaceans to polychlorinated biphenyls (PCBs) in particular and persistent organic pollutants (POPs) in general.*

15.1.2 Report on mercury in cetaceans

The impact of mercury exposure is still an issue of concern for cetaceans. SC/67b/E08, reviewed mercury in cetaceans, in response to Commission Resolution 2016-4, 'Resolution on Minamata Convention'. The paper (see discussion in Annex K, item 2.2) highlights continued global exposure and potential effect of mercury on cetaceans. Although cetaceans have a unique detoxifying mechanism which may protect them from the health effects of organic mercury, the resulting mercuric-selenide complexes may cause adverse effects in individuals experiencing other physiological and metabolic challenges. Research into identifying the toxic thresholds for mercury in cetaceans is still required.

The Committee also received several papers presenting information on mercury in cetaceans including river dolphins (SC/67b/E06), humpback whales (SC/67b/E09) and gray whales off Chukotka (SC/67b/E03). The Committee highlighted the need for standardisation in reporting units. It also discussed preferred tissues for mercury analyses. Discussion of these papers can be found in Annex K (item 2.2)

Attention: SC, CG-R

The Committee continued to work on mercury in cetaceans in response to Resolution 2016-4. It therefore:

(1) ***encourages*** *the continued provision of information on mercury and cetaceans;*
(2) ***encourages*** *researchers presenting such information to report concentrations on both wet and dry weight bases; and*
(3) ***recommends*** *that Contracting Governments support the continued monitoring of mercury in cetaceans, as this is required in order to assess the medium- and long-term impact of the Minamata Convention.*

15.1.3 Impact of heavy fuel oils on cetaceans

There is a paucity of information on the impacts of heavy fuel oils on cetacean health (Annex K, item 2.3). However, some new information comparing the occurrence of cancer and elevated PAH levels in St Lawrence Estuary white whales with similar cancers in the local human population, was highlighted. In addition, behavioural changes in white whales in the White Sea following exposure to oil have been observed.

Attention: CG-A, SC, G

The Committee:

(a) ***reiterates*** *the need to estimate the risk and impact of oil spills, particularly to cetaceans in the Arctic;*
(b) ***notes*** *that heavy fuel oil could pose an environmental threat in many regions due to its high viscosity and chemical composition;*
(c) ***notes*** *that heavy fuel oil poses a special threat in the Arctic due to difficulties in recovery and potential impacts of some recovery measures (e.g. dispersant use and in situ burning); and*
(d) ***encourages*** *the collection of baseline data for cetaceans, including standardisation of measures.*

15.1.4 Other pollution issues

Understanding the effects of oil dispersants and dispersed oil on cetaceans is a gap in our current knowledge. To address this need, the Coastal Response Research Center (CRRC) in the USA has co-ordinated a discussion among scientists with dispersant research expertise, as well as those with Arctic expertise, to determine the state-of-science regarding dispersants or dispersed oil, as it applies to Arctic waters. The Committee looks forward to the publication of the final report.

Attention: CG-A, SC, G

The Committee ***draws attention to*** *the lack of data the effects of oil dispersants and dispersed oil on cetaceans. It therefore:*

*(1) **encourages** Contracting Governments to support research on the effects of dispersants or dispersed oil to the Arctic and other ecosystems; and*
*(2) **requests** that the results of such research be brought forward to future meetings of the Scientific Committee.*

15.2 Cumulative effects

The Committee welcomed the summary of the Cumulative Effects Workshop (see Annex K, item 3) and looked forward to receiving the report. Overall, the Workshop found that there is considerable uncertainty in addressing this topic and thus in developing assessments and management advice.

The Scientific Committee also received a report on a workshop entitled 'Towards understanding the overlap of selected threats and Important Marine Mammal Areas (IMMAs) across the Mediterranean Sea', which was held jointly by the IUCN Joint Species Survival Commission/World Commission on Protected Areas (SSC/WCPA) Marine Mammal Protected Areas Task Force (the 'Task Force') and by the Agreement on Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS). The workshop provided the opportunity to support the ongoing effort to map specific threats to cetaceans in the ACCOBAMS area by overlaying the Mediterranean IMMAs with the available area-explicit information on shipping and seismic surveys, thereby giving preliminary indications of new Cetacean Critical Habitats in the ACCOBAMS area and facilitating the implementation of conservation actions at the regional level.

Attention: SC, G

*The Committee **recognises** the importance of understanding cumulative effects of threats on populations of cetaceans, as well as its complexity. It therefore:*

*(1) **concurs** with the Cumulative Effects Workshop recommendations (see Annex K, item 3) to improve our knowledge and enable quantitative assessments;*
*(2) **highlights** the recommendation that consideration needs to be given to 'developing a widely applicable approach for providing precautionary advice for populations in which cumulative effects are of concern';*
*(3) **agrees** to establish cumulative effects as a standing item on its agenda;*
*(4) **notes** the work on Important Marine Mammal Areas (IMMAs) and **encourages** additional efforts to identify the relevant threats in these, in order assist with the management of cumulative effects;*
*(5) **endorses** the results of the recent IUCN/ACCOBAMS workshop entitled 'Towards understanding the overlap of selected threats and Important Marine Mammal Areas (IMMAs) across the Mediterranean Sea';*
*(6) **encourages** that such an effort – aimed at overlaying different sources of threat and pressure on existing Important Marine Mammal Areas (IMMAs) – be continued and carried out in more detail in the other marine regions where IMMAs have already been identified; and*
*(7) **offers** its assistance in such assessments.*

15.3 Strandings and mortality events

15.3.1 Update on the IWC Strandings Initiative

The IWC strandings initiative was agreed by the Commission at its 2016 meeting (IWC, 2017d) and details can be found in Annex K (item 4.1). It noted that the rescue and welfare aspects of live strandings will be addressed by the Strandings Initiative but that this aspect is not within the purview of the Committee.

Attention: C-R, S, SC

*The Committee **reiterates** the importance of the IWC Strandings Initiative. It therefore:*

*(1) **welcomes** the excellent progress that has been made in the Strandings Initiative and the appointment of Sandro Mazzariol (Italy) as the Chair of the Strandings Expert Panel and Karen Stockin (New Zealand) as the Stranding Coordinator;*
*(2) **recommends** that the Commission (a) endorses the Strandings Initiative governance structure in Annex K (appendix 2) and (b) endorses the continuation of the Strandings Coordinator position for another two years (until IWC68) subject to available funding and requests the Secretariat make the necessary arrangements;*
*(3) **recommends** that the Strandings Initiative Steering Committee and Expert Panel, with the support of the Secretariat, should explore the best ways to gather information on strandings events and what basic data about these events should be recorded, focussing on what is useful for the Committee and the Commission;*
*(4) **agrees** that a phased approach to this, starting with an initial pilot project, will assist in this endeavour; and*
*(5) **agrees** that criteria for allocating funds for emergency responses should be developed by the Steering Committee and the Expert Panel and should be presented to the Committee at SC/68a.*

15.3.2 New information on unusual mortality events

Cetacean morbillivirus continues to be a major disease issue for cetaceans and a cause of unusual mortality events in dolphins in and around the Atlantic. Focus this year was on an outbreak of cetacean morbillivirus in the South Atlantic Ocean (SC/67b/E14) that is discussed in Annex K (item 4.2).

Attention: CG-R, SC

*The Committee **commends** the impressive rapid and comprehensive response to the cetacean morbillivirus outbreak in Brazilian Guiana dolphins. It therefore:*

*(1) **encourages** further work on the longer-term impact of the outbreak and the investigation of the occurrence and impact of this disease in cetaceans across different geographical areas;*
*(2) **draws attention to** the large number of animals that died during the outbreak (particularly mature females) and the historical high levels of human impacts affecting Guiana dolphins in Rio de Janeiro state, such as bycatch, chemical and noise pollution;*
*(3) **recommends** that immediate actions should be taken to protect affected populations in order to increase the chances of population recoveries;*
*(4) **draws attention to** the increase in Guiana dolphin deaths reported in Sao Paulo and Espirito Santo states in the weeks following the onset of the cetacean morbillivirus outbreak in Rio de Janeiro; and*
*(5) **encourages** the monitoring of the virus presence in neighbouring coastal dolphin populations, particularly species and populations in which immunosuppressive conditions or cumulative threats are identified.*

15.4 Noise

The Committee welcomed an update on international efforts addressing anthropogenic noise and their impacts on cetaceans, particularly regarding the appropriate assessment and protection of acoustic habitat quality as discussed in Annex K (item 5), and commended IWC engagement with organisations such as IMO and the UN.

Guidelines developed by the Convention on Migratory Species (CMS) Secretariat, also on behalf of the ASCOBANS and ACCOBAMS Secretariats, for Environmental Impact Assessments for noise-generating offshore industries were presented to the Scientific Committee. These guidelines had been endorsed through CMS Resolution 12.14 on Adverse Impacts of Anthropogenic Noise on Cetaceans and Other Migratory Species, and provide a pathway to implementing the Best Available Techniques (BAT) and Best Environmental Practice (BEP).

The Committee also considered the results of a study utilising modelling approaches to evaluate relative levels of communication masking for four baleen whale species in the Stellwagen Bank National Marine Sanctuary, in Massachusetts Bay, USA Cholewiak *et al.* (In press).

Attention: SC, G, CG-A

Recalling its previous recommendations on noise and the importance of addressing its impacts on cetaceans, the Committee:

*(1) **welcomes** and **draws attention** to the Convention on Migratory Species Family Guidelines on Environmental Impact Assessments for Marine Noise-Generating Activities (https://www.cms.int/en/guidelines/cms-family-guidelines-EIAs-marine-noise), noting that these guidelines will help improve global standards for environmental impact assessments;*
*(2) **recommends** that levels of anthropogenic noise and its effects on marine species be explicitly considered in the management of marine protected areas;*
*(3) **welcomes** the information received on using marine soundscape planning strategies to reduce interference between hydroacoustic instrumentation (e.g. echosounders and airgun arrays) and marine mammals, and **encourages** work to further develop this approach;*
*(4) **recognises** the commonalities identified among the concurrent efforts of multiple international bodies to develop national guidance on noise strategies, and **encourages** continuing efforts to identify synergies and develop priorities for actions to reduce exposure of cetaceans to anthropogenic noise;*
*(5) **welcomes** the work on modelling cetacean communication space, and **encourages** scientists engaged in the development of modelling techniques that address multiple anthropogenic impacts, such as noise and entanglement in fishing gear to bring these forward to the Scientific Committee;*
*(6) **agrees** that a pre-meeting on noise be organised for SC/68b and that an intersessional steering group be convened (Annex Y) to develop the agenda for that pre-meeting.*

15.5 State of the Cetacean Environment Report – SOCER

The Scientific Committee **thanks** the editors of the State of the Cetacean Environment Report (SOCER) for their work and commended them on compiling this information on the Mediterranean and Black Seas. Next year's region will be the Atlantic Ocean. The Scientific Committee would welcome input from the members for information on this region. A 5-year global compendium is being produced in cooperation with the Secretariat that will receive a dedicated webpage on the IWC website in time for presentation to the 2018 Commission meeting.

15.6 Update on other standing topics

15.6.1 Marine debris[litter]

The Committee received and discussed a number of papers relating to several aspects of marine debris as discussed under Annex K (item 7.1). Exposure to marine debris and microplastics in cetaceans is now widespread and common. However the impacts on cetacean health and populations is not fully understood.

Attention: C-A, SC

The Committee ***draws attention*** *to the fact that marine debris remains a threat, and that in particular, exposure to plastics (including microplastics) is a rapidly emerging area of concern.* It therefore:

(1) ***agrees*** *that an intersessional workshop on Marine Debris should take place, preferably to coincide with the World Conference on the Biology of Marine Mammals in Barcelona in December 2019.*

15.6.2 Climate change

Climate change was highlighted at SC/67a as being an overarching issue that is important to various topics, and that where relevant its impact should be discussed in conjunction with that topic (see discussion in Annex K, item 7.2). Notwithstanding that, the Committee may want to initiate a specific activity related to climate change in future (see intersessional correspondence group in Annex Y).

Attention: C-A, CG-A, SC

The Committee ***draws attention*** *to the fact that climate change remains a threat that interacts with other threats and stressors impacting cetacean populations.*

15.6.3 Cetacean diseases of concern

Monitoring health and disease agents in large whales in the Arctic is continuing to provide important information on changing patterns in prevalence, environmental status, and potential impacts. In addition, morbillivirus and Brucella continue to be important pathogens causing disease and increased mortality in cetaceans in the Atlantic.

Remote methods for assessing health and condition using visual and aerial photography (e.g. SC/67b/CMP13), is a major rapidly developing field, due to the widespread availability and reduced cost of unmanned aerial vehicles (UAVs). Standardisation efforts (e.g. see Annex S) for measuring body condition using UAVs for photogrammetry, and for collecting blow samples, should progress to ensure this useful tool can provide comparable data across studies, taking into account the differences between the various platforms available. Cross-validation with current methods for assessing body condition from visual health assessments is essential.

Attention: SC

The Committee ***agrees*** *to hold a focussed session next year (SC/68a) on our current understanding of the pathology and epidemiology of morbillivirus and* Brucella *and the potential for identifying and understanding the cumulative effects of exposure to other immunosuppressive stressors in cetaceans.*

15.7 Progress on previous recommendations

15.7.1 Pollution

The SC/67a recommendations were to (a) make the effect of contaminants on cetacean populations (SPOC) model available to the public; (b) review mercury in cetaceans; and (c) include new data into the contaminant mapping tool. These have all been completed.

15.7.2 Cumulative effects

As recommended last year, a workshop on understanding the cumulative effects of multiple stressors was held as a pre-meeting to SC/67b.

15.7.3 Diseases of concern

The Committee noted that the content on the Cetacean Diseases of Concern (CDoC) website will now be utilised and merged with the Strandings Initiative for the development of their training and outreach materials.

Whilst the recommended quarterly CDoC updates remain of interest to the Committee, a means of progressing this on a voluntary basis has not yet been identified although efforts to find such assistance are ongoing.

15.7.4 Strandings

The Strandings Initiative has progressed as recommended at SC/67a and a full progress report can be found in Annex K, Appendix 2.

15.7.5 Noise
In response to a previous recommendation, that Committee has received the recently developed seismic survey guidelines by the New Zealand government, a link to the technical working group reports created during the NZ seismic guidelines review is now available (*http://www.doc.govt.nz/our-work/seismic-surveys-code-of-conduct/work-of-the-technical-working-groups/*). However, these guidelines have not yet been discussed by the Committee.

As recommended and noted earlier under Item 15.5, the intersessional group assisted in the development of a summary of the IWC recommendations relevant to shipping noise for presentation to the International Maritime Organization's Marine Environment Protection Committee in 2018.

15.7.6 Thanks
The Committee would like to thank Teri Rowles for her exceptional support and hard work as Chair of the sub-committee on environmental concerns over recent years. Her extensive knowledge, expertise and guidance has been most appreciated and will be missed.

15.8 Workplan 2019-20
The Committee's workplan on environmental concerns is given as Table 20.

Table 20

Work plan for matters related to environmental concerns (for more details see Annex K, Appendix 4).

Item	SC68a	SC68b
Pollution 2020 (including oil spills)	If new information	Primary topic (including oil spills and mercury), summary report to Commission
Cetacean diseases of concern (incl. HAB toxins)	Primary topic	Primary topic
Strandings	If new information	Primary topic
Noise		Noise focus session
Marine litter	Pre-meeting on litter and plastics focus session	If new information
Cumulative impacts	If new information	If new information
Emerging issues	If new information	If new information
SOCER	Receive report	Receive report
Climate change	Over-arching topic	Over-arching topic

16. ECOSYSTEM MODELLING

The report of the Working Group on Ecosystem Modelling is given as Annex L. This group was first convened in 2007 (IWC, 2008b). It is tasked with informing the Committee on relevant aspects of the nature and extent of the ecological relationships between whales and the ecosystems in which they live.

Each year, that Working Group reviews new work on a variety of issues falling under three areas:

(1) reviewing ecosystem modelling efforts undertaken outside the IWC;
(2) exploring how ecosystem models can contribute to developing scenarios for simulation testing of the RMP; and
(3) reviewing other issues relevant to ecosystem modelling within the Committee.

16.1 Cooperation with CCAMLR on multi-species modelling

The Committee has been considering plans for joint workshops with CCAMLR on ecosystem modelling for some time (e.g. see IWC, 2017c, p.56), although this has not yet happened, the Committee remains interested.

Attention: SC

*The Committee **reiterates** its interest in holding joint workshops with CCAMLR. It **agrees:***

(1) that a two-year delay in the occurrence of the workshop will provide the opportunity to pursue and complete the relevant work with input from CCAMLR as needed; and
(2) that collaboration between SC-IWC/SC CCAMLR should be on going, and that the revised plan for the workshops (IWC, 2018e) be implemented.

16.2 Applications of species distribution models (SDMs) and ensemble averaging

The Committee had agreed in 2015 to review the application of species distribution modelling (SDM) and associated techniques as they pertain to the goals of the Committee and to develop good practice guidelines and recommendations. While the review has occurred (IWC, 2016b), there has been no significant progress in the intersessional correspondence group set up to develop the guidelines.

Attention: SC

The Committee ***reiterates*** *the importance of developing good practice guidelines and recommendations for species distribution modelling and* ***agrees*** *that this should be pursued by an intersessional correspondence group (Annex Y) with a view to reviewing and adopting guidelines within the next biennium.*

16.3 MODELLING OF COMPETITION AMONG WHALES

16.3.1 Individual-based energetic models
Enhancements to an individual-based energetics model (IBEM) were presented to the Committee (SC/67b/EM07). These included the explicit modelling of feeding on migration, individual dives and searching for prey schools. Results showed that carrying capacity and productivity were sensitive to the level of food available during migration, making it important that ecosystem models to cover the entire migratory range of the species. This is an important contribution to the determination of species' function response, which can play a pivotal role in ecosystem modelling. This approach is also discussed under Item 5.1.

16.3.2 Modelling of relationship between whales and prey
The Committee reviewed three papers relevant to modelling of the relationships between whales and prey, SC/67b/EM04, SC/67b/EM06 and de la Mare *et al.* (*in press*). The discussion of these can be found in Annex L (item 3.2).

16.3.3 Modelling of competition among baleen whales
The Committee noted that multi-species individual based energetic models (IBEM) such as those described under Items 16.3.1 and 16.3.2 could be used to model direct and indirect competition of different whale species in the same environment, and that relevant modelling work was nearing completion.

16.3.4 Stable isotope analyses
The Committee received preliminary results of the analysis of stable carbon (δ13C) and nitrogen isotope ratios (δ15N)) on samples from the edge of baleen plates in Antarctic minke whales (SC/67b/SP09). The details can be found in Annex L (item 3.5).

16.4 Standing topics

16.4.1 Effects of long-term environmental variability on whale populations
How long-term environmental variability might affect stock assessments is of particular interest to the Committee. Given the need for a literature review on the subject to facilitate discussions, an intersessional correspondence group (Annex Y) has been established.

16.4.2 Update on body condition analyses for the Antarctic minke whales
For several years, the Committee has been discussing whether there has been a statistically significant (5% level) decline in the blubber thickness and fat weight of Antarctic minke whales over the course of the JARPA surveys. In 2014, the Committee had agreed that there had been such a decline (IWC, 2015b). Since then, scientists from Australia, Japan and Norway have presented a series of models both supporting and challenging this conclusion. There has been collaboration over this period and significant development in the types of models used. In addition, there have been in-depth discussions regarding the proper handling of data, the explanatory variables to be included in the analysis and the appropriateness of various statistical methods.

New analyses were presented this year and detailed discussions can be found in Annex L, item 2. This year the debate focused on three points; (1) the use of a new variable of primary interest (the 'accumulated blubber thickness in each feeding season); (2) the use of FIC and (3) the appropriate handling of the data.

Attention: SC, G

The Committee has been discussing whether there has been a statistically significant (5% level) decline in the blubber thickness and fat weight of Antarctic minke whales over the course of the JARPA surveys for several years. In conclusion, the Committee ***agrees****:*

(1) that, for the data set considered as a whole, all approaches result in point estimates reflecting a decline when fit to a linear trend in time;
(2) however, the extent of the decline estimated differs amongst the methods, and is not statistically significant at the 5% level for all approaches;
(3) for some approaches, when the data are disaggregated by gender and/or area, some point estimates of trend are not negative;
(4) there are some indications of temporal variation that is more complex than linear.

In addition, the Committee:

(1) ***encourages*** *the authors to publish the results of their study in peer-reviewed journals; and*
(2) ***agrees*** *that this matter will not be considered during the forthcoming biennium.*

In discussion of the above, Norwegian scientists stated that since an error in parts of the Australian scientists' calculations has recently been acknowledged by them, and parts of the Australian scientists' conclusion and appendix had recently been withdrawn, the overall position regarding the blubber thickness and fat weight analyses now became as follows. There are no new analyses from the Australian scientists on the five response variables which have been considered and discussed in the Committee from 2011 to 2017. The results presented this year by the Norwegian scientists (SC/67b/EM02), which took into account some of the queries from the Australian scientists from last year, confirmed results presented by the Norwegian scientists earlier. Thus, the conclusions by the Committee in 2014 and 2017 on these variables remain valid. For this meeting the Australian scientists had presented analyses related to a new difficult dependent variable 'increase in blubber thickness during summer feeding in Antarctic waters' estimated from the blubber thickness at position BT11. The conclusion above about variables with a non-significant decline now pertains to the new variables only (points (2) and (3) above). The Norwegian scientists' position is that the conclusion drawn above was heavily influenced by the results of the calculations subsequently withdrawn, so that parts of those conclusion are no longer valid.

In response, the Australian scientists stated that results of some calculations carried out earlier were withdrawn because of a previously unidentified problem with a standard statistical package failing to converge on a solution without giving an error message. Subsequent collaborative checking with the Norwegian scientists led to the discovery of this problem. Withdrawing this calculation (which the Australian scientists had carried out to illustrate a property of the Norwegian scientists' methods) had no effect on the main results which the Australian scientists had presented in SC/67b/EM03. Nor did this retraction affect the results of analyses the Australian scientists had presented in 2017 showing non-significant trends in fat weight and blubber thickness (De La Mare *et al.*, 2017a; 2017b). The Australian scientists held the view that the assertion by the Norwegian scientists that "There are no new analyses from the Australian scientists on the five response variables which have been considered and discussed in the SC from 2011 to 2017" was not correct; the Australian scientists had provided full results of fitting models to BT11 in SC/67b/EM03. The main results in SC/67b/EM03 were based on differences between early- and late-season predictions from models with BT11 as the dependent variable. This difference was a simple measure of feeding in Antarctica. The earlier conclusion should not be materially affected by withdrawing the Australian scientists' compromised demonstration in relation to the Norwegian scientists' methods.

16.4.3 Review the information on krill distribution and abundance by NEWREP-A

The Committee received the results of the krill and oceanographic surveys during the third NEWREP-A survey in Area V-E and VI-W (SC/67b/EM05). Discussion of this information can be found in Annex L (item 6.1).

16.4.4 Ecosystem functioning

Resolution 2016-3 tasked the Committee with investigating the contribution of cetaceans to ecosystem functions. Last year, the Committee noted that its focus would be on scientific aspects of the issue and it established an intersessional correspondence group to progress this work. Progress made by that group, including development of a final terms of reference, can be found in Annex L, item 6.2. The Committee notes that the Conservation Committee will focus on the conservation and social science aspects of this issue.

It was noted that there is broad interest in understanding the role of cetaceans in ecosystem functions, and that the Committee's expertise relates to the scientific aspects of the issue. Given the broad international interest, it is suggested that the Committee work in collaboration with interested parties (e.g. CMS, CCAMLR, SCAR and SCOR) to share information and avoid the duplication of work.

C-A, CC, SC

Commission Resolution 2016-3 tasked the Committee with investigating the contribution of cetaceans to ecosystem functions. The Committee notes that the Conservation Committee will focus on the conservation and social science aspects of this issue. In responding to the Resolution 2016-3, the Committee ***advises*** *the Commission that with respect to the scientific aspects on the contribution of cetaceans to ecosystem functioning:*

(1) it is unlikely that the ultimate goal of reliably determining the contribution of cetaceans to ecosystem functioning could be achieved in under a decade, given the complexity of the issue and the data gaps; and
(2) a more immediate and achievable goal is the carrying out of a gap analysis to identify knowledge gaps and to develop a plan to address them.

To further this work, the Committee ***agrees****:*

(1) to hold a workshop to (a) define short- and medium-term objectives to be addressed and (b) to identify what further research is required in order to begin initial modelling of the contribution of cetaceans to ecosystem function; and
(2) that the Secretariat in conjunction with the Steering Group (Annex Y) should contact CMS to determine their interest in participating in such a workshop.

16.6 Workplan 2019-20

The Committee's work plan on ecosystem modelling is provided in Table 21.

Japan referred to its statement on the adoption of the Agenda (Annex Z) and considered that several of the items for the proposed workshop (Item 16.4.4 and Item (7) in Table 1) are outside the competence of IWC. Therefore, it cannot support the proposed workshop or associated funding from the Committee's budget.

Table 21

Summary of the two-year work plan on matters related to ecosystem modelling

Item	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting (SC/68b)
(1) Ecosystem modelling in the Antarctic Ocean	Continue further analyses.	Review results of further analyses	Continue further analyses.	Review results of further analyses
(2) Application of species distribution models (SDMs)	Intersessional group activity (Annex Y)	Review progress		
(3) Effect of long-term environmental variability on whale populations	Continue further analyses. Intersessional group activity (Annex Y)	Review results of further analyses. Review progress	Continue further analyses	Review results of further analyses
(4) Further investigation of individual-based energetic models	Continue further analyses	Review results of further analyses	Continue further analyses	Review results of further analyses
(5) Modelling of competition among whales	Continue further analyses	Review results of further analyses	Continue further analyses	Review results of further analyses
(6) Update of any exercises on krill distribution and abundance	Conduct NEWREP-A krill survey and an international cooperative krill survey. Conduct simulation analyses to resolve issues on survey design.	Review results of survey and analyses.	Conduct NEWREP-A krill survey. Conduct analysis of data taken by the international survey.	Review results of survey and analyses.
(7) Cetaceans & Ecosystem Functioning: a gap analysis workshop or pre-meeting	Review relevant scientific studies before the workshop in addition to preparation of workshop (Annex Y).	Review outcomes of workshop and develop clear work plans with priorities.	Continue analyses	Review results of analyses.

17. SMALL CETACEANS

The report of the Committee on Small Cetaceans is given as Annex M.

17.1 Overview of taxonomy, distribution and abundance for *Inia* and *Sotalia*

In this assessment, two species and two sub species of dolphins were considered, some of which have several common names. In addition, a new species has been proposed but has not yet been recognised (Table 22).

Table 22

Summary of names used in the description of *Inia* and *Sotalia*

Scientific name	Common Name
Inia geoffrensis	boto, Amazon River dolphin
I. g. boliviensis	Bolivian bufeo
I. g. geoffrensis	Common boto
I. araguaiensis	Araguaian boto
(proposed species)	(from the Tocantins and Araguaia basins)
Sotalia fluviatilis	tucuxi, delphín gris, bufeo negro
Sotalia guianensis	Guiana Dolphin

The river and estuarine dolphins of South America are subject to various threats from habitat degradation, competition with fisheries, bycatch and direct exploitation. A major threat to river dolphins in South America is population fragmentation, altered habitat productivity and regulation of natural river flow as a result of dam construction. The cumulative impacts from this type of infrastructure at the macrobasin scale exacerbate the threats to river dolphins and their habitat in the Amazon and Orinoco basins. It was estimated that more than 50% of the range of Araguaian *Inia* is affected by damming.

Two genera were discussed in depth, *Inia* and *Sotalia*, from the vast and convoluted systems within the Amazon, Orinoco, Tocantins and Araguaia River basins. In the case of *Sotalia*, two species are recognised: *Sotalia guianensis* (marine) and *Sotalia fluviatilis*, (freshwater) in the Amazon basin. *S. guianensis* in the Orinoco basin likely represents an independent population unit as it is isolated from other coastal populations. Two intersessional workshops have been proposed that aim to elucidate the status of *S. guianensis* and it is that divisions within this genus will be clearer on the completion of this work in 2020. The taxonomoy of *Inia* has a complex history and at this time, one species and two sub species are recognised: *Inia geoffrensis*, the Amazon river dolphin, *I. g. boliviensis*, the Bolivian bufeo, and *I. g. geoffrensis*, the common boto. There is a third putative subspecies, *I. g. humboldtiana*, in the Orinoco basin of Venezuela and Colombia. The information currently available suggests that *I. g. boliviensis* should be elevated to species level and that *I. g. humboldtiana* should be recognised. Another new species, *I. araguaiensis*, has been proposed for the dolphins that inhabit the Tocantins and Araguaia basins of central Brazil as this area is geologically and hydrologically separate from the Amazon basin.

Attention: SC, G

Given the incomplete resolution of Inia *taxonomy, the importance of clarifying and solidifying recognition (or elevation to species) of the* Inia *subspecies found in different river basins, the possibility that in such complex habitats localised specialisation is likely, and the need to focus attention on the conservation of demographically independent populations, the Committee* ***encourages*** *support for efforts to resolve* Inia *spp. taxonomy in light of the significant and diverse threats affecting the populations inhabiting the Amazon-Orinoco-Tocantins/Araguaia drainages.*

17.1.1 Inia

For *Inia*, there are estimates of abundance for some rivers, however, there is little information on population trends. It was suggested that new technologies, such as Unmanned Aerial Vehicles (UAV), may help to better refine population survey techniques. From telemetry studies and two long term studies some information on population parameters is available. In particular, the Committee commends an ongoing telemetry study as it begins to address some of the most important scientific questions concerning *Inia* ecology, habitat use, behaviour and, particularly movements.

In addition, and central to IUCN assessments, a generation time for *Inia* has been calculated as 24.8 years from a long-term mark and recapture study. Given the estimated rate of population decline, this equates to a loss of 82% per generation and in excess of 99% over three generations. Such values are well above the threshold for a Red List assessment of a species as Critically Endangered. Concern was also expressed at the high rate of mortality of <1 year calves in one study site, where examined carcasses show evidence of both deliberate killing and net entanglement.

The information presented on population parameters were based on direct observations in a very small geographic area of the Amazon and therefore, a very small proportion of the total range of *I. geoffrensis.* As such, extrapolation to the whole region would be unwarranted, nonetheless these results and their implications for population decline are alarming.

Attention: CG-A, G

The Committee ***draws attention*** *to declines in Inia numbers documented in two study areas and the lack of abundance surveys in most parts of its range. The Committee therefore* ***encourages*** *the collection of data, calculation of abundance estimates and undertaking of analyses to estimate population trends for* Inia *throughout its range, for use in assessments of the status of the species, subspecies, and regionally isolated populations.*

17.1.2 Sotalia

Sotalia fluviatilis, known as tucuxi (Brazil) delphín gris (Colombia) or bufeo negro (Peru and Ecuador) is restricted to the Amazon basin in Ecuador, Peru, Colombia and Brazil and has a more limited distribution than *Inia*. *Sotalia guianensis*, the Guiana dolphin, occurs mainly in nearshore and estuarine waters of the Atlantic from southern Brazil, along the coast of Central America, to Nicaragua and possibly Honduras. Small populations in Lake Maracaibo and in the lower reaches of the Orinoco River, Venezuela, were highlighted as being heavily impacted.

In the Mamirauá Reserve, Brazil, the population of *S. fluviatis*, has shown a precipitous decline in abundance over a 22-year study period. Using the average observed decline of 7.4% per year, and, from literature, a generation time estimate of 15.6 years, the Mamirauá population trend equates to a 97% reduction over 3 generations, qualifying this population as Critically Endangered under IUCN Red List criteria. Unlike *Inia*, which is heavily exploited for use as bait in the piractaninga fishery, the primary driver of the decline in Sotalia in this region is gillnet entanglement.

17.1.3 Threats shared by dolphins in the Amazon and Orinoco River systems and Lake Maracaibo

Throughout the range of both genera, illegal hunting was highlighted as a transnational problem, making it difficult to create and enforce effective conservation measures. This issue is severe for *Inia* throughout its range and, for *Sotalia* in the Orinoco River and particularly in Lake Maracaibo, Venezuela.

Attention: C-A, G, CC

The Committee ***draws attention to*** *the serious situation reported for Lake Maracaibo in Venezuela, where both directed takes and oil pollution are thought to be having serious impacts on populations of* S. guianensis. *The Committee* therefore ***recommends*** *that NGOs and researchers focus on documenting the threats to* Sotalia *and work with local communities to mitigate the impacts on these dolphin populations.*

In addition to direct exploitation, there are numerous other threats to both species throughout their habitat in South America: the recent increase in deforestation effects their prey species, as there is no deposition of seeds and fruits into the rivers to support productivity and sustain fish stocks; hydropower developments and channel dredging affects flows regimes, the connectivity of rivers, the migrations of fish and can fragment dolphin populations, as has already occurred in the Tocantins River basin; heavy metals, such as mercury, have been measured in high concentrations in dolphin tissues; negative interactions with fisheries, in addition to directed takes for use as bait and food, also include bycatch, deliberate poisoning and 'control' killing.

Attention: CG-A, G, CC

The Committee ***draws attention to*** *the multiple threats associated with development, habitat degradation and fragmentation, and pollutants facing river dolphins in the Amazon, Orinoco and Tocantins basins. It therefore:*

(1) ***advises*** *the Brazilian, Bolivian and Peruvian Governments, as they carry out their reviews of proposed construction of new dams for hydroelectric energy production, to explicitly consider the potential impacts on river dolphins (e.g. isolation, loss of genetic diversity, habitat degradation;*
(2) ***discourages*** *water pumping in the Araguaia-Tocantins river basin for agricultural use as such a practice causes dramatic decreases in water levels in rivers, thereby increasing the probability that dolphin populations will be extirpated;*
*(3) e****ncourages*** *range states of the Amazon basin and its tributaries to support and carry out baseline research into the impacts of the development of commercial waterways in the Amazon (hydrovias) and their potential impacts on dolphin populations and habitats, including but not limited to the ecological impacts of dredging, noise pollution, channelisation by embankments, altered sediment suspension and transfer, and changes in turbidity, light, oxygen availability and primary productivity, and (b) work to minimize or at least mitigate these impacts;*
*(4) e****ncourages*** *(a) a review of the status of dolphins trapped within dammed stretches of the Tocantins and Madeira rivers and (b) evaluation of possible relocation (translocation) of animals when environmental conditions create a high likelihood that they cannot continue to survive in this severely compromised habitat; and*
*(5) e****ncourages*** *the review of the effects and the scale of contaminant and heavy metal (e.g. mercury) pollution on river dolphins in key areas of the Amazon (Japura/Caquetá, Içá/Putumayo, in Brazil and Colombia) and Orinoco (Venezuela) basins.*

17.2 *Tursiops* populations occurring in estuarine areas in southern Brazil

Discussion focused on two populations of Lahille's bottlenose dolphins (*Tursiops truncatus gephyreus*) in Patos Lagoon Estuary (PLE) and Laguna (LGN), Brazil. Both have been the focus of long-term ecological studies that provide a good source of information on the conservation status of the subspecies. Mark-recapture studies indicate year-round residency and permanent emigration is unlikely. Population sizes are small (85 dolphins in PLE and 60 in LGN) with low to moderate genetic diversity (mtDNA and nuclear DNA variation) in both areas. Pollutant analyses indicated moderate levels of persistent organic pollutants (POPs). Of additional concern is a chronic dermal infection which is apparent in 14% of the LGN population, which may be related to pollution but this is not clear. The greatest threat to both populations is bycatch in artisanal gillnet fisheries. Whilst there is no clear evidence of a negative trend in abundance, there is a high probability of population decline in the near future, given the small population, the high degree of residency and the continuing mortality as a consequence of IUU (illegal, unreported, unregulated) fishing and other human activities in these areas.

In Santa Catarina, Paraná, and São Paulo provinces, Brazil, north of LGN and PLE, a total of 119 bottlenose dolphins (sub species unknown) and 442 Guiana dolphins were recorded stranded over 2 years. There was strong evidence that entanglement was indicated as the cause of death for bottlenose dolphins. The Committee was informed that the Brazilian Government is looking into this issue and is seeking ways to improve legislative effectiveness in protecting dolphins and other threatened species in these locations.

Attention: SC, CG-R

The Committee draws the attention of the range states (Argentina, Brazil, Uruguay) to its conservation concerns over the entire sub-species of Lahille's bottlenose dolphins (T. t. gephyreus) given their relatively small population sizes and constricted ranges, the high levels of bycatch and the high incidence of individuals with chronic dermatitis. The Committee therefore recommends:

(1) immediate action to reduce the level of bycatch in the southern Brazil populations;
(2) continued monitoring and photo-identification work on the populations throughout the subspecies' range to refine survival estimates and to assess trends in abundance and the prevalence and etiology of the chronic skin infections; and
(3) that the conservation status of the subspecies be prioritised for assessment in the future.

17.4 Franciscana CMP

In 2016, the IWC created a Conservation Management Plan (CMP) for the franciscana – see Item 10.1.4. In 2019, a review will be presented to the Committee. The review will be jointly conducted by the SM and CMP sub-committees and will include input from other relevant sub-committees.

17.5 Report of the 2018 *Tursiops* Taxonomy Workshop

In 2014 (IWC, 2015b) it was agreed that the Committee would undertake a review of taxonomy and population structure in the genus *Tursiops*, over several meetings. Understanding whether there is any consistency in the derivation of various local forms across the range, and to which taxonomic or population unit(s) they belong, has been challenging, and the taxonomy of the various forms is still unresolved. An additional aim of this exercise was to develop a widely applicable taxonomy assessment framework for small cetaceans. The review process concluded with an intersessional workshop, held in La Jolla in January 2018.

The 3-year review and workshop brought together researchers and experts from around the world to discuss this topic, motivated focussed research, and promoted new collaborations. Results from studies presented at previous meetings (2015-2017) and at the workshop itself were compiled and formed the basis for evaluation of taxonomic and population distinction issues in each geographic region.

Attention: SC, G

Having reviewed the extensive information included in the 2015-2017 review and 2018 workshop for evaluation of Tursiops *species, subspecies and population distinctions, the Committee* ***draws attention to*** *the need for* Tursiops *research in the areas identified as data deficient (the African coast of the eastern Atlantic, southern and eastern Mediterranean Sea, eastern South Pacific, Pacific coast north of California and off the Mexican mainland, Central American coast of the eastern North Pacific, Central American Atlantic and Caribbean Sea and Atlantic coast of northern and north-eastern Brazil, eastern Australia and in the western Pacific the islands of Micronesia, Melanesia, Polynesia, the Philippines and Vietnam). The Committee therefore* ***encourages****;*

(1) collection of additional data, including morphometrics, and high-resolution genetic analyses (e.g. ddRAD which may also be useful in other areas where there are similar questions requiring high-resolution analysis), to better characterise divergence between coastal and offshore forms in the western South Atlantic Ocean, to help confirm whether subspecies or species classification is more appropriate for T. t. gephyreus;
(2) further investigation of T. aduncus *lineages in the Indian Ocean and western South Pacific to assess potential subspecies recognition, extending the geographic coverage to include eastern Africa, the region between Pakistan and Indonesia, and the region between Australia and China;*
*(3) continued study of the genetics and morphology of southern Australia bottlenose dolphins with the "*T. australis*" mtDNA lineage, in the context of both* T. truncatus *and* T. aduncus;
(4) examination of the level of male-mediated gene flow between the coastal and offshore forms in the western North Atlantic to determine whether the coastal form should be elevated to species or subspecies status;
(5) more comprehensive morphometric analyses comparing T. truncatus in the Mediterranean, Black Sea, and eastern Atlantic to integrate with genetic data and evaluate whether any regions in addition to the Black Sea (T. t. ponticus) harbour a taxonomic unit above the level of population;
(6) comprehensive morphometric analyses of coastal and offshore T. truncatus in the eastern North Atlantic and comparison to those from the western North Atlantic to better evaluate potential regional differences;
(7) morphometric analyses of Gulf of California coastal and offshore dolphins relative to those from California and the eastern tropical Pacific, with a particular focus on the level of divergence of coastal dolphins in the upper Gulf of California to other areas; and
(8) the collection of additional genetic and morphological data throughout the eastern South Pacific and further studies to investigate coastal versus offshore forms throughout the region, including coastal and offshore waters from Central America to Mexico, and if possible around the southern tip of South America to Argentina.

The Committee also ***agrees*** *to continue compilation of specimen, study, and researcher details, and concentrated effort to improve our understanding of* Tursiops *in data-deficient areas.*
Finally, after reviewing the 2018 Tursiops *Taxonomy Workshop's evaluation of the support provided for taxonomic (subspecies, species) and population-level distinctions proposed in the publications reviewed, the subcommittee* ***concludes*** *that:*

(1) the current taxonomy provided for Tursiops *by the Society for Marine Mammalogy's Committee on Taxonomy is well supported by morphological and molecular genetic data, as well as ecological and distributional data; and*
*(2) discordance in currently available results from morphometric analyses and across different genetic markers of the recently described '*T. australis*' from southern Australia calls into question its validity at this time.*

In addition to the information and recommendations on *Tursiops*, the Committee noted that the review provided an opportunity to formulate some generic conclusions on taxonomic issues related to small cetaceans.

Attention: SC, G

After reviewing the development and use of a strategy for objective evaluation of species, subspecies, and population-level distinctions by the 2018 Tursiops *Taxonomy Workshop, the Committee:*

(1) ***agrees*** *with the strategy implemented at the workshop for the evaluation of species, subspecies and population level distinctions;*
(2) ***encourages*** *use of the criteria and guidelines in Reeves et al. (2004) for the assessment of species-level taxonomy, in Taylor et al. (2017) for subspecies-level taxonomy, and in Martien et al. (2015) for Demographically Independent Populations; and*
(3) ***concludes*** *that future taxonomic questions should be examined within an appropriately wide and inclusive geographic context and that multiple lines of evidence are necessary when positing taxonomic changes.*

The Committee applauded Natoli, Rosel and Cipriano for their considerable work and organisational skills during this effort.

17.6 Poorly documented takes for food, bait or cash and changing pattern of use

17.6.1 Intersessional Workshop on the use of Small Cetaceans for Food and Non-Food Purposes in South America

The poorly documented take of small cetaceans for use as wildmeat has been assigned as a priority topic. An ICG (and see Annex Y) has been tasked with the development of a toolbox of techniques that could guide and co-ordinate research into this topic, and as such a series of workshops were proposed to fulfil this task. The second of these workshops focused on South America and incorporated a detailed review of the use of Amazon river dolphins as bait in the piracatinga fishery, which, in turn, fed into the priority topic of the 2018 meeting.

Information was summarised for all countries, except Guyana and Suriname, and it was recognised that products from small cetaceans have been used throughout the region for both food and non-food purposes. This type of use is referred to as 'aquatic wildmeat'. The usefulness of various tools and techniques was discussed, including data gathering techniques and forensic investigation. A database, comprising more than 3000 references, was used to map existing knowledge and understand data gaps. A framework was also established that had the purpose of standardised future data collection. The workshop participants populated a database from which regional patterns were mapped. Areas that were highlighted as a cause of conservation concern were; Bolivia, Brazil, Colombia, Costa Rica, Ecuador, Peru and Venezuela.

The take of Amazon river dolphins as bait in the piracatinga fishery was also reviewed. All range countries of *Inia* and *Sotalia* have laws in place to protect dolphins and prohibit intentional killing. Fishing for piracatinga is banned in Brazil and its trade is prohibited in Colombia, due to its impact on river dolphins and other wildlife. The practice of using dolphins as bait has recently expanded to Peru, Bolivia and Venezuela, following the imposition of restrictions in Brazil, however, no other range country has developed specific legislative or regulatory action, beyond the general protection of river dolphins, in response to the emergence of this practice.

The workshop concluded that some species and population required urgent attention both due to the extent of their use as wildmeat and from other threats.

17.6.1.1 SCIENTIFIC CONCLUSIONS AND RECOMMENDATIONS

Attention: SC, G, CG-A

The Committee ***endorses*** *the scientific conclusions and recommendations from the recent intersessional workshop on the use of Small Cetaceans for Food and Non-Food Purposes in South America aimed at improving regional knowledge and conservation research. In particular, the Committee:*

(1) ***agrees*** *that potential divisions within the genus* Inia *should be evaluated and genetic conservation units established;*
(2) ***agrees*** *that an evaluation of historical data on river dolphins should be undertaken to better understand other threats (e.g., from bycatch), to provide further insights into current trends;*
(3) ***encourages*** *the use of new technologies, such as drones and satellite telemetry, to establish trends, habitat use and dispersion patterns of Inia within Amazon River Basin and*
(4) ***encourages*** *new efforts to improve regional research capacity.*

The Committee ***draws attention*** *to the evidence showing that several small cetacean species and/or populations are being negatively impacted by their use as wildmeat in South America, and therefore* ***recommends*** *that abundance and distribution surveys, in tandem with investigation into the magnitude of aquatic wildmeat use, be conducted on these species. Appropriate survey designs should be implemented that consider the statistical power required to detect trends and the resultant data should then be used to estimate the impact of deliberate take for wildmeat on the following populations:*

(1) Boto in Purus and Japurá rivers, Brazil, and Içá/Putumayo river in both Brazil and Colombia, using previously established standardised methods (studies should also be expanded into other areas where take for bait may be a cause for concern);
(2) Chilean dolphin in Chile;
(3) Burmeister's porpoises in both Chile and Peru, noting that current evidence suggests that the Peruvian population is distinct;
(4) Dusky dolphins in Peru, noting that evidence shows that landings of this species has decreased and populations may have been heavily impacted;
(5) Guiana dolphins and other small cetaceans in Amapá, Pará, Maranhão, Piauí, Ceará, Espírito Santo, São Paulo and Paraná, in Brazil, where there is a documented use of bycatch for wildmeat purposes;
(6) Bottlenose dolphins and pantropical spotted dolphins) in Bahia Solano, Colombia, noting that deliberate takes for a long line fishery is ongoing;
(7) Tucuxi throughout its range, in Brazil, Colombia, Ecuador, as it shares most of the same threats as Inia geoffrensis, *and may also be used as bait in the piracatinga fishery; and*
(8) Guiana dolphin (Sotalia guianensis) in Lake Maracaibo in Venezuela, noting that deliberate take for food is ongoing.

The Committee also ***draws attention to*** *the Boto dolphins that have been isolated within the dam system of the Tocantins and Maderia Rivers in Brazil. Given the confined condition of the dolphins' habitat, the Committee* ***agrees*** *that the status of these dolphins be evaluated, to include abundance, genetic, habitat, prey availability assessments, with a view to developing a translocation protocol, including under what circumstances such a protocol should be enacted.*
Finally, given the concerns over the extensive habitat modification that will result from the Mega Project 'Arco Minero del Orinoco', a large scale mining operation proposed along the river and watershed of Venezuela, the Committee ***recommends*** *that population sizes and trends of both* Inia geoffrensis *and* Sotalia guianensis, *in the Orinoco River basin, be monitored before and during this project.*

17.6.1.2 CONSERVATION AND MANAGEMENT ISSUES

Attention: CG-R, S, CC

The Committee ***draws attention to*** *the management recommendations within the Report of the Workshop on the Use of Small Cetaceans for Food and Non-Food Purposes in South America, in particular, the need to have a regionally co-ordinated fisheries management plan for the Amazon River basin and a regional strategy for the conservation of river dolphins. Given continued concern over the use of dolphins as bait in the piracatinga fishery, the Committee:*

(1) ***commends*** *the Government of Brazil on its swift action in declaring a moratorium on the piracatinga fishery and respectfully requests that it maintains the moratorium to allow sufficient time to evaluate the effectiveness of protective measures and ensure the necessary protection of river dolphins;*
(2) ***reiterates*** *previous recommendation of the IWC Scientific Committee that range states (Bolivia, Brazil, Colombia, Peru and Venezuela) engage in a co-ordinated effort to strengthen legislative, enforcement, management and scientific efforts to ensure protection of the Amazon River dolphins;*
(3) ***encourages*** *range state authorities to work together and exchange information on the movement of piracatinga products across international borders; and*
(4) ***requests*** *that progress reports be submitted to the Scientific and Conservation Committees.*
(5) ***recommends*** *that the Commission asks the IWC Secretariat to send a letter to the Buenos Aires Group highlighting the issue of dolphins being used as bait in the piracatinga fishery and requesting joint efforts to enhance enforcement on wildlife and trade laws.*

17.6.2 Wildmeat Database

In 2016 (IWC, 2017) an intersessional group was established to work with the IWC Global Database Repositories Convenor, to develop an overarching aim for any future cetacean wildmeat database and identify the specific questions that such a database might address. The results of this work were presented, including a research agenda the formulation of key questions that could be addressed through the development and analysis of an aquatic wildmeat database. The Aquatic Wildmeat Database, developed independently of the IWC, was presented again and the Committee was updated on its improvements made following suggestions made last year. The future value of this data repository was highlighted and this and related issues will be considered intersessionally (see Annex Y).

The work of the Steering Group (see Annex Y) will continue and a third workshop, focusing on Africa, will be conducted intersessionally. The framework for an IWC Wildmeat database established at the workshop in South America will be further refined and will be used at the forthcoming workshop.

17.7 Small cetacean task team

The Scientific Committee continues to support the Task Team Initiative and the latest Task Team, for the South Asia River Dolphin, is in the process of being established with Dipani Sutaria and Nachiket Kelkar nominated as co-conveners. The task team currently comprises 14 members with representation from Bangladesh, India, Nepal and Cambodia and includes university associated researchers and NGOs (WWF and the Wildlife Institute of India).

Under its Task Team Initiative (e.g. IWC, 2016), the Committee ***strongly supports*** *the work of a Task Team for the South Asia River Dolphin and* ***agrees*** *that its first meeting which will occur before the 2019 meeting, if sufficient funding is available.*

17.8 Progress on previous recommendations

17.8.1 Vaquita

The Report of the Tenth Meeting of the International Recovery Team for Vaquita (CIRVA-10) was summarised and the results of the acoustic monitoring program for vaquitas were presented (SC/67b/SM01). This shows a continued decline in vaquita detections with no change in the trend since the last report in 2016. A brief review of the VaquitaCPR project was presented. This initiative, conducted in October and November 2017, aimed to capture vaquitas and bring them into human care. Ninety experts from nine countries were involved, including researchers experienced in the capture and handling of harbour porpoises, animal care professional, and veterinarians. Two vaquitas were successfully captured (an immature female [V01F] and an adult female [V02F]). In both cases, medical and behavioural evaluations were conducted to determine the suitability of the animals for transport to the floating pen or shore-based facility. Through the whole process the animals' health was continuously monitored by a team of experienced marine mammal veterinarians. The first vaquita caught (V01F) was in good condition initially, but did not acclimate to either the vaquita care centre pool or to the sea-pen facility, and the vaquita was released. V02F was also considered to be in good condition for transport to the sea-pen, however, after initially showing signs of adapting to the facility, the animal stopped swimming and an emergency release was initiated. The release was unsuccessful and the vaquita was quickly recaptured for administration of emergency care. Following three hours of emergency response, the animal went into cardiac arrest and did not respond to resuscitation attempts. Analyses of tissues and material obtained from VH02 is ongoing and a full report on VaquitaCPR will be reported at SC68A.

The survival of the vaquita depends on gillnet-free habitat and efforts to remove gillnets, both derelict and active, have increased dramatically in the last three years, particularly, during the ongoing 2017-18 totoaba season. The net removal programme demonstrates that illegal totoaba gillnets are still routinely set in great numbers in vaquita habitat. Despite enhanced enforcement efforts, there is a continued failure to prevent illegal fishing. CIRVA have stated that immediate action is needed to improve the situation through implementation of a series of recommendations. In particular, CIRVA recommended that the Government of Mexico establish an enhanced enforcement area, extending the boundaries of the existing vaquita refuge.

Attention: SC, CC, CG-R

The Committee has stressed for many years that the vaquita population is at a critically low level, and the most recent evidence demonstrates that the cause of the decline – use of illegal large-mesh gillnets – continues, making extinction in the wild increasingly likely; *the long-term decline in the vaquita reported previously has continued in 2017.* The Committee yet again **re-emphasises the serious concerns** it has raised on the status of the vaquita, and in particular its recommendations of the past two Committee meetings. Whilst again **commending** the Government of Mexico for its attention and response to the CIRVA findings and recommendations, the Committee:

(1) respectfully ***requests*** *that reports continue to be provided annually to the IWC Scientific Committee on actions and progress towards saving the vaquita;*
(2) ***strongly endorses*** *the recommendations of CIRVA10 that:*

(a) the CIRVA10 acoustic monitoring programme, critical for evaluating the effectiveness of conservation actions, be continued as in previous years to provide an annual empirical estimate of population trend;
(b) all Mexican enforcement agencies increase their efforts on land and in water immediately and continue this enhanced enforcement programme for the duration of the period of illegal totoaba fishing (at least until June 2018) to eliminate all setting of gillnets in the range of the vaquita;
(c) emergency regulations be promulgated immediately to strengthen the current gillnet ban and enhance enforcement and prosecution by:

- *(i) eliminating all fishing permits for transient fishermen and limiting fishing access to only those fishermen who can demonstrate residency in the fishing villages;*
- *(ii) confiscating any vessel that does not have the appropriate vessel identification, permits, and the required vessel monitoring system;*
- *(iii) requiring vessel inspection for each fishing trip at the point of departure and landing;*
- *(iv) prohibiting the sale or possession of gillnets on land and at sea within the area of the current gillnet ban and on adjacent lands within a specified distance of the coastline.*
- *(v) requiring that all gillnets be surrendered or confiscated and destroyed.*

(vi) eliminating the exemptions for all gillnet fisheries, including the curvina and sierra fisheries.

(d) efforts to remove gillnets from vaquita habitat be continued and enhanced and the numbers and locations of new nets recovered be published monthly;
(e) the number of inspections, interdictions, arrests, sentences, and other enforcement actions be published monthly, together with information on observed levels of illegal activities obtained from intelligence operations, for example from drones;
(f) successful prosecution and subsequent penalties be sufficient to deter illegal fishing; and
(g) development of gillnet-free fisheries be enhanced and linkages to incentivise the conversion of the fleet to gillnet-free operations be strengthened.

17.8.2 Yangtze finless porpoise

A rangewide survey of Yangtze finless porpoises (*Neophocaena asiaeorientalis asiaeorientalis*) was conducted in 2017, giving a preliminary abundance of around 1,000 individuals. This indicates that the rapid decline observed between 2006 and 2012 has now slowed, and that numbers may even be increasing in some areas. Nevertheless, the Critically Endangered status of this species remains unchanged. The survey results were encouraging and regarded as a possible indication that *in situ* conservation of Yangtze finless porpoises is feasible, given the marked increase of the number of individuals in Dongting and Poyang Lakes. For the population to make a sustained recovery in both numbers and range, current measures directed towards improving the habitat in the Yangtze River as well as the Dongting and Poyang Lakes must be continued and expanded. The Government of China was commended for the efforts undertaken to improve the YFP habitat. Nevertheless, concern remain over threats such as vessel strikes, bycatch, underwater noise and bridge construction. In addition, the planned construction of a dam across the channel connecting Poyang Lake to the river is an additional concern.

Attention: SC, CG-R

Given the extensive and pervasive nature of the threats facing the Yangtze finless porpoise population, the Committee:

*(1) **commends** the efforts of the Government of China to improve its habitat; and*
*(2) **reiterates** that the primary conservation actions should focus on (a) restoring and maintaining suitable habitat throughout the Yangtze River and associated lakes, including the maintenance of a network of* in situ *reserves and (b) ensuring that genetic diversity is preserved and that harmful human activities are limited.*

17.8.3 Maui Dolphin

The Government of New Zealand reported that its review of management measures is scheduled for later this year. An update was provided on observer coverage of the set net fishery in Taranaki and the trawl fisheries adjacent to existing closure areas (95.5%, and 88.3%, respectively). Outside of this target coverage area, an additional 114 trawl fishing days were observed. No captures of Māui dolphins were reported by observers or fishermen in commercial fisheries in the 12-month reporting period to 31 March 2018. A species-specific, spatially explicit, multi-threat risk assessment is being developed for Māui and Hector's dolphins, the results of which will inform an updated Threat Management Plan later in 2018.

Attention: SC, CG-R, CC

The Committee notes that no new management action regarding the Māui dolphin has been enacted since 2013. It therefore concludes, as it has repeatedly in the past, that existing management measures in relation to bycatch mitigation fall short of what has been recommended previously and expresses continued grave concern over the status of this small, severely depleted subspecies. The human-caused death of even one individual would increase the extinction risk. In addition, the Committee:

*(1) **re-emphasises** that the critically endangered status of this subspecies and the inherent and irresolvable uncertainty surrounding information on most small populations point to the need for precautionary management;*
*(2) **reiterates** its previous recommendation that highest priority should be assigned to immediate management actions to eliminate bycatch of Māui dolphins including closures of any fisheries within the range of Māui dolphins that are known to pose a risk of bycatch to dolphins (i.e. set net and trawl fisheries);*
*(3) **notes** that the confirmed current range extends from Maunganui Bluff in the north to Whanganui in the south, offshore to 20 n. miles, and it includes harbours - within this defined area, fishing methods other than set nets and trawling should be used;*
*(4) **welcomes** the update on Maui dolphins provided and looks forward to receiving the species-specific, spatially explicit, multi-threat risk assessment in 2019.*
*(5) **respectfully encourages** the New Zealand; Government to commit to specific population increase targets and timelines for Māui dolphin conservation,*
*(6) **respectfully requests** that reports be provided on progress towards the conservation and recovery goals as updates become available.*

17.8.4 Cruise report from North Western Africa
For the third year, survey results were reported from cruises conducted in north western Africa waters. Fourteen schools comprising some five species and totalling 433 individuals were sighted, including bottlenose dolphins, both pantropical and Atlantic spotted dolphins and, spinner dolphins. This area is poorly surveyed and the continuation of this work was encouraged. The Committee **suggests** that a more substantive analysis of the data from all surveys be conducted and reported back next year, particularly as SC68A priority topic will be on African small cetacean species.

17.8.5 Monodontids Workshop Report
NAMMCO hosted a workshop and produced a Global Review of Monodontids. Researchers and subsistence hunters from across the Arctic and subarctic participated. Several IWC scientists also participated, including Litovka, Reeves, and Suydam. The report[9], summarises what is known about the status of 12 stocks of narwhals and 22 stocks of white whales. There may be more stocks than this as information on stock structure is incomplete for some areas. The summary information and identification of threats and concerns within the report will be helpful in prioritising future research. Some stocks are doing well, but conservation actions are desperately needed for some others. The IUCN Red List status and documentation for both species was updated to Least Concern in December 2017 and that the information summarised in the NAMMCO review was very useful for those assessments.

Attention: C-A

*The Committee **welcomes** the report of the NAMMCO workshop reviewing the monodontids[9]. It **draws attention to** the recommendations contained in the report and **encourages** their implementation, particularly those pertaining to the stocks of greatest concern.*

17.9 Takes of small cetaceans
7.9.1 New information on takes
The Committee received the summary of takes of small cetaceans in 2016–17 extracted from the online National Progress Reports and prepared by the IWC Secretariat, in addition to information obtained online.

No direct takes of small cetaceans were reported in the 2017 National Progress Reports. The Committee **notes** that it would be helpful if the Secretariat encouraged all member countries and IGOs (e.g. NAMMCO) to submit information on direct takes as a routine procedure.

The content of the Japan Progress Report on Small Cetaceans, a public document available from the website of the Fishery Agency of the Government of Japan[10], was summarised. It was noted that catch statistics in the Japan Progress Report on small cetacean cover catches in the calendar year, that is, from 1 January to 31 December, following the guidelines for IWC National Progress Report, while the catch quota of small cetacean fisheries are set seasonally. Thus, in some cases, the calendar yearly catch may exceed the seasonal (yearly) catch in appearance, but in such cases, the actual seasonal catch is aligned with the allocated catch quota. The Committee noted that the catch of 1,057 Dall's porpoises in the hand harpoon hunt was significantly lower than previously recorded reported and below the quota. It was stated that this is a result of the destruction of the community that conducts this hunt, rather than a change in the cetacean population, following the earthquake and tsunami of 2011.

7.9.2. Live captures
The Pacific Scientific Research Institute of Fisheries and Oceanography (TINRO) will consider a quota of 13 killer whales for 2018 and a public hearing was held on 3 May 2018 to make comments on this plan. This proposed new quota considers killer whales in the Sea of Okhotsk as one population, which is estimated to have an abundance of over 3,000 individuals. This number is considered minimal as only 50% of the sea was surveyed. In addition, the information available to the Russian Government on colour and fin patterns, feeding behaviour and distribution do not allow clear identification of different ecotypes, and that all genetic samples analysed to date belong to a single population. It was noted that most published information on Okhotsk Sea killer whale abundance and stock structure is in Russian-language literature, or as part of internal documentation.

Attention: C-A, CG-A
With respect to live captures, and specifically the capture of killer whales from the Sea of Okhotsk, the Committee:

*(1) **reiterates** its long-standing recommendation that no small cetacean removals (live capture or directed harvest) should be authorised until a full assessment has been made of their sustainability;*
*(2) **notes** that this is especially important for killer whales because populations are generally small and have strong social bonds and removals have unknown effects on their demographic structure; and*
*(3) r**eiterates** its concern that removals of killer whales are occurring from the Okhotsk Sea population.*

[9] https://nammco.no/wp-content/uploads/2018/05/report-global-review-of-monodontids-nammco-2018_after-erratum-060518_with-appendices_2.pdf
[10] http://www.jfa.maff.go.jp/j/whale/w_document/attach/pdf/index-9.pdf

In light of the verbal report received at this meeting that Russian authorities intend to proceed to consider limits of allowable live-capture removals of killer whales in the Sea of Okhotsk on the basis that there is no stock structure and there are no ecotype differences between the populations in this region, the Committee:

*(1) **encourages** more extensive effort to examine these issues; and*
*(2) **requests** that relevant analyses be provided for the Scientific Committee's consideration at its next meeting.*

17.10 Status of the voluntary fund for small cetacean conservation research

In 2017, donations for the Voluntary Fund for Small Cetacean Conservation Research totalling £13,122 were received from the Government of Italy. At the end of the financial year 2017, this brought the total of the fund to £81,077.

The Committee **expresses its sincere gratitude** for Italy's contributions and notes that these funds support critical conservation research projects of direct relevance to the work of the Committee.

Five projects were offered funding in 2016 and were implemented in 2017. One of the projects has since been withdrawn and one project, the Indus river dolphin abundance survey, was completed and reported on in 2017. The remaining three projects, on the 'Chilean Dolphin' in Chile, the 'Use of small cetaceans as wildmeat in China' and the 'Development of a business model for sustainable fisheries in the Upper Gulf of California, Mexico', are all near completion and will be reported on fully next year. Updates are available on the IWC website.

17.11 Work plan and budget requests

17.11.1 Priority topics for 2019 to 2024

The sub-committee on Small Cetaceans discussed ongoing priorities and will continue the development of these intersessionally; however, given the location of the meeting it is likely that the focus will be on African species or areas during 2019-20. Other potential priorities identified in discussions were *Inia* (e.g. taxonomy), *Sotalia guianensis*, *Phocoena phocoena*, *Delphinus delphis*, southern hemisphere beaked whales, *Steno bredanensis*, Northwest Pacific *Orcinus orca* and 'the Caribbean'.

17.11.2 Work plan for 2019 – 2020

The workplan on issues related to small cetaceans is given in Table 23.

Table 23

Work plan on small cetaceans

Topic	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting
Franciscana CMP	ICG (Annex Y) to co-ordinate outcomes of CMP across sub-committees	Report	ICG (Annex Y) to synthesis actions from 2019 SC report and develop a work plan	Report
Wildmeat	ICG (Annex Y) to plan and conduct African Workshop.	Report	ICG (Annex Y) group to summarise workshop series and develop future work plan.	Report
Small Cetacean Task Team	Intersessional Workshop on South Asian river dolphins.	Report	Act on recommendations from 2018/19 River dolphin workshop.	Report
Sotalia	SG (Annex Y) to plan and conduct workshop #1 (at SOLOMAC)	Report	SG (Annex Y) to plan and conduct workshop #2	Report

18. WHALE WATCHING[11]

The report of the sub-committee on whale watching is given as Annex N.

18.1 Assess the impacts of whale watching and swim-with-whale operations on cetaceans

18.1.1 Review progress of Modelling and Assessment of Whale Watching Impacts (MAWI)

Modelling and Assessment of Whale Watching Impacts (MAWI) has been on the Committee's agenda for several years. In April 2018, an intersessional workshop was held to identify the key research questions for understanding the potential impacts of whale watching on cetaceans (SC/67b/Rep03). A number of issues were highlighted, including: (a) the need to better understand the impact of recreational whale watching vessels as compared to commercial vessels; (b) the importance of looking at the potential impact of whale watching at short-term (e.g., behaviour change), mid-term (e.g., shift in habitat use) and long-term (e.g., population dynamics) time scales; (c) the use of existing and new data to explore the mid- and long-term impacts, as opposed to replicating short-term studies; and (d) the importance of building scientific capacity in the locations where the research would take place. More information can be found in Annex N, item 2.1.

[11] In response to a request from the Chair of the Whale Watching Working Group of the Conservation Committee, we have changed our past practice of treating whalewatching as a single word to the use of two words.

Attention: SC, C-R

The Modelling and Assessment of Whale Watching Impacts (MAWI) initiative held a workshop in Italy in April 2018, in conjunction with the 32nd European Cetacean Society conference.

The Committee ***endorses*** *the following recommendations from this workshop:*

(1) the incorporation of both social and natural sciences to better understand whale watching impacts;
(2) the development of a Strategic Framework, supported by a Decision Tree, to aid in the prioritisation of policy and research choices;
(3) the development of toolkits and resources that can be accessed globally; and
(4) the standardisation of data collection.

The Committee also ***agrees*** *that a third MAWI workshop be held intersessionally, ideally just before or after the 2nd World Marine Mammal Science Conference in 2019, in Barcelona, with the following objectives:*

(1) to determine in detail which data should be collected to best answer the natural and social science research questions developed in SC/67b/Rep03;
(2) to identify the best locations for conducting research projects that address these questions; and
(3) to continue to develop modelling approaches for assessing the long-term impacts of whale watching on cetacean populations (using data on short- and mid-term impacts).

18.1.2 Review specific papers assessing impacts

The Committee received several papers regarding impacts to cetaceans from whale watching activities. Those papers included (1) efforts to assess stress hormones in baleen of southern right whale calves, (2) 'solitary sociable' cetaceans, (3) land-based observations in the Canary Islands to assess and mitigate potential impacts of whale watching vessels on cetaceans, (4) a Whale Welfare Assessment Tool (also presented and discussed in Plenary) and (5) the 15th year of a summary of papers published in the previous year related to a better understanding of impacts, mitigation and compliance to regulations. Additional details on these papers and projects can be found in Annex N, item 2.2.

Attention: SC, CG-A

The term 'solitary sociable dolphin' or cetacean is usually taken to apply to cetaceans that have little or no contact with conspecifics and who regularly closely approach humans, often including touch, social, sexual and play behaviours (Wilke et al.*, 2005). Given that solitary sociable cetaceans often end up in circumstances where they are harmed and killed and that they may come to present a threat to human swimmers, the Committee:*

(1) ***agrees*** *to continue intersessionally to monitor the phenomenon of solitary sociable cetaceans as part of its work;*
(2) ***advises*** *that, where these animals occur, research be conducted to determine whether the emergence of harmful behaviours either to the animal or to people can be reversed; and*
(3) ***advises*** *local authorities and other concerned parties to keep people away from them in order not to encourage behaviour that may prove harmful to the animal or swimmers.*

In addition, the Committee ***agrees*** *that the Whale Welfare Assessment Tool (currently being developed at the Royal Veterinary College, University of London, in the context of the IWC Whale Killing Methods and Welfare Issues Action Plan), for which a hypothetical whale watching case study was trialled (Annex N, item 2.2), be applied to real-world whale watching situations. The southern resident killer whales in Washington, USA and the bottlenose dolphins in Bocas del Toro, Panama were proposed. These two populations are subject to intense whale watching pressure and may be suffering welfare and health impacts related to this pressure. Both locations have data relevant to the assessment tool and therefore seem ideal as pilot projects for its application.*

18.1.3 Consider documented emerging areas of concern (e.g., habituation, new areas/species, new technologies, in-water interactions) and how to assess them

The Committee received several papers about emerging areas of concern regarding whale watching, including (1) human-induced behavioural changes, (2) impacts from recreational in-water interactions with cetaceans and (3) purposeful and inadvertent feeding by humans.

The Secretariat for the Convention of Migratory Species (CMS) submitted several documents to SC/67b including a global review of in-water interactions with aquatic mammals. That review had resulted in a CMS resolution that encouraged Parties to facilitate research allowing for an assessment of the long-term effects and biological significance of disturbances from 'swim-with-marine-mammal' programmes. The topic of swimming with cetaceans is also addressed under Item 18.6.

The Committee received reports about several studies to assess the impacts and compliance with regulations of commercial 'swim-with-whale' operations in Australia. The discussion of this issue can be found in Annex N, item 2.3.

Attention: SC, CC, S

The Committee ***agrees*** *that the habituation intersessional correspondence group, now named human-induced behavioural changes of concern, should continue (see Annex N, table 3).*

Given the substantial effort the Convention on Migratory Species (CMS) Secretariat has made in preparing several documents for the Committee to consider this year, the Committee:

(1) ***recommends*** *a continuation and an expansion of this exemplary collaboration between the IWC and CMS Secretariats and their various committees;*
(2) ***endorses*** *the intention of CMS to work with the IWC Scientific Committee on guidelines for in-water interactions with aquatic mammals and* ***offers*** *to provide the scientific underpinning for these guidelines;*
(3) ***agrees*** *that the Committee's intersessional correspondence group on swim-with-whales work intersessionally with the CMS Aquatic Mammals Working Group to develop draft guidelines; and*
(4) ***offers*** *to review draft guidelines when they are ready, with a view to* ***agreeing*** *a joint product of the IWC and CMS and hosted by both websites as a global resource.*

See also Item 18.6 for additional recommendations related to swimming with cetaceans.

18.2. Consider information from platforms of opportunity of potential value to the Scientific Committee
The Committee received examples of several platforms of opportunity where data have been collected concerning habitat use, behaviour, changes in distribution and potential risks from shipping for multiple different species in several different areas. Of particular interest was Peninsula Valdés, Argentina, where approximately 460,000 photographs have been taken from whale watching boats and provided to researchers from the Instituto de Conservación de Ballenas and Ocean Alliance (SC/67b/WW04). See Annex N, item 3.

The Committee offered numerous suggestions as to how to handle the large number of images and **encourages** the researchers to network with other researchers around the world, particularly humpback whale researchers dealing with similarly large numbers of photographs and multiple catalogues, to improve the processing time of the photographs.

18.3 Whale watching in east Africa and the wider Indian Ocean
A proposal for Concerted Action for Arabian Sea humpback whales was passed by CMS with strong support from range states. This was discussed in Annex N, item 4.

Attention: CC, S, CG-A

Noting the Committee's discussions over several years on the status of the Arabian Sea humpback whales (see Item 10.2.1), the Committee:

(1) ***welcomes*** *the CMS proposal for Concerted Action for Arabian Sea humpback whales;*
(2) ***notes*** *that humpback whales are the target of one emerging whale watching operation in the south of Oman and* ***highlights*** *the likelihood that the population could become the target of future whale watching activities;*
(3) ***emphasises*** *the need for regulators and scientists to work with the industry to ensure that whale watching does not add to the many other pressures on this small, isolated, non-migratory and endangered population.*

The Committee therefore:

*(1) r****ecommends*** *that building capacity to conduct needed research and to ensure consistent training of whale watching operators be a high priority for Omani authorities and other parties working on the recovery of the endangered Arabian Sea humpback whale population;*
(2) ***notes*** *that boat operators for cetacean watching operations appear to turn over at a high rate in this area, and* ***recommends*** *that training workshops should be regularly offered and conducted;*
(3) ***welcomes*** *the offer from the Pacific Whale Foundation to help organise and conduct another training workshop, but* ***recommends*** *a more comprehensive plan be implemented by the Omani authorities, working with the IWC and other interested parties, to build local capacity for such training; and*
(4) ***agrees*** *to retain a review of whale watching in east Africa and the wider Indian Ocean region in its work plan (see Annex N, table 4) and to conduct an intersessional review of whale watching in these areas, to be presented at SC/68a.*

18.4 Review Whale Watching Strategic Plan (2018-2024) and joint work with the Conservation Committee
18.4.1 Review and provide recommendations on the draft Strategic Plan
At SC/67a, the Conservation Committee's SWG on Whale Watching requested the Scientific Committee to review a draft of the next iteration of the IWC's Strategic Plan (2018-2024) on Whale Watching (see SC/67b/WW02). This was accomplished primarily during a SC/67b pre-meeting and then further discussed in Annex N (item 5 and appendix 2).

Attention: CC

The Committee ***draws the attention*** *of the Conservation Committee's Standing Working Group on Whale Watching (SWG) to Annex N, appendix 2, which provides a full set of comments on the draft Strategic Plan (2018-2024) on Whale Watching. The most important comments and recommendations from the appendix are highlighted below:*

(1) The addition of an Action 1.5: Develop a communications strategy to actively promote IWC whale watching resources (e.g., the Handbook, reports and training opportunities), with approaches tailored to target key audiences. These audiences include the public and whale watching managers, researchers, operators, and on-board naturalists. Communication actions could include preparing publicly accessible summaries of IWC whale watching reports, improving the whale watching pages on the IWC website (which is already underway with the new Whale Watching Handbook, see Item 18.5), and promoting resources on social media, at key meetings and via press releases to industry bodies and trade publications. The implementation of this action could be coordinated intersessionally via the Secretariat. A joint intersessional working group, which includes key Secretariat staff, could develop a communications strategy for consideration at IWC/67 (the Brazil Plenary meeting) and/or the joint session of the CC/SC at SC/68a.

(2) The replacement of the actions of Objective 2 in the draft Strategic Plan with the following:

a) Action 2.1 – Continue the Modelling and Assessment of Whale Watching Impacts (MAWI) initiative, to develop tools and methodologies to assist researchers and managers in their efforts to assess potential impacts of whale watching on cetaceans and to mitigate them. This initiative is ongoing and could focus on:

i) Investigating modelling methods to link short- (e.g., behavioural reactions) and medium-term (e.g., changes in population distribution) responses with potential impacts from whale watching to long-term (i.e., >10 to 20 years) consequences (e.g., vital rates).

ii) Establishing standard data collection methodologies, including from platforms of opportunity.

iii) Identifying key locations for whale watching research projects and programmes, taking into consideration logistics, capacity and management urgency;

b) Action 2.2 – Develop a long-term integrated research programme to better understand the potential impacts of whale watching on the demographic parameters of cetacean populations. Seek to:

i) Investigate whether there is a causal relationship between whale watching exposure and the survival and vital rates of exposed cetacean individuals and populations;

ii) Understand the mechanisms involved in causal effects, if they exist, in order to define a framework for improved management;

c) Action 2.3 – Develop processes and mechanisms for whale watching activities to collect and provide scientifically robust and useful data to researchers and research programmes; and

d) Action 2.4 – Develop an approach (e.g., hold an intersessional workshop; establish a joint intersessional working group) to integrate social and ecological scientific research within the IWC to inform whale watching management and promote potential benefits. This is a coordinated action between the SWG and the sub-committee.

In particular, Action 2.2 will require a dedicated person to guide and coordinate the development and implementation of a research programme or plan. The best option would be for the SWG to contract with someone, full- or part-time, to carry out this task, whilst recognising the budgetary concerns. Therefore, the Committee ***recommends*** *that the search for funding for this and all other actions in the Strategic Plan be focused, broad-ranging, and innovative. An alternative, if budgetary issues are prohibitive, is to have the research programme developed intersessionally by an intersessional correspondence group or the convenor and co-convenor of the Committee's sub-committee on whale watching.*

Lastly, the Committee ***reiterates*** *its previous recommendation to improve the coordination between the SWG and the Committee's sub-committee on whale watching in the development and implementation of a Strategic Plan on Whale Watching. This year's 21 April pre-meeting to review the draft Strategic Plan was intended to improve coordination and provided an opportunity to contribute to the draft Strategic Plan but it did not completely achieve the goal of coordination, as a limited number of SWG members were able to attend the pre-meeting.*

18.4.2 Develop procedures to provide scientific advice as requested in the plan (including the online handbook) and make the Committee more effective at providing information to the Commission

The revised Actions 2.1-2.4 in Item 18.4.1 outline how the sub-committee on whale watching will collect information needed to inform the Conservation Committee's SWG on Whale Watching. Procedures for providing this advice will be discussed and determined cooperatively with the Conservation Committee, during the joint meeting immediately after SC/67b and intersessionally through the intersessional correspondence group (see Annex N, table 3,).

18.5 Whale watching handbook

18.5.1 Review and provide comments on the IWC's Whale Watching Handbook

The Whale Watching Handbook (Handbook) was presented. Before being made available to the public it will also be translated into French and Spanish with support from CMS. Annex N (item 6) provides additional comments and suggestions for fine-tuning and improving the already-admirable Handbook.

Attention: CG-R, SC, S, CC, C-R

The Committee ***welcomes*** *the presentation of the online Whale Watching Handbook and* ***agrees*** *that it is comprehensive, scientifically substantive, user-friendly and well designed.*

To ensure the IWC Whale Watching Handbook comes to the attention of the international whale watching community, including managers, operators and the public, the Committee ***recommends*** *that all Contracting Governments provide a link to the Handbook on the relevant agency pages of their own government websites once the Handbook goes 'live'.*

The Committee also ***recommends*** *that the Conservation Committee and the Commission develop a plan for identifying and securing long-term funding for the further development (e.g., translations into additional languages, writing additional case studies or country profiles) and the ongoing maintenance (e.g., periodic reviews of content) of the IWC Whale Watching Handbook. The Handbook must be updated regularly to remain a vibrant, living document.*

18.6 Review reports from intersessional correspondence groups

The Committee received information from the intersessional correspondence groups (ICG) of swim-with-whale operations and communication with IORA. Annex N provides details of (1) the discussion related to the intersessional work of the ICG on swim-with-whale operations (item 7.1) and (2) the discussion related to the intersessional work of the ICG on IORA communication (item 7.2).

Attention: S, SC, CC, CG-A, CG-R

Regarding swim-with-cetacean operations, the Committee:
(1) ***agrees*** *that the intersessional correspondence group on swim-with-whale operations (Annex N, table 3) should continue;*
(2) ***draws attention*** *to guiding principles for whale watching, including in-water interactions, that are being or have been developed by various regional bodies, such as the Convention on Migratory Species and UNEP in the Wider Caribbean (see Annex N, item 2.3 and UNEP-CEP, 2012), that advise that swimming with cetaceans be discouraged where it is not already established; and*
(3) ***recommends*** *that, in jurisdictions where swim-with-cetacean activities have not been occurring or are just starting, this practice be prohibited until there is scientific evidence that supports allowing it, noting that the risks to both humans and cetaceans are substantial if operators are inexperienced and not following any relevant guidelines; and*

The Committee also ***welcomes*** *the increased communications between IORA and the IWC over the past year. The IORA Sustainable Whale and Dolphin Watching Tourism Network was established and Australia will convene the Network in its first year of operation and will produce a biannual newsletter. Consequently, the Committee:*

(1) ***agrees*** *that the intersessional correspondence group on communication with IORA (Annex Y) should continue; and*
(2) ***encourages*** *greater engagement between the IWC and IORA on whale watching, beyond the exchanges amongst the intersessional correspondence group (Annex N, table 3).*

18.7 Review progress on scientific recommendations

18.7.1 Global influence of recommendations

The Committee received information about the influence of previous recommendations in numerous countries. Details can be found in Annex N, item 8.1.

18.7.2 Tracking progress on previous recommendations

The sub-committee on whale watching reviewed 27 of its recommendations and agreed statements from the past two years. Of those, 15 were completed or partially completed, nine are on-going, and three have not yet been addressed. Annex N, item 8.2, provides details about those recommendations and agreed statements. There is also ongoing work to update and finalise the terms of reference for the sub-committee on whale watching.

18.7.3 Update on dolphin watching in Bocas del Toro, Panama

Concern continues about the number of dolphins from the small population in Bocas del Toro, Panama that are found dead. Nine deaths in 2016 and 2017 are known to have occurred, five of them confirmed boat strikes. These losses are unsustainable. Research to better understand impacts on the population includes measuring stress hormones in biopsy samples and acoustic monitoring. A regulatory update to strengthen management of whale and dolphin watching in Panama, including Bocas del Toro, was released in October 2017, with the support of the Ministry of Environment.

Attention: SC, C, CG Panama

The Committee ***reiterates*** *its grave concern regarding the intense and uncontrolled dolphin watching in Bocas del Toro, Panama. This concern has been expressed and reiterated for several years due to continuing mortalities, including from vessel strikes, in this small population (probably fewer than 100 animals). In this regard, the Committee:*
(1) ***welcomes*** *the ongoing research to monitor this dolphin population and the impacts it is facing from dolphin watching;*
(2) ***reiterates*** *its welcome of Panama's increased responsiveness to protect the local dolphin population by minimising negative impacts from dolphin watching (IWC, 2018a) and* ***welcomes*** *the regulatory update, supported by the Ministry of Environment, which is meant to lead to stronger management of whale and dolphin watching in Panama, including Bocas del Toro; and*

*(3) **expresses serious concern** at the number of deaths reported in 2016 and 2017 and **recommends** action from the Government of Panama as a matter of urgency, including the immediate and committed implementation of the updated regulations.*

18.8. Work plan and budget requests for 2019-2020

18.8.1 Work plan for 2019-2020

The work plan for matter related to whalewatching is shown in Table 24.

Table 24

Summary of the work plan for matters related to whale watching. Many of these items have intersessional correspondence groups (ICG) or intersessional advisory groups (IAG). Those groups will work intersessionally and provide updates at SC/68a (see Annex X)

Topic	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting
Assessing impacts	-	Papers to be presented	-	Papers to be presented
Third MAWI workshop	Workshop planning	Receive update on planning	Workshop (Annex Y)	Report
Update IWC whale watching guidelines and principles	Revise guidelines and principles	Review	Continue if needed	Receive update
Indian Ocean review	ICG (Annex Y)	Papers to be presented	-	-
East Africa review	Work to prepare review	Paper to be presented	-	-
Intersessional correspondence groups	See Annex Y	Receive reports	See Annex Y	Receive reports
Joint meeting with Conservation Committee Standing Working Group on Whale Watching (SWG) to discuss incorporation of social science in joint work streams	Meeting planning	Receive update	Meeting planning	Joint meeting with SWG
IWC Whale Watching Handbook	-	Receive updates	-	Receive updates

19. SPECIAL PERMITS

19.1 General considerations on improving the evaluation process

This issue is considered as part of the process to revise 'Annex P' (see discussion in Item 28.3).

19.2 NEWREP-A

Summaries of NEWREP-A papers are given in Annex U1.

19.2.1 Report on ongoing research

In plenary, the Committee received and briefly discussed four papers on ongoing work – as indicated below, some of these were discussed more fully in sub-groups.

SC/67b/SP08 presented the results of the third biological field survey of NEWREP-A during the 2017/18 austral summer season. In discussion, it was noted that the high apparent pregnancy rate (95.3%; 122 of 128 mature females) of Antarctic minke whales was consistent with previous results (e.g. from JARPA and JARPA II).

SC/67b/ASI07 presented a summary of results of the NEWREP-A dedicated sighting survey during the 2017/18 austral summer season whilst SC/67b/ASI11 presented the research plan for the next systematic vessel-based sighting survey in the Antarctic under NEWREP-A 2018/19. The new NEWREP-A 2018/19 sighting survey plan has been endorsed by the Committee; Annex Q (item 4.2) provides more details on both these papers.

SC/67b/EM05 presented results of the krill and oceanographic surveys undertaken during the third NEWREP-A survey in Area V-E and VI-W (see Annex L, item 6.1 for details).

19.2.2 Update on previous recommendations

19.1.2.1 AGE DATA AND RMP/IST (RECOMMENDATION 1)

SC/67b/RMP03 provided updated draft specifications for an RMP/IST type simulation exercise to evaluate management procedures based on modified catch limit algorithms that use information on recruitment inferred from age data from Antarctic minke whales. Details and discussion are given in Annex D, section 2.3.2.

Attention: S

*The Committee **agrees** that methods currently used or proposed to be used in the Committee that use age data should (as necessary) be investigated to evaluate the relationship between their results and the accuracy and precision of the age data that they use where this is pertinent to the results of import from these methods. The Committee **agrees** to include this as an agenda item for next year's meeting.*

19.1.2.2 BIOPSY SAMPLING AND TELEMETRY FEASIBILITY STUDIES (RECOMMENDATIONS 4 AND 5)

SC/67b/SP04 summarised the results of a feasibility study on biopsy sampling and satellite tagging of Antarctic minke whales under NEWREP-A. The authors concluded that in the context of the NEWRREP-A objectives, (a) the efficiency of biopsy sampling is much lower than that of lethal sampling for Antarctic minke whales and (b) that the amount of tissue derived from biopsy samples is insufficient to conduct the suite of biomarkers targeted by NEWREP-A. They therefore concluded that biopsy sampling was not a feasible approach to fulfil the objectives of NEWREP-A.

This paper prompted considerable discussion in the Committee, both with respect to ‘efficiency’ of the method and the amount of material required.

One issue raised was that there was the need for better clarification of terminology used in the paper (e.g. ‘sampling’ versus ‘killing) in order, for example, to interpret properly the conclusion that biopsy sampling took approximately three times longer than lethal sampling. It was not clear, for example, whether the median times for biopsy and lethal sampling provided were truly comparable because of the lack of information on when the time for these methods started and ended. In particular, handling time for lethal sampling appeared to not be included in the total time calculations.

The authors responded that in SC/67b/SP04 ‘the efficiency’ of sampling techniques was defined as ‘Success Proportion’ rather than ‘Time of Experiment’ because ‘Success Proportion’ represents a better indicator of the efficiency. To fulfil the purposes of NEWREP-A, random sampling is required in which generally only one animal from a school is sampled. Notwithstanding this clarification, they provided definitions of ‘Time of Experiment’ (see details in Yasunaga *et al*. in Annex U2).

Another issue raised was that the NEWREP-A review workshop (ref) had suggested ‘involving people with expertise in successfully biopsy sampling common minke whales in the North Atlantic’, meaning collaborating in the field with experienced foreign experts. However, Table 2 of SC/67b/SP04 showed an ongoing decline in success proportion (number of biopsy samples / number of targeted whales which were chased for sampling by the SSVs) between 2015/2016 and 2017/2018 rather than the increase one would expect with increasing experience. The authors responded that they had consulted with foreign scientists although they were not on the vessels, that they used experienced marksmen and that the decline was an artefact of weather and sea state conditions under which samples were collected. However, the counter-comment was made that in authors’ analyses, the best model did not include “weather conditions” as a significant factor.

In response the authors provided results of a GLM analysis based on the binomial distribution assumption to examine the differences in success proportion in the biopsy sampling experiment using research seasons as explanatory variables. The coefficients for each year were not significant, suggesting that the differences of success proportions among the seasons are not statistically significant and consequently provide no evidence that shooters’ efficiency has decreased significantly over the three research seasons (see details in Yasunaga *et al*. in Annex U2).

Some Committee members (see Clapham et al. I, in Annex U2) disagreed with the authors’ conclusion that the study revealed that biopsy sampling was not feasible for the NEWREP-A programme. Rather, they believed that it showed that it was both feasible and appropriate. They also disagreed that the amount of tissue obtained was insufficient, citing the large number of research programmes that successfully use biopsy samples to fulfil research objectives including using a single sample for a variety of biomarkers (e.g. stable isotopes, fatty acids, hormones, genetics).

In response, the authors agreed that the amount of epidermal tissue collected by biopsy sampling is enough for the requirement of genetic, epigenetic and stable isotope analyses. However, they stressed that the amount of adipose tissue collected by biopsy sampling was not large enough to measure progesterone, lipid content and fatty acid in the context of the objectives of NEWREP-A (see details in Yasunaga *et al*. in Annex U2).

In their closing comments, the authors stated that in response to the recommendation of the Expert Panel, dedicated experiments for biopsy sampling of Antarctic minke whales had been carried out which had generated the results presented at this meeting and from which the authors had drawn their conclusions. No further dedicated time for biopsy experiments was planned at this stage, but this could be reconsidered at the mid-term review. Meanwhile, NEWREP-A will only collect additional biopsy samples opportunistically.

With respect to the best approach to assess the efficiency of biopsy versus lethal sampling, a standard approach for measuring the efficiency of biopsy sampling and to compare this to the process of lethal sampling was proposed (Clapham et al. II, in Annex U2).

Attention: S

The Committee had last year agreed on establishing an intersessional Advisory group tasked ‘to provide advice on developing an experimental protocol for ascertain whether it is possible to reliably biopsy minke whales and, if so, under what circumstances (experience, vessel type, equipment, environmental conditions, etc.). This group could use as starting point the advice provided by the Expert Panel’ (JCRM 19 suppl:431-490). Due to a clerical error the group did not convene. Attention was drawn to a protocol to evaluate non-lethal techniques presented to SC66b (Mogoe et al., 2016). This protocol included four questions to help identify the feasibility and practicability of non-lethal methods.

The Committee ***agrees*** *to re-establish the Advisory group (Annex Y), under Palka for consideration at SC68a. It also* ***agrees*** *that suggestions for refining questions in the method used by Mogoe and colleagues (2016) should be added to the tasks of this group.*

19.1.2.3 EPIGENETIC AGEING (RECOMMENDATION 8)

Recently, epigenetic (DNA-methylation) ageing has been successfully used to estimate age in humpback whales (Polanowski *et al.* 2014). As noted under Item 11.4.4, this year, the Committee invited Jarman, the leading specialist in this technique to give an overview presentation to the Committee as a special night session. This covered topics such as current and future prospects for this class of methods (see Annex I, item 5.5).

SC/67b/SDDNA04 presented a feasibility study on epigenetic ageing in Antarctic minke whales in response to Recommendation 8 from the Expert Panel (for details see Annex I, item 5.5).

Some suggestions were made on how to improve resolution (in particular, evaluate more loci and then restrict to those loci highly correlated with age); the current set of loci do not provide sufficient precision for use in the population dynamics modelling exercise recommended for NEWREP-A. Given that there is an upper limit to the degree of precision that can be achieved using this technique, the Committee noted that the utility of epigenetic age estimation (and other methods of age determination) will depend on the degree of precision needed for the specific application of interest (see recommendation under Item 11.4.1).

19.1.2.4 DETERMINING SEXUAL MATURITY IN BLUBBER (RECOMMENDATION 9)

SC/67b/SCSP05 presented results from the NEWREP-A research component focused on determining sexual maturity in female Antarctic minke whales, during the feeding season based, on concentrations of progesterone in blubber. The authors concluded that the progesterone concentration in blubber samples cannot be used as a diagnostic index to discriminate between mature and immature female Antarctic minke whales and that lethal sampling is required to obtain information on sexual maturity for use in population dynamic models.

Some members of the Committee disagreed with that conclusion, as they demonstrated that the amount of misclassification in immature versus mature females would be small (~1%, see Wade *et al.* in Annex U2) and thus that progesterone levels in biopsy samples would allow discrimination between mature and immature animals.

They noted that the stated purpose of the study was to discriminate between immature and mature females for fitting population dynamics models such as the catch-at-age analysis; the only misclassification that occurred was a total of 3 (out of 230) whales between the resting and the immature classes, and therefore the only misclassification rate that is important remains ~1% of the total sample.

Some other members noted, also in relation to recommendation 10, that misclassification for discriminating between resting and immature animals was higher and thus the method less reliable for that task.

In response to a request, the authors provided a histogram showing the numbers of immature, resting, ovulating and pregnant animals (Figure 1 of Yasunaga *et al*. in Annex U2). Based on the assumption of cut off values (1.0 ng/g) of progesterone set in Wade *et al.* (see in Annex U2), six of 56 immature whales and three of 11 resting whales were misclassified. Misclassification ratios were thus10.7% and 27.2%, respectively, and these were not considered negligible by the authors (see details in Yasunaga *et al*. in Annex U2).

19.1.2.5 SAMPLE SIZES REQUIRED TO DETECT CHANGE IN ASM (RECOMMENDATION 26)

SC/67b/SCSP01 focused on the need to complete NEWREP-A recommendation 26 on the calculation of sample size. The Committee discussed its previous conclusions in this regard. In 2016, the Committee assessed that three of six aspects of the Expert Panel's recommendations had been adequately addressed in relation to sample sizes. Some members of the Committee consider that until the proponents fully implement the Expert Panel recommendations for calculating sample sizes, the proponents have not demonstrated that they are able to meet their stated objectives in relation to the NEWREP-A programme. The proponents' position and that of some Committee members is that the work has been completed to a reasonable level and that any further work on sample sizes will be afforded a low priority.

The Proponents reiterated their position regarding the work on and status of recommendation 26 ('Provide a thorough power analysis of sample sizes required to detect change in ASM and follow the other recommendations in this item') from the NEWREP-A Review Workshop (IWC, 2016). In view of the proponents, the work on recommendation 26 has been completed to a reasonable level. Details can be found in GOJ (2015; 2016a) and GOJ (2016b). The IWC SC has already concluded that the approach being taken to address the recommendation is appropriate (IWC 2018). Consequently, the proponents have concluded that the reasonableness of the proposed sample size (333) has been adequately demonstrated. The proponents recognize that in 2016 the Scientific Committee suggested some further refinement work; however, they consider that such refinement work goes beyond the original scope of recommendation 26 from the NEWREP-A review workshop. Nevertheless, in deference to the Committee, it was the proponent's intention to address the refinement work for this year's Scientific Committee. However, because of unanticipated specialist personnel unavailability, this has had to be postponed. The proponent's intention is to continue contributing to this work subject to logistical constraints and the availability of specialist analysts.

19.1.2.6 COMMITTEE'S ADVICE

The table in Annex U4, provides a detailed update of the Committee's view of progress on previous recommendations. An overview is given in Table 25.

Table 25

NEWREP-A – Overview on progress with recommendations.

Recommendations in are not in priority order. Recommendations that relate to purposes A, B, C and D are higher priority for completion. Recommendations coded uniquely as "*E: Relevant to improve existing components of the proposed programme*" are excluded from this table as they were optional. Key for 'Purpose': *A: To evaluate the contribution of a particular objective or sub-objective of the programme to meet conservation and management needs*; *B: To evaluate the feasibility of particular techniques (whether lethal or non-lethal)*; *C: Relevant to a full evaluation of whether any new lethal sampling is required*; *D: Relevant to issues related to sample size (irrespective of method used to obtain data).*

Recommendation	Purpose	Deadline	Proponents self-evaluation on progress as of SC67b	Committee's comments
(1) Age data and RMP/IST	A, C, D	August 2016	Completed to a reasonable level	SC66b: A range of opinions as to the extent to which this recommendation has been addressed. SC67a: No new information. SC67b: Some information presented (See section 19.1.2.1).
(2) Stock definition	A, D	May 2016	In progress.	SC66b: No progress. SC67a: As in SC66b. SC67b: As in SC66b.
(3) Mixing rates (simulations on precision and bias)	A, D	May 2016	To be completed by the mid-term review.	SC66b: No progress. SC67a: As in SC66b. SC67b: As in SC66b.
(4) Biopsy feasibility study	B, C, D, E	Field season 2017-2018	Completed.	SC66b: Some progress (SC/66b/IA05). SC67a: Some progress (SC/67a/ASI07). SC67b: Partially completed, further refined analysis is needed (see 19.1.2.2). A WG was formed to review and improve methods.
(5) Telemetry feasibility study	B, E	Field season 2018-2019	Completed.	SC66b: Some progress (SC/66b/IA05). SC67a: Some progress (SC/67a/ASI07). SC67b: Completed.
(8) DNA methylation ageing technique	B, C, D	March 2017	Completed.	SC66b: No progress. SC67a: As in SC66b. SC67b: Partially completed, further refined analysis is encouraged. See section 19.1.2.3.
(9) Hormones in blubber and sexual maturity	B, C, D	March 2018	Completed.	SC66b: No progress. SC67a: As in SC66b. SC67b: Blubber hormones analysis completed. On accuracy see section 19.1.2.4.
(10) SCAA and misassignment 'resting' females/immature females.	A, C, D	August 2016	To be completed by the mid-term review*.	SC66b: No progress. SC67a: As in SC66b. SC67b: New information presented (SC/67b/SCSP05).
(11) SCAA, density- dependence, and stock mixing	A, C, D	May 2016	Completed*.	SC66b: Partially completed: updates on stock mixing and mixing rates still necessary. SC67a: As in SC66b. SC67b: As in SC66b.
(12) Time-varying natural mortality and SCAA	A, C, D	August 2016	To be completed by the mid-term review*.	SC66b: No progress. SC67a: As in SC66b. SC67b: As in SC66b.
(13) Time varying ASM data and SCAA	A, C, D	May 2016	To be completed by the mid-term review*.	SC66b: No progress. SC67a: As in SC66b. SC67b: As in SC66b.
(15) Krill acoustic sampling	B, E	March 2017	Completed.	SC66b: Completed.
(17) Power analysis for krill abundance	A, E	August 2016	To be addressed.	SC66b: Will be addressed in consultation with CCAMLR specialists SC67a: No progress. SC67b: As in SC66b.
(18) Stomach contents vs krill survey	A, B, C	May 2016	To be addressed.	SC66b: Will be addressed in consultation with CCAMLR specialists SC67a: No progress. SC67b: As in SC66b.
(22) Energy intake (requirements)	A, B, D	August 2016	To be addressed. Need clarification from the IWC SC	SC66b: No Progress. SC67a: As in SC66b. SC67b: As in SC66b.
(23) Stable isotopes in baleen plates	B	August 2016	Completed.	SC66b: Will be addressed in consultation with other research institutions. SC67a: Some progress presented. SC67b: Completed.
(26) Sample sizes required to detect change in ASM	D	May 2016	Completed to a reasonable level	SC66b: Overall, the approach being taken to address the recommendation is appropriate, but some further refinements are required. SC67a: No Progress. SC67b: As in SC67a.

*See note in Table #, Annex U4.

19.3 JARPN II

The new information provided on JARPN II is relevant only to the discussion of the NEWREP-NP 'non-lethal vs lethal' feasibility study (see Item 19.3).

19.4 NEWREP-NP

19.4.1 Report on ongoing research

Three papers were presented on progress made during the 2017 surveys of different aspects of the NEWREP-NP programme (SP03, 06, 07, see Annex U3 for summaries).

In particular, SC/67b/SP03 reported the results of the satellite tagging ofn North Pacific sei whales. A total of 44 tagging attempts were made using SPOT6 tags with the LKArts attachments system. A total of 15 tags were deployed on sei whales, and eight whales were tracked. Two sei whales were tracked for more than 35 days, and both showed longitudinal movement. The authors concluded that the tagging experiment showed that deploying such tags from sighting/sampling vessels was practical, but identified technical improvements to try to increase the tracking period.

In discussion, it was noted that the proportion of successful deployments was low (7 failures in 15 attempts); and suggestions on how to improve this included: (a) strategic placement of tags on the upper body of whales to ensure tag longevity and reduce potential physical impacts (e.g. lesions) and (b) replacement of the current screw-on anchor system with an integrated tag design to decrease the possibility of tag breakage. It was noted that guidelines for cetacean tagging should become available within the next year and published in the IWC Journal. It was noted by the authors that the cause of the failures in SP03 were difficult to evaluate since a tag in an optimal position on the whale had also failed. New tags with a modified anchor system and stopper will be used during the next season.

The Committee welcomes new information on the feasibility of satellite tagging sei whales and notes the valuable movement data collected from two of the longer-term (>35 days) deployments. The Committee **encourages** the collection of more telemetry data and notes that this may help improve abundance estimation (by providing information on correction factors) and provide inferences on stock structure.

SC/67b/ASI10 presented a summary of results of the NEWREP-NP dedicated sighting survey in the western North Pacific in 2017 whilst SC/67b/ASI06 presented the research plan for the next systematic vessel-based sighting survey in the western North pacific under NEWREP-NP in 2018 and 2019. As indicated under Item 24.3, the new NEWREP-NP sighting cruise plan has been endorsed by the Committee; Annex Q (item 4.2) provides more details on both these papers.

19.4.2 Update on previous recommendations

The table in Annex U4, provides a detailed update of the Committee's view of progress on previous recommendations. An overview is provided in Table 26 (see next page).

Table 26

Summary of status of recommendations relevant to NEWREP-NP

No. of recommendation	Priority by the Committee	Timeline	Proponents self-evaluation on progress as of SC67b	Scientific Committee Evaluation
(1) Lethal vs non-lethal quantitative review of data	Very high	Before start	SC67a: Completed.	SC67a: Different opinions as to whether the recommendation has been met. SC67b: No progress.
(3) Sexual maturity (blubber and serum)	High	Before start	SC67a: Completed.	SC67a: The Proponents demonstrated intention to include analysis of blubber for progesterone, but there are few details of how. SC67b: Partially addressed.
(4) Sightings surveys	High	Before start and annually	Addressed and ongoing.	SC67a: Completed: survey plan was presented. SC67b: Completed: survey plan was presented.
(5) Stomach contents	High	Before start	SC67a: Completed.	SC67a: Completed.
(7) Immune function assays	High	Before start	SC67a: Completed.	SC67a: Completed.
(8) Lipophilic compounds	High	Before start	SC67a: Completed.	SC67a: Completed.
(10) Coordination with IWC-POWER	High	Before start and annually	Addressed and ongoing	SC67a: Completed annually.
(11) Coastal component: sampling strategy	High	Before start	Disagree with Panel	SC67a: No progress as proponents disagree with Panel. SC67b: No progress.
(12) Offshore components: sampling strategy	Very high	Before start	SC67a: Completed.	SC67a: Completed.
(13) downweight historical age-composition data	Very high	Before start	Disagree with Panel.	No progress.
(15) efficiency of biopsy sampling (additional captures unnecessary)	Very high	High priority ASAP in 2017	Disagree with Panel.	No progress.
(17) Telemetry	High	Before start	Ongoing	SC67a: Partially addressed. SC67b: New information (SC/67b/SCSP03).
(21) Sample size (potential reduction of lethal sample size)	Very high	Before start	To be considered by the mid-term review.	SC67a: The possibility for further work has been considered. SC67b: No progress.
(22) Sample size (in general)	Very high	Before start	Not relevant.	SC67a: Small progress. SC67b: No progress.
(23) Impact of catches on common minke whales (subset of 2013 *Implementation*)	Very high	Before start	Disagree with Panel.	SC67a: Major concerns addressed. SC67b: Completed. Refined analyses were presented. It could be reconsidered in the next *Implementation Review*.
(24) Impact of catches on common minke whales (new abundance)	Very high	Before start	Disagree with Panel.	SC67a: Major concerns addressed. SC67b: Completed. Refined analyses were presented. It could be reconsidered in the next *Implementation Review*.
(25) Sei whale (abundance, $MSYR_{1+}$=1%, $MSYR_{mat}$=4%)	Very high	Before start	SC67a: Completed.	SC67a: Completed.
(27) Higher priority to analyses and modelling	High	Before start	Ongoing	SC67a: It is not clear that additional qualified personnel have been hired. SC67b: No progress.
(28) Sample and data archiving, relational database(s)	High	Before start	Ongoing	SC67a: Partially addressed for DNA data and associated biological information.
(29) Contingency plan	High	Before start	Ongoing	SC67a: Partially addressed.

20. WHALE SANCTUARIES

20.1 Review of the Southern Ocean Sanctuary Management Plan

The Schedule amendment establishing the Southern Ocean Sanctuary (SOS) requires the Sanctuary to be reviewed at succeeding ten-year intervals, unless otherwise revised by the Commission. The first review of the SOS took place in 2004 (IWC, 2005) and the second review was completed in 2016 (IWC, 2017). In 2014 (IWC, 2015c), the Commission adopted eight objectives for the SOS (summarised in Annex R, item 3). The Commission also provided terms of reference for the review to be undertaken by the Scientific and Conservation Committees. The Scientific Committee review made several recommendations (IWC, 2017c). These recommendations were taken into account in a draft Southern Ocean Sanctuary Management Plan (SC/67b/SAN01) developed by Australian scientists and discussed in Annex R (item 3). It was noted that, while the draft Plan does contain performance measures, it does not contain criteria for its own review.

The purpose of the draft Management Plan is twofold: (1) to inform the Commission and public about the sanctuary objectives and actions planned for the next ten years; and (2) to propose strategies toward the achievement of the SOS's goals using the best means available and provide clear performance measures for each proposed action.

The operative part of the Plan is a Research and Action Plan that involves assessing and addressing threats and research on the recovery of whale populations and their habitats. The Research and Action Plan is structured based on the Commission's agreed objectives for the SOS. Each objective is linked directly to a measurable objective, action or approach and performance measure.

The Committee also discussed the potential contributions that data and results from the Japanese whale research programme in the Southern Ocean (NEWREP-A) could make to the objectives and goals of the Plan and the Committee agrees to incorporate reference to NEWREP-A under Objectives 4-6.

The amended Plan, with Objectives 1 and 8 (relating to policy) and the chapeau of Objective 5 redacted to clarify that the Committee did not address these elements of the Plan, is given as Annex R (Appendix 2).

A statement from the Government of Japan regarding its position on the SOS and this draft Management Plan is attached as Annex R, Appendix 3.

Attention: C-A, CC, SC,

The Committee reviewed the components of a draft Management Plan for the Southern Ocean Sanctuary (SOS) that are related to science and therefore within its remit and:

*(a) **endorses** the measurable objectives, approach/actions and performance measures of Objectives 2 -7 of the amended draft Southern Ocean Sanctuary (SOS) Management Plan (Annex R, appendix 2); and*
*(b) **agrees** to include a new standing item on the agendas of all relevant sub-committees and working groups: 'new information relevant to the SOS Management Plan' in order to assist the Commission in monitoring and measuring progress on the scientific objectives of the Plan.*

21. SATELLITE TAGGING DEVELOPMENT AND BEST PRACTICES

21.1 Tag Workshop Meeting, Silver Spring, MD, USA 6-8 September 2017

A workshop on cetacean tag development, tag follow-up and tagging best practices was held at the National Marine Fisheries Service in Silver Spring, Maryland, USA from 6-8 September 2017. The workshop was co-sponsored by the Office of Naval Research (ONR), the International Whaling Commission (IWC), and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA/NMFS). The purpose of the workshop was to review and evaluate progress in tag design and attachment since the 2009 ONR Cetacean Tag workshop (ref - attached), with an emphasis on (a) recent tag attachment improvements, (b) follow-up studies that examined the effects of tagging, and (c) reviewing and providing input on draft cetacean tagging best practices guidelines.

Several presentations were made, with a focus on sharing information and discussion of the best available science of design and effects of tagging to facilitate future advancements in tag design and application, maximising attachment durations to the extent required to answer the questions being posed, whilst minimising potential impacts to the animals.

Discussion on the status of tag attachment development and follow-up studies occurred, along with extensive discussion regarding the cetacean tagging best practices guidelines. While much was accomplished towards the collective goals of the workshop, one item not covered in sufficient detail was discussion on the future directions in tag attachment technology. Therefore, a second smaller workshop will be convened in June of 2018 with a subset of the original attendees that focus specifically on tag attachments. The final report will merge the results of the September 2017 workshop and the June 2018 workshop.

22. IWC LIST OF RECOGNISED SPECIES

The Committee has agreed to follow the guidance of the Society for Marine Mammalogy's Committee on Taxonomy. This year (see Item 17.5), in completing its review of the taxonomy of *Tursiops*, the Committee noted that the current taxonomy provided by the SMM Committee for *Tursiops* was well supported by morphological and molecular genetic data, as well as ecological and distributional data.

23. IWC DATABASES & CATALOGUES

23.1 Guidelines for IWC catalogues and photo-ID databases

At last year's meeting, the Committee agreed IWC Guidelines for Photo-identification Catalogues (IWC, 2018f), noting that adding technical Appendices would be valuable in the future. Draft items for inclusion as Appendices were discussed by the *Ad hoc* Working Group on Photo-identification (Annex S, item 5.1) covering five issues: (1) cataloguing software; (2) image matching software; (3) seminal papers defining individual identification, by species; (4) photo quality guides; and (5) photo/data collection apps. Work will continue on developing these appendices intersessionally (Annex Y).

23.2 Progress with existing or proposed new catalogues

23.2.1 Integration of eastern South and Central Pacific blue, humpback, and fin whale photo-catalogues

There was no new information specific to this item this year.

23.2.2 Southern Hemisphere and Indian Ocean humpback whale catalogues

23.2.2.1 ANTARCTIC HUMPBACK WHALE CATALOGUE

The Antarctic Humpback Whale Catalogue (AHWC), maintained at College of the Atlantic, USA, was established in 1987 and during the past 30 years its data have been used in dozens of studies and publications (Stevick *et al.*, 2017). With a recent loss in funding, the catalogue database is now 'frozen' and is not being actively updated. The Working Group expressed strong disappointment at this news as well as the hope that the AHWC's funding situation will change and enable the catalogue to continue.

Attention: SC, G

The Scientific Committee has been informed that due to a loss of funding, the Antarctic Humpback Whale Catalogue curated by the College of the Atlantic, USA will no longer be updated. The Committee:

(1) ***draws attention*** *to the great value this catalogue (established in 1987) has provided to the Committee, including receiving photographs from the IWC IDCR and SOWER cruises and providing information for the Committee's Comprehensive Assessment of Southern Hemisphere humpback whales;*
(2) ***welcomes*** *news that the existing catalogue will remain a resource for scientists; and*
(3) ***encourages*** *potential funders to support future continuation of the catalogue.*

The Committee also received an update on the development and status of 'Happywhale', a web-based marine mammal photo-ID crowd-sourcing platform (SC/67b/PH05)[12]. This is discussed in Annex S (item 2.2). In recent months Happywhale provided images to catalogues relevant to the IWC and IWC-SORP of Southern right whales, Antarctic blue whales, and Antarctic killer whales. It will also contribute to the ongoing in-depth assessment of North Pacific humpback whales (see Annex F item 4.2.1).

23.2.2.2 ARABIAN SEA WHALE NETWORK'S FLUKEBOOK

In 2016 (IWC, 2017), the IWC approved funding for the development of a regional data platform for the Arabian Sea Whale Network (ASWN), to be implemented in collaboration with Wild Me, the developers of Flukebook. This year the Committee received information SC/67B/PH/03 that described Flukebook, a non-profit, open source cetacean data archiving and photo matching tool as discussed in Annex S (item 2.1; SC/67B/PH/03). The ASWN is joining Flukebook with two primary objectives: (1) to consolidate and more effectively manage humpback whale and other cetacean data collected in Oman over the past 20 years; and (2) to provide an online platform that will allow comparison and regional-level analysis of cetacean data collected by different research groups throughout the Arabian Sea (so far photographs are mainly from Oman, with a few from Pakistan and India). The Committee **looks forward** to updates on this work.

23.2.3 Southern Hemisphere Antarctic and pygmy blue whales: Catalogues and databases

23.2.3.1 SOUTHERN HEMISPHERE BLUE WHALE CATALOGUE (SHBWC)

The SHBWC has become the largest repository of Southern Hemisphere blue whale photo-identifications. It now includes a total of 1,519 individual blue whale photo-identifications from areas off Antarctica, Chile, Peru, Ecuador-Galapagos, Eastern Tropical Pacific (ETP), Australia, Timor Leste, New Zealand, southern Africa, Madagascar and Sri Lanka. The Committee received information on the progress made with the catalogue (SC/67B/PH/04), especially in light of the recommendations made last year to conduct catalogue comparisons in the Indo-Australian region (IWC, 2018b). This is discussed in more detail in Annex S (item 3.2). Comparison work (SC/67B/SH16) found (a) no matches between Australia, New Zealand and Sri Lanka, reinforcing the hypothesis of separate populations; and (b) exchange within Australia, suggested a single population; and (c) re-sights found in New Zealand suggest some site fidelity. Additional work is underway. The relevance of the catalogue to population assessments is discussed in Annex H Item 7.1.1.2.

23.2.3.2 ANTARCTIC BLUE WHALE CATALOGUE (ABWC)

In 2017, the Antarctic Blue Whale Catalogue compared photographs from the IWC IDCR/SOWER cruises in 1989/1990, 1993/1994, and 1997/1998 as well as opportunistic photographs collected by collegial scientists, naturalists, and tourists 2015-2018. The catalogue now contains almost 460 individuals. The results of the comparison of new Antarctic blue whale identification photographs to the ABWC is summarised in SC/67B/PH02 and discussed in Annex S (item 3.1); 17 new individual blue whales were identified. The collection of Antarctic blue whale identification photographs provide data for capture-recapture estimates of abundance (SC/67B/SH08) as well as information on the movement of individual blue whales within the Antarctic region. The relevance of the catalogue to population assessments is discussed Annex H, Item 7.1.1.1.

Attention: SC

(1) The Southern Hemisphere Blue Whale Catalogue provides data useful for estimating abundances and examining connectivity between feeding and breeding grounds. The Committee ***agrees*** *that the catalogue continue.*
(2) The Committee ***agrees*** *that the Antarctic Blue Whale Catalogue continue its work collecting adding photo-identification data to the catalogue in order to assist with developing estimates of population abundance for Antarctic blue whales.*
(3) The Committee ***agrees*** *that the development of a simple guide (physical and electronic versions) to help tourists and naturalists take photos that are suitable for photo-identification should be undertaken. This will support the photo-ID*

[12] https://happywhale.com

catalogues from the Antarctic region for use in population assessments by the IWC, particularly for blue whales, right whales, fin whales, and humpback whales.

23.2.4 Southern Hemisphere fin whale photo catalogues

The Committee received information on on a new photo-identification catalogue of Antarctic fin whales. Photographs from SOWER cruises 2004-2008 are included as well as those collected opportunistically near the South Orkney Islands during a Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) fisheries research voyage (SC/67B/PH01). This is discussed in Annex S (item 4.1). The catalogue serves as a foundation for future photo-ID studies, especially those proposed for the western Antarctic Peninsula. The relevance of the photo-identification of fin whales to population assessments is discussed Annex H, Item 7.1.2.

Attention: S, SC

1) The Committee ***encourages*** *continuation of the Antarctic Fin Whale Catalogue which can potentially provide data toward estimating abundance or identifying movement patterns.*
2)The Committee ***agrees*** *that an exhaustive search be conducted to locate SOWER photos that are missing from the IWC archives, including those of fin whales.*

23.2.5 Western Pacific gray whale photo catalogues

The Committee received information on two photo-identification catalogues relating to the Sakhalin Island feeding aggregation: one (SC/67B/ASI04), based on work undertaken as part of an industry-sponsored Exxon Neftegas Limited-Sakhalin Energy Investment Company joint monitoring program discussed in Annex S, item 4.2); and the other conducted by the Russia gray whale project (SC/76b/CMP/7) discussed in Annex O (item 2.1.3). The Committee welcomed news that the two catalogues would be unified under the auspices of the IWC.

23.3 Work plan

The work plan on work related to catalogues is provided in Table 27.

Table 27

Work plan on issues related to catalogues.

Topic	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting
Appendices for IWC Guidelines for Photo-identification	Continue compilation	Appendices ready for review	Continue compilation	Appendices ready for review
Upload all available New Zealand blue whale identification photographs to SHBWC (also pertains to Annex H item 7.1.1)	Cross-reference between separate area catalogue holdings before uploading to SHBWC avoid duplication; intersessional correspondence group (Annex Y)	Included in SHBWC report	-	-
Development of how-to photo-ID materials for naturalists and citizen scientists (also pertains to Annex H item 7.1.1.2)	Prepare hard copy and PPT photo-ID guides	Guide completed and available (pending funding)		
4) Search for missing SOWER photographs, especially fin whale photos from 2006/2007	Search Secretariat archives and contact SOWER researchers for personal copies of photos	Report		

23.4 Potential future IWC databases

23.4.1 Global database for disentanglement activities

As discussed under Item 13.2, development of a dedicated entanglement database will be considered further at the June 2018 meeting of the Global Whale Entanglement Response Network (see Annex J, item 2.3).

23.4.2 Global bycatch database

No new information was presented on the development of a global bycatch database was presented this year. Consideration of such a database could take place as part of the Bycatch Mitigation Initiative and should it be taken further, follow the guidelines for the proposal of new databases developed last year (IWC, 2018, pp. 403-404).

23.4.3 Development of simple technical guidelines for new proposals

No changes were suggested to the guidelines developed at last year's meeting (IWC, 2018, pp. 403-404).

24. IWC MULTINATIONAL RESEARCH PROGRAMMES AND NATIONAL RESEARCH CRUISES THAT REQUIRE IWC ENDORSEMENT

24.1 IWC-POWER

The Committee received the results of the 8th annual IWC-POWER cruise conducted between 3 July and 25 September 2017 in the eastern Bering Sea. Researchers from Japan, USA and IWC participated on the surveys (SC/67b/ASI12). The Committee also received the report of the planning meeting for the 2018 IWC-POWER cruise, which will be conducted in the central Bering Sea, and cruise plans for the 2019 and 2020 cruises (SC/67b/Rep02). Details and preliminary results of the 2017 IWC-POWER survey and future plans for 2018, 2019 and 2020 are provided in Annex Q, item 4.1.

Attention: SC, C-A, CG-R

*The Committee **reiterates** to the Commission the great value of the data contributed by the IWC-POWER cruises which cover many regions of the North Pacific Ocean not surveyed in recent years and so address an important information gap for several large whales. The Committee:*

*(1) **thanks** Japan who generously supplies the vessel and crew, for their continued support of this IWC programme;*

*(2) **thanks** the USA who provided an acoustician and acoustic equipment for the 2017 cruise and will do so for the 2018 cruise;*

*(2) **agrees** that the 2017 cruise was duly conducted following the requirements and guideline of the Committee (IWC, 2012) and looks forward to receiving abundance estimates based on these data;*

*(3) **endorses** the plans for the 2018, 2019 and 2020 POWER cruise and **recommends** a meeting of the Technical Advisory Group along with the planning meetings for 2019 and 2020 cruises;*

*(4) **strongly recommends** that Russia facilitates the proposed research by providing permits for the IWC-POWER cruise to survey the Russian Exclusive Economic Zone in 2019;*

*(5) **looks forward** to receiving a report from the 2018 survey at the next SC meeting.*

24.2 Southern Ocean Research Partnership (IWC-SORP)

The Southern Ocean Research Partnership (IWC-SORP) was established in March 2009 as a multi-lateral, non-lethal scientific research programme with the aim of improving the coordinated and cooperative delivery of science to the IWC. The Partnership currently has 13 member countries: Argentina, Australia, Belgium, Brazil, Chile, France, Germany, Italy, New Zealand, Norway, South Africa, the United States of America, and Luxembourg was welcomed at this meeting. New members are warmly welcomed.

There are five ongoing IWC-SORP themes:

(1) ‘The Antarctic Blue Whale Project’;

(2) ‘Distribution, relative abundance, migration patterns and foraging ecology of three ecotypes of killer whales in the Southern Ocean’;

(3) ‘Foraging ecology and predator-prey interactions between baleen whales and krill’;

(4) ‘Distribution and extent of mixing of Southern Hemisphere humpback whale populations around Antarctica?’ focused initially on east Australia and Oceania; and

(5) ‘Acoustic trends in abundance, distribution, and seasonal presence of Antarctic blue whales and fin whales in the Southern Ocean’.

Bell presented the IWC-SORP Annual Report 2017/18 on the continued progress of research undertaken researchers involved in the five themes since last year (SC/67b/SH21). This progress includes the production of 33 peer-reviewed publications during 2017/18, bringing the total number of peer-reviewed publications related to IWC-SORP since the start of the initiative to 126. In addition, 125 IWC-SORP related papers have been submitted to the Scientific Committee, 22 of them this year.

Fieldtrips were undertaken to a variety of places during the past year, including the western Antarctic Peninsula, Marion Island, the Ross Sea, the Chesterfield-Bellona Reef complex west of mainland New Caledonia, and the Great Barrier Reef, Australia. Thousands of images for photo-identification have been collected; a variety of satellite tag-types deployed on Antarctic minke whales, humpback whales and killer whales as well as biopsy samples collected from these same species; video suction cup tags have been deployed on Antarctic minke whales and humpback whales; and hundreds of hours of acoustic recordings have been made and analysed. The support of tour companies in providing opportunistic research platforms to facilitate these activities and external data contributors were acknowledged by the Committee.

Attention: SC, G

The Committee reiterates the great value of the IWC-SORP (Southern Ocean Research Partnership) programme to its work. The Committee:

(1) ***encourages*** *the continuation of the Southern Ocean Research Partnership programme;*

(2) ***commends*** *the researchers involved who are key to the overall success of the Partnership in IWC-SORP for:*

(a) the impressive quantity of work carried out across diverse member nations;

(b) their contributions to the work of the Committee; and

(3) ***encourages****:*

(a) the continued development, testing and implementation of leading edge technology; and

(b) the continued development of collaborations between ships of opportunity and external bodies that can provide platforms for research and/or contribute data, inter alia, photo-identification data, to IWC-SORP and the wider Committee

24.2.1 Workplan

The work plan for issues related to IWC-SORP is given in Table 28.

Table 28

Workplan for the Southern Ocean Research Partnership.

Topic	Intersessional 2018/19	2019 Annual Meeting (SC/68a)	Intersessional 2019/20	2020 Annual meeting
Analyses	Continued analysis of data/samples from previous IWC-SORP voyages/fieldwork	Report	Continued analysis of data/samples from previous IWC-SORP voyages/fieldwork	Report
Voyages	Argentine coastguard '*Tango*' voyage along Western Antarctic Pensinsula (early 2019)	Cruise report		
	Almirante Maximiano voyage along Western Antarctic Pensinsula (early 2019)	Cruise report		
	Australian-led *RV Investigator* voyage to Ross Sea (early 2019)	Cruise report		
	New Zealand-led *RV Tangaroa* voyage to Ross Sea (early 2019)	Cruise report		
	German-led *RV Polarstern* voyage to Scotia Sea (early 2019)	Cruise report		
	Baleen whale and krill research voyages along Western Antarctic Peninsula	Reports	Baleen whale and krill research voyages along Western Antarctic Peninsula	Reports
Ships of opportunity	Continued use of ships of opportunity to conduct cetacean research	Reports	Continued use of ships of opportunity to conduct cetacean research	Reports
Acoustics	Retrieval and redeployment of passive acoustic recorders	Report	Retrieval and redeployment of passive acoustic recorders	Report
	Completion of annotated library of acoustic detections	Report		

24.3 National cruises that require IWC oversight

The Committee welcomed plans for national research cruises to be conducted in the intersessional period of 2018-2019. Details on the cruise plans and cruise reports are presented in Annex Q, item 4.2.

Attention: SC, C-A

The Committee ***recognises*** *the great value to its work provided by data from national cruises. The Committee:*

(1) ***endorses*** *the proposed sighting survey plans for cruises to be conducted with IWC oversight in the southwestern Okhotsk Sea by Russia, and in the North Pacific and the Antarctic by Japan; and*
(2) ***encourages*** *submission of abundance estimates from these studies the future.*

24.4 Review of cruise reports from national programs with IWC oversight

The Committee considered a process to optimise the review of cruise reports from national research programs with IWC oversight. Details are given in Annex Q, item 2.7

Attention: SC, CG-R

The Committee ***recognises*** *the value of information provided by national cruises with IWC oversight. The Committee noted that a process to optimise the review of national cruise reports is needed and*

(1) ***recommends*** *contracting governments to submit reports of multi-year cruises with IWC oversight biennially, in years between Commission meetings (e.g., SC "A" years);*
(2) ***agrees*** *that cruise reports will be summarised in a table;*
(3) ***notes*** *that that in certain circumstances, cruise reports may require additional evaluation; and*
(4) ***agrees*** *that the 'Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme' should be modified at next year's meeting to accommodate procedural changes with respect to the submission and review of national cruise reports.*

24.5 Work Plan
The Committee's work plan for continuing the IWC-POWER programme in 2019 and 2020 is provided below in Table 29.

Table 29

Workplan for issues related to IWC-POWER.

Item	Intersessional 2018-19	SC68a	Intersessional 2019-20	SC68b
IWC-POWER Cruise	Conduct 2018 survey and planning meeting for the 2019 Cruise (Bering Sea)	Review cruise report, report from the planning meeting and new abundance estimates from IWC-POWER cruises.	Conduct 2019 survey and planning meeting for the 2020 Cruise	Review cruise report, report from the planning meeting and new abundance estimates from IWC-POWER cruises.

25. SCIENTIFIC COMMITTEE BUDGET FOR THE CURRENT BIENNUM

25.1 Status of previously funded research, workshop proposals, data processing and computing needs
25.1.1 Funded proposals for the current biennium 2017-2018
Table 30summarises the status of the work funded by the Committee last year. The majority have been completed, but several remain ongoing. The projects all contributed considerably to the work of the Committee and the Committee thanked all of those involved.

25.1.2 Funded proposals in previous years still ongoing
A number of projects from previous years are still ongoing (see Table 30). These are all still of great value to the Committee and should be completed before the next meeting. Details of all ongoing projects can be found in SC/67B/01 Rev1.

25.1.3 Report on funds reallocations and contingencies for the Research Fund, Voluntary Fund for Small Cetaceans and SORP Voluntary Fund
SC/67b/01Rev1 provides information on the actual position against budget for the Research fund for 2017 as well as the position to 31st March for the 2018 financial year. The paper gives summary level and detailed information for the Research fund as well as the expected level of contingency available, which remains static at around 10% of the Research budget, or £32k. The document also provides details of the reallocations of budget amongst budget headings for 2017 and the 2018 year-to-date. Annex 1 gives a detailed position along with a status report for each budget line. Section 3 also provides details of voluntary funds which relate to Scientific Committee business – the Gray Whale Tagging Fund, the Small Cetaceans Fund and the SORP fund. For each there is an update of 2017 expenditure and 2018 to-date information along with details of commitments to future work in these funds.

Table 30

Summary of progress on proposals funded at SC67a

SC/67a RP no.	Title	Status
SC01	Invited Participants - SC/67b	Completed
IA01(67a)	Workshop for an in-depth assessment of North Pacific humpback whales	Ongoing (Annex F)
EM01	Two joint SC-CAMLR and IWC-SC Workshops	Ongoing (Annex L)
AWMP01	AWMP first intersessional Workshop and genetic work	Completed (SC/67b/Rep06)
AWMP02	AWMP second intersessional Workshop	Completed (SC/67b/Rep06)
CMP01(67a)	5th Workshop on the rangewide review of population structure and status of North Pacific gray whales	Completed (SC/67b/Rep07rev1)
BRG04	Satellite tagging best practices Workshop	Ongoing, Item 21
WW01	Intersessional Workshop: data gaps and modelling requirements for assessing the impacts of whale watching	Completed (SC/67b/Rep03rev1)
RMP01	Intersessional Workshop: *Implementation Review* of North Pacific Bryde's whales	Completed (SC/67b/Rep02)
RMP01(67a)	Intersessional Workshop: *Implementation Review* for Western North Pacific minke whales	Completed (SC/67b/Rep05)
WW01(67a)	Review CC Strategic plan on whalewatching pre-meeting on intersessional workshop	Completed (Annex N)
E05/E01(67a)	Cumulative impacts - pre-meeting or intersessional meeting	Completed (Annex K)
SM01	Intersessional Workshop: resolving *Tursiops* taxonomy	Completed (SC/67b/SM18rev1)
SM01(67a)	Intersessional Workshop: boto mortality	Completed (SC/67b/Rep01)
SH07	Defining blue whale population boundaries and estimating associated historical catches, using catch data in the Southern Hemisphere and northern Indian Ocean	Completed (SC/67b/SH23)
AWMP02	AWMP developers fund	Completed (Annex D)
IA02	Assessment modelling for an in-depth assessment of North Pacific sei whales	Ongoing (SC/67b/IA01)
RMP02	Essential computing support to the Secretariat for RMP	Completed (Annex D)
Research		
BRG01	Aerial photographic survey of southern right whales on the South Africa Cape nursery ground	Completed (SC/67b/SH01)
BRG03	Passive acoustic monitoring of the eastern South Pacific southern right whales, improving CMP outputs	Completed (SC/67b/CMP18)
SH03a	Northern Indian Ocean humpback subspecies determination-genetics	Ongoing (Annex H)
IA03	IWC-POWER cruise	Completed (SC/67b/Rep04)
SH01(67a)	Coding for Australian blue whale photo catalogue	Ongoing (Annex PH)
E02(67a)	Mercury in cetaceans (requested by the Commission)	Ongoing (SC/67a/E08)
SH02	Southern Hemisphere Blue Whale Catalogue	Completed (SC/67a/PH04)
SH08	Development of a permanent blue whale song reference library	Completed (SC/67a/SH11Rev1)
HIM01	Ship Strike Database Coordinator	Completed (SC/67a/HIM11)
E01	Cetacean Diseases of Concern	Ongoing (Annex K)
E03(67a)	IWC strandings initiative	Ongoing (Annex K)
E04	SOCER (State of the Cetacean Environment Report)	Completed (SC/67a/E01)

The Committee received a brief report on the IWC-SORP Research Fund. Following an open, competitive Call for Proposals (26 July to 17 August 2016) a total of £144,058 GBP was allocated from the IWC-SORP Research Fund to 10 research projects, ahead of the 2016-2017 austral summer survey season. Progress on these projects is detailed in SC/67b/SH18.

The Committee also noted that since SC67a, substantial vessel time has also been secured by IWC-SORP researchers for the 2019 and 2020 austral field seasons.

Attention: C, F&A, S

A full report on the new Call for Proposals, opened in September 2017 and closed in January 2018, was also received. A total of 19 proposals were received and evaluated by the Assessment Panel under the coordination of the Chair of the Scientific Committee. The Committee thanks Fortuna for convening the Assessment Panel and expressed its gratitude to the Panel members who all provided valuable and thoughtful input into the assessment process. The Committee welcomes the outcome of the Assessment Group and agrees with the allocation of a total of £493,544 GBP from the IWC-SORP Fund to 15 projects (Table 31).

The Committee agrees on these recommended allocations and requests the Secretariat to submit them to the Finance and Administration Committee, as soon as feasible, for it consideration. Should the Commission endorse these financial recommendations, the Committee requests the Secretariat to inform successful and unsuccessful proponent immediately after the next Commission's meeting.

Table 31
List of the funding allocations by project recommended by the IWC-SORP Assessment Panel

ID	Chief Investigator	Title	Requested amount (£)	Recommended amount (£)	Level of funding (Partial/Full)
1	Baker & Steel	Is migratory connectivity of humpback whales in the Central and Eastern South Pacific changing? A decadal comparison by DNA profiling	27,598	26,375 (deducted in house instrument expenses)	P
2	Charrassin	Application of satellite telemetry data to better understand the breeding strategies of humpback whales in the Southern Hemisphere	21,200	21,200	F
3	Branch	Modelling somatic growth and sex ratios to predict population-level impacts of whaling on Antarctic blue whales	32,594	32,594	F
4	Friedlaender & Constantine	Pregnancy rates in Southern Ocean humpback whales: implications for population recovery and health across multiple populations	29,334	19,984 (equipment deducted and some analytical costs)	P
5	Herr	Recovery status and ecology of Southern Hemisphere fin whales (*Balaenoptera physalus*)	82,300	81,900 (equipment deducted)	P
6	Friedlaender & Constantine	A circumpolar analysis of foraging behaviour of baleen whales in Antarctica: Using state-space models to quantify the influence of oceanographic regimes on behaviour and movement patterns	34,711	34,711	F
7	Buchan & Miller	A standardized analytical framework for robustly detecting trends in passive acoustic data: A long-term, circumpolar comparison of call-densities of Antarctic blue and fin whales	43,369	41,369 (publication costs)	P
8	Lang & Archer	Inferring the demographic history of blue and fin whales in the Antarctic using mitogenomic sequences generated from historical baleen	22,710	22,710	F
9	Zerbini & Clapham	Assessing blubber thickness to inform satellite tag development and deployment on Southern Ocean whales	22,646	22,426 (supply costs deducted)	P
10	Širović & Stafford	Acoustic ecology of foraging Antarctic blue whales in the vicinity of Antarctic krill studied during AAD interdisciplinary voyage aboard the *RV Investigator*	34,183	30,107 (airfares deducted)	P
12	Kelly &Maire	Development of statistical and technical methods to support the use of long-range UAVs to assess and monitor cetacean populations in the Southern Ocean	30,576	30,576	F
13	Reisinger & de Bruyn	An integrative assessment of the ecology and connectivity of killer whale populations in the southern Atlantic and Indian Oceans	33,650	33,650	F
14	Bengston Nash	Implementation of humpback whales for Antarctic sea-ice ecosystem monitoring; Inter-program methodology transfer for effective circumpolar surveillance	91,202	51,555 (equipment costs deducted)	P
17	Carroll, Torres, Graham	Circumpolar foraging ecology of southern right whales: past and present	21,290	21,290	F
18	Iñíguez Bessega	Habitat use, seasonality and population structure of baleen and toothed whales in the Scotia sea and the western Antarctic Peninsula using visual and passive acoustic methods and genetics	26,579	23,097 (equipment costs reduced, communication & network costs deducted)	P
		TOTAL	693,195	493,544	

Finally, the Committee was informed that the next Call should open prior to SC/68b (i.e. late 2019/early 2020) in readiness for IWC68 (2020). This timing would allow strategic prioritisation of the research toward which the Call is directed in order to meet IWC-SORP and IWC/SC priorities; allow knowledge gaps to be identified; and allow the IWC-SORP SSC to seek additional funding to augment the funds available in the IWC-SORP Research Fund.

26. COMMITTEE PRIORITIES AND INITIAL AGENDA FOR THE BIENNUM 2019-2020

The Committee's priorities and work plan by broad subject matter are provided in Tables under the relevant agenda items.

The Committee ***agrees*** *that the Chair, Vice-Chair and Head of Science, in co-operation with the Convenors, should examine the individual work plans by topic and develop an overall Committee biennial workplan and priorities taking into account the overall work load, meeting venues and efficiency. This should be submitted to the Commission meeting as an Annex to their two-year overview.*

27. SCIENTIFIC COMMITTEE BUDGET FOR THE BIENNUM 2019-2020

27.2 Budget for the next biennium

As in 2016, the Committee has developed a two-year budget, based on the proposed work plans. The process given in Annex S IWC, 2016) was applied, with extensive discussion carried out in each of the sub-committees and Working Groups to establish priorities among the presented proposals. Funding was not approved for one project (*Gulf of Penas, Southern right whales*) as further information is needed before funding can be agreed. The savings from 2018, some self-reductions and adjustments between years allowed inclusion of all funding proposals for 2019 and 2020 in the new budget of £315,800 per year.

Table 32

Workshop proposals agreed during this meeting (TBD: to be decided).

Title	Relevance	Date	Venue
Western gray whale update of CMP and conservation issues within modelling framework	CMP		
Marine debris	E	December 2019	Barcelona, Spain
Noise pre-meeting	E	Pre-meeting 2020	TBD
Cetaceans & ecosystem functioning: a gap analysis*	EM	TBD	TBD
Joint IWC-IUCN workshop to evaluate how the data and process used to identify Important Marine Mammal Areas (IMMAs) can assist the IWC to identify areas of high risk for ship strike	HIM	April 2019	Greece
Comprehensive Assessment of North Pacific humpback whales	NH		
Comparative biology, health, status & future of NA right whales	NH	Late 2019	Boston, USA
Implementation Review: North Pacific minke whales	RMP		
Catch series: Southern right whales	SH	Pre-meeting 2020	TBD
Intersessional workshop of the task team on South Asian River dolphins	SM	Feb 2019	TBD
Guiana dolphin pre-assessment	SM	October 2019	Curitiba, Brazil
Modelling whale watching impacts (MAWI)	WW	December 2019	
POWER planning meeting	ASI	Oct 2018	Tokyo, Japan
Wildmeat workshop	SM	Late 2019/early 2020	Africa
Tagging best practices	ASI	Jun 2018	Seattle, USA

* Japan referred to its statement on the adoption of the Agenda (Annex Z) and considered that several of the items for the proposed workshop (Item 16.4.4) are outside the competence of IWC. Therefore, it cannot support the proposed workshop or associated funding from the Committee's budget.

Table 33 shows the Committee budget requests for the biennium for each of the proposed priority activities.

27.2.1 Invited Participants

INVITED PARTICIPANTS

Invited participants (IPs) are a vital component of the working of the IWC's Scientific Committee. IPs contribute in many ways including as sub-committees and Working Groups Convenors, co-Convenors and rapporteurs, subject area experts and Convenors of intersessional groups. All sub-committees and Working Groups benefit from this budget item. This year under this budget item, 62 scientists from Australia, Argentina, Belgium. Brazil, Canada, Chile, China, Colombia, France, Germany, Italy, Japan, Mexico, Netherlands, Norway, Oman, Peru, Slovenia, South Africa, Spain, UK, USA were supported.

27.2.2 Workshops

RP16 WESTERN GRAY WHALE UPDATE OF CMP AND CONSERVATION ISSUES WITHIN MODELLING FRAMEWORK

The CMP is over 10 years old and requires updating. Initial work has been undertaken but the results of the rangewide workshop need to be incorporated and conservation-related questions need to be developed that can be addressed within the new population modelling framework developed as a result of the Committee's work. This is primarily related to the CMP and AWMP groups, however, it is also of importance to the work of IA and ASI in terms of precedents for future assessments and the work of HIM in terms of examining scenarios that take into account bycatch and the uncertainty associated with estimating it.

RP06 MARINE DEBRIS WORKSHOP

There remains an urgent need to better understand and address the threats posed by marine debris to cetaceans. The most effective way to do this, building on earlier work by the IWC and taking into account the greatly expanded interest in this topic by many other international bodies, is to hold a workshop. It is proposed that the workshop is held in Barcelona in December 2019 just before the World Conference on Marine Mammalogy (the joint meeting of the SMM and ECS).

RP05 NOISE PRE-MEETING

The sub-committee on Environmental Concerns will address Anthropogenic Noise as a focus topic during the Scientific Committee meeting in 2020. A pre-meeting workshop is proposed for SC68b, to address emerging issues related to the management of underwater noise and its impacts on marine species.

RP08 CETACEANS & ECOSYSTEM FUNCTIONING: A GAP ANALYSIS

Experts on the role and impact of cetaceans on ecosystem functioning will participate in a workshop/pre-meeting to discuss the current state of knowledge on the ecosystem functioning provided by cetaceans as requested by the Commission in Resolution 2016-3. This Resolution directed 'the Scientific Committee to further incorporate the contribution made by live cetaceans to ecosystem functioning into [its] work' and asked 'the Scientific Committee to screen the existing research studies on the contribution of cetaceans to ecosystem functioning, to develop a gap analysis regarding research and to develop a plan for remaining research needs'.

RP17 JOINT IWC-IUCN WORKSHOP TO EVALUATE HOW THE DATA AND PROCESS USED TO IDENTIFY IMPORTANT MARINE MAMMAL AREAS (IMMAS) CAN ASSIST THE IWC TO IDENTIFY AREAS OF HIGH RISK FOR SHIP STRIKE

The identification of 'high risk areas' for ship strikes of cetaceans is a key step toward establishing mitigation actions, through scheduling, re-routing or speed reduction. IUCN's proposed initiative to identify Important Marine Mammal Areas (IMMAs), would likely assist this effort. The SC has encouraged cooperation with the IUCN Task Force on this. The IUCN TF has completed three regional IMMA workshops, including the Mediterranean Sea. This proposed joint workshop will focus on identifying overlap between shipping and the IMMAs identified in the Mediterranean Sea.

Table 33
Summary of budget requests for the 2019-20 period. For explanation and details of each project see text.

RP no.	Title	Sub-committee/ working group	2019 (£)	2020 (£)
Invited Participants				
	Invited Participants - SC/68a and SC/68b	SC	85,000	65,000
Meeting/Workshop				
RP16	Western gray whale update of CMP and conservation issues within modelling framework	CMP	10,500	0
RP06	Marine debris	E	0	20,000[1]
RP05	Noise pre-meeting	E	0	12,000
RP08	Cetaceans & ecosystem functioning: a gap analysis	EM	0[2]	0
RP17	Joint IWC-IUCN workshop to evaluate how the data and process used to identify Important Marine Mammal Areas (IMMAs) can assist the IWC to identify areas of high risk for ship strike	HIM	10,000	0
RP19	Comprehensive Assessment of North Pacific humpback whales	NH	1000[3]	0
RP37	Comparative biology, health, status & future of NA right whales	NH		20,000
RP21	*Implementation Review*: North Pacific minke whales	RMP	13,000[4]	15,000
RP29	Catch series: Southern right whales	SH	0	15,800
RP25	Intersessional workshop of the task team on South Asian River dolphins	SM	7,000[5]	0
RP26	Guiana dolphin pre-assessment	SM	0	9,990
RP27	Modelling whale watching impacts (MAWI)	WW	0	17,000[6]
Modelling/computing				
RP20	In Depth Assessment of North Pacific sei whales	ASI	5,000	0
RP22	Develop an age-structured emulator for the individual-based energetics model (IBEM)	RMP	7,000	0
RP23	Essential computing support	RMP	11,500	11,500
RP36	Simulating line transect data to investigate robustness of novel analysis methods	ASI	6,000	0
Research				
RP01	IWC-POWER cruise	ASI	22,500[7]	22,500[8]
RP11	Abundance estimates of the franciscana dolphin in Buenos Aires province, Argentina	CMP	7,100	0
RP09	Gulf of Penas, Southern right whales	CMP	0	0[9]
RP10	Population dynamics of southern right whales at Península Valdés, Argentina	CMP	19,130	0
RP12	ES Pacific Southern right whales acoustic monitoring	CMP	13,700	16,800
RP13	Sample holotype specimen of *Megaptera indica* at the Muséum National d'Histoire Naturelle (Paris)	CMP	0	1,975
RP14	Assessing isolation of Arabian Sea humpback whales and continuity across the Arabian Sea through geographic variation in song	CMP	16,400	0
RP15	Quantitative assessment of threats to Arabian Sea humpback whales using existing photographic and UAV data	CMP	9,500	0
RP24	Collaborative analysis of WNP minke whale stock structure	SD-DNA	6,247	0
RP28	Updated catch series and assessments of four pygmy blue whale populations	SH	0[10]	12,865
RP30	Multi-ocean analysis of southern right whale demographic parameters and environmental correlates	SH	13,600	13,600
RP31	Southern Hemisphere fin whale song	SH	0	12,000
RP34	Photo-Identification information placards for naturalists and citizen scientists	SH	1000	0
RP07	IWC strandings initiative – emergency response and investigations	E	4,500	4,500
Databases				
RP18	Ship strikes database coordinator	HIM	7,000[11]	7,000[12]
RP33	Antarctic Blue Whale Catalogue: comparison of new photographs from 2014-20	SH	3,000	800
RP32	Southern Hemisphere blue whale photo catalogue	SH	16,810	3,000[13]
RP38	Secretariat database management	SC	3,000	3,000
Reports				
RP03	Mercury in cetaceans	E	0[14]	0
RP04	State of the Cetacean Environment Report	E	3,000[15]	3,000[16]
RP02	Amendment of RMP Guidelines to incorporate spatial modelling approaches to estimate abundance	RMP	3,000	0
General items				
	Implementation: resolutions and instructions from Commission & follow up from previous years' recommendations	SC	10,313	28,470
Total request			£315,800	£315,800

Notes: [1]Budget was reduced from £22,200, [2]£20,300 was the expected financial need for 2019 but savings from 2018 allowed for the reduced budget of £0; [3]£11,400 was the expected financial need for 2019 but savings from 2018 allowed for the reduced budget of £1,000; [4]£15,000 was the expected financial need for 2019 but savings from 2018 allowed for the reduced budget of £13,000. [5]Budget was reduced from £8,958, [6]£20,000 was the expected financial need for 2020 but financial savings for 2018 allowed for the reduced budget of £17,000, [7]£32,500 was the expected need for 2019 but financial savings from 2017 allowed for the reduced budget of £22,500, [8]£32,500 was the expected need for 2020 but financial savings from 2018 allowed for the reduced budget of £22,500, [9]The requested budget was £15,000 but further information is required before funding can be considered. The project will be re-evaluated at the 2019 SC meeting, [10]£6,185 was the expected financial need for 2019 but financial savings from 2018 allowed for the reduced budget of £0, [11]budget was reduced from £10,000, [12]budget was reduced from £10,000, [13]funding of approximately £7,280 may be requested for 2020 next year depending on progress, [14]£4,000 was the expected financial need for 2019 but savings from 2018 allowed for the reduced budget of £0, [15]budget was reduced from £4,000, [16]budget was reduced from £4,000.

27.2.1 Invited Participants

INVITED PARTICIPANTS

Invited participants (IPs) are a vital component of the working of the IWC's Scientific Committee. IPs contribute in many ways including as sub-committees and Working Groups Convenors, co-Convenors and rapporteurs, subject area experts and Convenors of intersessional groups. All sub-committees and Working Groups benefit from this budget item. This year under this budget item, 62 scientists from Australia, Argentina, Belgium. Brazil, Canada, Chile, China, Colombia, France, Germany, Italy, Japan, Mexico, Netherlands, Norway, Oman, Peru, Slovenia, South Africa, Spain, UK, USA were supported.

RP19 COMPREHENSIVE ASSESSMENT OF NORTH PACIFIC HUMPBACK WHALES

At SC67a, following discussion of the results of an assessment workshop held in April 2017, a Steering Group was established to facilitate a second North Pacific humpback whale assessment workshop, and to coordinate work required for this meeting. This meeting was not held prior to SC67b and the workshop is now planned for prior to the 2019 meeting of the Scientific Committee, with a view to completing or significantly advancing the assessment.

RP37 BALAENID WORKSHOP: BIOLOGY, HEALTH, STATUS

The North Atlantic right whale's population rate of increase is much lower than that of all other well-studied balaenid populations. This workshop will compare reproductive biology, health and status of North Atlantic right whales with those of other balaenid populations with the goal of determining their potential for growth and assessing the role of anthropogenic mortality as a driver of current population decline. Possible causes of the NARW's lower reproductive rate need reassessment include: sub-lethal effects of entanglements; environmental contaminants or marine biotoxins; inadequate prey base; stress from noise; genetic factors; and infectious diseases. This review will also help understanding of population changes for other balaenid populations.

RP21 *IMPLEMENTATION REVIEW*: NORTH PACIFIC MINKE WHALES

These workshops are essential in order for the Committee to conduct a full *Implementation Review* for Western North Pacific common minke whales following the Committee's Requirements and Guidelines. Conducting *Implementation Reviews* are a required activity under the RMP.

RP29 CATCH SERIES: SOUTHERN RIGHT WHALES

A new review of available catch data for measuring regional takes of southern right whales is overdue and the availability of new sources suggests that it is timely to do this. The expected outcome of this workshop is updated regional estimates of southern right whale catches, which can be used to conduct regional assessments of southern right whale past exploitation and develop population trajectories to measure past abundance and current recovery levels.

RP25 INTERSESSIONAL MEETING OF THE TASK TEAM ON SOUTH ASIAN RIVER DOLPHINS

The South Asian river dolphin, *Platanista gangetica*, is listed as an endangered cetacean species by the IUCN Red List assessment. Across its range, in the countries of India, Pakistan, Nepal, and Bangladesh, the species remains highly threatened by a range of anthropogenic activities at multiple scales. These range from localised threats caused by hunting, fisheries bycatch, or local disturbances as well as from large-scale alterations of the rivers by dams, barrages, waterways and river-linking schemes. In particular, large-scale and rapidly accelerating water development in the Indo-Ganges-Brahmaputra floodplains make the outlook for the South Asian river dolphin conservation grim. In recognition of this situation, the Scientific Committee has established a Task Team for the species and the team of experts will meet in person and discuss how to go forward.

RP26 GUIANA DOLPHIN PRE-ASSESSMENT (*SOTALIA GUIANENSIS*)

An intersessional workshop will assess the geographic extent of Guiana dolphin threats and conservation measures needed in both national and international contexts. The outcomes of the workshop shall include: (1) a Comprehensive Assessment of the status of Guiana dolphins; (2) recommendations to potentially improve management actions and the monitoring efforts associated with the current conservation plans of actions; and (3) a consolidated report to be presented to the SC at next year's meeting for review.

RP27 MODELLING WHALE WATCHING IMPACTS (MAWI)

There is little research on the potential mid- and long-term impacts of whale watching on cetacean populations. This is due to the complexity of the required modelling approaches, lack of clarity regarding the data needed to inform them, and the need to identify locations suitable for data collection. Without addressing these issues understanding the potential mid- and long-term impacts of whale watching is not possible. The workshop will bring together modellers and field researchers to achieve the following outcomes: (1) identify existing modelling approaches that could be used to understand the potential mid- and long-term impacts of whale watching, and determine whether new approaches are required; (2) determine which data currently being collected are suitable for answering questions regarding the mid- and long-term impacts of whale watching, and what new data are required; and (3) determine the feasibility of data collection, and identify locations where this has already been done or could be achieved.

27.2.3 Modelling/computing

RP20 ASSESSMENT MODELING FOR AN IN-DEPTH ASSESSMENT-NORTH PACIFIC SEI WHALES

The IA sub-committee is currently conducting a Comprehensive Assessment for North Pacific sei whales. This involves evaluating the status of a population using a population dynamics model that is specific to the biological parameters and movement behaviour of that particular population and is fitted to monitoring data. During the intersessional periods after the 2018 SC meeting and possibly also after 2019 SC meeting, it is expected that population dynamics models will be finalised and run using the existing data. This will result in an assessment of the status of the population.

RP22 DEVELOP AN AGE-STRUCTURED EMULATOR FOR THE INDIVIDUAL-BASED ENERGETICS MODEL (IBEM)

An IBEM provides an alternative population dynamics model to the usual cohort models, particularly because density dependence in births, growth and age-specific mortality are emergent properties of a species in a given environment (which can be stochastic). The IBEM is computationally infeasible for conducting *IST*s; the proposal is to develop a computationally efficient cohort model (emulator) which uses demographic parameters and their covariances generated using the IBEM.

RP23 ESSENTIAL COMPUTING SUPPORT TO THE SECRETARIAT

Regular *Implementation Reviews* are required under the RMP and AWMP. Computing support is alos required for Comprehensive and in-depth assessments. The Committee is currently about to undertake an *Implementation Review* for the North Pacific common minke whales, and more will follow. The Committee has developed a complex trials structure for *Implementation Reviews*. A key task in this process is to develop and validate the code for the simulation trials that are the core component of this process. Experience has shown that the Secretariat staff alone cannot handle this complete process themselves, so computing support is needed.

RP36 SIMULATING LINE TRANSECT DATA TO INVESTIGATE ROBUSTNESS OF NOVEL ANALYSIS METHODS

The IWC SC has already invested time and money in developing simulated line transect data to evaluate the robustness of the Norwegian minke whale and Antarctic minke whale survey data. This project will update the old code for the simulator to make it more user-friendly so that it can be made available to all SC members and to produce some standard data sets in accordance to the specifications of the ASI sub-committee.

27.2.4 Databases/catalogues

RP01 IWC-POWER CRUISE

The Committee has strongly advocated the development of an international medium- to long-term research programme involving sighting surveys to provide information for assessment, conservation and management of cetaceans in the North Pacific, including areas that have not been surveyed for decades. This is one of the most important international collaborations undertaken by the IWC and the cost to the IWC is minimal given the generous contribution of a vessel by Japan and acoustic equipment by the USA . Committee objectives have been developed for the overall plan and requested funding will allow for the continuing work of the initial phase and progress on developing the medium-term phase. The IWC contribution is for: (1) IWC researchers and equipment; (2) to allow the Committee's Technical Advisory Group to meet to review the multi-year results thus far and develop the plans for the next phase of POWER based on the results obtained from Phase I; and (3) to enable analyses to be completed prior to the 2020 Annual Meeting.

RP11 ABUNDANCE ESTIMATES OF THE FRANCISCANA DOLPHIN IN BUENOS AIRES PROVINCE, ARGENTINA

Abundance estimates of franciscanas will be based on a series of aerial surveys along the coast of Buenos Aires Province, with the same survey design of surveys carried out in 2003 and 2004 (Crespo *et al*., 2010). The new estimate will allow comparing density values with those obtained in the previous surveys. This item represents only one third of the funds required for the project, with the remainder being provided by the Government of Argentina.

RP09 GULF OF PENAS, SOUTHERN RIGHT WHALES

Eastern South Pacific (ESP) Southern right whales (SRW) are classified as critically endangered as there are no more than 50 SRW in this population and there is no information on the ESP SRW breeding and feeding grounds. Gulf of Penas is one of the most remote and exposed areas in Chile, with limited access and wild weather that have prevented its exploration. The largest baleen whale mass mortality of almost 400 sei whales occurred in this area and almost remained unnoticed. Recently, a local living nearby the Gulf of Penas recorded the presence of SRWs, including several calves. The Gulf might be the unknown breeding ground of the ESP SRW. This area will be explored during the austral winter breeding season with a group of researchers and government officers to confirm this finding and if so, start immediately working towards the protection and management of the species and the area.

RP10 POPULATION DYNAMICS OF SOUTHERN RIGHT WHALES AT PENÍNSULA VALDÉS, ARGENTINA: THE INFLUENCE OF KELP GULL LESIONS ON THE HEALTH, CHANGES IN INCREASE AND MORTALITY RATES IN THE CONTEXT OF A DENSITY-DEPENDENT PROCESS

The recent mortality of southern right whales at Península Valdés, Argentina is the highest ever recorded for the species. Understanding the causes is critical to propose management and mitigation actions. Preliminary results from glucocorticoids in baleen from stranded calves show that stress from injuries due to Kelp Gull attacks negatively affects their physiological homeostasis, potentially leading to death. Also, aerial counts show an important reduction in population rate of increase as a whole (from 7% in the past to 0.5% at present), and changes in distribution (mainly of adults) and density along the Argentinian coast.

RP12 PASSIVE ACOUSTIC MONITORING OF THE EASTERN SOUTH PACIFIC SOUTHERN RIGHT WHALE

The Eastern South Pacific southern right whale population is Critically Endangered and in 2012 the IWC adopted a Conservation Management Plan (CMP). Over the years, few opportunistic sightings have been recorded and no breeding area has yet been identified. Until a breeding ground is found many CMP priority actions cannot be implemented. Thus, in 2016 the IWC Scientific Committee decided to support this passive acoustic monitoring (PAM) project to facilitate the identification of potential breeding areas along the coast of Chile and Peru. This project seeks to obtain temporal coverage over a complete annual cycle and spatial coverage depending on the number of sites. The PAM project is likely the most cost-effective way to investigate the seasonal and temporal distribution of southern right whales along the coast of Chile and Peru. The information will be crucial to identify aggregation areas and facilitate the implementation of CMP for this population.

RP13 SAMPLE THE HOLOTYPE SPECIMEN OF *MEGAPTERA INDICA* (GERVAIS, 1883) AT THE MUSÉUM NATIONAL D'HISTOIRE NATURELLE (PARIS)

Several lines of evidence suggest that humpback whales in the Arabian Sea/Northern Indian Ocean comprise a discrete, isolated and non-migratory population that merits a taxonomic revision. Genetic analyses of available samples are now underway in order to determine whether sub-species/species designation is merited. The resultant nomenclature will necessarily draw on a description of the type specimen of *Megaptera indica*, which is held at the Muséum National d'Histoire Naturelle in Paris. This work will develop an approach for examining and sampling this specimen so that the taxonomy of Arabian Sea humpback whales can be accurately defined, better informing regional conservation efforts, highly relevant to the IWC's stated interest in the establishment of a Conservation Management Plan for Arabian Sea humpback whales.

RP14 ASSESSING ISOLATION OF THE ARABIAN SEA HUMPBACK WHALE POPULATION AND CONTINUITY ACROSS THE ARABIAN SEA THROUGH GEOGRAPHIC VARIATION IN SONG

A study of geographic variation in humpback whale song indicates that the Arabian Sea song from Oman is distinct from the Southwest Indian Ocean (SWIO) song, and evidence from a small Indian sample suggesting continuity in song between the western and eastern Arabian Sea. This work will be followed up on with a detailed comparison of song across the Arabian Sea and continued assessment of song differences with the SWIO: The project will (1) assess the connectivity of Arabian Sea humpback whales from Oman to India by comparing existing samples of song between the two regions from several different years; and (2) assess and re-examine the differences in song exhibited between Oman and the SWIO with more recent data, particularly in light of evidence that SWIO singers were found off Oman during the Boreal summer of 2012.

RP15 A QUANTITATIVE ASSESSMENT OF THREATS TO ARABIAN SEA HUMPBACK WHALES USING EXISTING PHOTOGRAPHIC AND UAV DATA

The research will assess the prevalence of anthropogenic and natural threats to Arabian Sea humpback whales through a robust and quantitative assessment of available photographic data. These data include the entire Oman photo-ID catalogue, imagery recently acquired using UAVs (drones) and images provided by third parties. The latter include several images from elsewhere in the populations range. The project will provide an assessment of the relative prevalence of a suite of indices typically associated with major threats (fisheries entanglements, ship-strikes, other scars) as well as scars associated with natural sources (barnacles, cyamids, Penella sp., killer whales). Project outcomes will include assessment of the risks posed by each threat, as well as the development of a set of metrics with which further changes can be monitored. Project results will be reported to the IWC SC in 2019 and will contribute to the development of a draft Conservation Management Plan for this population.

RP24 COLLABORATIVE ANALYSIS OF WNP MINKE WHALE STOCK STRUCTURE USING JAPANESE MICROSATELLITE DNA DATABASE AND SPATIALLY EXPLICIT POPULATION STRUCTURE ANALYSES.

This item will help address the recommended 'analysis 2' from the report of the workshop on Western North Pacific common minke whale stock structure (SC/67b/Rep05) in support of the next intersessional meeting on WNP common minke whale stock structure. This specific aspect of the work will apply spatially explicit population structure analyses that provide greater power than the program STRUCTURE together with geographic context. The data will be analysed as a total dataset (not based on any assignment in STRUCTURE), but also include temporal subdivision to assess possible seasonal changes in patterns of connectivity. The latter aspect may be critical to understanding the true pattern of structure, but it will also be the most time-consuming, requiring extensive replication of the analyses. The results of these analyses will provide an assessment of structure in the context of biogeography using methods that have considerably more power than the program STRUCTURE and using an approach that will consider temporal patterns of movement.

RP28 UPDATED CATCH SERIES AND ASSESSMENTS OF FOUR PYGMY BLUE WHALE POPULATIONS

The SH sub-committee is conducting in-depth assessments of populations of Southern Hemisphere blue whales. Assessments have previously been conducted for two of the six populations (Antarctic blue whales, and Chilean blue whales), but not for the four pygmy blue whale populations addressed by this research. This project will provide crucial catch separation data and associated uncertainty needed to conduct stock assessments and provide the first stock assessments for each of the four populations. Such data are critical inputs for the assessments planned by the SC.

RP30 MULTI-OCEAN ANALYSIS OF SOUTHERN RIGHT WHALE DEMOGRAPHIC PARAMETERS AND ENVIRONMENTAL CORRELATES

This study aims to compare population demographics of southern right whales in Southern Hemisphere wintering grounds and investigate correlations between reproductive success and abundance trends, and environmental variables. This study is a component of the proposed SORP project - The right sentinel for climate change: linking foraging ground variability to population recovery in the southern right whale.

RP 31 ANALYSIS OF FIN WHALE SONG VARIABILITY ACROSS SOUTHERN HEMISPHERE

Fin whale songs consist of short pulses repeated at regular interpulse intervals (IPIs). These songs have been suggested as a tool to distinguish populations. Features that have be used for fin whale song separation include: spectral structure of individual pulses; their patterning; the IPIs; and presence of a higher frequency component of the pulses. Based on this higher frequency component, there appear to be two fin whale song types in the Southern Ocean. We propose to use a combination of song feature measurements to identify whether fin whale songs in the Southern Hemisphere could be indicative of population structure. Data to be used include recorders deployed in the Western Antarctic Peninsula, Weddell Sea, and Eastern Antarctica (Kerguelen and Casey) from 2014-16. Additional SH lower-latitude recordings are available in southeastern Pacific and South Indian Ocean. Overall, the analysis will enable a comprehensive review of fin whale song variability across the SH.

RP34 PHOTO-IDENTIFICATION INFORMATION PLACARDS FOR NATURALISTS AND CITIZEN SCIENTISTS

Pre-cruise training and reference placards describing examples of photo-identification subjects (large whales) will be developed for distribution to the tourist vessel industry in the South Georgia and Antarctic Peninsula region. Information will include primary ID features used for seven species likely to be encountered; right, blue, sei, fin, humpback, sperm and killer whales (key species). A Powerpoint presentation will be developed for distribution to naturalists working on tourist vessels, to orient them and their clients to the basics of whale identification photography. Minimal training is required for a considerable improvement to the quality of identification photographs that are collected by naturalists and citizen scientists and ultimately provided to the established photo-ID catalogues from the region. A formal collaboration with the global photo-ID platform, HappyWhale will be established.

RP07 IWC STRANDINGS INITIATIVE – EMERGENCY RESPONSE AND INVESTIGATIONS

Over the next two years, the Emergency Response and Investigations fund will support response, collection of data to determine the cause(s) or contributing factors for the event and/or to fill critical data gaps identified by the SC or Commission. The Initiative will be evaluated annually and policies and procedures adapted according to feedback from responses and through Steering Group/Expert Panel advice.

27.2.5 Databases and catalogues

RP18 SHIP STRIKE DATABASE COORDINATOR

The ongoing development of the IWC ship strike database requires data gathering, communication with potential data providers and data/database management. This project will provide support for expanding and maintaining the database.

RP33 ANTARCTIC BLUE WHALE CATALOGUE: COMPARISON OF NEW PHOTOGRAPHS FROM 2014-2020

In year one (2019) this project will compare the identification photographs of an estimated 45 individual Antarctic blue whales collected during ICR cruises 2014-17, to the Antarctic Blue Whale Catalogue. These identifications would increase the size of the catalogue (458 individuals) by almost 10%. In year two (2020) additional photos representing approximately 12 IDs are expected from collaborating scientists and citizen scientists that will be compared to the catalogue. The expected outcome is an expanded dataset that may improve estimates of population abundance and reveal new information on movement patterns.

RP32 SOUTHERN HEMISPHERE BLUE WHALE PHOTO CATALOGUE

The Southern Hemisphere Blue Whale Catalogue (SHBWC) is an international collaborative effort to facilitate cross-regional comparison of blue whale photo-identifications catalogues. To date more than 1,500 individual blue whales have been contributed to the SHBWC from researchers groups working on areas off Antarctica, Chile, Peru, Ecuador-Galapagos, Eastern Tropical Pacific, Australia, Timor Leste, New Zealand, Madagascar and Sri Lanka. Therefore, the SHBWC has become the largest repository of Southern Hemisphere blue whale photo-identifications. Results of comparisons among different regions will improve the understanding of basic questions relating to blue whale populations in the Southern Hemisphere such as defining population boundaries, migratory routes, visual health assessments, and to model abundance estimates. The results will contribute primarily to the IWC Southern Hemisphere blue whale assessments.

RP38 DATABASE MANAGEMENT

The IWC Secretariat hosts several databases for the SC. These have annual service costs associated with them including, web/database servers, storage, backups, software licences and other associated infrastructure or costs.

27.5.6 Reports

RP03 MERCURY IN CETACEANS: BIOGEOCHEMICAL CYCLING, TOXICOLOGICAL IMPACTS

In response to the Commission resolution on mercury, the objective of the work is to comple the global review of mercury in cetaceans, resulting in the documentation and mapping of decadal trends. The Scientific Committee will also invite experts in mercury in the environment and its cycling and in mercury and selenium cetacean toxicology to participate to provide further detail and interpretation of the current status and potential impact of mercury on cetacean populations at an ocean basin scale.

RP04 PRODUCTION OF ANNUAL STATE OF THE CETACEAN ENVIRONMENT REPORT (SOCER) FOR THE SCIENTIFIC COMMITTEE AND COMMISSION (2019 AND 2020)

SOCER is a long-standing effort to provide information to Commissioners and Committee members on key current global developments that are affecting the cetacean environment. Focus will be on the Atlantic Ocean (2019) and the Pacific Ocean (2020). It will, in both years, also present key current global developments that are affecting the cetacean environment. It will also contain a glossary of technical terms used and species names. A 5-year compendium spanning all regions is also being produced.

RP02 AMENDMENT OF THE RMP GUIDELINES TO INCORPORATE SPATIAL MODELLING APPROACHES TO ESTIMATE ABUNDANCE

The 'Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme', referred to as the 'RMP Guidelines' (IWC, 2012) constitutes a document prepared by the Scientific Committee to state the requirements and to guide the collection and analysis of survey data to compute abundance estimates for use in the Revised Management Procedure (RMP). Currently this document provides detailed guidance for developing estimates using design-based line transect shipboard and aerial surveys. Amendments are required to consider other methods, for example, model-based analysis of survey data and mark-recapture models. This project will update the RMP Guidelines as required by the Scientific Committee. This update will be completed in consultation with the project's steering committee and presented for consideration of the SC by SC68b. The expected outcome is a new, revised document of with the 'RMP Guidelines'.

27.5.7 General items

***IMPLEMENTATION*: RESOLUTIONS AND INSTRUCTIONS FROM COMMISSION & FOLLOW UP FROM PREVIOUS YEARS' RECOMMENDATIONS**

This line is required to accommodate additional work requested by the Commission at IWC67 and work generated by meetings, workshops and projects funded and concluded in the first year (2019). This line can also accommodate new project proposals generated during the 2019 Scientific Committee meeting.

28. WORKING METHODS OF THE COMMITTEE

28.1 Rules of Procedure of the Scientific Committee

Attention: C, S

As per usual practice in the last biennium the Committee has been reviewing its working methods to improve transparency and align its processes with the biennial pace of the Commission. These changes and a number of changes that were made in previous years and approved by the Commission (i.e. SORP Voluntary Fund, new process to allocate and manage the Research Fund and the Small Cetacean Voluntary Fund Rules of Procedure) require a number of adjustments and additions to the Commission Rules of Procedure, Financial Regulations and Scientific Committee Rules of Procedure. The Committee ***agrees*** *to submit all proposed amendments to the Commission for its consideration (Annex W).*

The updated Rules also refer to the online 'Scientific Committee Handbook' that has been updated at this meeting. The Committee ***requests*** *the Secretariat to post the updated version online as soon as feasible. The Committee also* ***agrees*** *to that a pdf version of the Handbook be made available as a document for the Commission meeting.*

28.2 Biennial reporting and related matters

At its 2015 meeting, the Joint Conservation Committee and Scientific Committee Working Group (Joint CC/SC WG) agreed to undertake a collation and analysis of conservation-relevant recommendations from the Scientific Committee and organise these recommendations into key issues/areas highlighting those that feature regularly, including the creation of a pilot database. Double, Convenor of the Global Databases and Repositories Steering Group (GDR), presented an update on the development of this database. The Scientific Committee is fully engaged in this process and, this year, a standing agenda item was added to all sub-committee agendas to ensure a regular, more formal review of progress in delivering recommendations than was the case in the past.

Attention: SC, CC

The Committee ***welcomes*** *the development of the IWC Database of Recommendations, noting that this tool will give recommendations more prominence and improve the ability to measure progress. The Committee* ***agrees*** *to:*

(1) continue to improve its standardised way to present recommendations to include core information[13] to facilitate input into the database; and
(2) to work closely with the Secretariat to assist with the overall process of data entry.

28.3 Additional proposals for revisions to 'Annex P'

The Committee continued this year the work begun last year to update Annex P in response to Commission Resolution 2016-2 and recommendations by previous Expert Panels.

Attention: C-R, SC,

The Committee ***recommends*** *the revisions to the previous Annex P reported in Annex P in response to Resolution 2016-2 and recommendations made by Expert.*

[13] IWC/MAY18/CCSC/01

28.4 Succession plan for key Scientific Committee experts

Last year, the Committee had identified the need to consider 'succession planning' for key participants, particularly in relation to the *Implementation Reviews* and assessment processes. Informal discussions continued informally during the intersessional period and invitations were issued to three modellers to evaluate their interest in becoming active members of the IWC Scientific Committee, but only one could attend. Concern regarding succession planning of these other key positions on the Committee still remains and an intersessional group has been re-established to look at this and report back to the Committee next year (Annex Y).

The Committee also refers to its discussion related to a Deputy Head of Science in its review if the governance report (see Item 28.6.2).

28.5 Update on Data Availability requests

Suydam provided a summary of requests received under the Data Availability Agreement shown in Table 34.

Table 34

Summary of requests under the Data Availability Agreement.

Date	Requested by	Objective/Subject	Outcome
June 2015	de la Mare Australia) – Procedure B	(a) Consistent with recent advice of the Scientific Committee with particular respect to minke whale nutritive condition analyses, to develop a set of models that best capture the Committee's previous recommendations, taking into account the structure of the underlying processes giving rise to the data; and (b)To provide analyses relevant to the determination of sample sizes for detecting specified trends in the age at sexual maturity (ASM).	SC/66B/EM/02, SC/67A/EM/01, SC/67A/EM/02, SC/67A/EM/03, SC/67A/EM/04, SC/67A/EM/07, SC/67A/EM/08, SC/67B/EM/01 Rev1, SC/67B/EM/02, SC/67B/EM/03, SC/67B/EM/08, See EM Annexes, 2016 to 2018. Differing results between research groups about changes in body condition of Antarctic minke whales
January 2018	Baker (USA	The intent of the request is to examine plausible stock hypotheses. Analyses will rely primarily on tests of Hardy-Weinberg expectations, exact tests of differentiation, randomized Chi-squared tests (contingency tables), Analyses of Molecular Variance (AMOVA), as well as mixed-stock analyses, clustering methods and kinship (parent offspring pairs), to investigate dispersal and differences in haplotype frequencies, genotypes and sex for various geographic and temporal strata.	On-going

28.6 Any other matters

28.6.1 Welfare Assessment Tool

Since our last discussion in 2015 on animal welfare related matters relevant to the Committee (IWC, 2016, p.86), Dr. Nicol (Professor of the Royal Veterinary College, London) developed a 'Welfare Assessment Tool' following the recommendations of the Workshop to 'Develop Practical Guidance for the Handling of Cetacean Stranding Events' (South Africa, 2016) on this matter. This year, the Committee received a report from Nicol on the latest phase of the development of such a tool, that is being developed to help assess non-hunting related threats in the context of the IWC's Welfare Action Plan and in a joint project between the RVC and Humane Society International, supported by the UK Department for Environment, Food and Rural Affairs (Defra). The approach is based on application of the 'five domains model' (Beausoleil and Mellor, 2015; Mellor *et al*., 2015) and two hypothetical case studies have been explored, one related to marine debris and the other to whale-watching.

Trial assessments were presented and the Scientific Committee was asked for assistance and advice in the development of real examples for consideration. The Committee welcomed the information provided and further discussions were held informally. The Tool was also considered by the Whale Watching Subcommittee (see Annex N) and will be presented for consideration by the Commission at the next meeting of the Working Group on Whale Killing Methods and Associated Welfare Issues.

28.6.2 Review of the IWC review report

The final report from the Governance Review was released on the 16th April 2018 (downloadable here: https://archive.iwc.int/?r=6890). The Independent Review Panel report represents the view of the three panellists, based on a survey, in-person interviews and analysis of documents. It represents only the first step of the Governance Review process. The Chair of the Operational Effectiveness Working Group of the Finance and Administration Committee asked the Scientific Committee to provide a voluntary feedback to the Commission on recommendations related to the Committee.

The Scientific Committee formed an *ad hoc* Working Group to develop an initial response, which was then discussed in Plenary. The initial WG membership was restricted to the Scientific Committee Chair and Vice Chair, all Heads of Delegations present at the meeting, sub-groups Convenors that are also delegates, and former Scientific Committee Chair present at the meeting. This subset represented the view of Committee members that, given their roles, had a strong knowledge on the current and past structure and procedures of the Committee. More delegates and invited participants joined the discussion in Plenary. The final version of this preliminary feedback, which has the support of all 32 delegations attending the meeting and additional members of the Scientific Committee is provided in Annex X.

The Scientific Committee organised its discussion and feedback on Review Panel's recommendations and comments around five mutually exclusive subject areas (pre-eminence of the Scientific Committee, IWC strategic planning, communication, Scientific Committee function in relation to Commission and other subsidiary bodies, Secretariat function in relation to the Scientific Committee). Within each subject area, those recommendations of perceived importance to the WG were identified. Where feasible, a timeline for developing a response was proposed.

Attention: C, SC

Given the fact that both the Chair of the Commission (Morishita) and the Chair of the F&A Working Group on Operational Effectiveness (Phelps) reminded the Committee that the Commission has not yet decided the fate of the 'IWC review report', nor has yet requested a full engagement by the Committee, the Committee ***agrees*** *to submit the preliminary feedback on the report (Annex X) for the Commission's consideration.*

In addition, given the productive exchange of opinions and ideas on several aspects of the Committee working methods that occurred in during its discussions, the Committee ***agrees*** *to establish an Intersessional Correspondence Group on 'Improving on-going working practices of the IWC Scientific Committee' under DeMaster (see Annex Y). The ICG will provide a written summary of its proposals to the Scientific Committee 60 days prior to the start of the annual meeting of the Scientific Committee in 2019. This ICG will also be in charge dealing with the preparation of a draft document for the follow-up on Governance Review, should the Commission instruct the Committee to do so at its next biennial meeting.*

28.6.3 Additional discussion on other issue related to the Committee working procedures

A number of suggestion for improving the ability to follow a topic during the Scientific Committee meeting were discussed by the Committee and the Convenors group. In order to facilitate the full participation of members of the Committee to various sub-groups and, especially, to the discussion of cross-cutting issues relevant to different groups, the Committee **agrees** that next years the Convenors should: (a) organise joint-sessions early in the meeting and release draft reports of those discussion, as soon as feasible; (b) adopt a simple coding system for 'hot topics' (e.g. North Pacific common minke whales: NPMW, Antarctic minke whales: AMW; biopsy sampling; etc.), which will be included in the daily timetable together or instead of the Agenda item. The Convenors group will carefully consider these issues intersessionally.

29. PUBLICATIONS

The Secretariat reported on the excellent progress made with the *Journal* this year, and in particular that the previously noted backlog has now been dealt with. This has been particularly assisted by the excellent work of the new Associate Editors including Fortuna, Leaper, New, Jackson, Punt, Tiedemann, Zerbini. The Committee **thanked** the Publications Team for its dedication and hard work and **reiterated** the importance of the *Journal* and *Supplements* to its work.

30. ELECTION OF OFFICERS

This was the final year of office for the Chair (Fortuna) and the Vice-Chair (Suydam). In accordance with its Rules of Procedure, the Vice-Chair becomes the new Chair for the next three years. The Committee elects Zerbini (Brazil) to be the new Vice-Chair by consensus. The outgoing Chair will provide the formal report to IWC67 in Florianopolis, Brazil of the SC Reports from the 67a and 67b SC meetings.

The Committee rose in appreciation to thank the outgoing Chair. It wished to formally record its immense gratitude for her excellent leadership over the past three years. Dr. Fortuna's scientific and organizational skills provided a lasting legacy to the Committee. She adeptly faced the many complex and challenging issues during her term and tremendous progress has been made for the benefit of the entire Commission in meeting its science and stewardship objectives. The Chair, Head of Science, and Executive Secretary of the Commission added their thanks and congratulations to the many participants expressing their appreciation to Dr. Fortuna.

The Committee also welcomed with enthusiasm the new team of Suydam and Zerbini and looked forward to working with them over the next three years.

31. ADOPTION OF REPORT

The Committee adopted the report at 17:45 hrs on 6 May 2018, apart from the final items discussed during the last session. As is customary, these items were agreed by the Chair, rapporteurs and convenors. The Chair thanked the participants for their scientific contributions as well as their constructive dialogue. Given the sensitivity of several agenda items, this positive approach helped ensure that all views could be presented and rigorously discussed for a productive outcome. The Chair especially thanked the convenors, rapporteurs, Head of Science, and Vice-Chair for their excellent assistance. Finally, she reiterated her thanks to the government of Slovenia and the hotel staff for the facilities and great service, which contributed greatly to the success of the meeting.

Fortuna concluded that it had been an honour to serve as the IWC Scientific Committee Chair over the past three years. She expressed her gratitude for all the support provided by so many as she led this effort. She voiced her thanks for the Secretariat, and in particular her deep appreciation for the guidance provided by the Head of Science (Donovan) without whom she could not have accomplished her work.

Suydam congratulated Fortuna for having expertly led the Scientific Committee as their Chair over the past three years. He noted that the praise and applause from the participants in the room were well very much deserved given her outstanding leadership. Suydam noted that it will be a particular challenge to follow the incredible example set by Fortuna and thanked her for her mentorship. The Executive Secretary (Lent) added to these words of gratitude and commendation on behalf of the Secretariat and wished her all the best. She also offered the full support of the Secretariat to the incoming SC Chair Suydam.

Echoing the sentiments raised under Item 30, participants thanked the Chair for her adept, fair and efficient handling of the meeting, her unflagging dedication and her great contribution to the effective working of the Committee.

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Annex P[1]

Amendments to the Schedule Adopted at the 67th Meeting

At the 67th meeting of the International Whaling Commission held in Florianopolis, Brazil from 10-14 September 2018, no modifications were made to the provision for zero catch limits for commercial whaling with effect from the 1986 coastal and 1985/86 pelagic seasons.

The following updates to the Schedule of the International Convention for the Regulation of Whaling therefore become necessary (changes in ***bold italic*** type):

For paragraphs 11 and 12, and Tables 1, 2 and 3:

> . Substitute the dates 2016/2017 pelagic season and 2017 coastal season for ***2018/2019*** pelagic season and ***2017*** season as appropriate.

Modifications were made to the provisions for aboriginal subsistence whaling at the 67th meeting of the International Whaling Commission and the following updates to the Schedule of the International Convention for the Regulation of Whaling with regards to aboriginal subsistence whaling therefore become necessary (text to be deleted is shown in ~~strikethrough~~ and text to be added is shown in **underline** **and bold**).

Other Operations

5. Each contracting Government shall declare for all whale catchers under its jurisdiction not operating in conjunction with a factory ship or land station one continuous open season~~s~~ not to exceed six months out of any period of twelve months during which the taking or killing of minke whales by such whale catchers may be permitted. Notwithstanding this paragraph one continuous open season not to exceed nine months may be implemented so far as Greenland is concerned. **This paragraph shall not apply to aboriginal subsistence whaling under paragraphs 13(b)(3)(ii) and 13(b)(3)(iii).**

Baleen Whale Catch Limits

13(a) . . .

(6) Commencing in 2026, and provided the appropriate Strike Limit Algorithm has been developed by then, strike/catch limits (including any carry forward provisions) for each stock identified in sub-paragraph 13(b) shall be extended every six years, provided: (a) the Scientific Committee advises in 2024, and every six years thereafter, that such limits will not harm that stock; (b) the Commission does not receive a request from an ASW country relying on the stock ('relevant ASW country'), for a change in the relevant catch limits based on need; and (c) the Commission determines that the relevant ASW country has complied with the approved timeline and that the information provided represents a status quo continuation of the hunt.

(7) The provisions for each stock identified in sub-paragraph 13(b), especially the provisions for carryover, shall be reviewed by the Commission in light of the advice of the Scientific Committee.

13(b) Catch limits for aboriginal subsistence whaling are as follows:

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[1] **The 90 day objection period will expire on 29 December 2018. In the absence of objections by that date the updates will become effective. Contracting Governments will be notified accordingly.**

(1) The taking of bowhead whales from the Bering-Chukchi-Beaufort Seas stock by aborigines is permitted, but only when the meat and products of such whales are to be used exclusively for local consumption by the aborigines and further provided that:

(i) For the years ~~2013, 2014, 2015, 2016, 2017 and 2018~~ **2019, 2020, 2021, 2022, 2023, 2024 and 2025**, the number of bowhead whales landed shall not exceed ~~336~~ **392**. For each of these years the number of bowhead whales struck shall not exceed 67, except that any unused portion of a strike quota from ~~any year (including 15 unused strikes from the 2008–2012 quota)~~ **the three prior quota blocks** shall be carried forward and added to the strike quotas of ~~any~~ subsequent years, provided that no more than ~~15 strikes~~ **50 percent of the annual strike limit** shall be added to the strike quota for any one year.

(ii) ~~This provision shall be reviewed annually by the Commission in light of the advice of the Scientific Committee.~~

(2) The taking of gray whales from the Eastern stock in the North Pacific is permitted, but only by aborigines or a contracting Government on behalf of aborigines, and then only when the meat and products of such whales are to be used exclusively for local consumption by the aborigines.

(i) For the years ~~2013, 2014, 2015, 2016, 2017 and 2018~~ **2019, 2020, 2021, 2022, 2023, 2024 and 2025**, the number of gray whales **landed** ~~taken in accordance with this sub-paragraph~~ shall not exceed ~~744~~ **980**, provided that the number of gray whales **struck** ~~taken~~ in any one of the years ~~2013, 2014, 2015, 2016, 2017 and 2018~~ **2019, 2020, 2021, 2022, 2023, 2024 and 2025** shall not exceed 140**, except that any unused portion of a strike quota from the prior quota block shall be carried forward and added to the strike quotas of subsequent years, provided that no more than 50 percent of the annual strike limit shall be added to the strike quota for any one year**.

(ii) ~~This provision shall be reviewed annually by the Commission in light of the advice of the Scientific Committee.~~

(3) The taking by aborigines of minke whales from the West Greenland and Central stocks **from the East Greenland hunt** and fin whales from the West Greenland stock and bowhead whales from the West Greenland feeding aggregation and humpback whales from the West Greenland feeding aggregation is permitted and then only when the meat and products are to be used exclusively for local consumption.

(i) The number of fin whales struck from the West Greenland stock ~~in accordance with this subparagraph~~ shall not exceed 19 in each of the years ~~2015, 2016, 2017 and 2018~~ **2019, 2020, 2021, 2022, 2023, 2024 and 2025, except that any unused portion of a strike quota from the prior quota block under a Strike Limit Algorithm management advice shall be carried forward and added to the strike quotas of subsequent years, provided that no more than 50 percent of the annual strike limit shall be added to the strike quota for any one year**.

(ii) The number of minke whales struck from the Central stock ~~in accordance with this sub-paragraph~~ shall not exceed ~~12~~ **20** in each of the years ~~2015, 2016, 2017 and 2018~~ **2019, 2020, 2021, 2022, 2023, 2024 and 2025**, except that any unused portion of ~~the~~ **a** strike quota ~~for each year~~ shall be carried forward ~~from that year~~ and added to the **strike** quota**s** of ~~any~~ subsequent years, provided that no more than 3 **strikes** shall be added to the **strike** quota for any one year. **Commencing in 2020, and provided a Strike Limit Algorithm for this stock has been developed by then, any unused portion of a strike quota from the prior quota block under a Strike Limit Algorithm management advice shall be carried forward and added to the strike quotas of subsequent years, provided that no more than 50 percent of the annual strike limit shall be added to the strike quota for any one year.**

(iii) The number of minke whales struck from the West Greenland stock shall not exceed 164 in each of the years ~~2015, 2016, 2017 and 2018~~ **2019, 2020, 2021, 2022, 2023, 2024 and 2025**, except that any unused portion of ~~the~~ **a strike** quota ~~for each year~~ **from the prior quota block under a**

Strike Limit Algorithm management advice shall be carried forward ~~from that year~~ and added to the strike quota**s** of ~~any of the~~ subsequent years, provided that no more than ~~15 strikes~~ **50 percent of the annual strike limit** shall be added to the strike quota for any one year. ~~This provision will be reviewed if new scientific data become available within the 4 year period and if necessary amended on basis of the advice of the Scientific Committee.~~

(iv) The number of bowhead whales struck off West Greenland ~~in accordance with this sub-paragraph~~ shall not exceed 2 in each of the years ~~2015, 2016, 2017 and 2018~~ **2019, 2020, 2021, 2022, 2023, 2024 and 2025**, except that any unused portion of ~~the~~ **a strike** quota ~~for each year~~ **from the prior quota block under a Strike Limit Algorithm management advice** shall be carried forward ~~from that year~~ and added to the **strike** quota**s** of ~~any~~ subsequent years, provided that no more than ~~2 strikes~~ **50 percent of the annual strike limit** shall be added to the **strike** quota for any one year. ~~This provision will be reviewed if new scientific data become available within the 4 year period and if necessary amended on basis of the advice of the Scientific Committee.~~

(v) The number of humpback whales struck off West Greenland ~~in accordance with this sub-paragraph~~ shall not exceed 10 in each of the years ~~2015, 2016, 2017 and 2018~~ **2019, 2020, 2021, 2022, 2023, 2024 and 2025**, except that any unused portion of ~~the~~ **a strike** quota ~~for each year~~ **from the three prior quota blocks under a Strike Limit Algorithm management advice** shall be carried forward ~~from that year~~ and added to the strike quota**s** of ~~any of the~~ subsequent years, provided that no more than ~~2 strikes~~ **50 percent of the annual strike limit** shall be added to the strike quota for any one year. ~~This provision will be reviewed if new scientific data become available within the remaining quota period and if necessary amended on basis of the advice of the Scientific Committee.~~

(4) For the seasons ~~2013-2018~~ **2019-2025** the number of humpback whales to be taken by the Bequians of St. Vincent and The Grenadines shall not exceed ~~24~~ **28**. The meat and products of such whales are to be used exclusively for local consumption in St. Vincent and The Grenadines.

Baleen Whale Size Limits

15(b) It is forbidden to take or kill any fin whales below 57 feet (17.4 metres) in length in the Southern Hemisphere, and it is forbidden to take or kill fin whales below 55 feet (16.8 metres) in the Northern Hemisphere; except that fin whales of not less than 55 feet (16.8 metres) may be taken in the Southern Hemisphere for delivery to land stations and fin whales of not less than 50 feet (15.2 metres) may be taken in the Northern Hemisphere for delivery to land stations, provided that, in each case the meat of such whales is to be used for local consumption as human or animal food. **This paragraph shall not apply to aboriginal subsistence whaling under paragraph 13(b)(3)(i).**

PROPOSAL FOR A SCHEDULE AMENDMENT ON ABORIGINAL SUBSISTENCE WHALING

(SUBMITTED BY THE KINGDOM OF DENMARK, RUSSIAN FEDERATION, ST. VINCENT AND THE GRENADINES AND THE UNITED STATES OF AMERICA)

The governments of the Kingdom of Denmark, the Russian Federation, Saint Vincent and the Grenadines and the United States of America jointly submit this amendment to the Schedule to enable our respective indigenous peoples to continue meeting their aboriginal subsistence needs. As further detailed in the accompanying **EXPLANATORY NOTE**, the proposal includes the following elements:

- Updated carryover provisions related to the Aboriginal Whaling Scheme
- One-time 7-year extension through 2025
- Limited automatic renewal with safeguards to protect whale stocks
- Minor technical adjustments to Schedule paragraphs 5 and 15(b), which were originally intended to apply to commercial hunts
- Increased annual strike limit for common minke whales off East Greenland in order to satisfy ASW need
- Increased annual strike limit for Eastern North Pacific gray whales in order to address the "stinky" whale problem and to satisfy ASW need
- Technical adjustment to Schedule paragraph 13(a) to include an overarching provision for Commission review of catch/strike limits in light of the advice of the Scientific Committee

This amendment is being circulated in accord with: (1) advice from the 2018 Scientific Committee meeting; (2) Rules of Procedure J.1 and J.4; and (3) the pilot timeline for submission of Aboriginal Subsistence Whaling Schedule amendments to IWC67. The co-sponsors welcome comments from Contracting Governments.

Text proposed to be deleted is shown in ~~strikethrough~~ and text proposed to be added is shown in **underline and bold**.

PROPOSED SCHEDULE AMENDMENT

Other Operations

5. Each contracting Government shall declare for all whale catchers under its jurisdiction not operating in conjunction with a factory ship or land station one continuous open season~~s~~ not to exceed six months out of any period of twelve months during which the taking or killing of minke whales by such whale catchers may be permitted. Notwithstanding this paragraph one continuous open season not to exceed nine months may be implemented so far as Greenland is concerned. **This paragraph shall not apply to aboriginal subsistence whaling under paragraphs 13(b)(3)(ii) and 13(b)(3)(iii).**

Baleen Whale Catch Limits

13(a) . . .

(6) Commencing in 2026, and provided the appropriate Strike Limit Algorithm has been developed by then, strike/catch limits (including any carry forward provisions) for each stock identified in sub-paragraph 13(b) shall be extended every six years, provided: (a) the Scientific Committee advises in 2024, and every six years thereafter, that such limits will not harm that stock; (b) the Commission does not receive a request from an ASW country relying on the stock ('relevant ASW country'), for a change in the relevant catch limits based on need; and (c) the Commission determines that the relevant ASW country has complied with the approved timeline and that the information provided represents a status quo continuation of the hunt.

(7) The provisions for each stock identified in sub-paragraph 13(b), especially the provisions for carryover, shall be reviewed by the Commission in light of the advice of the Scientific Committee.

13(b) Catch limits for aboriginal subsistence whaling are as follows:

(1) The taking of bowhead whales from the Bering-Chukchi-Beaufort Seas stock by aborigines is permitted, but only when the meat and products of such whales are to be used exclusively for local consumption by the aborigines and further provided that:

(i) For the years ~~2013, 2014, 2015, 2016, 2017 and 2018~~ **2019, 2020, 2021, 2022, 2023, 2024 and 2025**, the number of bowhead whales landed shall not exceed ~~336~~ **392**. For each of these years the number of bowhead whales struck shall not exceed 67, except that any unused portion of a strike quota from ~~any year (including 15 unused strikes from the 2008- 2012 quota)~~ **the three prior quota blocks** shall be carried forward and added to the strike quotas of ~~any~~ subsequent years, provided that no more than ~~15 strikes~~ **50 percent of the annual strike limit** shall be added to the strike quota for any one year.

(ii) ~~This provision shall be reviewed annually by the Commission in light of the advice of the Scientific Committee.~~

(2) The taking of gray whales from the Eastern stock in the North Pacific is permitted, but only by aborigines or a contracting Government on behalf of aborigines, and then only when the meat and products of such whales are to be used exclusively for local consumption by the aborigines.

(i) For the years ~~2013, 2014, 2015, 2016, 2017 and 2018~~ **2019, 2020, 2021, 2022, 2023, 2024 and 2025**, the number of gray whales **landed** ~~taken~~ ~~in accordance with this sub-paragraph~~ shall not exceed ~~744~~ **980**, provided that the number of gray whales **struck** ~~taken~~ in any one of the years ~~2013, 2014, 2015, 2016, 2017 and 2018~~ **2019, 2020, 2021, 2022, 2023, 2024 and 2025** shall not exceed 140**, except that any unused portion of a strike quota from the prior quota block shall be carried forward and added to the strike quotas of subsequent years, provided that no more than 50 percent of the annual strike limit shall be added to the strike quota for any one year**.

(ii) ~~This provision shall be reviewed annually by the Commission in light of the advice of the Scientific Committee.~~

(3) The taking by aborigines of minke whales from the West Greenland and Central stocks **from the East Greenland hunt** and fin whales from the West Greenland stock and bowhead whales from the West Greenland feeding aggregation and humpback whales from the West Greenland feeding aggregation is permitted and then only when the meat and products are to be used exclusively for local consumption.

(i) The number of fin whales struck from the West Greenland stock ~~in accordance with this subparagraph~~ shall not exceed 19 in each of the years ~~2015, 2016, 2017 and 2018~~ **2019, 2020, 2021, 2022,**

2023, 2024 and 2025, except that any unused portion of a strike quota from the prior quota block under a Strike Limit Algorithm management advice shall be carried forward and added to the strike quotas of subsequent years, provided that no more than 50 percent of the annual strike limit shall be added to the strike quota for any one year.

(ii) The number of minke whales struck from the Central stock ~~in accordance with this sub-paragraph~~ shall not exceed ~~12~~ **20** in each of the years ~~2015, 2016, 2017 and 2018~~ **2019, 2020, 2021, 2022, 2023, 2024 and 2025**, except that any unused portion of ~~the~~ **a** strike quota ~~for each year~~ shall be carried forward ~~from that year~~ and added to the **strike** quota**s** of ~~any~~ subsequent years, provided that no more than 3 **strikes** shall be added to the **strike** quota for any one year. **Commencing in 2020, and provided a Strike Limit Algorithm for this stock has been developed by then, any unused portion of a strike quota from the prior quota block under a Strike Limit Algorithm management advice shall be carried forward and added to the strike quotas of subsequent years, provided that no more than 50 percent of the annual strike limit shall be added to the strike quota for any one year.**

(iii) The number of minke whales struck from the West Greenland stock shall not exceed 164 in each of the years ~~2015, 2016, 2017 and 2018~~ **2019, 2020, 2021, 2022, 2023, 2024 and 2025**, except that any unused portion of ~~the~~ **a strike** quota ~~for each year~~ **from the prior quota block under a Strike Limit Algorithm management advice** shall be carried forward ~~from that year~~ and added to the strike quota**s** of ~~any of the~~ subsequent years, provided that no more than ~~15 strikes~~ **50 percent of the annual strike limit** shall be added to the strike quota for any one year. ~~This provision will be reviewed if new scientific data become available within the 4 year period and if necessary amended on basis of the advice of the Scientific Committee.~~

(iv) The number of bowhead whales struck off West Greenland ~~in accordance with this sub-paragraph~~ shall not exceed 2 in each of the years ~~2015, 2016, 2017 and 2018~~ **2019, 2020, 2021, 2022, 2023, 2024 and 2025**, except that any unused portion of ~~the~~ **a strike** quota ~~for each year~~ **from the prior quota block under a Strike Limit Algorithm management advice** shall be carried forward ~~from that year~~ and added to the **strike** quota**s** of ~~any~~ subsequent years, provided that no more than ~~2 strikes~~ **50 percent of the annual strike limit** shall be added to the **strike** quota for any one year. ~~This provision will be reviewed if new scientific data become available within the 4 year period and if necessary amended on basis of the advice of the Scientific Committee.~~

(v) The number of humpback whales struck off West Greenland ~~in accordance with this sub-paragraph~~ shall not exceed 10 in each of the years ~~2015, 2016, 2017 and 2018~~ **2019, 2020, 2021, 2022, 2023, 2024 and 2025**, except that any unused portion of ~~the~~ **a strike** quota ~~for each year~~ **from the three prior quota blocks under a Strike Limit Algorithm management advice** shall be carried forward ~~from that year~~ and added to the strike quota**s** of ~~any of the~~ subsequent years, provided that no more than ~~2 strikes~~ **50 percent of the annual strike limit** shall be added to the strike quota for any one year. ~~This provision will be reviewed if new scientific data become available within the remaining quota period and if necessary amended on basis of the advice of the Scientific Committee.~~

(4) For the seasons ~~2013-2018~~ **2019-2025** the number of humpback whales to be taken by the Bequians of St. Vincent and The Grenadines shall not exceed ~~24~~ **28**. The meat and products of such whales are to be used exclusively for local consumption in St. Vincent and The Grenadines.

Baleen Whale Size Limits

15(b) It is forbidden to take or kill any fin whales below 57 feet (17.4 metres) in length in the Southern Hemisphere, and it is forbidden to take or kill fin whales below 55 feet (16.8 metres) in the Northern Hemisphere; except that fin whales of not less than 55 feet (16.8 metres) may be taken in the Southern Hemisphere for delivery to land stations and fin whales of not less than 50 feet (15.2 metres) may be taken in the Northern Hemisphere for delivery to land stations, provided that, in each case the meat of such whales is to be used for local consumption as human or animal food. **This paragraph shall not apply to aboriginal subsistence whaling under paragraph 13(b)(3)(i).**

EXPLANATORY NOTE

This explanatory note provides an overview of the proposed Schedule amendment, which is intended to:

- Update carryover provisions related to the Aboriginal Whaling Scheme (AWS) and allow for variability in environmental conditions affecting the hunts;

- Alleviate the chronic political challenges surrounding the renewal of Aboriginal Subsistence Whaling (ASW) catch limits through a one-time 7-year extension and a limited automatic renewal with safeguards to protect whale stocks;

- Adjust Schedule paragraphs 5 and 15(b), which were originally intended to apply to commercial hunts, so that they do not apply to affected ASW hunts;

- Increase the annual strike limit for common minke whales off East Greenland from 12 to 20 in order to satisfy ASW need in that area;

- Increase the annual strike limit for Eastern North Pacific gray whales in order to address the “stinky” whale problem and to satisfy ASW need; and

- Technical adjustment to Schedule paragraph 13(a) to include an overarching provision for Commission review of catch/strike limits in light of the advice of the Scientific Committee.

<u>Updated Carryover Provisions Related to the Aboriginal Whaling Scheme</u>. After nearly 20 years developing the Aboriginal Whaling Management Procedure (AWMP), completion of all the Strike Limit Algorithms (SLAs) and the Aboriginal Whaling Scheme (AWS) has remained an impediment to final acceptance of the AWMP. The AWS incorporates several components:

(a) Operational rules (generic to the extent possible) including carryover provisions, block quotas and interim relief allocations;

(b) Guidelines for *Implementation Reviews*; and

(c) Guidelines for data and analysis (e.g., guidelines for surveys, other data needs)

Carryover is the use of a limited number of previously allocated, but unused strikes in subsequent years, in order to adjust for variation in hunting conditions. In 2018, the Scientific Committee explained:

> “Carryover is a provision to enable (some) strikes not used in one year to be used in a subsequent year or years, in order to allow for the inevitable fluctuations in the success of hunts (e.g., due to environmental conditions and/or whale availability). Whilst providing flexibility, carryover does not allow hunts to take more than the total number of strikes agreed by the Commission. . . . The concept is not new, and ad hoc provisions incorporating carryover have been included in the Schedule for many [more than 30] years.”

Carryover provisions contained in Schedule paragraphs 13(b)(1) and (3) address unused strikes and how they can be used in subsequent years. At SC67b, the Scientific Committee indicated that a carryover approach should include: (a) a start date/expiration period for unused strikes so that unused strikes cannot be carried over indefinitely; and (b) limits on use of strikes in any one year.

With regard to limits on the use of strikes in any one year, the Scientific Committee reiterated its previous advice, applicable for all SLAs, that inter-annual variation of 50 percent within a block, with the same allowance from the last year of one block to the first year of the next, is acceptable. The rationale for this limitation has not changed from a scientific perspective. SLAs are robust with respect to this carryover provision, particularly since all allocated strikes are considered as taken in the testing process.

Proposed updates to the carryover provisions would address the need for management flexibility to deal with increasing variability in environmental conditions currently affecting the success of the hunts from one year to the next, within limits that conserve the whale stocks.

Given that the Scientific Committee has advised that the 50 percent carryover provision is acceptable for all SLAs, the Russian Federation and the United States propose the addition of a 50 percent carryover provision to Schedule paragraph 13(b)(2), regarding Eastern North Pacific gray whales. Likewise, the Kingdom of Denmark proposes the addition of a 50 percent carryover provision to Schedule paragraph 13(b)(3)(i), regarding fin whales from the West Greenland stock.

Also at SC67b, the Scientific Committee advised that, for the Bowhead SLA (applicable to the Bering-Chukchi-Beaufort Seas stock) and the Humpback SLA (applicable to the West Greenland feeding aggregation), provisions allowing for the carry forward of unused strikes from the previous three blocks, subject to the limitation that the number of such carryover strikes used in any year does not exceed 50 percent of the annual strike limit, has no conservation implications.

After the Scientific Committee evaluates the other Greenland SLAs in 2019, the carry forward allowance from one previous quota block would be changed, commencing in 2020, provided the Scientific Committee advises that provisions allowing for the carry forward of unused strikes from the previous three blocks, subject to the limitation that the number of such carryover strikes used in any year does not exceed 50 percent of the annual strike limit, has no conservation implications.

Unused strikes would initially be counted from the year a Strike Limit Algorithm was first used to provide management advice for a particular stock. The start date/expiration period would then follow a rolling timeline consisting of a defined number of prior quota blocks ranging from one to three depending on the evaluation of the Scientific Committee.

Hunters would still be subject to applicable block limits. Further, hunters would also continue to be subject to annual reporting requirements about hunting efficiency and infractions. The efficiency of the hunt (i.e., the number of whales landed compared to the number of whales struck) is very important to the hunters. For the Alaska Natives, hunting efficiency has increased from about 50 percent between 1973 and 1978 to an average of 75.2 percent in the last ten years (i.e., 2007-2016). In 2017, hunting efficiency was 88 percent, near the highest level recorded. Improvements reported in both the struck and lost rate and the time to death of the five different stocks hunted in Greenland is shown in the "Description of the hunt, information on recent catches."

Comparison of Current and Proposed BCB Bowhead Whale Carryover Provisions

Schedule Component	**Current**	**Proposed**
Start/Expiration dates	". . . any unused portion of a strike quota from any year (including 15 unused strikes from the 2008-2012 quota) shall be carried forward and added to the strike quotas of any subsequent years . . . "	". . . any unused portion of a strike quota from the three prior quota blocks shall be carried forward and added to the strike quotas of subsequent years . . . "

Carryover limit	"... provided that no more than 15 strikes shall be added to the strike quota for any one year."	"... provided that no more than 50 percent of the annual strike limit shall be added to the strike quota for any one year."

Note that the carryover limit would increase from 15 strikes to 50 percent, i.e., 33 strikes. The initial starting year for accumulation of unused strikes would be 2003. The Scientific Committee has advised that this increase in the carryover limit would have no conservation implications. Note also that the hunters would continue to be subject to the total block cap of landed whales, which for a six-year block is 336 landed whales and would be 392 landed whales for a seven-year block.

Comparison of Current and Proposed ENP Gray Whale Carryover Provisions

Schedule Component	Current	Proposed
Start/Expiration dates	There is no carryover provision.	"... any unused portion of a strike quota from the prior quota block shall be carried forward and added to the strike quotas of subsequent years."
Carryover limit	There is no carryover provision.	"... provided that no more than 50 percent of the annual strike limit shall be added to the strike quota for any one year."

Note that the carryover limit would 50 percent, i.e., 70 strikes. The Scientific Committee has advised that a 50 percent carryover limit would have no conservation implications. Note also that the hunters would continue to be subject to the total block cap of landed whales, which for a six-year block is 744 landed whales and would be 980 landed whales for a seven-year block.

Comparison of Current and Proposed West Greenland Fin Whale Carryover Provisions

Schedule Component	Current	Proposed

Start/Expiration dates	There is no carryover provision.	". . . any unused portion of a strike quota from the prior quota block under a Strike Limit Algorithm management advice shall be carried forward and added to the strike quotas of subsequent years …"
Carryover limit	There is no carryover provision.	". . . provided that no more than 50 percent of the annual strike limit shall be added to the strike quota for any one year."

Note that the carryover limit would be 50 percent, i.e., 9 strikes. The initial starting year for accumulation of unused strikes would be 2018. The Scientific Committee has advised that this increase in the carryover limit would have no conservation implications. Note that in the event unused strikes are available for carryover from the previous block, the block cap could be increased by up to 50 percent.

<u>Comparison of Current and Proposed East Greenland Minke Whale Carryover Provisions</u>

Schedule Component	**Current**	**Proposed**
Start/Expiration dates	". . . any unused portion of the quota for each year shall be carried forward from that year and added to the quota of any of the subsequent years . . ."	". . . any unused portion of a strike quota shall be carried forward and added to the strike quotas of subsequent years…" "…Commencing in 2020, and provided a Strike Limit Algorithm for this stock has been developed by then, any unused portion of a strike quota from the prior quota block under a Strike Limit Algorithm management advice shall be carried forward and added to the strike quotas of subsequent years…"

Carryover limit	". . . provided that no more than 3 shall be added to the quota for any one year."	". . . provided that no more than 3 strikes shall be added to the strike quota for any one year. ". . .provided that no more than 50 percent of the annual strike limit shall be added to the strike quota for any one year."

Note that the carryover limit would remain 3 strikes in 2019 and 2020. When the Strike Limit Algorithm has been established, the carryover limit would increase from 3 strikes to 50 percent, i.e., 10 strikes based on the evaluation of the Scientific Committee that this increase in the carryover limit will have no conservation implications. The initial starting year for accumulation of unused strikes would be 2020. Note that in the event unused strikes are available for carryover from the previous block, the block cap could be increased by up to 50 percent.

Comparison of Current and Proposed West Greenland Minke Whale Carryover Provisions

Schedule Component	**Current**	**Proposed**
Start/Expiration dates	". . . any unused portion of the quota for each year shall be carried forward from that year and added to the strike quota of any of the subsequent years . . ."	". . . any unused portion of a strike quota from the prior quota block under a Strike Limit Algorithm management advice shall be carried forward and added to the strike quotas of subsequent years."
Carryover limit	". . . provided that no more than 15 strikes shall be added to the strike quota for any one year."	". . . provided that no more than 50 percent of the annual strike limit shall be added to the strike quota for any one year."

Note that the carryover limit would increase from 15 strikes to 50 percent, i.e., 82 strikes. The Scientific Committee has advised that this increase in the carryover limit would have no conservation implications. The initial starting year for accumulation of unused strikes would be 2018. Note that in the event unused strikes are available for carryover from the previous block, the block cap could be increased by up to 50 percent.

Comparison of Current and Proposed West Greenland Bowhead Whale Carryover Provisions

Schedule Component	**Current**	**Proposed**

Start/Expiration dates	". . . any unused portion of the quota for each year shall be carried forward from that year and added to the quota of any subsequent years. . ."	". . . any unused portion of a strike quota from the prior quota block under a Strike Limit Algorithm management advice shall be carried forward and added to the strike quotas of subsequent years . ."
Carryover limit	". . . provided that no more than 2 shall be added to the quota for any one year."	". . . provided that no more than 50 percent of the annual strike limit shall be added to the strike quota for any one year."

Note that the carryover limit would decrease from 2 strikes to 50 percent, i.e., 1 strike. The Scientific Committee has advised that this decrease in the carryover limit would have no conservation implications. The initial starting year for accumulation of unused strikes would be 2015. Note that in the event unused strikes are available for carryover from the previous block, the block cap could be increased by up to 50 percent.

Comparison of Current and Proposed West Greenland Humpback Whale Carryover Provisions

Schedule Component	**Current**	**Proposed**
Start/Expiration dates	". . . any unused portion of the quota for each year shall be carried forward from that year and added to the strike quota of any of the subsequent years . . ."	". . . any unused portion of a strike quota from the three prior quota blocks under a Strike Limit Algorithm management advice shall be carried forward
		and added to the strike quotas of subsequent years . . ."
Carryover limit	". . . provided that no more than 2 strikes shall be added to the strike quota for any one year."	". . . provided that no more than 50 percent of the annual strike limit shall be added to the strike quota for any one year."

Note that the carryover limit would increase from 2 strikes to 50 percent, i.e., 5 strikes. The Scientific Committee has advised that this increase in the carryover limit would have no conservation implications. The initial starting year for accumulation of unused strikes would be 2014.[1] Note that in the event unused strikes are available for carryover from the previous block, the block cap could be increased by up to 50 percent.

[1] Unused strikes would initially be counted from 2014, the year a Strike Limit Algorithm was first used to provide management advice for this stock. The start date/expiration period would then follow a rolling timeline consisting of the three prior quota blocks.

One-Time 7-Year Extension through 2025. Another proposed revision for each ASW stock would be to create a "buffer" year by updating the number of years for each block to seven years rather than six. This "buffer" year would accommodate issues arising from the "objections" procedure, and provide an additional year for the Commission to agree upon catch/strike limits, if necessary. The Scientific Committee agrees that there is no conservation issue associated with a one-time seven-year extension of the catch limits. In practice, the one-time seven-year extension would work as follows: Even though the seven-year block would not expire until 2025, at the 70th Commission meeting in 2024, the catch limits would be reviewed and, in accord with Scientific Committee advice, extended for an additional six years from 2026 through 2031.

Note that the block limits would be increased to account for the 7th year. For all the stocks except for Eastern North Pacific gray whales and Central Stock minke whales, as discussed below, block limits would be increased by ⅙ to account for the 7th year.

Limited Automatic Renewal with Safeguards for Whale Stocks. A third proposed revision, for Schedule paragraph 13(a), would address the challenges the Commission faces regarding ASW catch limit renewals. This proposal is intended to eliminate the fear of voting down a catch limit proposal while continuing to safeguard the stocks. Allowing limited automatic renewal for status quo catch limits would not only build trust and transparency, but also increase the time and resources that the Commission could spend on other issues.

There would be restrictions on the application of the automatic renewal in order to safeguard the stocks. Subject to Scientific Committee advice on the sustainability of the hunt, the catch limits from the previous block would be extended for an additional six years, provided the following conditions were met:

(a) The catch limits do not change;

(b) The Scientific Committee continues to advise that the status quo catch limits will not harm the stock; and

(c) The Commission determines that the relevant ASW country has complied with the approved timeline and that the information provided represents a status quo continuation of the hunt.

In addition:

(d) Annual Scientific Committee review and regular (5-6 years) *Implementation Reviews* will continue; and

(e) ASW countries would still follow any approved timeline and provide all the relevant information they do now.

If all of these conditions are met and events occur, then the proposed renewal provision would automatically extend the catch limits for an additional six years.

Accordingly, the automatic renewal would ***not*** occur if: (1) there is a requested change in the catch limit based on need; (2) the Scientific Committee is unable to advise that the status quo catch limits will not harm the stock; or (3) the ASW countries do not follow an approved timeline for review of catch limits or do not report relevant information on the hunts such that the Commission and its Scientific Committee were unable to evaluate the status quo continuation of the hunt. At that point, the Commission would have to decide whether to extend the catch limits.

The continued requirement for Scientific Committee advice that the status quo catch limits will not harm the hunt is an important safeguard. If, for example, there were a catastrophic decline in abundance, or any other basis for concern by the Scientific Committee such that it was unable to advise on the sustainability of the hunt, then the renewal would not automatically occur. Alternatively, if there were a request in the catch limits based on a change in need, then the automatic renewal would also not occur.

Example Timeline: Proposed Change in Commission Practice Every Six Years

Year	Commission Activities	Scientific Committee Activities
2019	**Year 1**: ASW catch limits for a one-time seven-year block begin. No Commission meeting.	Annual SC review of ASW catch limits. Appropriate *Implementation Reviews* completed.
2020	IWC 68 - **Year 2** of seven-year block. Commission evaluation of SC advice on ASW catch limits.	Annual SC review of ASW catch limits. Appropriate *Implementation Reviews* completed.
2021	**Year 3** of seven-year block. No Commission meeting.	Annual SC review of ASW catch limits. Appropriate *Implementation Reviews* completed.
2022	IWC 69 - **Year 4** of seven-year block. Commission evaluation of SC advice on ASW catch limits.	Annual SC review of ASW catch limits. Appropriate *Implementation Reviews* completed.
2023	**Year 5** of seven-year block. No Commission meeting.	Annual SC review of ASW catch limits. Appropriate *Implementation Reviews* completed.
2024	IWC 70 - **Year 6** of seven-year block. Commission evaluation of SC advice. ASW countries provide updated information and Commission reviews ASW catch limits. **Status quo and no change in science**: *Proposed change in Commission practice.* If the SC advises that status quo ASW catch limits *will not* harm the relevant stock(s), and the Commission makes the appropriate determination, then the relevant ASW catch limits are automatically extended for an additional six years from 2026 through 2031. **Status quo and change in science**: Current Commission practice. If the SC is *unable to* advise that the status quo ASW catch limits will not harm the relevant stock(s), and the Commission is unable to make the appropriate determination, then the relevant ASW catch limits *will not* automatically be extended, and a Commission decision will be required. **Change in need**: Current Commission practice. A request for a change in ASW catch limits would also require a Commission decision.	Annual SC review of ASW catch limits. Appropriate *Implementation Reviews* completed. **Status Quo**: SC review of existing ASW catch limits. **Change in science**: SC review of existing and/or proposed ASW catch limits. **Change in need**: SC review of proposed ASW catch limits.

2025	**Year 7** of seven-year block, i.e., "buffer" year. Seven-year block of ASW catch limits expires. No Commission meeting.	Annual SC review of ASW catch limits. Appropriate *Implementation Reviews* completed.
2026	IWC 71 - **Year 1** of new six-year block begins if: (1) status quo ASW catch limits were automatically extended at IWC 70; or (2) Commission approved new ASW catch limits at IWC 70. Commission evaluation of SC advice.	Annual SC review of ASW catch limits. Appropriate *Implementation Reviews* completed.

Adjustments to Schedule Paragraphs 5 and 15(b). A fourth proposed revision would make adjustments to Schedule paragraphs 5 and 15(b) so that these provisions would not apply to the affected ASW hunts. These paragraphs were intended to apply to commercial hunts, not ASW, and the changes would facilitate the Commission's objectives for management of ASW. For Schedule paragraph 5, the allowable minke whale hunting season would increase from nine months to 12 months, as it is for the other ASW hunts. For Schedule paragraph 15(b), the length limit for fin whales would be removed for ASW hunts given that there are already ASW prohibitions relating to the taking of calves. In each case, the existing provisions in Schedule paragraphs 5 and 15(b) unnecessarily limit the affected ASW hunts. In each case, the Scientific Committee has advised that the changes would have no conservation implications.

Increased Annual Strike Limit for Common Minke Whales off East Greenland in Order to Satisfy ASW Need. A fifth proposed revision would increase the annual strike limit for the Central stock of minke whales from 12 to 20. The Scientific Committee has advised that an annual strike limit of 20 whales will not harm the stock and meets the Commission's conservation objectives. As indicated in Resolution 2014-1 and the 2015 IWC Maniitsoq Expert Workshop Report, and consistent with the concept of respect for the rights of indigenous peoples, it is up to the Contracting Government to determine ASW needs. The Kingdom of Denmark has determined that East Greenlanders' need for Central stock minke whales has increased because of the reduced availability of other food sources. The Commission's 1979 Expert Workshop on ASW describes those other sources.

Increased Annual Strike Limit for Eastern North Pacific Gray Whales in Order to Address the "Stinky" Whale Problem and to Satisfy ASW Need. A sixth proposed revision would increase the annual strike limit for Eastern North Pacific gray whales from a six-year block of 744 whales to a seven-year block of 980 whales. In order to accommodate increased subsistence need *as well as* a 7th year in the Eastern North Pacific gray whale quota block, the Russian Federation, taking into account interests of the United States, requested Scientific Committee advice on the following:

> *'For the seven years 2019, 2020, 2021, 2022, 2023, 2024 and 2025, the number of gray whales taken in accordance with this sub-paragraph shall not exceed 980 (i.e. 140 per annum on average) provided that the number of gray whales taken in any one of the years 2019, 2020, 2021, 2022, 2023, 2024 and 2025 shall not exceed 140, except that any unused portion of the strike quota for each year shall be carried forward, provided that no more than 50 percent of the annual strike limit shall be added to the strike quota for any one year.'*

The Scientific Committee advised that an average annual strike limit of 140 whales for the Russian Federation and United States will not harm the stock and meets the Commission's conservation objectives. The estimated annual strike limit of 140 gray whales would remain unchanged, and so, the six-year block limit of 744 would increase to a seven-year block limit of 980. The Russian Federation's basis for this proposed change is twofold: (1) the use of the term "strike"[2] instead of the term "take," where "strike" includes all whales landed, as well as stinky whales

[2] The block limit would be for whales landed instead of whales struck.

and struck and lost whales (not just landed edible whales); and (2) increased need of the Native population of Chukotka. (See SC/67B/AWMP/17 and SC/67B/AWMP/20.)

Safeguards, Commitments and Process for Limited Automatic Renewal

The following statement is for incorporation into the report of the 2018 meeting in order to assure countries of safeguards associated with a limited automatic renewal process.

The four ASW countries reaffirm their commitment to continued management by the Commission of ASW at the same level of scrutiny as now. We look forward to continued review of the ASW hunts by the Commission, informed by the advice and recommendations of the Scientific Committee, the Infractions Subcommittee, the ASW Subcommittee, and the Whale Killing Methods and Welfare Issue Working Group. This ongoing oversight will ensure that the Commission's objectives for management of ASW will continue to be met.

There would be restrictions on the application of the automatic renewal in order to safeguard the stocks. Subject to Scientific Committee advice on the sustainability of the hunt, the catch limits from the previous block would be extended for an additional six years, provided the following conditions were met:

(a) The catch limits do not change;

(b) The Scientific Committee continues to advise that the status quo catch limits will not harm the stock; and

(c) The Commission determines that the relevant ASW country has complied with the approved timeline and that the information provided represents a status quo continuation of the hunt.

In addition:

(d) Annual Scientific Committee review and regular (5-6 years) *Implementation Reviews* will continue; and

(e) ASW countries will still follow the approved timeline and provide all the relevant information in the descriptions of the hunt.

If all of these conditions are met and events occur, then the proposed renewal provision would automatically extend the catch limits for an additional six years.

Accordingly, the automatic renewal would ***not*** occur if: (1) there is a requested change in the catch limit based on need; (2) the Scientific Committee is unable to advise that the status quo catch limits will not harm the stock; or (3) the Commission cannot determine that the relevant ASW country has complied with the approved timeline and that the information provided represents a status quo continuation of the hunt. At that point, the Commission would have to decide whether to extend the catch limits.

The continued requirement for Scientific Committee advice that the status quo catch limits will not harm the stock is an important safeguard. If, for example, there were a catastrophic decline in abundance, or any other basis for concern by the Scientific Committee such that it was unable to advise on the sustainability of the hunt, then the renewal would not automatically occur. Alternatively, if there were a request in the catch limits based on a change in need, then the automatic renewal would also not occur.

The Commission has endorsed at this meeting the Scientific Committee's recommendations on the scientific components of an Aboriginal Whaling Scheme, including operational rules on carryover, block quotas, Interim Relief allocations and the guidelines for Implementation Reviews, for surveys and other data.

The four ASW countries reaffirm the continued importance of reporting relevant hunting data to the WKM&WI-WG, including time to death information, instantaneous death rates where possible, and struck and loss, and recognize the importance of ensuring transparency and improving the welfare of ASW hunts. To that end, the four ASW countries further reaffirm their commitment to Resolution 1994-4 on Review of Aboriginal Subsistence Whaling Management Procedures, Resolution 1997-1 on Improving the Humaneness of ASW Hunts, Resolution 1999-1 arising from the working on whale killing methods, and in particular, the provision of relevant information, and Resolution 2014-1 on Aboriginal Subsistence Whaling.

Commitments from the Russian Federation

Implement more humane killing methods/weapons/training: Pursuant to available funds, including in the Aboriginal Subsistence Whaling Voluntary Fund, the Russian Federation will:

I. Participate in an expert (IWC and relevant organizations) workshop, including ballistics experts, veterinarians, native whalers from the United States, federal and regional government officials, and other invited experts to identify more humane methods and weapons for use in the gray whale hunt and recommend a programme to implement improvements;

II. Implement the improvement program recommended by the expert workshop; and

III. Report the outcomes of this implementation of the workshop, including any time to death data, to the WKM&WI-WG in order to facilitate the measurement of progress achieved by 2024.

IV. Report time to death information (including instantaneous death rates where possible), and struck and loss data, to all meetings of the WKM&WI-WG in order to facilitate measurement of progress.

Determining the cause and extent of stinky whales: Pursuant to available funds, including in the Aboriginal Subsistence Whaling Voluntary Fund, the Russian Federation will participate in collaborative efforts with scientists, other contracting governments, laboratories, relevant wildlife trade enforcement and permitting authorities, and academics with a view to determine the cause and extent of stinky whales by 2025.

TRENDS AND STATUS OF HARBOR SEALS IN WASHINGTON STATE: 1978–1999

STEVEN JEFFRIES,[1] Marine Mammal Investigations, Washington Department of Fish and Wildlife, 7801 Phillips Road S.W., Tacoma, WA 98498, USA
HARRIET HUBER, National Marine Mammal Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle, WA 98115, USA
JOHN CALAMBOKIDIS, Cascadia Research Collective, Waterstreet Building, 2181/2 West 4th Avenue, Olympia, WA 98501, USA
JEFFREY LAAKE, National Marine Mammal Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle, WA 98115, USA

Abstract: In the first half of the twentieth century, harbor seal (*Phoca vitulina richardsi*) numbers were severely reduced in Washington state by a state-financed population control program. Seal numbers began to recover after the cessation of bounties in 1960 and passage of the Marine Mammal Protection Act (MMPA) in 1972. From 1978 to 1999, aerial surveys were flown at midday low tides during pupping season to determine the distribution and abundance of harbor seals in Washington. We used exponential and generalized logistic models to examine population trends and size relative to maximum net productivity level (MNPL) and carrying capacity (K). Observed harbor seal abundance has increased 3- fold since 1978, and estimated abundance has increased 7 to 10-fold since 1970. Under National Marine Fisheries Service (NMFS) management, Washington harbor seals are divided into 2 stocks: coastal and inland waters. The observed population size for 1999 is very close to the predicted *K* for both stocks. The current management philosophy for marine mammals that assumes a density-dependent response in population growth with MNPL > K/2 is supported by growth of harbor seal stocks in Washington waters.

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Key words: generalized logistic, harbor seal, Marine Mammal Protection Act, maximum net productivity level, optimum sustainable population, *Phoca vitulina*, pinniped, population growth, trend, Washington.

The MMPA of 1972 established criteria for management of marine mammals by the NMFS and U.S. Fish and Wildlife Service (USFWS). These criteria stated that marine mammal populations "should not be permitted to diminish beyond the point at which they cease to be a significant functioning element in the ecosystem of which they are a part, and, consistent with this major objective, they should not be permitted to diminish below their optimum sustainable population" (16 U.S.C. 1361 Sec. 2). The intent of the MMPA was clear, but the language was too vague to provide an operational definition for management.

Eberhardt (1977) suggested that optimum sustainable population (OSP) should be interpreted as the range of population sizes from the maximum (*K*) down to the size that gives maximum productivity or maximum sustainable yield (MSY). The NMFS adopted the definition for OSP as a population level between *K* and the population size that provides the maximum net productivity level (MNPL; Federal Register, 21 December 1976, 41FR55536). Maximum net productivity level was chosen because, unlike MSY, MNPL is independent of harvest structure (Gerodette and DeMaster 1990).

Defining OSP was a first step, but implementing the definition was difficult due to a lack of biological knowledge about population parameters and sufficiently precise data (Gerodette and DeMaster 1990, Ragen 1995). Difficulties in implementing an OSP management scheme led to the 1994 amendments to the MMPA that provided an alternative approach based on managing incidental take. In this approach, potential biological removals (PBR) must remain below a percentage of a minimum population size (Wade 1998, Read and Wade 2000). However, determinations of OSP and population status are still required by the MMPA to transfer management authority to a state government. Also, an assessment of population growth rates and status relative to MNPL can be incorporated into the calculation of PBRs in the existing management scheme.

Ragen (1995) questioned the utility of MNPL because he was unable to measure it precisely in a well-studied northern fur seal (*Callorhinus ursinus*) population. He stated that "under ideal conditions, MNPL would be determined by accurate and precise monitoring of a discrete population unit during natural growth from some level well below MNPL ... to a level above MNPL." Those ideal conditions are rare indeed, but they did exist for harbor seals in Washington state. Harbor

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[1] E-mail: jeffrsjj@dfw.wa.gov

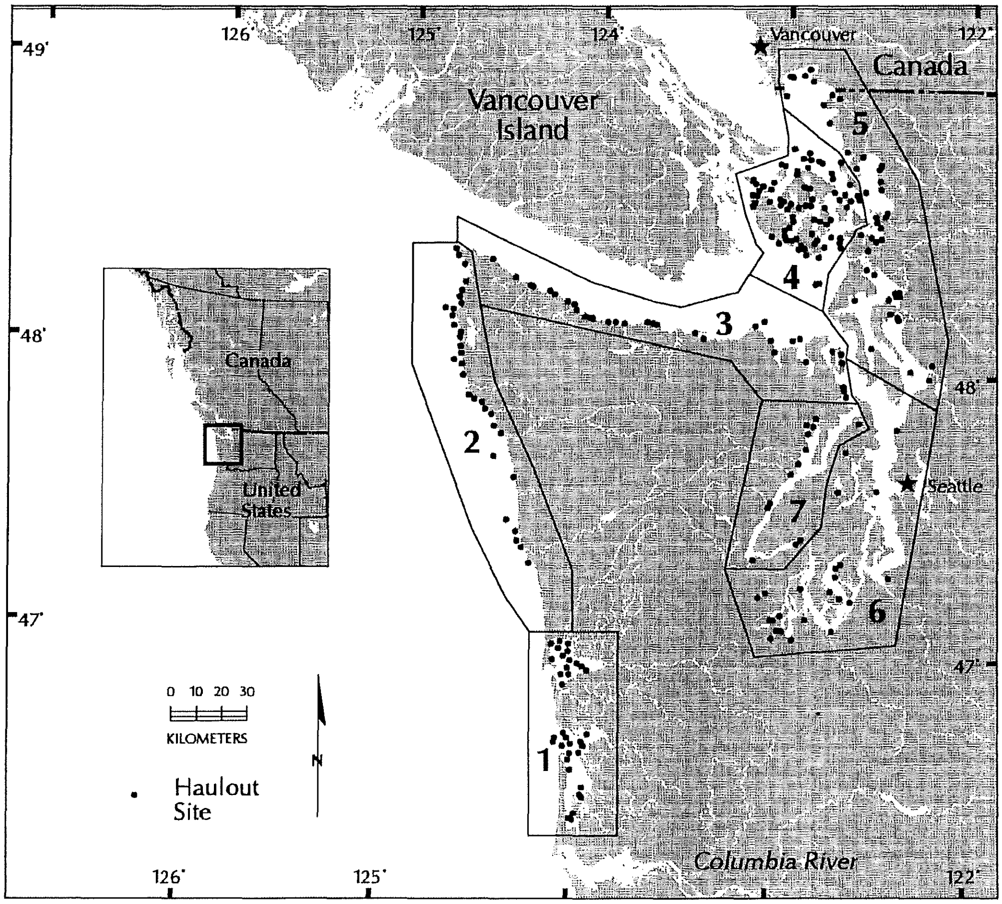

Fig. 1. Map of harbor seal haulout sites and survey regions for Washington, USA, coastal and inland stocks. The Washington coastal stock includes Coastal Estuaries (1) and Olympic Peninsula (2). The inland stock includes Strait of Juan de Fuca (3), San Juan Islands (4), Eastern Bays (5), Puget Sound (6), and Hood Canal (7).

seal numbers were severely reduced in the early 1900s by bounty hunters under a state-financed program that considered harbor seals to be predators in direct competition with commercial and sport fishermen. After the bounty program ceased in 1960 and MMPA was passed in 1972, Washington harbor seals began to recover. Newby (1973) estimated that 2,003,000 harbor seals resided in Washington state in the early 1970s. Beginning in 1978, systematic surveys of Washington's harbor seal population were initiated by Washington Department of Fish and Wildlife (WDFW) and continued through 1999.

This 22-year time series of systematic surveys provided a unique opportunity to describe an unharvested marine mammal's population growth. Because a large number of harbor seals haul out onto land in discrete aggregations at specific times, we were able to count a large proportion of the population to provide an index of population trends. We described population growth using exponential and generalized logistic models.

METHODS

Study Area

As managed by NMFS, harbor seals in Washington and Oregon have been separated into coastal and inland stocks because of differences in cranial morphology, pupping phenology, and genetics (Temte 1986, Lamont et al. 1996). The Washington inland stock includes all harbor seals in U.S. waters east of a line extending north-south between Cape Flattery on the Olympic Peninsula and Bonilla

Point on Vancouver Island (Fig. 1). Harbor seals on the outer coast of Washington are part of a stock that includes seals in Oregon, from the Columbia River southward to the Oregon/California border.

Interchange between inland and coastal stocks is unlikely, since no radiomarked seals from the inland stock (n = 140) were observed in coastal areas or vice versa (n = 188). Harbor seal haulout sites in Washington state were combined into 7 survey regions: Coastal Estuaries, Olympic Coast, Strait of Juan de Fuca, San Juan Islands, Eastern Bays, Puget Sound and Hood Canal (Fig. 1). In the Strait of Juan de Fuca, seals were counted annually in the eastern portion of the strait (east of Port Angeles). The western portion—where few suitable haulout sites exist and few pups are born—was surveyed only twice and was excluded from our analysis. Survey regions were determined by pupping phenology and a geographic area that could be surveyed within a 34 hr tidal window.

Survey Methods

Harbor seal aerial surveys were flown at low tide during the pupping season when maximum numbers were onshore. All known haulout sites were surveyed and potential new sites were examined on each survey. Seals in the water were not counted. Because of differences in pupping phenology among regions, surveys were flown in late May to mid-June for the coastal stock and August through September for the inland stock. Surveys were scheduled as closely as possible (tides permitting) to the time when peak number of pups were expected to be present. All regional surveys occurred within a week of peak pupping for each region (Huber et al. 2001). Surveys were flown between 2 hr before low tide to 2 hr after low tide in a single engine plane at 700–800 ft altitude at 80 knots. To provide consistency in data collection, about 80% of pupping season surveys were flown by 1 observer, while the others were flown by a second observer. Data collected during surveys included date, time, location, a visual estimate of seal numbers, and photographs of all sites with ≥25 seals. We took photographs with a 35mm SLR camera with 70210 mm lens, using 200 or 400 ASA Ektachrome film, and shutter speeds of 1/500 to 1/1,000 s. We counted the seals (including pups) at each site from slides. Evidence of recent disturbances (haulout marks on the beach or seals milling in the water off the haulout site) also was noted.

We scheduled at least 2–3 surveys for each region during annual survey windows, although some surveys were canceled because of inclement weather. A complete survey of each region was attempted in 1 day; if this was impossible, we combined surveys from 2 to 3 days. We excluded surveys with low counts (due to disturbance on a haulout or bad weather, and surveys outside the survey window were discarded. In some years, no count was available for ≥1survey regions.

Population Growth Models

Two simple non-age-structured deterministic models of population growth were considered to represent the growth in the harbor seal stocks: exponential and generalized logistic (Pella and Tomlinson 1969, Gilpin et al. 1976). These models are discrete in nature with an annual time step to represent the annual pupping pulse. Exponential growth assumes that the population grows without limit at a constant annual rate (R_{max}):

$$N_t = N_{t-1} + N_{t-1}R_{max} \tag{1}$$

Clearly, the exponential model cannot be true forever, but populations can experience exponential growth prior to approaching K. Therefore, the exponential model can be used as a null model to test for density dependence. In the generalized logistic growth model, the rate of increase is a function of the population size relative to the maximum population size K:

$$N_t = N_{t-1} + N_{t-1}R_{max}\left[1-\left(\frac{N_{t-1}}{K}\right)^z\right] \tag{2}$$

Annual net production is the difference in consecutive population sizes and the MNPL is the value of N_{t-1} when annual net production is maximized. The shape of the growth curve and the per capita production curve is governed by the exponent z, which determines the timing of the density dependent effect and the position of MNPL relative to K:

$$\frac{N_t - N_{t-1}}{N_{t-1}} = R_{max}\left[1-\left(\frac{N_{t-1}}{K}\right)^z\right] \tag{3}$$

The standard logistic curve is obtained when z = 1: per capita production is a linear function of N and MNPL/K= 0.5. If z >1, per capita production is a concave nonlinear function of N and MNPL/K> 0.5 and if z < 1, per capita production is a convex nonlinear function of N and MNPL/K < 0.5.

An approximate relationship between MNPL/K and z (Polachek 1982) is given by:

$$\text{MNPL}/K \approx (z+1)^{-1/z} \quad (4)$$

Incorporating z into the growth model is important for harbor seal populations because long-lived marine mammals are expected to demonstrate the strongest density-dependent effect as N approaches K ($z > 1$; Eberhardt and Siniff 1977, Fowler 1981). However, in most cases, survey data were not sufficiently precise to estimate z adequately (Goodman 1988, Hilborn and Walters, 1992, Ragen 1995). The parameters R_{max} and z have a strong negative correlation in the model and diametrically opposed parameter values can yield nearly identical population trajectories for portions of the overall trajectory (Fig. 2). Without precise population estimates, z will almost surely be poorly estimated. The correlation between R_{max} and z is lessened by observing the population over a wide range of growth.

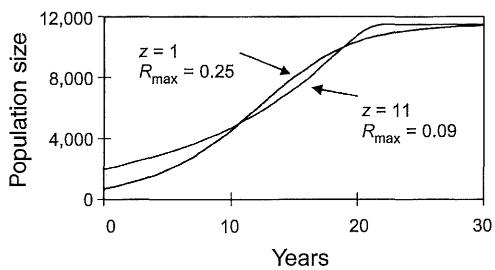

Fig. 2. Two similar generalized logistic growth curves of harbor seals in Washington, USA, achieved by choosing different values for z, R_{max}, and initial population size. Discriminating between these 2 growth curves would be nearly impossible if the population were observed from year 10 and beyond. However, if the population is observed from year 0, the parameters would be estimated more precisely as the 2 models imply different starting population sizes.

Growth Model Fitting

Our survey count data represented some variable proportion of the population (Jeffries 1985, Huber et al. 2001). Fitting growth models to the harbor seal count data involved finding parameter values that provided the best fit to the data. The best fit depended on the assumed statistical model for the observed data. We used deterministic population growth models (i.e., given the parameter values, the population size in year N_t determined exactly the size in year N_{t+1}) but the observed count C_t of harbor seals represented some unknown and variable proportion of the population abundance N_t:

$$C_t = N_t p_t \quad (5)$$

If p_t has a normal distribution with expectation p and variance s^2, the statistical model for the counts can be expressed as:

$$C_t = N_t(p+\delta_t) = N_t p + N_t\delta_t = N_t p + \varepsilon_t \quad (6)$$

where the distribution for δ_t is $N(0, s^2)$, and the distribution for $\varepsilon_t = N_t\,\delta_t$ is $N(0, s^2 N_t^{\,2})$. Thus, the coefficient of variation (c) of the errors ε_t is constant:

$$\text{c} = \text{CV}(\varepsilon_t) = \frac{sN_t}{pN_t} = \frac{s}{p} \quad (7)$$

An estimate of p requires additional data (e.g., radiomarking; Huber et al. 2001). If p had been estimated for each region and year, the growth model could have been based on estimates of population size. However, estimates of p were only available for 2 regions in different years. Thus, we fitted growth models to the count data and our inference to population growth depends on the assumption no temporal trend in p_t exists.

Based on these assumptions, we used the following statistical model:

$$C_t = N_t + \varepsilon_t \quad (8)$$

where N_t is now the size of the population onshore at time t as specified by the generalized logistic or exponential growth model, and ε_t are independent normal errors with zero expectation and constant coefficient of variation. The growth model parameters are R_{max}, K, z, and an intercept N_0, which is an initial size of the population onshore for some arbitrarily chosen time designated as $t = 0$. We only used counts to fit the growth models, but to express N_0 and K in terms of the population we multiplied N_0 and K by the correction factor (CF) of 1.53 (Huber et al. 2001), which is the reciprocal of the average proportion ashore (p) for an assumed age–sex structure. The parameters R_{max} and z remain unchanged by the constant scaling but would be affected by any trends in p_t.

To obtain parameter estimates for the growth curve, we used maximum likelihood. For k counts conducted at years $t_1, t_2, ..., t_k$, the log-likelihood is:

$$\ln L = -\frac{k}{2}\ln\left(\sum_{i=1}^{k}\left[\frac{C_{t_i}-N_{t_i}}{N_{t_i}}\right]^2\right) \quad (9)$$

The log-likelihood is a function of the growth curve parameters which define the values for N_t from equations (1) or (2). Maximizing (9) is equivalent to minimizing the sum of squared proportional residuals:

$$\sum_{i=1}^{k}\left[\frac{C_{t_i}-N_{t_i}}{N_{t_i}}\right]^2 \quad (10)$$

Use of the normal distribution probably is reasonable as long as p is not close to 0 or 1 and c^2 is sufficiently small such that there is little area in the tails of the distribution >1 or <0. A more complex alternative model could be constructed by assuming p_t follows a Beta distribution, which is bounded between 0 and 1, and C_t follows a binomial distribution with parameters N_t and p_t (or normal approximation).

Parameter estimates were obtained by using an optimization search algorithm in a FORTRAN program to find the values which maximize (9) or likewise minimize (10). We estimated variances and confidence intervals based on parametric bootstrapping (Efron and Tibshirani 1993). We implemented a parametric bootstrap by using the estimated parameters to construct a single "true" population trajectory. For each bootstrap, we constructed a data set by adding a random set of residuals drawn from the fitted error distribution to the true population trajectory. The model was then fitted to the new bootstrap data. We repeated the bootstrapping process 1,000 times to develop a distribution of parameter estimates.

One of the complications in the harbor seal data was missing counts. A count for each year was unnecessary. Ideally, however, for any year, the entire range should have been counted completely. In certain instances, some regions were not surveyed due to bad weather, disturbance, logistical problems, or lack of funding. In other instances, surveys began in 1 region and then expanded into other regions over time. For example, in Washington, the Coastal Estuaries were surveyed as early as 1975 but surveys of the Olympic coast region were not begun until 1980 (Table 1). Although counts for inland waters for 1978 were available (Calambokidis et al. 1979), consistent counts for all regions in the inland waters stock did not begin until 1983. A simple solution was to limit counts to years in which seals were counted in all regions. However, this would have wasted valuable data and severely restricted the survey time frames.

Instead, we fitted separate growth curves for each of the 7 regions (Fig. 1) using counts that were available for each region. Fitting separate growth models to the regions used only observed data but required more parameters that applied to the regions and not the entire population. Any random movement between regions would create additional variation in counts and any directed movement (i.e., permanent emigration/immigration) would be reflected in the parameters of regional growth models.

Separate growth models for each of the 7 regions were fitted by maximizing the sum of the regional log-likelihoods (9) assuming separate and independent regional error models:

$$\ln L = -\frac{1}{2}\sum_{j=1}^{r} k_j \ln\left(\sum_{i=1}^{k_j}\left[\frac{C_{t_{ij}}-N_{t_{ij}}}{N_{t_{ij}}}\right]^2\right) \quad (11)$$

where k_j is the number of surveys in the j^{th} region and r is the number of regions. Because the predicted abundance for survey i in region j (N_t) may be determined by unique regional parameters, the number of estimated parameters expands substantially. However, some of the parameters could be held constant for some or all of the regions. In general, z is difficult to estimate (Hilborn and Walters 1992), and our data would not likely support a different z for each region. Also, R_{max} was likely to be constant among regions unless there was a strong movement component. However, K and N_0 were unlikely to be constant across regions because of differences in region size and habitat quality.

We fitted a series of models for each of the 5 regions in the inland Washington stock and separately for the 2 regions in the coastal stock. For each model, we assumed that N_0 and K (for the logistic model only) were different for each region. We fitted exponential models that assumed R_{max} was constant or varied by region. Likewise, we fitted logistic models that assumed R_{max} and z were either constant or varied by region. After selecting the best logistic model for each stock, we also explored whether R_{max} and z varied by stock.

We used the small sample Akaike Information Criterion ($AIC_c = -2 \ln L + 2m + 2m[m+1]/[n-m-1]$, where m is the number of parameters and n is the number of surveys) to choose the most

Table 1. Average annual harbor seal haulout counts for 2 regions in the coastal stock and 5 regions in the inland stock of Washington, USA, 1975–1999.

	Coastal stock		Inland stock				
Year	Coastal Estuaries	Olympic Peninsula	Strait of Juan de Fuca	San Juan Islands	Eastern Bays	Puget Sound	Hood Canal
1975	1,694						
1976	1,742						
1977	2,082						
1978	2,570		417	852	755	337	732
1979							
1980	2,864	1,639					
1981	4,408	1,677					
1982	5,197						
1983	4,416	2,359	883	1,688	1,347		
1984	4,203		1,025	2,308	1,727		
1985	6,008		1,288	1,859	1,416	732	
1986	4,807	1,789	849	2,193	1,613		
1987	7,600	3,204	1,016	2,179	1,751		
1988	6,796		1,518	2,847	1,902		
1989	6,475	3,667	1,402	2,884	1,839		
1990			1,142	3,157			
1991	8,681	3,832	1,238	3,510	1,939	891	1,206
1992	7,761	4,191	1,580	3,640	2,102	708	989
1993	8,161	3,544	2,154	4,524	2,175	972	592
1994	5,786	3,505	1,488	4,529	2,144	854	
1995	6,492	4,867	2,281	4,852	2,068		
1996	7,191	3,124	1,988	5,330	2,521	1,119	975
1997	7,643	4,221	2,284	4,277	2,008	1,060	695
1998			1,734	4,441	1,810	1,026	577
1999	7,117	3,313	1,752	3,588	1,873	1,025	711

parsimonious model (Burnham and Anderson 1998). We evaluated the model goodness of fit with the Kolmogorov-Smirnov test to examine whether the standardized residuals were normally distributed. For graphical display of the growth curve for each stock and the entire state, we summed the predicted values across regions. For observed values, we summed the average of regional counts for years in which 1 counts were available for each region. To supplement the observed values for the entire state, we added predicted counts for a few years with missing counts in 1 or 2 areas.

Status Determination

A harbor seal stock was considered to be at OSP if the current predicted population size was above MNPL. We determined whether OSP > MNPL by comparing population sizes as a proportion of K, because (4) provides a simple computation of MNPL/K. For each parametric bootstrap, we compared $\hat{N}_{1999}/K$ to MNPL/K. If <5% of the replicates were below MNPL/K, we concluded that the stock was at OSP. We also constructed bootstrap confidence intervals for $\hat{N}_{1999}/K$, MNPL/K, and $\hat{N}_{1999}$/MNPL. A similar approach was taken by Wade (1999) to investigate whether a spotted dolphin population was above or below MNPL.

Proportion Ashore

Our growth model based on seal counts would only reflect population growth if no trend in the proportion of seals ashore existed. A trend in p could occur if, over the 2 decades of surveys, the seals spent more or less time ashore as the population increased. A plausible scenario would be a decrease in the time ashore because more time could be required for foraging as the population increased and food resources decreased.

We examined whether the proportion ashore changed in Grays Harbor or Boundary Bay during the 1990s. Huber et al. (2001) applied VHF radio-transmitters to harbor seals in 1991 at Grays Harbor (GH; coastal stock) and in 1992 at Boundary Bay (BB; inland stock) to estimate p. We applied the same techniques as Huber et al. (2001) at GH in 1999 and BB in 2000. In each survey, all seals

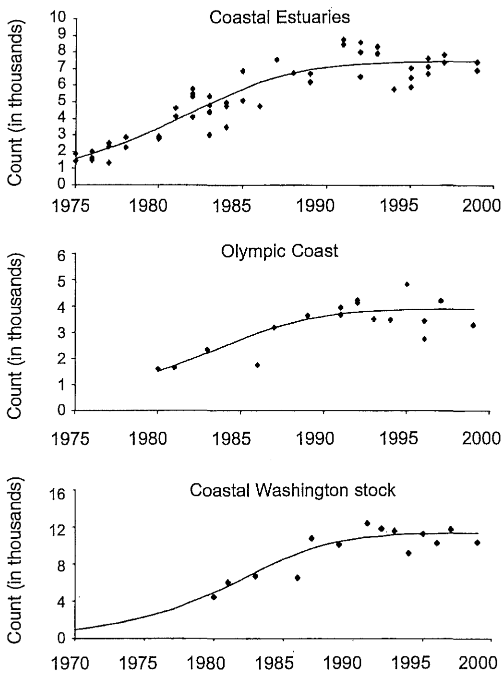

Fig. 3. Generalized logistic growth curves of harbor seals in Washington, USA, portion of the coastal stock for coastal estuaries and outer Olympic Peninsula coast regions and their sum.

with active tags were determined to be either ashore or not. Using each seal as a sample, we modeled the number of surveys the seal was ashore using a generalized linear model based on a binomial distribution and logit link function.

We fitted models that included 4 age–sex categories (adult female, adult male, pup subadult), year (1991–1992 vs. 1999–2000), and region (GH or BB) and the interaction of these parameters. Using the most general model with all interactions, we estimated an overdispersion scale (residual deviance/df; McCullagh and Nelder 1991) to adjust model selection using minimum $QAIC_c$ (Burnham and Anderson 1998). We also examined whether any observed annual differences in the proportion ashore would influence our conclusion regarding population growth.

RESULTS

Aerial Surveys

Between 1978 and 1999, counts of harbor seals in Washington state increased nearly 3-fold, from 6,786 to 19,379. The earliest surveys began in 1975 in the Coastal Estuaries (Table 1). By 1978, surveys had begun in all areas (Calambokidis et al. 1979) except the outer coast of the Olympic Peninsula where surveys began in 1980 (Table 1). Consistent surveys of inland waters did not begin until 1983 (Figs. 3, 4). The regions were not always surveyed annually nor were they surveyed an equal number of times/year. Growth between 1978 and 1999 was not evenly distributed throughout all regions. Most growth occurred in the San Juan Islands and the Strait of Juan de Fuca, and the least growth occurred in Hood Canal (Table 1).

Growth Model

The generalized logistic model with constant R_{max} and z was clearly the best model (Table 2) to describe inland and coastal seal stock population growth. The large discrepancy in AIC_c between exponential and logistic models provides strong evidence for a density dependent response in population growth (Table 2). When we examined models that shared R_{max} and z parameters between stocks the choice was less clear.

We selected the model with separate parameters for each stock because these stocks are genetically different and unlikely to be demographically linked. As expected, we estimated N_0 and K of the onshore population with reasonable precision, whereas less precision was achieved for R_{max} and z (Tables 3, 4). The initial size estimates, using 1970 as the base year, were quite consistent with counts for 1970–1972 by Newby (1973), with the exception of San Juan Islands region (Tables 3, 4). The growth curves demonstrate the growth rate slowing as numbers approached K (Figs. 3–5) and demonstrate a reasonable fit. Pooled standardized residuals did not differ from the assumed normal distribution (KS = 0.05, P = 0.21).

Status Relative to Optimal Sustainable Population

Although the evidence is not strong, the growth models of both stocks agree with the speculation that MNPL is indeed $>K/2$ (Table 5; Eberhardt and Siniff 1977, Fowler 1981). The predicted population size for 1999 is very close to K for both stocks (Table 5), and none of the bootstrap replicates predicted a 1999 population size that was below MNPL. The coastal stock recovered earlier than the inland stock, as evidenced by the status of the stocks in 1990 (Table 5).

Proportion Ashore

We radiomarked 29 seals and conducted 5 surveys at GH in 1999. We radiomarked 43 seals and

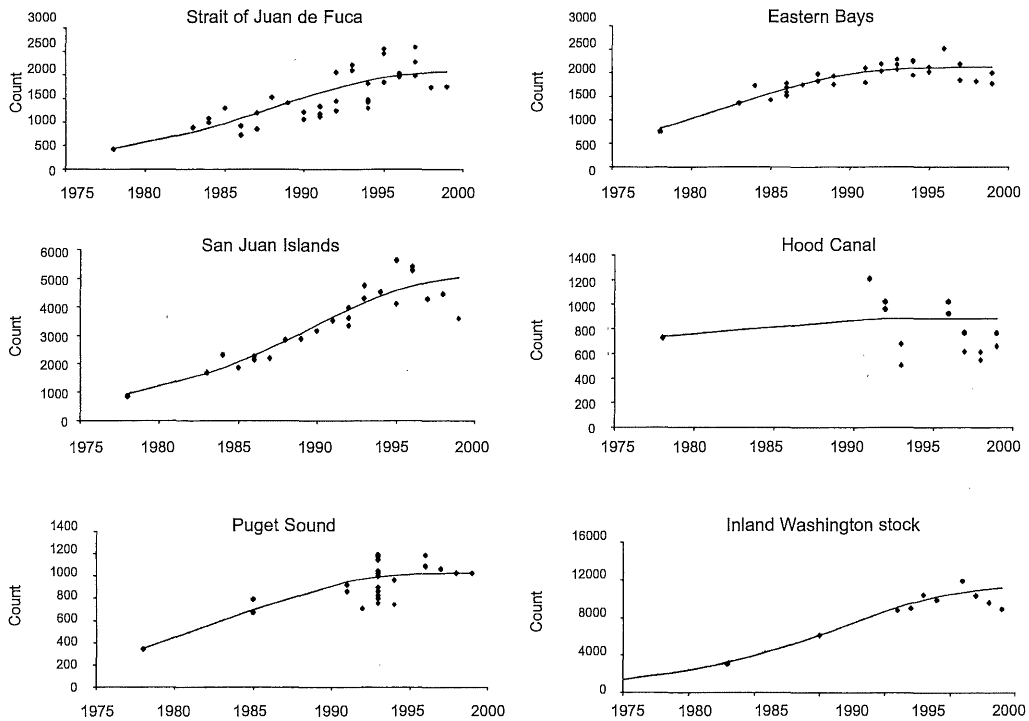

Fig. 4. Generalized logistic growth curves of harbor seals in the Washington, USA, inland stock for Strait of Juan de Fuca, Eastern Bays, San Juan Islands, Hood Canal, and Puget Sound regions and their sums.

conducted 7 surveys at BB in 2000 (Table 6). As expected during the pupping season, adult males and subadults spent considerably less time ashore than adult females and pups (Fig. 6). The full model with 16 parameters for age–sex, year, region, and parameter interactions explained 59% of the deviance. The residual deviance/df (124.82/113 = 1.11) suggested a minor amount of overdisper-

Table 2. Model selection results for exponential and generalized logistic growth models of inland and coastal harbor seal stocks in Washington, USA, 1975–1999. In addition to R_{max} and z, the number of parameters m includes initial size and carrying capacity (for logistic models) for each region.

Stock	Model	R_{max}	z	m	AIC_c
Inland	Exponential	Constant	NA	6	26.8
		Region	NA	10	–3.8
	Generalized logistic	Constant	Constant	12	–39.9
		Region	Constant	16	–28.7
		Constant	Region	16	–28.6
		Region	Region	20	–13.9
Coastal	Exponential	Constant	NA	3	68.7
		Region	NA	4	70.9
	Generalized logistic	Constant	Constant	6	20.5
		Region	Constant	7	23.3
		Constant	Region	7	23.5
		Region	Region	8	25.0
Both	Generalized logistic	Constant	Constant	16	–20.2
		Stock	Constant	17	–19.3
		Consant	Stock	17	–20.4
		Stock	Stock	18	–19.9

Table 3. Generalized logistic growth model for counts of all harbor seals in the Washington, USA, inland stock: parameter estimates and bootstrap standard errors and percentile confidence intervals (1,000 replicates). The 1970–1972 counts were obtained from Newby (1973).

Parameter	Region	Estimate	1970–1972 estimate	Standard error	95% confidence interval
N_{1970}	Strait of Juan de Fuca	172	150	39.2	104 to 262
	Eastern Bays	325	290	45.1	238 to 421
	San Juan Islands	361	160	82.9	216 to 541
	Hood Canal	390		123.6	156 to 628
	Puget Sound	138	210	23.9	94 to189
	All	1,386		197.8	1,033 to 1,807
K	Strait Juan de Fuca	2,121		185.5	1,920 to 2,619
	Eastern Bays	2,132		71.0	2,034 to 2,317
	San Juan Islands	5,222		472.6	4,584 to 6,450
	Hood Canal	882		60.2	819 to 1,052
	Puget Sound	1,033		49.7	972 to 1,175
	All	11,390		645.7	10,671 to 13,257
R_{max}	All	0.126		0.023	0.094 to 0.187
z	All	2.43		1.75	1.07 to 8.57
c	Strait of Juan de Fuca	0.207			
	Eastern Bays	0.088			
	San Juan Islands	0.124			
	Hood Canal	0.258			
	Puget Sound	0.135			

sion. The model with minimum $QAIC_c$ included all of the main effects and 2-way interactions ($QAIC_c = 145.6$), although a much simpler model with only age–sex, year and their interaction had a similar value ($QAIC_c = 145.8$). Based on $QAIC_c$, these 2 models are indistinguishable. The model with age-sex only ($QAIC_c = 150.3$) accounted for 63% of the explained deviance of the full model.

The year influence was not consistent across the age–sex classes (Fig. 6). Females and pups spent less time ashore in 1999–2000 than in 1991–1992, whereas adult males and subadults spent more time ashore 1999–2000 than in 1991–1992. Most of the annual difference and the interaction resulted from shifts at GH. We computed an annual average proportion ashore for all seals (Table 6) by weighting age–sex specific values against the expected age–sex proportions of seals in the population (Huber et al. 2001), which adjusted for differences in sample sizes between the age–sex classes across years. The largest decrease in the average proportion ashore occurred at GH, with very little change at BB.

DISCUSSION

Aerial Surveys

Haulout behavior of harbor seals varies with season. In general, the number of seals ashore is highest during annual pupping and molt and

Table 4. Generalized logistic growth model for counts of all harbor seals in the Washington, USA, coastal stock: parameter estimates and bootstrap standard errors and percentile confidence intervals (1,000 replicates). The 1970–1972 counts were obtained from Newby (1973).

Parameter	Region	Estimate	1970–1972 estimate	Standard error	95% confidence interval
N_{1970}	Coastal Estuaries	714	800	128.8	518 to 1,019
	Olympic Coast	303	100+	73.3	184 to 487
	All	1,017		196.5	717 to 1,497
K	Coastal Estuaries	7,510		328.0	7,102 to 8,406
	Olympic Coast	3,934		206.9	3,585 to 4,398
	All	11,444		425.2	10,909 to 12,600
R_{max}	Both	0.185		0.037	0.129 to 0.268
z	Both	1.75		1.47	0.90 to 6.76
c	Coastal estuaries	0.165			
	Olympic Coast	0.154			

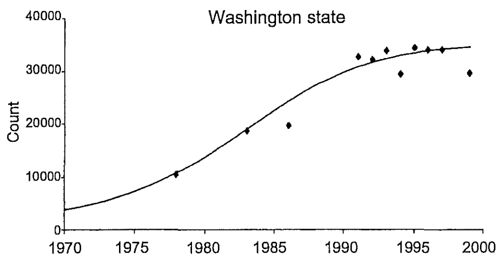

Fig. 5. Generalized logistic growth curve for harbor seals in Washington, USA, expressed population size. The observed values for 1978, 1983, 1986, 1994, and 1995 were supplemented with model predictions for regions with missing counts that accounted for 17, 12, 13, 5, and 8% of the total abundance.

lowest during winter. Many variables, such as height of tide, time of day, weather, and disturbance affect seal haulout patterns. The proportion of seals ashore during a pupping survey will depend on tide state, timing relative to peak pupping, age, sex, and reproductive condition of seals using the haulout. Several approaches exist to obtain maximum counts and reduce variability in counts within a chosen season. Some researchers have surveyed during a broad range of time and tide conditions and adjusted counts for date and tide height after the fact (Frost et al. 1999, Olesiuk et al. 1990). In contrast, we reduced variability in our counts by restricting our surveys to a narrow time frame at the peak of the pupping season in each survey region and surveying only at low tides between 2.0 and +2.0 feet, when maximum numbers of seals were hauled out.

Corrections for Proportion Ashore

Harbor seal haulout behavior varies by age, sex, and reproductive condition of seals. During pupping season, adult females and nursing pups spend 90–100% of their time on shore during the 4–6 week nursing period (Huber et al. 2001). After weaning, pups spent an increased amount of time in the water and hauled out only infrequently, whereas males and subadults were on shore during 40–60% of surveys. These differences in haulout behavior have strong implications for timing of surveys and the use and interpretation of correction factors associated with seasonal surveys.

We did find changes in the proportion of seals ashore during our surveys in 1991–1992 and 1999–2000. However, these changes do not invalidate our conclusions regarding growth and status of harbor seal stocks in Washington. The largest decrease in the proportion ashore occurred at GH, declining from 0.71 to 0.62. However, the seal counts reflected this change decreasing from 8,681 in 1991 to 7,118 in 1999. If we apply the individual annual correction factors (Table 6), we get estimates of 12,285 and 11,548, respectively. Thus, the population estimates are even closer than the counts, which is consistent with our conclusion that the population stabilized during the 1990s.

At BB little difference was noted in the average proportions ashore but the counts were not as consistent, decreasing from 797 in 1992 to 564 in 2000. However, these values are consistent with a lack of growth during the 1990s. We believe that the leveling trend in seal abundance is real and not related to a change in proportion of seals hauled out during surveys.

Trends and Status

Because the analysis was based on counts of seals ashore during a survey, estimated K and N_0 represent only a proportion of the entire population. To get estimates of the true population size,

Table 5. Parameter estimates for status determination of inland and coastal stocks of harbor seals in Washington, USA, with bootstrap standard errors and 95% confidence intervals.

Parameter	Stock	Estimate	Standard error	95% confidence interval
MNPL/K	Inland	0.60	0.064	0.51 to 0.77
	Coastal	0.56	0.066	0.49 to 0.74
$\hat{N}_{1999}/K$	Inland	0.98	0.025	0.90 to 1.00
	Coastal	1.00	0.004	0.99 to 1.00
$\hat{N}_{1990}/K$	Inland	0.76	0.046	0.65 to 0.84
	Coastal	0.94	0.034	0.88 to 1.00
$\hat{N}_{1999}$/MNPL	Inland	1.63	0.14	1.29 to 1.85
	Coastal	1.78	0.18	1.35 to 2.10

Table 6. Comparison of proportion of radiomarked harbor seals ashore during surveys at 2 sites 1991–1992 and 1999–2000 in Washington, USA. 1991–1992 data from Huber et al. (2001). The average proportion ashore was computed as a weighted average of the age-sex specific proportions using an assumed structure of 31% adult females, 26% adult males, 23% pups and 19% subadults.

	Grays Harbor		Boundary Bay	
	1991	1999	1992	2000
Active radio tags	33	29	24	43
Adult female	9	9	7	14
Adult male	7	7	5	16
Pup	8	8	7	8
Subadult	9	5	5	5
Number of surveys	4	5	5	7
Average proportion ashore (p)	0.71	0.62	0.69	0.72
Correction factor ($1/p$)	1.42	1.62	1.44	1.38

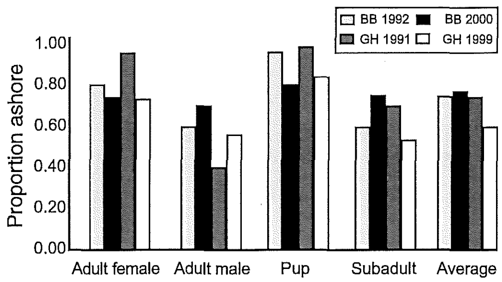

Fig. 6. Average proportion ashore for radiotagged harbor seals in each of 4 age–sex categories and a weighted average for Boundary Bay (BB) in 1992 and 2000 and Grays Harbor (GH) in 1991 and 1999, Washington, USA.

K and N_0 must be scaled by a correction factor (the inverse of the proportion ashore). Using the correction factor of 1.53 (Huber et al. 2001), we estimated that during 1999, Washington coastal stock contained 15,958 harbor seals (95% CI: 13,645 to 18,662) and the inland stock contained 13,692 seals (95% CI: 11,707 to 16,012). Because there are no records of the pre-exploitation population size in Washington, whether the present population is more or less than before is unknown. Changes that may have lowered K include decreases in harbor seal prey such as hake (*Merluccius productus*; Gustafason et al. 2000) and herring (*Clupea pallasi*; Stout et al. 2001), reduced habitat, and increased disturbance. However, we have shown that both stocks of Washington harbor seals are above MNPL and are near the current carrying capacity of the environment. These stocks can decline or be reduced by 20% and they will still be above MNPL with a high degree of certainty (Table 5).

MANAGEMENT IMPLICATIONS

Management implications for harbor seal stocks in Washington are quite clear. If formally determined to be at OSP, NMFS could return management authority for harbor seals to Washington state, if requested. Local selective removals of seals could be considered at river mouths where endangered or threatened salmonids occur, if harbor seals are consuming and threatening fish populations of concern (National Marine Fisheries Service 1997). From our analysis, selective removal of harbor seals around river mouths is unlikely to have detrimental effects on harbor seal populations in Washington state. Harbor seal stocks in Washington could decline by 20% and still be above MNPL.

The current management philosophy for marine mammals that assumes a density-dependent response in population growth with MNPL $>K/2$ is supported by growth of harbor seal stocks in Washington waters. We expect that further monitoring of other pinniped and cetacean stocks (Wade 2002) will also support this concept. Our analysis demonstrated that it was not possible to determine whether harbor seals in Washington had reached MNPL until several years after the fact. Our study highlights the importance of long-term, precise monitoring to help understand population dynamics and support management decisions.

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Gray whale southbound migration surveys 1967–2006: an integrated re-analysis

Jeffrey L. Laake[1], Andre E. Punt[2], Roderick Hobbs[1], Megan Ferguson[1], David Rugh[1] and Jeffrey Breiwick[1]

Contact e-mail: Jeff.Laake@noaa.gov

ABSTRACT

Between 1967 and 2007, 23 seasons of shore-based counts of the Eastern North Pacific (ENP) stock of gray whales (*Eschrichtius robustus*) were conducted throughout all or most of the southbound migration near Carmel, California. Population estimates have been derived from these surveys using a variety of techniques that were adapted as the data collection protocol evolved. The subsequent time series of estimates was used to evaluate trend and population status, resulting in the conclusion that the population was no longer endangered and had achieved its optimum sustainable population (OSP) level. We re-evaluated the data from all of the surveys using a common estimation procedure and an improved method for treatment of error in pod size and detection probability estimation. The newly derived abundance estimates between 1967 and 1987 were generally larger (–2.5% to 21%) than previous abundance estimates. However, the opposite was the case for survey years 1992 to 2006, with estimates declining from –4.9% to –29%. This pattern is largely explained by the differences in the correction for pod size bias, which occurred because the pod sizes in the calibration data over-represented pods of two or more whales and underrepresented single whales relative to the estimated true pod size distribution.

KEYWORDS: ABUNDANCE ESTIMATE; GRAY WHALES; WHALING – ABORIGINAL

INTRODUCTION

The National Marine Fisheries Service (NMFS) has conducted shore-based counts of the Eastern North Pacific (ENP) stock of gray whales (*Eschrichtius robustus*) in central California during December–February for 23 years with the first survey in 1967–1968 and the most recent in 2006–2007. Since 1974–1975 these surveys have been conducted from a cliff overlooking the ocean at Granite Canyon (36° 26’ 41” N), 13km south of Carmel. Prior surveys (1967–1974) were conducted at Yankee Point (36° 29’ 30” N), 6km north of Granite Canyon. The surveys have been conducted in this region because most gray whales migrate within 6km of land along this section of the coastline (Shelden and Laake, 2002), apparently due to the deep marine canyons north of Granite Canyon.

These survey data have been used to estimate abundance of the gray whale stock using various techniques (Buckland *et al.*, 1993; Hobbs *et al.*, 2004; Laake *et al.*, 1994; Reilly, 1981; Rugh *et al.*, 2008b; Rugh *et al.*, 2005). The resulting sequence of abundance estimates has been used to estimate the population’s growth rate (Buckland and Breiwick, 2002; Buckland *et al.*, 1993), which resulted in removal of ENP gray whales from the US List of Endangered and Threatened Wildlife on 16 June 1994 (Federal Rule 59 FR 31095), and the more recent conclusion reported by Angliss and Outlaw (2008) and Angliss and Allen (2009) that the ENP gray whale stock was within its optimum sustainable population (OSP) range as defined by the US Marine Mammal Protection Act (MMPA).

Recently, Rugh *et al*. (2008c) evaluated the accuracy of various components of the shore-based survey method, with the focus on pod size estimation. They used a pair of observers working together to track one pod of whales at a time to evaluate error in pod size estimates made by the independent observers conducting the standard survey. They compared their correction factors to similar values constructed from aerial surveys in 1978–1979 (Reilly, 1981), 1992–1993 and 1993–1994 (Laake *et al.*, 1994), and from paired thermal sensors in 1995–1996 (DeAngelis *et al.*, 1997). The additive correction factors that had been used to compensate for bias in pod size estimates differed among the various data sets; in particular, the correction factors estimated by Laake *et al.* (1994) were substantially larger than those estimated by Reilly (1981). This was of concern because the 1987–88 abundance estimate (Buckland *et al.*, 1993) used the correction factors from Reilly (1981) and all subsequent estimates (1992–1993 to 2006–2007) used the correction factors from Laake *et al.* (1994). Also, the estimates for the surveys prior to 1987 in the trend analysis were scaled based on the abundance estimate from 1987–88. This meant that the first 16 abundance estimates used one set of correction factors, and the more recent seven abundance estimates used different (and larger) correction factors which would influence the estimated trend and population trajectory.

Additionally, there have been other subtle differences in analysis methods used for the sequence of abundance estimates. For example, the number of hours on watch has been reduced from 10 to 9 per day. Also, a pod was the sample unit used for fitting the migration curve for estimates prior to 1995, whereas whales were used (after correcting for bias in pod size estimates) subsequently. Thus, a re-evaluation of the analysis techniques and a re-analysis of the abundance estimates were warranted to apply a more uniform approach throughout the years. We have explored the additive correction factor for pod size bias developed by

[1] *National Marine Mammal Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.*
[2] *School of Aquatic and Fisheries Sciences, University of Washington, Seattle, WA 98195-5020.*

Reilly (1981) and show that it requires some strong assumptions that are unlikely to be met in practice. We devised a better approach with weaker assumptions and incorporated it into an analysis that was used to estimate abundance for all 23 surveys.

METHODS

Field survey methods

The survey data collection protocol has remained largely unchanged over the 40-year time span, but some refinements to the protocol have been made to reduce observer fatigue, collect more data, and provide more accurate data measurements (Table 1). During the survey, an observer scans the ocean (typically without binoculars) and locates passing whales that are visible when they blow, surface or dive showing their flukes. For all surveys, the sighting times, pod size estimates, and some measure of offshore distance were recorded. Also, start and end of watch effort and environmental conditions (e.g. Beaufort sea state (wind force) and visibility) were also recorded. In earlier years, observers may have searched a wide area, but since the late 1980s, there has been increasing emphasis on searching only the area directly west and north of the site. This has reduced confusion with sightings at great distances. In more recent years, when a whale was first seen, the time, horizontal angle, and reticle were recorded for the initial sighting and, if seen again, when the whale surfaced again near an imaginary line perpendicular to the coast (at a magnetic angle of 241°). This allowed calculation of travel speed and trajectory relative to the coast.

The primary shift in survey protocol occurred in 1987–1988 when several important changes were made (Table 1):

(1) Prior to 1987–1988, changes in environmental conditions (i.e. Beaufort sea state and visibility classification) were recorded only at the beginning of a watch and when a sighting occurred, or up to two more times during the watch if no sightings occurred during the watch. This approach precluded measuring the exact amount of time spent surveying at specific environmental conditions, which is important because these factors affect the observers' ability to detect whales. That was corrected starting in 1987–1988 when the survey protocol was changed to record the time and conditions whenever they changed, regardless of whether any sightings occurred.

(2) Offshore distance (perpendicular to the coast at the observer's location) prior to 1987–1988 was estimated visually without calibration, and the accuracy of these estimates is unknown. All subsequent measurements of distance were made with reticle readings etched in 7 × 50 binoculars. These marks provided quantification of the angle from the horizon to a sighting. Using an observer's eye height above the surface of the ocean (between 21 and 23m depending on which part of the research station bluff was used), the reticle measurements were converted to a radial distance from the observer to the whale (Lerczak and Hobbs, 1998). The distance offshore is computed from the radial distance and the horizontal angle measured with the

Table 1

Gray whale shore-based count locations, dates, and field methods. The index y for year refers to the year at the beginning of the survey (e.g. y = 1995 for the 1995–1996 survey). YP refers to Yankee Point and GC to Granite Canyon survey locations.

Year(y)	Location	Start date	End date	Watch periods per day[1]	Paired obs.	Distance data[2]	Visibility[3]	Pod size bias
1967	YP	18/12/1967	03/02/1968	2–5h each	–	Intervals	Sky/dist	–
1968	YP	10/12/1968	06/02/1969	2–5h each	–	Intervals	Sky/dist	–
1969	YP	08/12/1969	08/02/1970	2–5h each	–	Intervals	Sky/dist	–
1970	YP	09/12/1970	12/02/1971	2–5h each	–	Intervals	Sky/dist	–
1971	YP	18/12/1971	07/02/1972	2–5h each	–	Intervals	Sky/dist	–
1972	YP	16/12/1972	16/02/1973	2–5h each	–	Intervals	Sky/dist	–
1973	YP	14/12/1973	08/02/1974	2–5h each	–	Intervals	Sky/dist	–
1974	GC	10/12/1974	07/02/1975	2–5h each	–	Intervals	Sky/dist	–
1975	GC	10/12/1975	03/02/1976	2–5h each	–	Intervals	Sky/dist	–
1976	GC	10/12/1976	06/02/1977	2–5h each	–	Intervals	Sky/dist	–
1977	GC	10/12/1977	05/02/1978	2–5h each	–	Intervals	Sky/dist	–
1978	GC	10/12/1978	08/02/1979	2–5h each	–	Intervals	Vis codes	Aerial
1979	GC	10/12/1979	06/02/1980	2–5h each	–	Intervals	Vis codes	–
1984	GC	27/12/1984	31/01/1985	2–5h each	–	Intervals	Vis codes	–
1985	GC	10/12/1985	07/02/1986	3–3 or 3.5h each	–[4]	Intervals	Vis codes	–
1987	GC	10/12/1987	07/02/1988	3–3 or 3.5h each	✓	Reticles	Vis codes	–
1992	GC	10/12/1992	07/02/1993	3–3 or 3.5h each	✓	Reticles	Vis codes	Aerial
1993	GC	10/12/1993	18/02/1994	3–3h each	✓	Reticles	Vis codes	Aerial
1995	GC	13/12/1995	23/02/1996	3–3h each	✓	Reticles	Vis codes	Thermal[5]
1997	GC	13/12/1997	24/02/1998	3–3h each	✓	Reticles	Vis codes	Tracking
2000	GC	13/12/2000	05/03/2001	3–3h each	✓	Reticles	Vis codes	–
2001	GC	12/12/2001	05/03/2002	3–3h each	✓	Reticles	Vis codes	–
2006	GC	12/12/2006	22/02/2007	3–3h each	✓	Reticles	Vis codes	–

[1]1967–68 to 1984–85: two watch periods per day of 5 hours each, from 07:00–17:00; 1985–86 to 1992–93: three watch periods per day (07:00–10:30 hours, 10:30–13:30 hours, 13:30–17:00 hours); 1993–94 to 2006–07: three 3 hour watch periods (07:30–10:30 hours, 10:30–13:30 hours, 13:30–16:30 hours).
[2]Intervals were 0–¼ nautical miles (nmi), ¼–½ nmi, ¾–1 nmi, 1–1.5 nmi, 1.5–2 nmi, etc. Distances have been based on binocular reticles since 1987–88.
[3]No visibility codes were recorded prior to 1978–79. Instead observers recorded sky conditions and sometimes miles as an indication of visibility. Those values were translated to visibility codes 1–5 used through 1987–88. In 1992–93 observers began recording visibility in six subjective categories (1 = excellent; 6 = useless), a system used since.
[4]Small-scale trial double-observer study conducted for 6 days but not used in the analysis.
[5]Thermal data for pod size bias were not used in this analysis because pod and observer were not recorded.

binocular compass. During the 1987–1988 and 1992–1993 surveys, a reticle measurement was recorded only for the whale sighting closest to the 241° line. For all subsequent surveys, reticle readings were recorded for both the north and south sightings of a pod, if it was seen twice. This provided calculations of whale travel speed.

(3) Until 1987–1988, all surveys were conducted with a single observer on watch at a time, with the exception of a small test conducted in 1986 (Rugh *et al.*, 1990). To enable estimation of pods missed by an observer during the watch, a second concurrent independent observer was used throughout the 1987–1988 survey and for portions of the survey in all subsequent surveys. By matching the measurements of offshore distance, timing of the whale passage across the 241° line, and pod size, it was possible to assess which pods were seen in common and which were missed by one of the observers. This double-count approach follows standard capture-recapture methodology (Buckland *et al.*, 1993; Otis *et al.*, 1978).

Analysis methods

Past abundance estimates have been derived as the product of the count of pods and a series of multiplicative correction factors. Buckland *et al.* (1993) and Laake *et al.* (1994) used the following abundance estimator:

$$\hat{N} = m\bar{s}f_t f_n f_m f_s \ , \quad (1)$$

where the observed number of pods (under acceptable visibility conditions), *m,* was multiplied by the mean pod size ($\bar{s}$) (i.e. $m\bar{s}$ is the total whale count) and correction factors for: (1) pods passing outside watch periods, f_t; (2) night travel rate, f_n ; (3) pods missed during watch periods, f_m ; and (4) bias in pod size estimation, f_s. Not included in these corrections are whales passing beyond the viewing range of the observers (only 1.28% of the population, according to Shelden and Laake (2002)) and whales passing the station well before or after the census, which is assumed to be a very small number. Estimates from 1995–1996 to 2006–2007 used the abundance estimator of Hobbs *et al*. (2004):

$$\hat{N} = \hat{W}f_t f_n \ , \quad (2)$$

where $\hat{W}$ is an estimate of the number of whales that passed during the watch periods and includes corrections for both pod size bias (f_s) and pods missed by the observers during the watch (f_m).

The analysis method developed here is even more integrated than the method used by Hobbs *et al*. (2004), and the resulting abundance estimator can be expressed simply as:

$$\hat{N} = \hat{W}f_n \ , \quad (3)$$

where $\hat{W}$ is an estimate of the number of whales that passed during the entire migration with corrections for pod size bias and missed pods but without differences in night vs. day passage rates. Although explicit multiplicative correction factors are not used, equivalent values for comparison to previous analysis were calculated.

Ideally, there would be data in each year to construct a year-specific value for each correction factor. However, there is no single year in which all of the data were collected to estimate each correction factor (Table 1). Despite this shortcoming, it is possible to estimate $f_{t,y}$ for each year, so a naïve estimate of abundance ($\tilde{W}_y$) can be constructed for each year (y):

$$\tilde{W}_y = m_y \bar{s}_y f_{t,y} \ , \quad (4)$$

where $\tilde{W}_y$ is an estimate of whales passing during the migration with a correction only for whales that passed outside of the watch periods, $f_{t,y}$.

Calibration data for pod size bias were collected during only five surveys (Table 1), so year-specific data were not available but the correction factor ($f_{s,y}$)was partially year-specific due to annual differences in the distribution of pod sizes. A year-specific value for missed pods ($f_{m,y}$) was computed for each of the last eight surveys (Table 1) because independent double-observer data were collected for all or portions of the survey such that each observer's detection probability could be estimated. Thus, for the last eight surveys a more 'complete' estimate of abundance with year-specific correction factors $f_{t,y}$, $f_{m,y}$, and $f_{s,y}$ but a constant night time correction factor was constructed. To construct comparable estimates for the first 15 surveys when these data were not available, a conventional ratio estimator (Cochran, 1977) was used with $\hat{W}_y$ and $\tilde{W}_y$ values for the last eight surveys and that estimated ratio was used to scale the naïve abundance estimates from each of the first 15 surveys.

Detail of each of the methods for handling pod size error, pods missed by the observer while on watch and estimation of abundance for each year are outlined below. All of the methods described here were implemented in the R (*R* Development Core Team, 2009) statistical computing environment. Both the data and the R code have been archived into an R package named ERAnalysis[3] that can be used with R to reconstruct the analysis and results presented here.

Pod size calibration

Estimates of the size of migrating gray whale pods are subject to error, with a tendency to undercount the number of whales in a pod because of the observer's oblique view from shore and the asynchrony of diving among whales in a pod. That is, multiple whales surfacing separately within a pod are often confused with a single whale surfacing multiple times. The magnitude and sign of the errors obviously depends on the true size of the pod. For example, it is possible that close, multiple dives of a single whale could be misconstrued as more than one whale in a pod, but by definition, underestimation cannot occur for a single whale. In contrast, a large pod of whales could be potentially counted as a single whale if the whales were close together and no more than one whale was observed at the surface simultaneously. The most reliable count of a pod occurs when all of the whales are observed at the start of a deep dive, when there is some synchrony to the group and each shows its fluke.

To address this source of error, two calibration methods were used (Table 2). In the first method, an aircraft was used to observe whale pods and count the number of whales in a pod while observers from shore recorded their independent

[3] *http://www.afsc.noaa.gov/nmml/software/eranalysis.php*

Table 2

Summary of gray whale pod size calibration data. Some observers provided estimates in more than one year and each pod was not observed by each observer. Only one or two estimates per pod were obtained via land tracking because they calibrated the single or double observers during the standard watch.

Year	Type	No. of pods	No. of observers	No. of observations
1978–79	Aerial	25	12	295
1992–93	Aerial	21	5	79
1993–94	Aerial	39	7	157
1997–98	Land tracking	111	10	192
Total		196	28	723

estimates of pod size. With the aerial view and relatively clear water, an accurate count of whales in a pod could be obtained, considered here to be the true pod size. Aerial surveys were conducted during the 1978–1979 southbound survey (Reilly, 1981) and during the 1992–1993 and 1993–1994 surveys (Laake *et al.*, 1994). To avoid the expense of an aircraft survey, another test of pod size estimation was conducted wherein pairs of observers tracked whales continuously through the viewing area with a theodolite or binoculars while observers on the standard watch maintained an independent effort (Rugh *et al.*, 2008c). The pod size measurements determined during the tracking were considered to be the true pod size and were later compared to the estimates of the observers conducting the standard watch. The aerial survey has the obvious advantage of providing a more reliable true pod size but was not as realistic because the shore-based observers were not conducting a standard watch and were focused solely on estimation of a single pod size. The tracking experiments more closely emulated pod size measurement for an observer conducting a standard watch, but the 'true' pod size measurement from the trackers may have not always been accurate because their view was similar to the shore observer. Pod size calibration data were also generated with paired thermal sensors in 1995–1996 (DeAngelis *et al.*, 1997). However, these data were not recorded such that each pod and observer could be identified (W. Perryman, Southwest Fisheries Science Center, National Marine Fisheries Service, pers. comm.), so these data were not considered in this analysis because it was not possible to evaluate those random effects.

It is important to examine the methodology of Reilly (1981) to understand the differences between the correction factors from these various data sources as reported by Rugh *et al*. (2008c). Initially we develop the notation and outline an alternative method with a much weaker assumption to be used in the re-analysis. Let S represent true pod size and s represent recorded pod size. With the survey data, we can measure $h(s)$, the distribution of observed (recorded) pod sizes, but we want to measure $f(S)$, the distribution of true pod sizes. If we knew the probability that an observer would record a pod of true size S as size s, $g(s|S)$, we could solve for $f(S)$ from the following convolution:

$$h(s) = \sum_S f(S) g(s|S) \ . \qquad (5)$$

For the calibration data, we know S. We measure the proportion of times observers record s for a pod of true size S, which provides a direct measurement of $g(s|S)$. Determination of $f(S)$ from equation (5) is a standard approach with discrete data for deriving the distribution of the true values (S) from the recorded values (s) and estimated calibration function, $g(s|S)$. (e.g. Heifitz et al. 1998). This approach does assume that $g(s|S)$ remains constant but $f(S)$ can vary annually, so the 'correction factor' expressed as the ratio of average true pod size to average recorded pod size ($\sum_S Sf(S)/ \sum_s sh(s)$) will likely vary.

In contrast, Reilly (1981) constructed a set of adjustments, $c(s)$, from the pod size calibration data that were added to each recorded pod size s in the survey data. The c(s) were constructed by tabulating the values of S for each pod the observers recorded as size s and computing $c(s) = \bar{S} - s$. In the Appendix we provide the details to demonstrate that these additive adjustments are valid only if the distribution of true pod sizes selected for calibration $f^*(S)$ equals the distribution of true pod sizes during the survey $f(S)$. However, a simple thought experiment can demonstrate why the method could be substantially biased and hence is not appropriate in general. Consider, a survey in which $f(S) = 0.25$ for $S = 1, \ldots, 4$, but for the calibration experiment only pods of true size $S = 4$ were selected. That would lead to $c(s) = 4 - s$ because the average true size in the calibration data ($\bar{S}$) would always be 4 regardless of the value of s. Use of those data would lead to an estimate of 4 for the average pod size when the true value was 2 for the scenario we proposed. While such a pod selection strategy would never be chosen, it does demonstrate the potential bias that could occur if the distribution of selected pods for calibration did not match the true pod size distribution. While it may be possible to select pods randomly with regard to true size, the Reilly (1981) approach would require the pod size calibration data to be collected each year unless true pod size distribution never changed, which seems unlikely.

Differences in adjustment values, $c(s)$, for different calibration data sets as reported in Rugh *et al.* (2008c) can result from differences in either $f^*(S)$ or $g(s|S)$. If the differences reported by Rugh *et al.* (2008c) are due to differences in $g(s|S)$, that may reflect inherent variability in observer ability or variability due to inherent difference in the calibration pods (e.g. frequency and timing of surfacing, proximity of whales within a pod, and distance from observer). However, substantial bias could result if the differences are due to the selection of pods $f^*(S)$ during the different calibration experiments and $f(S)$ varies annually.

Four pod size calibration data sets (Table 2) were used to estimate $g(s|S)$, an Sxs calibration matrix with a row for each true value S and a column for each observed value s up to some reasonable maximum true pod size S^{max}. We used $S^{max} = 20$. If there were sufficient calibration data for all true pod sizes, a saturated multinomial model could be used with each cell estimated as the proportion of observations that were recorded to be size s that were in fact a true pod size S. However, the available calibration data were fairly sparse for true pod sizes >3 because most pods contain only 1–3 whales. Instead, a more parsimonious approach of fitting parametric distributions for $g(s|S)$ was chosen. We considered a truncated Poisson (for s–1)

$$g(s|S) = \frac{\alpha_S^{s-1} e^{-\alpha_S}}{(s-1)!\mu_S} \ , \qquad (6)$$

and a truncated discretised gamma distribution defined as:

$$g(s|S) = \int_{s-1}^{s} \frac{b_S^{a_S} x^{a_S-1} e^{-xb_S}}{\Gamma(a_S)\mu_S} dx \ . \quad (7)$$

Each of the distributions was truncated such that $s \le S^{max}$ (i.e. $\mu_S = \sum_{s=1}^{s_{\max}} g(s|S)$). The calibration function depends on S through the parameters. Models with separate parameters for S = 1,2,3 were considered because they represented the majority of the data, and we collapsed pods of true size >3 (4+). For $S > 3$, the log of the rate parameter (b_S in the gamma and α_S in the Poisson) of the distribution was expressed as a linear function of S. For the gamma shape parameter (a_S), four parameters, one for each S in the set S = 1,2,3,4+ were specified. The likelihood without any random effects is:

$$\mathcal{L}(\psi \mid s_{ij}) \propto \prod_i \prod_j g(s_{ij} \mid S_i) \ , \quad (8)$$

where ψ is the vector of parameters for the distributions, i indexes the pod, j indexes the observer and $g(s|S)$ is replaced with either of the parametric distributions. The dependence of $g(s|S)$ on ψ is implicit. As an example, the likelihood for a Poisson distribution is:

$$\mathcal{L}(\alpha_1,\alpha_2,\alpha_3,a,b \mid s_{ij}) \propto \prod_{S=1}^{3} \left(\frac{\alpha_S^{s-1} e^{-\alpha_S} / (s-1)!}{\mu_S} \right)^{n_{s,S}} \prod_{S>3} \left(\frac{e^{(s-1)(a+bS)} e^{-e^{(a+bS)}} / (s-1)!}{\mu_S} \right)^{n_{s,S}} \ , \quad (9)$$

where the parameter vector for this example is ψ = ($\alpha_1,\alpha_2,\alpha_3,a,b$), $n_{s,S}$ is the number of observers that recorded size s when the true size was S and μ_S is the S-specific normalising sum over s = 1,…20 to ensure that the largest pod size s was less than or equal to S^{max} ($s \le S^{max}$).

The four calibration data sets (Table 2) were pooled and models fitted with a single set of S-dependent parameters. Models were also fitted with different S-dependent parameters for each of the four calibration data sets. In addition models with random effects for pod, observer and year (data set) were considered. The random effect was implemented by assuming a normal distribution $N(0,\sigma_\varepsilon^2)$ for the random effect (ε) on the log of the rate. Using the gamma distribution, a general likelihood for any single random effect was:

$$\mathcal{L}\left(\boldsymbol{a_S},\boldsymbol{b_S},\sigma|s_{ij},S_i\right) \propto \sum_k log \int_{-\infty}^{\infty} \left[\prod_{i\in I_k} \prod_{j\in J_k} \int_{s_{ij}-1}^{s_{ij}} \frac{e^{a_{S_i}(\log(b_{S_i})+\varepsilon)} x^{a_{S_i}-1} e^{-xe^{(\log(b_{S_i})+\varepsilon)}}}{\Gamma(a_{S_i})\mu_{S_i}} dx \right] \frac{e^{-\varepsilon_k^2/2\sigma_\varepsilon^2}}{\sqrt{2\pi}\sigma_\varepsilon} d\varepsilon_k, \quad (10)$$

where the summation is over the k sets defined by the random effect (e.g. k = 1,....,n), i,j indexes the pods and observers within the respective sets I_k, J_k defined by the k^{th} random effect value, and $\boldsymbol{a_S}$ = (a_1,a_2,a_3,a_{4+}) and $\boldsymbol{b_S}$ = (b_1,b_2,b_3,b_{4+} = $e^{\beta_0+\beta_1 S}$). As an example, for a pod random effect k = 1,....,n = 196, $I_k = k$ and J_k is the set of observers that made estimates for the k^{th} pod. For the gamma random effect model $g(s \mid S)$ is:

$$g(s|S) = \int_{-\infty}^{\infty} \int_{s-1}^{s} \frac{e^{a_S(\log(b_S)+\varepsilon)} x^{a_S-1} e^{-xe^{(\log(b_S)+\varepsilon)}}}{\Gamma(a_S)\mu_S} dx \frac{e^{-\varepsilon^2/2\sigma_\varepsilon^2}}{\sqrt{2\pi}\sigma_\varepsilon} d\varepsilon \ . \quad (11)$$

Random effects models for the Poisson were constructed similarly. Each parametric distribution was fitted by solving for the maximum likelihood estimates using *optim* in R 2.9.1 (*R* Development Core Team, 2009); the most parsimonious model was selected using AIC.

Using the estimated $g(s|S)$ from the calibration data, allows derivation of an estimate of $f(S)$from the survey data for any year using a multinomial likelihood with either a saturated model (i.e. separate parameter for each value of S) or a parametric model for $f(S)$. The latter was chosen because it was more parsimonious and used a discretised gamma distribution:

$$f(S \mid \theta) = \int_{S-1}^{S} \frac{b^a x^{a-1} e^{-bx}}{\Gamma(a)} dx \ , \quad (12)$$

where $\boldsymbol{\theta}$ = (a,b). Other parametric models could be formulated for $f(S)$ but the gamma is sufficiently flexible to fit a variety of distribution shapes. To derive an estimate of $f(S)$ directly from the observed distribution of pod sizes $h(s)$, involves an assumption that the size of the pod did not influence the probability that the pod was seen. However, previous analyses (Buckland *et al.*, 1993; Hobbs *et al.*, 2004; Laake *et al.*, 1994; Rugh *et al.*, 2008b) show that larger pods are more likely to be seen. Consequently, an unbiased estimator for $f(S)$ from the observed data cannot be derived without accounting for detection probability.

Correcting for missed pods

From 1967 to 1985, a single observer searched and recorded migrating gray whale pods during the surveys. Beginning in 1987, two observers surveyed independently for all or some portion of the survey timeframe. These independent counts provided the mark-recapture framework (Buckland *et al.*, 1993) to estimate the proportion of pods that were missed by an observer by matching recorded pods based on offshore distance, timing, and pod size (Rugh *et al.*, 1993). The Appendix contains the details of the algorithm that was used to assess which pods were seen by both observers and which were missed by one of the observers. As part of that matching process pods seen in close proximity (time and offshore distance) by the same observer were linked (combined) for both observers prior to matching. Pods were linked to cope with situations in which one observer combined two close pods and the other observer recorded them as two separate pods. Estimated detection probability from the mark-recapture analysis and the abundance estimates were based on these linked pods. The notation n^* is used for the number of pods recorded by an observer and n ($\le n^*$) is used to denote the number of linked pods used in the analysis.

In each of the prior analyses of the gray whale survey data (Buckland *et al.*, 1993; Hobbs *et al.*, 2004; Laake *et al.*, 1994; Rugh *et al.*, 2008b), pod size was an important predictor for pod detection. A pod with more whales will involve more surfacings and will provide more obvious visual cues resulting in a greater number of opportunities for detection. In each of those prior analyses, the recorded pod size (s) was used as the covariate but this approach has a couple of disadvantages. When a pod was seen by both observers, disagreement between the recorded sizes was ignored in the analysis. In addition, recorded pod size s is not the best predictor for detection probability. For example, an observer might record a pod of three whales as a single whale if only one whale was at the surface at a time. Yet, one would expect far more surfacing events from asynchronous surfacing of a pod of three whales than a single whale, and would expect that it would be more likely to be detected than the single whale even though $s = 1$ in both cases. Detection probability was represented in terms of the true unknown size S and summed over the distribution of true pod sizes $f(S)$ which was simultaneously estimated from the data by including the pod size calibration matrix (eqn 11). Independent errors in pod size measurement were used when both observers detect a pod.

The additional notation ignores the year index to simplify the notation. Let,

x_{ij} = an indicator variable = 1 if the i^{th} of n pods is seen by the observer at the j^{th} station (j = 1,2) and 0 otherwise;

s_{ij} = recorded size of the i^{th} pod by the observer at the j^{th} station (j = 1, 2) if it was seen by the observer at the j^{th} station; and

$\gamma_j(\boldsymbol{C}_i,S)$ = probability that the observer at the j_{th} station (j = 1,2) sees the i^{th} pod which has a vector of associated covariates $\boldsymbol{C}_i$ and a true pod size S.

S is unknown, and the recorded pod size (s) is known only for observed pods. Either one or two estimates of pod size result if observers at one or both stations detect the pod. We sum over all possible values of S (1 to S^{max}) weighting by the estimated probability distribution $f(S)$ and the estimated pod size calibration matrix $g(s|S)$. For each observed pod, we compose the vector of indicator variables (x_{i1}, x_{i2}) which has the possible observable values (1,0), (0,1) and (1,1). The vector (0,0) represents a pod that was missed by the observers at both stations.

Given that at least one observer detected the pod, the probability of observing the vector (x_{i1}, x_{i2}, s_{i1}, s_{i2}) for the i^{th} pod is:

$$p(x_{i1},x_{i2},s_{i1},s_{i2}) = \sum_S f(S)\prod_{j=1}^{2} g(s_{ij}|S)^{x_{ij}} \frac{\gamma_j(\boldsymbol{C}_i,S)^{x_{ij}}\left[1-\gamma_j(\boldsymbol{C}_i,S)\right]^{1-x_{ij}}}{1-\prod_{j=1}^{2}\left[1-\gamma_j(\boldsymbol{C}_i,S)\right]}, \quad (13)$$

Let $\boldsymbol{\theta}$ be the parameter vector for $f(S)$ and let $\boldsymbol{\varphi}$ be the parameter vector for the detection function γ. Then, the likelihood for the double-observer data, conditional on $g(s|S)$ is:

$$\mathcal{L}(\theta,\varphi|\psi,\boldsymbol{x}_1,\boldsymbol{x}_2,\boldsymbol{s}_1,\boldsymbol{s}_2) = \prod_{i=1}^{n} p(x_{i1},x_{i2},s_{i1},s_{i2}), \quad (14)$$

where $n = n_1+n_2-n_3$ is the total number of pods seen by either observer, and n_1 were seen by the primary observer, n_2 were seen by the secondary observer, and n_3 were seen by both observers. When there was only a single observer on watch, no information about γ can be derived, but the single observers' sightings for estimation of $f(S)$ can be used and γ will influence those measurements through the effect of S on detection. The conditional distribution for true pod size S for detected pods with covariates $\boldsymbol{C}$ is:

$$f(S|detected) = \frac{f(S)\gamma(\boldsymbol{C},S)}{\sum_S f(S)\gamma(\boldsymbol{C},S)} \quad (15)$$

The likelihood for the n_1 observations by the single observer also conditional on $g(s|S)$ is:

$$\mathcal{L}(\theta,\varphi|\psi,s_1,\ldots,s_{n_1}) = \prod_{i=1}^{n_1} \frac{\sum_S f(S)\gamma(\boldsymbol{C}_i,S)g(s_i|S)}{\sum_S f(S)\gamma(\boldsymbol{C}_i,S)} \quad (16)$$

The two component likelihoods for the single- and double-observer data can be multiplied (or log-likelihoods summed) to derive the maximum likelihood estimates for the parameter vector ($\boldsymbol{\theta},\boldsymbol{\varphi}$). Pod size calibration data alone provide information about the $g(s|S)$ parameter vector $\boldsymbol{\psi}$ because there is no known true pod size contained in the double-observer data to assess bias.

A logistic distribution was used for the detection function $\gamma(\boldsymbol{C},S)$ and models considered with covariates $\boldsymbol{C}$ containing offshore (perpendicular) distance (km) with intervals (0–1, 1–2, 2–3, 3–4, 4+), and observer (each person). Additional models with Beaufort sea state or visibility as numeric covariates or visibility classified as Excellent–Good and Fair–Poor were then considered. The data from each of the eight years were analysed separately. The model that minimised Akaike Information Criterion (AIC) in each year was used but any models containing Beaufort sea state or visibility that showed an increase in detection probability with worsening environmental conditions were excluded.

Abundance estimation

With the correction for pod size bias and missed pods, we expanded the recorded number of whales during a watch to an estimate of the number of whales that actually passed during the watch. That prediction could be based on data from observers at both stations when two observers were on watch and a single observer when only one station was occupied. However, we chose to avoid this complication and used only the data from the observer at the designated primary station because in most years the additional data would not have improved precision very much. The predicted number of whales was based on a Horvitz-Thompson estimator ($1/p$), which provides an estimate of the number of pods (whales) that passed from those that were seen using the estimated detection probabilities. The reasoning for this estimator can be illustrated with a simple example. If one observes a pod and estimates its detection probability to be 0.5, then it is expected that one pod was missed for every pod that was seen, so the Horvitz-Thompson estimator results in a doubling of the observed number of pods ($1/0.5 = 2$).

The observed pod size was used with the correction for pod size bias and the estimate of $f_y(S)$ to make inference about the probable true pod size S from the recorded size s using the conditional distribution:

$$f_y(S|s) = \frac{f_y(S)g(s|S)}{\sum_S f_y(S)g(s|S)} \quad , \tag{17}$$

where we now use index y for survey year to be explicit about which portions vary by year. Using this conditional distribution, the estimator for the number of pods passing during the j^{th} period of year y when the primary observer was searching (on watch) in year y from the n_{1jy} linked pods is:

$$\hat{P}_{jy} = \sum_{i=1}^{n_{1jy}} \sum_S f_y(S|s_{ijy}) \frac{1}{\gamma_y(\boldsymbol{C}_{ijy}, S)} \quad , \tag{18}$$

and the estimator for the number of whales is:

$$\hat{W}_{jy} = \sum_{i=1}^{n_{1jy}} \sum_S f_y(S|s_{ijy}) \frac{S}{\gamma_y(\boldsymbol{C}_{ijy}, S)} \quad . \tag{19}$$

Surveys were conducted for 9 to 10 hours a day, and it is known that whales migrate throughout the day and night (Perryman *et al.*, 1999). In addition, the environmental conditions can compromise sighting probability or become so poor that migrating whales are not visible to the observer and survey effort is suspended. Thus, it is also necessary to expand the estimate from the time observed to the total migration timeframe to account for whales that passed when no observers were surveying.

This second prediction component of the abundance estimate uses a migration curve fitted to the predicted number of whales passing when the observer was searching (on watch) to predict the total number passing including periods when the observer was not on watch (i.e. night time or poor visibility). The fitted migration curve is needed because the migration rate changes during the course of the survey (typically exhibiting a peak in mid-January) and because the amount of survey effort throughout the migration timeframe varies unpredictably due to varying visibility conditions. The timing and duration of those off-effort periods can severely impact the observed count of whales due to the variation in the migration rate (e.g. missing a day in mid-January has a greater impact than missing a day in early December).

For each survey year y, consider a sample of $j = 1, \ldots, m_y$ effort periods of length $l_{1y}, l_{2y}, \ldots, l_{m_y y}$ for time intervals that are not always consecutive such that $l_{jy} = t_{1jy} - t_{0jy}$, where the 0 and 1 indices represent the beginning and ending times of the interval. A curve can be fitted to the sequence of migration passage rates (whales/hour) $\hat{W}_{jy}/l_{jy}$, at the time mid-points ($t_{jy} = (t_{0jy} + t_{1jy}) / 2$). Following Buckland *et al.* (1993), we added an assumed value of 0 whales passing for day 0 and T to anchor the fitted curve when it was assumed whales did not pass. For each year a generalised additive model (GAM) was fitted with an assumed quasi-Poisson family for the $\hat{W}_{jy}$ $j = 1,\ldots,m_y$ with an offset of $\log(l_{jy})$ to account for varying length of observation period and to allow for over-dispersion. The function *mgcv* (version 1.5–5) (Wood, 2006) in R 2.9.1 (*R* Development Core Team, 2009) was used to fit the GAMs. The Poisson mean $\lambda_y(t) = e^{\xi_y(t)}$ used a log-link with a default smoother over time $\xi_y(t)$. This approach provides a much more flexible modelling technique than the normal-Hermite adjustment modelling of Buckland *et al.* (1993).

With a fitted migration curve, abundance was estimated by summing the expected value of the number of whales passing each day from time 0 to T_y:

$$\hat{W}_y = \sum_{t=0.5}^{T_y - 0.5} \hat{\lambda}_y(t) \quad . \tag{20}$$

For most years, $T_y = 90$ where the days are counted with the origin ($t = 0$) at 12:00 am 1 December. The only exceptions were 2000 and 2001 when the migration extended to $T_y = 100$ days. Buckland *et al.* (1993) constructed a multiplier as the integral of the migration model over the migration period (0, T_y) divided by the integral over the sampled periods:

$$f_{ty} = \frac{\int_0^{T_y} \lambda_y(u)du}{\sum_{j=1}^{m_y} \int_{t_{0jy}}^{t_{1jy}} \lambda_y(u)du} \quad , \tag{21}$$

and the multiplier was used to inflate the estimate of the whales passing during the sampled periods to the entire migration as follows:

$$\hat{W}_y = f_{ty} \sum_{j=1}^{m_y} \hat{W}_{jy} \quad . \tag{22}$$

The formulation for abundance (eqn 20) provided an easier way to formulate a variance and it provided nearly identical results as eqn 22.

For each of the eight survey years from 1987–1988 to 2006–2007, an estimate of abundance $\hat{W}_y$ (y indexes the year) was derived using the above methods. However, there were no double-count data prior to 1987, and there was almost no overlap in personnel during these two periods. Offshore distance was also not reliably measured prior to 1987. From prior analyses, it is known that detection of whales depends on the observer and offshore distance (Buckland *et al.*, 1993; Hobbs *et al.*, 2004; Laake *et al.*, 1994; Rugh *et al.*, 2008b; Rugh *et al.*, 2005). Thus, we could not use a common detection model from recent years and apply it to the earlier years because both distance and observer could not be used as covariates for years prior to 1987. As an alternative, we chose to construct a common total correction factor for a naïve estimate of abundance ($\tilde{W}_y$) was developed by fitting a GAM with a smooth over time $\tilde{\lambda}_y(t)$ for the observed count of whales $\tilde{W}_{jy} = \sum_{i=1}^{n^*_{1jy}} s_{ijy}$ in each of the m_y effort periods of length l_{jy} and predicting total abundance based on the sum of the predicted daily numbers of whales passing $\tilde{W}_y = \sum_{t=0.5}^{T_y - 0.5} \tilde{\lambda}_y(t)$. This was essentially the same process defined above but without any correction factors for missed pods, pod size bias, etc. A conventional ratio estimator (Cochran, 1977) was then constructed using the $\hat{W}_y$ and $\tilde{W}_y$ values for the eight surveys from 1987 to 2006:

$$\hat{R} = \frac{\sum_{y=1987}^{2006} \hat{W}_y}{\sum_{y=1987}^{2006} \tilde{W}_y} \quad , \tag{23}$$

The ratio was used as a multiplicative correction factor for the naïve estimates prior to 1987 ($y = 1967, \ldots, 1985$):

$$\hat{W}_y = \hat{R}\tilde{W}_y \tag{24}$$

Applying the ratio estimator to naïve abundance estimates for previous years, involves the assumption that the factors that affect detection of whales and bias in pod size measurement were similar on average across years. Survey data that were collected only when the conditions were such that the Beaufort sea state was 4 or less and visibility was fair or better (codes 1 to 4) were used to minimise variation due to environmental conditions. Data were filtered based on entire watch periods, because environmental conditions were not recorded continuously prior to 1987. If recorded environmental conditions exceeded the criterion for any sighting or effort period within the watch, all of the data for the watch were excluded. This filter was applied to all surveys, even though that was not necessary for the last eight surveys, because we thought that it was important to maintain a consistent treatment of the data to apply the ratio and to obtain a valid assessment of trend and population status.

Estimation of the variance-covariance matrix for the sequence of abundance estimates is complicated because there are three sources of estimation error: (1) Σ_1 includes variation from parameter estimation error for pod size ($\boldsymbol{\theta}$) and detection probability ($\boldsymbol{\varphi}$), (2) Σ_2 includes variation from parameter estimation error for the pod size calibration parameters ($\boldsymbol{\psi}$), and (3) Σ_3 includes variation from estimation error in fitting the GAM passage rate parameters and residual temporal variation in the number of migrating whales. The element-wise total of the three component matrices, each 23 × 23 (23 surveys), provides the variance-covariance matrix of the abundance estimates. We will use i = 1,...,23 and j = 1,...,23 to index the rows and columns of the elements of the covariance matrix. The estimates of abundance co-vary because the first 15 estimates depend on $\hat{R}$ which was computed from the last eight estimates, and the last eight estimates co-vary because they all used the same estimated set of pod size calibration parameters $\boldsymbol{\psi}$ for $g(s|S)$.

The delta method was used to estimate each of the variance-covariance matrices for abundance. The estimator can be represented in general as $\mathbf{D}'\mathbf{\Sigma}_\zeta\mathbf{D}$ where $\boldsymbol{\zeta}$ is a vector of k parameters, $\mathbf{\Sigma}_\zeta$ is the kxk variance-covariance matrix for $\boldsymbol{\zeta}$ and $\boldsymbol{D}$ is a kxm matrix of first derivatives of the quantities derived from $\boldsymbol{\zeta}$. For this specific case, m = 23 for the 23 estimates of abundance and k varied depending on the set of parameters in the variance component. For some of the parameters, the complex interaction of the parameters and the abundance estimators was such that it was only reasonable to estimate the derivative matrix $\boldsymbol{D}$ numerically, which meant computing each of the abundance estimates for each value of $\zeta_k \pm \delta\zeta_k$ (where δ = 0.001 and ζ_k is the maximum likelihood estimator of the k^{th} parameter) and estimating the rate of change (first derivative) for each abundance estimator.

For Σ_1, the variance-covariance matrix of the pod size ($\boldsymbol{\theta}$) and detection probability ($\boldsymbol{\varphi}$) parameters was obtained from the inverse of the Hessian matrix derived from the optimization of the log-likelihood, which was derived with the function *optim* in R 2.9.1 (*R* Development Core Team, 2009). The first derivative matrix was estimated by varying each parameter, which in turn would change the predicted number of whales passing in each watch, so each GAM model was refitted to predict the change in total abundance. The detection and pod size parameters for each of the 8 recent survey years were fitted separately so the covariances are all 0 (σ_{ij} = 0 for i = 16, …, 23 and j = 16, …, 23 and $i \neq j$). All other σ_{ij} were non-zero due to the use of R to scale the first 15 survey estimates.

For Σ_2, the variance-covariance matrix of the pod size calibration parameters ($\boldsymbol{\psi}$) were also obtained from the inverse of the Hessian matrix using the selected parametric distribution for S = 1, 2, 3, and 4+. The same general technique used for Σ_1 was used for this variance-covariance matrix except that the pod size calibration parameters affect both estimated detection probability ($\boldsymbol{\varphi}$) and pod size ($\boldsymbol{\theta}$) parameters and the fitted GAM model. For each of the pod size calibration parameters in $\boldsymbol{\psi}$, evaluating the first derivative numerically required optimising the likelihood for the detection and pod size model and then subsequently re-fitting the GAM and predicting each abundance.

For Σ_3, the variance components required the computation of the variance for the predicted total abundance from the fitted GAM. The smooth function derived using *mgcv* is represented as a matrix of linear predictors (**L**) and parameters ($\boldsymbol{\beta}$). For year y, let $\mathbf{\Sigma}_{\mathbf{L}y}$ be the variance-covariance matrix of the k parameters for the linear predictor and let $\mathbf{L}_\mathbf{y}$ be the T_yxk linear predictors for the GAM. Then the variance estimator for total abundance in year y (for $y \geq 1987$) is:

$$v\hat{a}r(\hat{W}_y) = \left(\lambda_y \boldsymbol{L}_y\right)' \Sigma_{L_y} \left(\lambda_y \boldsymbol{L}_y\right) + c_y \hat{W}_y \ , \qquad (25)$$

where $\boldsymbol{\lambda}_y = e^{\boldsymbol{L}_y\boldsymbol{\beta}_y}$ is a vector of T_y predicted daily abundances of migrating whales, $\boldsymbol{\beta}_y$ is the vector of k parameters and c_y is the over-dispersion scale parameter of the fitted quasi-Poisson. A similar variance can be constructed for naïve abundance estimator $\tilde{W}_y$ for all surveys derived from fitting the GAM to the observed whale counts:

$$v\hat{a}r(\tilde{W}_y) = \left(\tilde{\lambda}_y \tilde{\boldsymbol{L}}_y\right)' \tilde{\Sigma}_{L_y} \left(\tilde{\lambda}_y \tilde{\boldsymbol{L}}_y\right) + \tilde{c}_y \tilde{W}_y \ , \qquad (26)$$

For σ_{ii}, i = 1,…,15, the diagonal elements $v\hat{a}r(\tilde{W}_y)$ for y < 1987 are estimated using the delta method:

$$v\hat{a}r(\hat{W}_y) = \tilde{W}_y^2 \sigma_R^2 \left(k+1\right) + \hat{R}^2 v\hat{a}r\left(\tilde{W}_y\right) \ , \qquad (27)$$

where σ_R^2 is the variance of the ratio estimator $\hat{R}$ (Cochran, 1977) for the k = 8 surveys. The first term is the prediction variance for $\hat{R}$ and the second term includes variance for the naïve abundance estimator. For the off-diagonal elements i = 1,...,15 and j = 1, …,15 and $i \neq j$, $\sigma_{ij} = \tilde{W}_{yi}\hat{W}_{yj}\sigma_R^2$. For i = 1, ...,15 and j = 16,...,23,

$$\sigma_{ij} = \sigma_{ji} = \tilde{W}_{y_i} \left(\frac{v\hat{a}r(\hat{W}_{y_j})}{\tilde{W}_{y_j}} - \frac{\hat{W}_{y_j}^2}{\tilde{W}_{y_j}^3} v\hat{a}r(\tilde{W}_{y_j}) \right) . \qquad (28)$$

Night time differential

For surveys conducted during 1994–1996, Perryman *et al.* (1999) demonstrated that the night time passage rate was 28% higher during the latter half of the migration (> 15 Jan.). Using this as the median migration date (f = 0.5; 50% migrated before and 50% after), based on a 9-hour day and 15-hour night, Rugh *et al.* (2005) estimated a multiplicative correction factor of 1.0875 with a standard error of $f \times 15$ / 24 × 0.116 after correcting the typographical errors in Perryman *et al.* (1999). Here, a 14-hour night is assumed to avoid the minor but complicating adjustment that would be needed to account for the 10-hour survey from 1967 to 1987 and 9-hour survey since 1992. A constant night time correction factor of f_n = 1.0817 (SE = 0.0338) was applied to each of the 23 estimates to create the final abundance estimates

$$\hat{N}_y = f_n \hat{W}_y \quad (29)$$

The adjusted variances and covariances in the matrix $\boldsymbol{V}$ are:

$$\hat{var}\left(\hat{N}_y\right) = \hat{var}\left(f_n \hat{W}_y\right) = (f_n \hat{W}_y)^2 \left(\left(\frac{0.0338}{1.0817}\right)^2 + \frac{\hat{var}(\hat{W}_y)}{(\hat{W}_y)^2} \right) \quad (30)$$

and

$$\hat{cov}(\hat{N}_{y_i}, \hat{N}_{y_j}) = f_n^2 \hat{cov}(\hat{W}_{y_i}, \hat{W}_{y_j}) \quad (31)$$

Where $\hat{var}(\tilde{W}_y)$ are the diagonal elements of $\Sigma_1+\Sigma_2+\Sigma_3$ and are the off-diagonal elements.

RESULTS

Naïve abundance estimates

GAMs were fitted to the observed passage rates (whales/hour) over time for each survey year (Fig. 1), using the recorded data from the primary observer during survey periods in which Beaufort sea state never exceeded 4 and visibility was fair or better (1 to 4). With the fitted GAMs, naïve estimates of abundance were computed (Table 3), that ranged from 7,000 to nearly 16,000. Without corrections for error in pod size, missed pods, or a night time differential, the naïve estimates would expectedly be lower than the true abundance.

Pod size calibration

Pod size calibration data were collected on 196 pods in four years (Table 2). The distribution of pods included 69, 56, 28, and 26 of true sizes S = 1 to 4, and an additional 8,6,2,1 pods of true sizes of 5, 6, 8, and 10, respectively. For each pod, as few as 1 and as many as 12 observers estimated a size for the pod (Table 2).

The more flexible gamma model provided a better fit than the Poisson (Table 4). A gamma mixed-effects model with a random effect for pod (eqn 10) was the most parsimonious (Table 5). A random pod effect captured the apparent variation amongst whale pods in the whale's behaviour, spatial separation of whales and synchronicity in surfacing of whales in a pod. As expected, pod size was typically underestimated with some small (usually <0.1) probability of overestimation (Fig. 2).

Correcting for missed pods

There were two independent observers throughout the 1987–1988 survey, so the number of matched observations was considerably greater than for the other survey years that had only partial double counts (Table 6). The average detection rate for the primary observer, ignoring any covariates, ranged from 0.70 to 0.81 across years (Table 6); thus, it can crudely be estimated that 20 to 30% of the pods that passed through the viewing area during watch periods with adequate visibility were missed by the observer at the primary station.

The fitted detection probability models (Table 7) demonstrated that the observers were most likely to miss pods of single whales and whales at offshore distances greater than 4km. There was also considerable variation among observers. For example, observers #6 and #10 in 2001 had respective detection probabilities of 0.91 and 0.71 for pods with two whales at the intermediate distances of 1 to 2km. With the exception of the 1995–1996 survey, observers were most likely to detect pods between 1 to 2km which was the corridor where most whales passed (Shelden and Laake, 2002). Pods within 1km were less likely to be detected because of the observer's focus farther offshore and because whales were in view for less time when travelling closer to shore. Visibility was an important predictor only in 1987 and 1993 and Beaufort sea state only in 2006 (Table 7).

Expected pod size $E(S)$ from the fitted survey-specific gamma pod size distributions, ranged from 1.72 to 2.63 whales per pod and was on average 11% (range: 3.9 – 18.8%) greater than the year-specific observed mean size of linked pods ($\bar{s}$) (Table 7). The computed $E(S)$ adjusts for two sources of bias $\bar{s}$ in with opposite directions. Inclusion of pod size calibration data $g(s|S)$ increased $E(S)$ relative to and accounting for size-biased detection of pods (i.e. larger pods are easier to see) decreased $E(S)$.

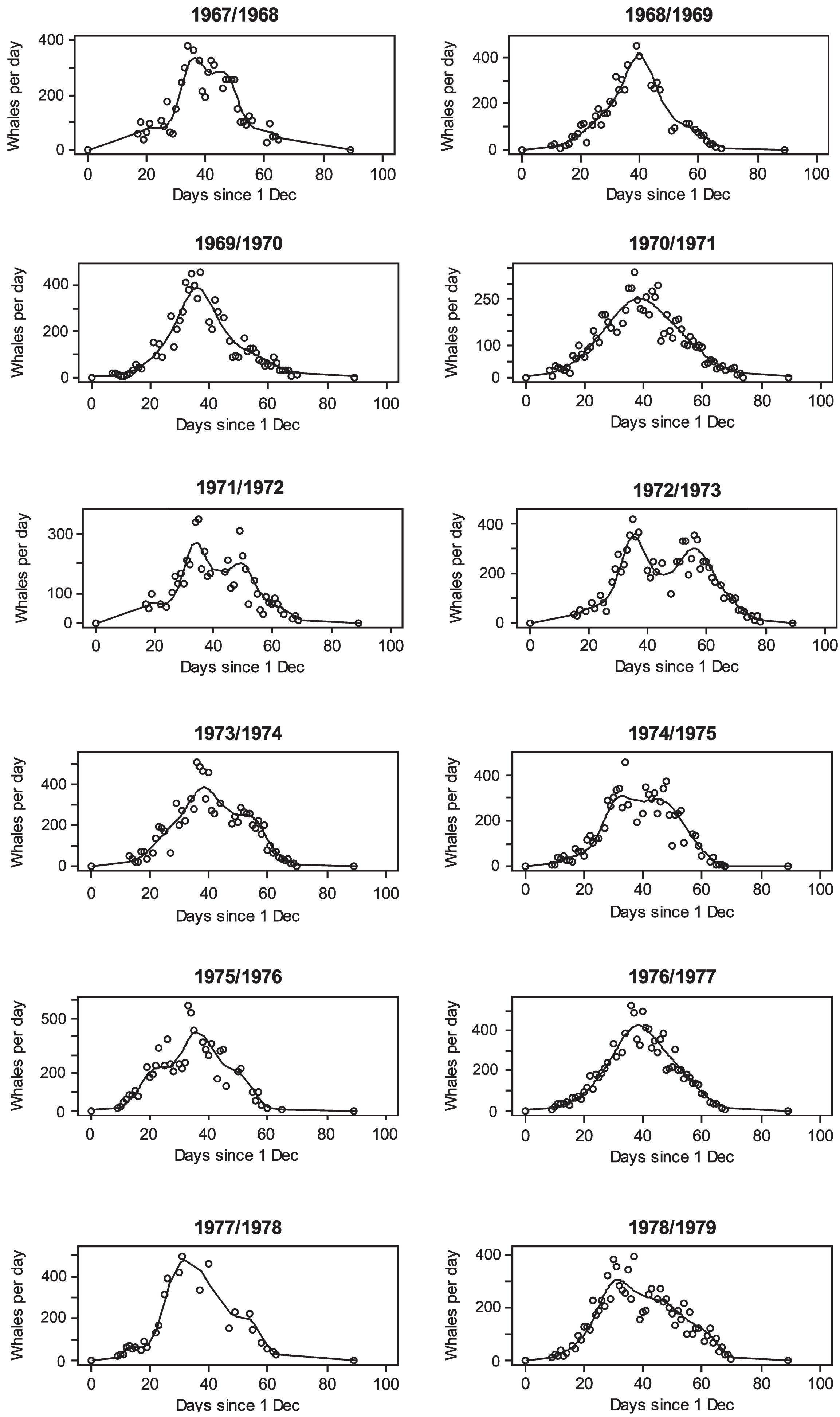
Abundance estimation

Whale passage rates (whales/hour) were estimated within each watch interval using the year-specific fitted models for pod size and missed pods (eqn 19), based on the observations from the primary observer after linking pods to correspond with the linking process for matched pods (Table 8). A year-specific GAM (Fig. 3) was fitted to the estimated whale passage rates to estimate total abundance ($\hat{W}_y$) (eqn 20) based on the daytime passage rate (Table 8). The ratio estimate $\hat{R}$ (eqn 23) was used to correct the naïve abundance estimates (eqn 24) for the 15 surveys from 1967 to 1985. Then all of the year-specific estimates were multiplied by the nighttime correction factor to obtain the final abundance estimate $\hat{N}_y$ (eqn 29) for each year (Table 9).

The newly derived abundance estimates (Fig. 4) between 1967 and 1987 were generally larger (–2.5% to 21%) than those reported by Rugh *et al.* (2008a). However, the opposite was the case for survey years 1992 to 2006 with estimates declining from –4.9% to –29%. This pattern is largely explained by the differences in the correction for pod size bias (Table 9) which occurred because the distribution of pod sizes from the calibration data over-represented pods of two or more whales and underrepresented single whales relative to the estimated true pod size distribution (Fig. 5).

DISCUSSION

When the southbound gray whale surveys were initiated in 1967 and a single observer searched and counted passing whales, those researchers had not anticipated that such a complicated process was needed to estimate abundance of the gray whale population. However, the data collection and estimation processes had to be adapted to account for the apparent deficiencies and biases resulting from variable environmental conditions, the limits of human visibility and cognition, and vagaries in whale behaviour as the survey process was evaluated (Perryman *et al.*, 1999; Reilly, 1981;


1967/1968
1968/1969
1969/1970
1970/1971
1971/1972
1972/1973
1973/1974
1974/1975
1975/1976
1976/1977
1977/1978
1978/1979
Whales per day
Days since 1 Dec

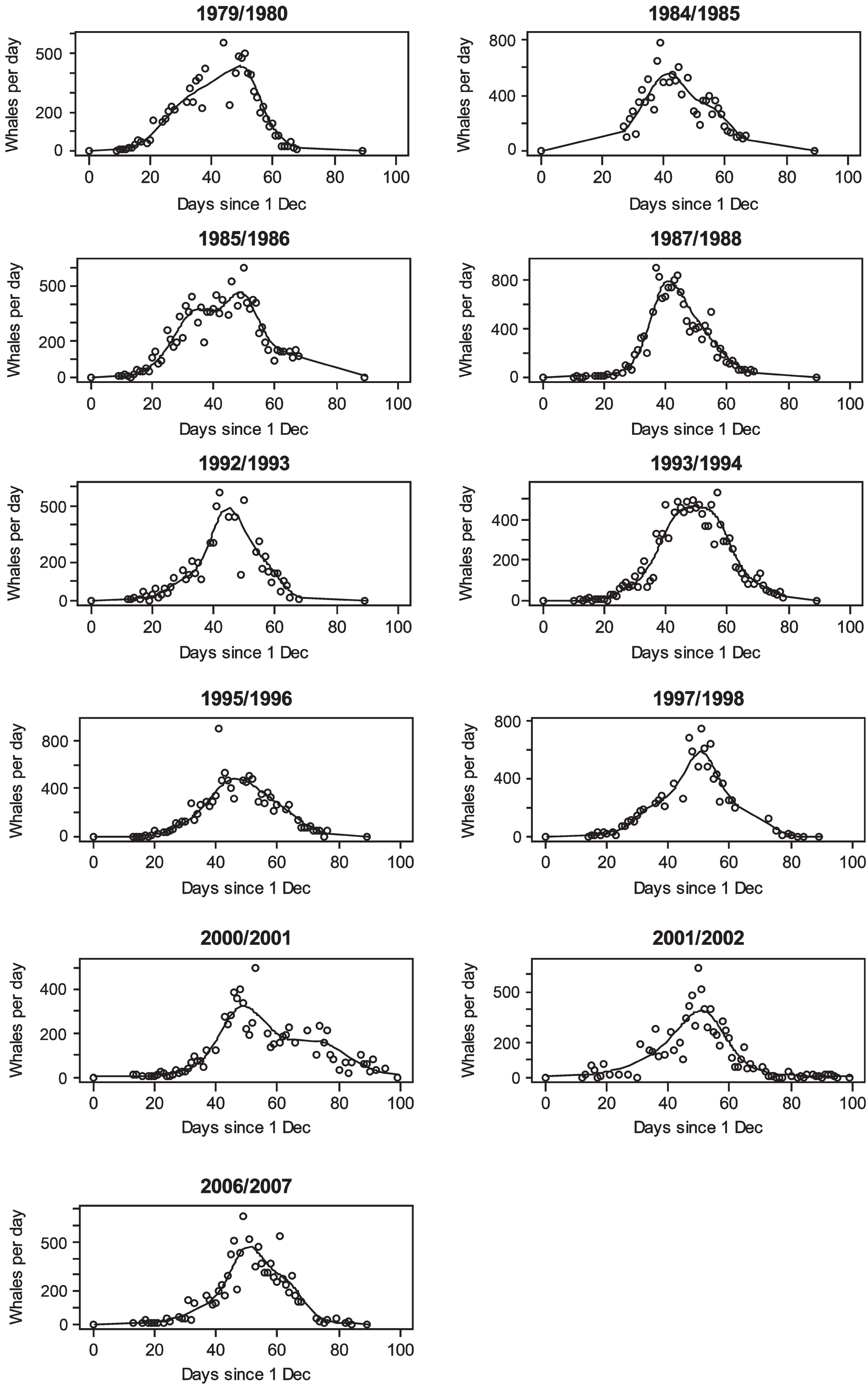


Fig. 1. Observed whale passage rates expressed as whales per day (circles) and fitted GAM model for the 23 southbound gray whale surveys during 1967–1968 to 2006–2007. The shift to later migration timing since 1992 is evident in this series of plots.

Table 3

Recorded number of pods and whales passing during acceptable effort periods of the southbound gray whale surveys from 1967 to 2006. Naïve abundance ($\widetilde{W}_y$) was estimated by smoothing observed whale passage rates (whales/hr) over time within each survey using a GAM (Fig. 1) and predicting total number of whales passing during the migration without applying correction factors.

Year	Number of pods	Number of whales	Average pod size	Effort (hours)	Naïve abundance
y	n^*_{1y}	$\sum_{i=1}^{n^*_{1y}} s_{iy}$	$\bar{s}=\sum_{i=1}^{n^*_{1y}} s_{iy} / n^*_{1y}$	$\sum_{j=1}^{m_y} l_{jy}$	$\widetilde{W}_y$
1967	903	2,202	2.44	303.0	8,558
1968	1,072	2,290	2.14	380.0	9,273
1969	1,236	2,626	2.12	465.0	9,276
1970	1,463	2,951	2.02	594.7	8,140
1971	859	1,885	2.19	345.0	7,062
1972	1,539	3,365	2.19	465.0	11,068
1973	1,497	3,139	2.10	425.0	11,074
1974	1,508	3,068	2.03	475.0	9,746
1975	1,188	2,462	2.07	293.5	11,195
1976	1,992	4,087	2.05	519.0	11,713
1977	657	1,211	1.84	195.0	12,453
1978	1,726	3,474	2.01	516.4	9,805
1979	1,457	2,998	2.06	376.3	12,596
1984	1,736	4,006	2.31	268.0	14,978
1985	1,840	4,119	2.24	456.5	14,609
1987	2,370	4,991	2.11	441.0	15,934
1992	1,002	1,772	1.77	297.5	10,438
1993	1,925	3,522	1.83	462.4	13,195
1995	1,439	2,669	1.85	304.0	13,741
1997	1,564	2,531	1.62	284.1	14,507
2000	1,089	1,869	1.72	399.0	10,571
2001	1,194	2,030	1.70	390.2	9,808
2006	1,254	2,568	2.05	310.0	11,484

Rugh *et al.*, 1993; Rugh *et al.*, 2008c; Shelden and Laake, 2002; Swartz *et al.*, 1987). Ideally, we would have all of the data needed to construct independent year-specific estimates that accounted for all of the potential biases affecting the counts. However, there is no way to obtain those data for the early surveys. Even when the data needs were apparent, budgets were not always sufficient to collect the data in each year. Thus, compromises have been necessary to construct a complete time series of abundance estimates.

One of those compromises was incorporation of a 'correction' for error and bias in observers' estimation of the size of pods. Corrections are based on calibration data from aircraft and intense effort by dedicated shore-based teams. However, these data were not collected for each survey. In hindsight, both the method proposed by Reilly (1981) and

Table 4

Model selection results for pod size calibration data. The rate model ~size + True:plus represents the structure with separate rates for S = 1, 2, 3 and a linear model (intercept + slope × S) for S>3 (k = 5 parameters). Each of the Gamma models also contained four shape parameters for sizes S = 1, 2, 3, >3. The most parsimonious model (smallest AIC_c – small sample version of AIC) is shown in bold.

	Poisson		Gamma	
Rate model	AIC_c	k	AIC_c	k
Fixed: ~size + True:plus	1,548.12	5	1,532.64	9
Fixed: ~year*(size + True:plus)	1,514.95	20	1,466.23	36
Fixed: ~size + True:plus, Random:pod	1,506.32	6	**1,454.21**	**10**
Fixed: ~size + True:plus, Random:observer	1,542.96	6	1,517.07	10
Fixed: ~size + True:plus, Random:year	1,536.89	6	1,517.94	10

Table 5

Parameter estimates for the gray whale pod size calibration data. The estimates are based on a discrete gamma distribution that includes a pod random effect on the rate parameter (b_S) and fixed effects for the rate (b_S) and shape (a_S) parameters based on true size of the pod.

	Estimate	Standard error
log (σ_ε)	–0.9361	0.0089
S = 1; log(b_1)	1.0040	0.2875
S = 2; log(b_2)	1.6177	0.0090
S = 3; log(b_3)	1.2783	0.2070
S > 3; log(β_0)	1.6714	0.1873
S > 3; log(β_1)	–0.1998	0.0085
S = 1; log(a_1)	0.4934	0.3361
S = 2; log(a_2)	1.7361	0.0089
S = 3; log(a_3)	1.8518	0.1920
S > 3; log(a_{4+})	1.1586	0.1644

Table 6

Number of pods seen by observers at primary and secondary station and by both observers upon completion of linking and matching for watch periods with double observers during acceptable environmental conditions (as determined by assessment of observer at primary station). Linking of pods in close proximity reduced number of pods by 1.1% to 4.6%. Linking and matching used the scoring algorithm with the defined weights as described in the Appendix.

Year	Seen by primary (n_1)	Seen by secondary (n_2)	Seen by both (n_3)	Primary detection rate (n_3/ n_2)
1987	2,258	2,296	1,710	0.745
1992	323	301	228	0.757
1993	719	697	532	0.763
1995	401	378	305	0.807
1997	748	788	588	0.746
2000	657	677	513	0.758
2001	603	691	483	0.699
2006	395	405	303	0.748

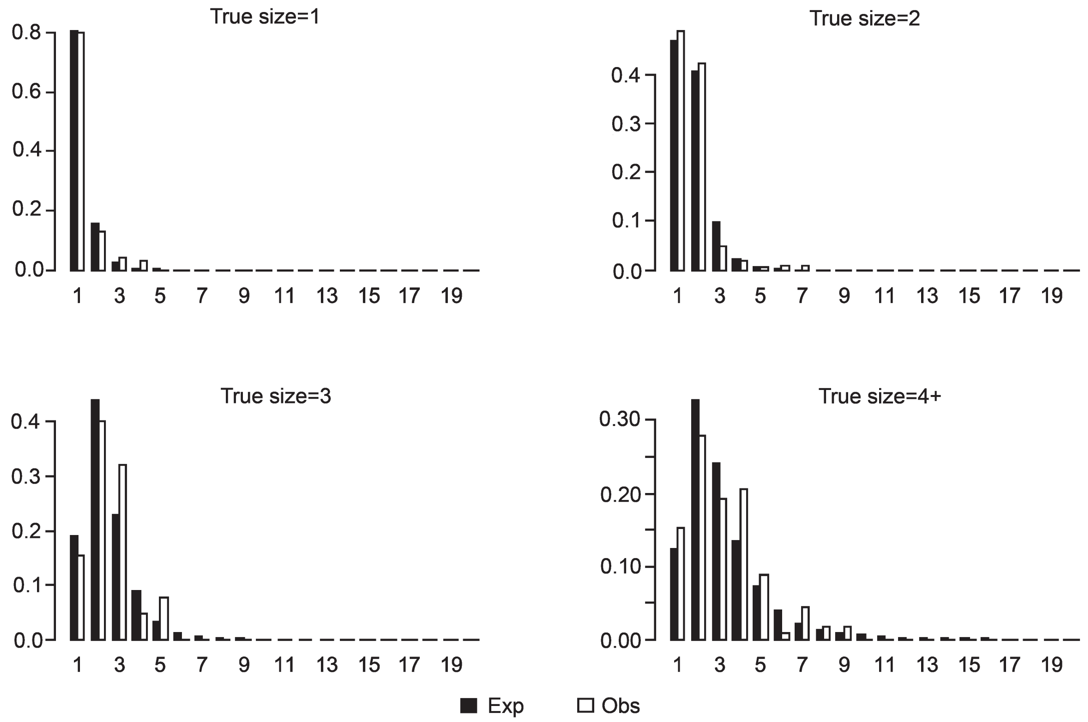


Fig. 2. For true pod sizes S = 1,2,3,4+, probability distributions for recorded (observed) pod sizes (s) and expected values from the gamma model with random pod effects for calibration data (Table 3).

the change in data selection for pod size bias (Buckland *et al.*, 1993; Hobbs *et al.*, 2004; Laake *et al.*, 1994; Rugh *et al.*, 2008b; Rugh *et al.*, 2005) were not optimal choices. At the very least all of the pod size calibration data should have been pooled to estimate a common correction factor for the entire time series. Here we have devised a more robust estimation approach for handling pod size bias, and we used all of the calibration data, with the exception of the thermal imaging data of DeAngelis *et al.* (1997).

Re-evaluation of the correction for pod size bias and the other changes made to the estimation procedure yielded a substantially different trajectory for population growth.

Table 7

Parameter estimates (standard errors in parentheses) for the gamma distribution of pod size (S), the expected pod size ($E(S)$) and detection probability parameters from the selected model for each year for the eight most recent southbound gray whale surveys. Parameters for the gamma distribution are on the log-scale (e.g., for 1987 shape = exp(0.422) and rate = 1/scale = exp(–0.326). Parameters for detection probability are on logit scale. Intercept represents observer #1 for pod of size 0 at distance < 1km and for either Vis <4 or Beaufort = 0 depending on model. For example, detection probability for observer #3 with pod size = 2 at distances between 2–3km in 1987 with visibility <4 was: 1/(1+exp(0.310+0.087+0.172–0.553×2). Observers are arbitrarily numbered and different for each year. Average pod size $\bar{s}$ here is for linked primary pods (Table 8).

	1987	1992	1993	1995	1997	2000	2001	2006
Gamma shape	0.422 (0.060)	–0.073 (0.161)	–0.070 (0.100)	–0.063 (0.111)	–0.598 (0.131)	0.089 (0.127)	–0.095 (0.131)	–0.106 (0.106)
Gamma rate	–0.326 (0.062)	–0.347 (0.147)	–0.474 (0.094)	–0.545 (0.106)	–0.674 (0.118)	–0.280 (0.122)	–0.366 (0.125)	–0.685 (0.102)
$E(S)$	2.626 (0.044)	1.886 (0.067)	2.060 (0.051)	2.176 (0.066)	1.724 (0.047)	1.995 (0.058)	1.885 (0.056)	2.340 (0.075)
$E(S)/\bar{s}$	1.188	1.054	1.079	1.127	1.039	1.115	1.065	1.104
(Intercept)	–0.310 (0.183)	–0.044 (0.730)	0.579 (0.427)	1.840 (0.583)	0.267 (0.336)	–0.458 (0.429)	1.050 (0.534)	0.867 (0.495)
Podsize	0.553 (0.063)	0.747 (0.260)	0.938 (0.189)	0.438 (0.141)	0.553 (0.151)	0.908 (0.192)	0.485 (0.141)	0.343 (0.104)
Distance 1–2km	0.289 (0.138)	0.528 (0.440)	0.012 (0.273)	–0.660 (0.483)	0.476 (0.281)	0.656 (0.352)	0.277 (0.401)	0.274 (0.350)
Distance 2–3km	–0.172 (0.147)	–0.183 (0.438)	–0.391 (0.278)	–1.310 (0.498)	–0.035 (0.278)	0.328 (0.357)	–0.261 (0.404)	–0.327 (0.355)
Distance 3–4km	–0.702 (0.203)	–0.683 (0.488)	–0.713 (0.367)	–1.740 (0.570)	–0.223 (0.315)	–0.361 (0.438)	–0.944 (0.448)	–0.788 (0.479)
Distance >4km	–1.840 (0.288)	–1.790 (0.704)	–1.410 (0.506)	–2.580 (0.754)	–0.825 (0.385)	–0.793 (0.676)	–1.340 (0.548)	–1.380 (0.621)
Observer 2	0.483 (0.137)	–0.219 (0.651)	–0.827 (0.302)	–0.552 (0.395)	0.978 (0.397)	–0.845 (0.424)	–0.580 (0.407)	0.121 (0.300)
Observer 3	–0.087 (0.128)	0.317 (0.615)	–0.478 (0.334)	–0.307 (0.373)	0.340 (0.295)	0.048 (0.295)	–0.776 (0.443)	0.278 (0.318)
Observer 4	0.136 (0.115)	–0.192 (0.607)	–1.340 (0.331)	–0.360 (0.344)	0.246 (0.284)	–0.865 (0.237)	–0.635 (0.390)	0.142 (0.314)
Observer 5	0.156 (0.116)	0.060 (0.613)	–0.840 (0.302)	–0.747 (0.376)	0.528 (0.301)	0.090 (0.286)	–1.100 (0.376)	–0.546 (0.419)
Observer 6	0.416 (0.136)	0.182 (0.634)	–1.550 (0.339)	–1.000 (0.560)	–0.262 (0.172)	–0.052 (0.295)	0.051 (0.414)	0.220 (0.299)
Observer 7	0.120 (0.172)	–0.574 (0.603)	–0.451 (0.354)	–0.748 (0.364)	–0.236 (0.276)	–0.553 (0.207)	–0.542 (0.424)	–1.110 (0.299)
Observer 8	0.282 (0.166)		0.076 (0.605)	0.640 (0.465)	0.129 (0.229)	–0.706 (0.235)	–1.200 (0.406)	0.473 (0.424)
Observer 9	0.237 (0.171)				–0.481 (0.227)	–0.017 (0.385)	0.030 (0.437)	1.170 (0.641)
Observer 10					0.247 (0.339)	–0.079 (0.255)	–1.410 (0.420)	
Observer 11							–0.690 (0.466)	
Observer 12							–0.591 (0.433)	
Observer 13							–0.659 (0.418)	
Observer 14							–0.956 (0.426)	
Vis >3	–0.345 (0.106)		–0.316 (0.165)					
Beaufort								–0.128 (0.125)

Table 8

For recent eight gray whale surveys from 1987 to 2006, number of pods and linked pods seen by the primary observer, average linked pod size, naïve abundance, estimated abundance (without night-time correction) and ratio estimate for correction factor for estimates from surveys prior to 1987.

Year	Number of pods	Number of linked pods	Average linked pod size	Naïve abundance	Abundance	Ratio
Y	n^*_{1y}	n_{1y}	$\bar{s} = \sum_{i=1}^{n_{1y}} s_{iy} / n_{1y}$	$\widetilde{W}_y$	$\widehat{W}_y$	$\widehat{W}_y / \widetilde{W}_y$
1987	2,370	2,262	2.21	15,934	24,883	1.562
1992	1,002	991	1.79	10,438	14,571	1.396
1993	1,925	1,848	1.91	13,195	18,585	1.408
1995	1,439	1,388	1.93	13,741	19,362	1.409
1997	1,564	1,522	1.66	14,507	19,539	1.347
2000	1,089	1,043	1.79	10,571	15,133	1.432
2001	1,194	1,150	1.77	9,808	14,822	1.511
2006	1,254	1,213	2.12	11,484	17,682	1.540
Ratio						1.450
SE						0.030

Previously, the peak abundance estimate was in 1998 followed by a large drop in numbers (Rugh *et al.*, 2008c). Now the peak estimate is a decade earlier (Table 9; Fig. 4), and the predicted population trajectory has remained flat and relatively constant since 1980 (Fig. 4).

The correction for night time differential migration rate should be revisited and more data should be collected to evaluate within-year and annual variation in day and night migration rates described by Perryman *et al.* (1999). The assessment of population growth will be improved by collection of data in each survey that provides survey-specific correction factors. Incorporation of thermal imaging and land tracking in each survey would provide survey-specific estimates for pod size calibration and night time differential. In addition, independent double-observer data should continue to be collected as part of the survey protocol to provide survey-specific measures of detection probability for pods.

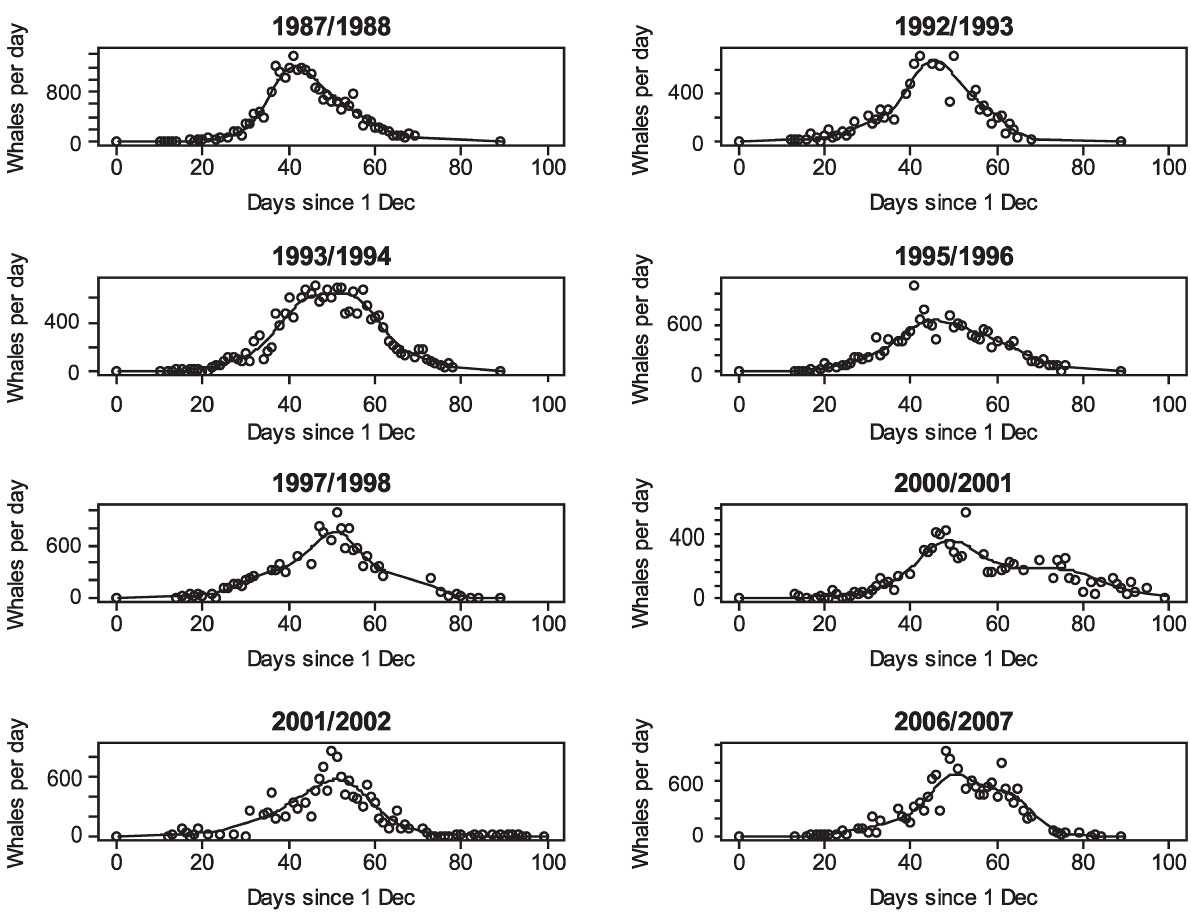


Fig. 3. Estimated number of whales passing per day during watch periods (circles) from year specific models for detection probability and pod size, and fitted GAM model (line) for the eight southbound gray whale surveys during 1987 to 2006.

Table 9

Current and previous gray whale abundance estimates and coefficient of variation (CV = standard error/estimate) constructed from southbound migration surveys conducted from 1967–68 to 2006–07. Ratio of current to previous estimates shows proportional change which is largely explained by f_s ratio which is $E(S)/\bar{s}$ from Table 7 divided by f_s, the pod size correction from previous surveys.

	Current		Previous				
Year	$\hat{N}_y$	$cv(\hat{N}_y)$	$\hat{N}_y$	$cv(\hat{N}_y)$	Ratio	f_s	f_s ratio
1967–68	13,426	0.094	13,776	0.078	0.975	–	–
1968–69	14,548	0.080	12,869	0.055	1.130	–	–
1969–70	14,553	0.083	13,431	0.056	1.084	–	–
1970–71	12,771	0.081	11,416	0.052	1.119	–	–
1971–72	11,079	0.093	10,406	0.059	1.065	–	–
1972–73	17,365	0.080	16,098	0.052	1.079	–	–
1973–74	17,375	0.082	15,960	0.055	1.089	–	–
1974–75	15,290	0.084	13,812	0.057	1.107	–	–
1975–76	17,564	0.086	15,481	0.060	1.135	–	–
1976–77	18,377	0.080	16,317	0.050	1.126	–	–
1977–78	19,538	0.088	17,996	0.069	1.086	–	–
1978–79	15,384	0.080	13,971	0.054	1.101	–	–
1979–80	19,763	0.083	17,447	0.056	1.133	–	–
1984–85	23,499	0.089	22,862	0.060	1.028	–	–
1985–86	22,921	0.082	21,444	0.052	1.069	–	–
1987–88	26,916	0.058	22,250	0.050	1.210	1.131[1]	1.050
1992–93	15,762	0.068	18,844	0.063	0.836	1.430[2]	0.737
1993–94	20,103	0.055	24,638	0.060	0.816	1.420[2]	0.760
1995–96	20,944	0.061	24,065	0.058	0.870	1.399[3]	0.806
1997–98	21,135	0.068	29,758	0.105	0.710	1.516[4]	0.685
2000–01	16,369	0.061	19,448	0.097	0.842	1.486[4]	0.750
2001–02	16,033	0.069	18,178	0.098	0.882	1.485[4]	0.717
2006–07	19,126	0.071	20,110	0.088	0.951	1.361[5]	0.811

[1]Buckland *et al.*, 1993, [2]Laake *et al.*, 1994, [3]Hobbs *et al.*, 2004, [4]Rugh *et al.*, 2005, [5]Rugh *et al.*, 2008a.

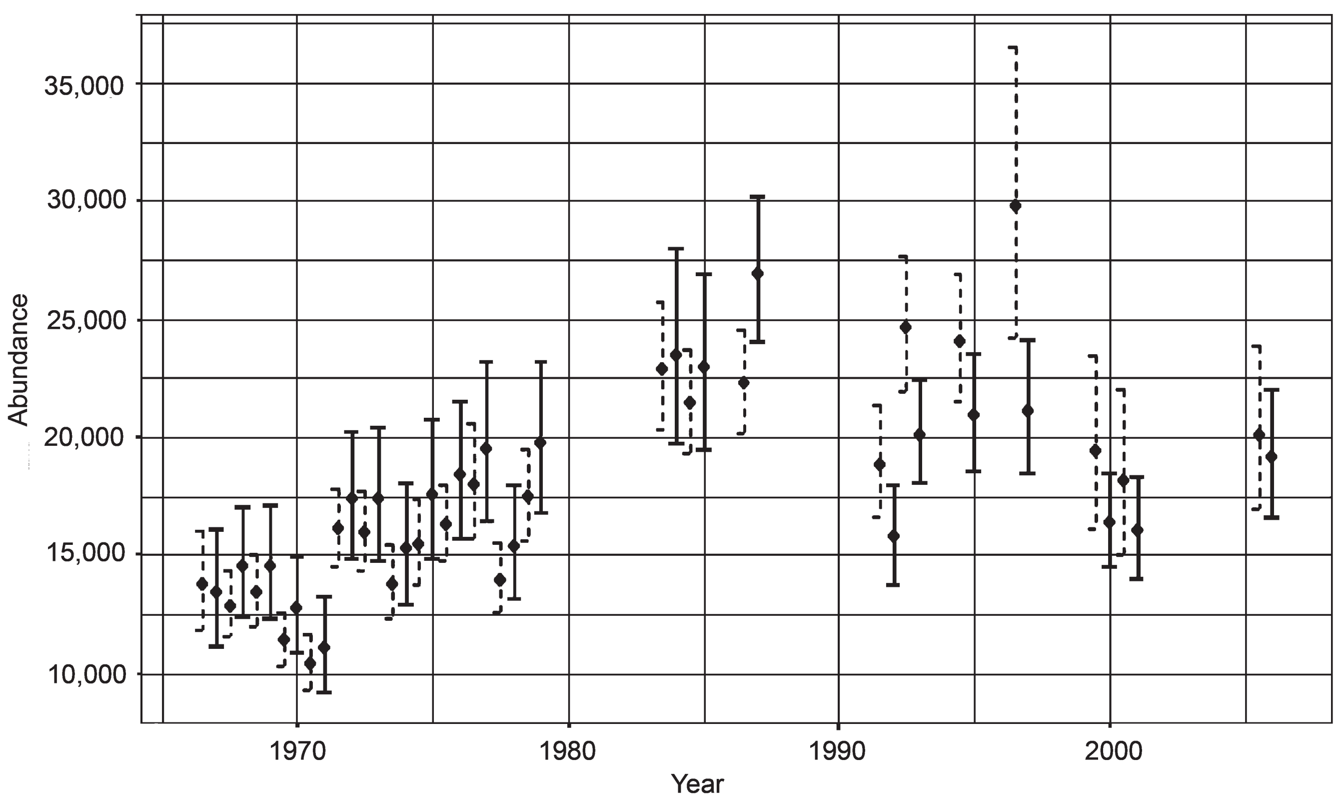


Fig. 4. Abundance estimates with 95% log-normal confidence intervals for previous estimates (dashed line) taken from Rugh *et al.* (2008a) and current estimates (solid line).

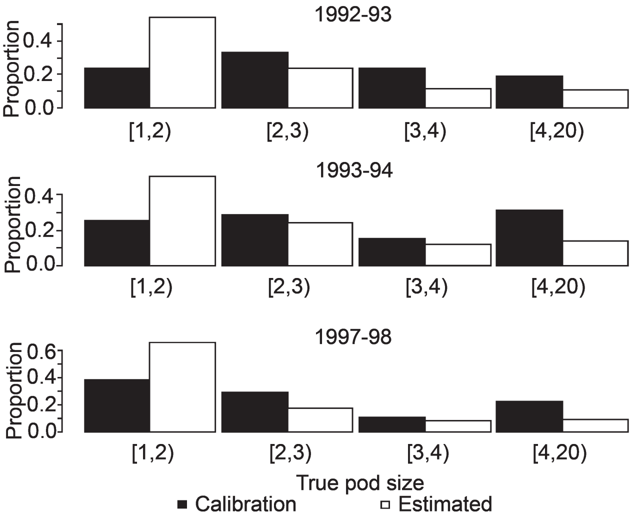


Fig. 5. Pod size distributions for calibration data (light) and estimated true pod size distribution using estimated parameters for gamma distribution (see Table 7). Calibration data from 1978–1979 are not shown because it was not possible to derive estimates of the true pod size distribution with the survey data in that year.

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APPENDIX

Additive pod size correction factor

We will use the following notation to describe the methodology of Reilly (1981):

S = true pod size

s = recorded pod size

$f(S)$ = probability distribution of true pod sizes

$h(s)$ = probability distribution of recorded pod sizes

$g(s|S)$ = probability that an observer will record a group of true size S as size s.

$f^*(S)$ = probability distribution of true sizes in the calibration data

From the calibration data, the probability that a group is of true size of S given that it was recorded as size s is:

$$f^*(S|s) = \frac{f^*(S)g(s|S)}{\sum_S f^*(S)g(s|S)} .$$

With the method of Reilly (1981), the calibration data are used to construct a set of adjustments, $c(s)$, which are added to the recorded pod size s

$$c(s) = \sum_S (S-s) f^*(S|s) = \left[\sum_S S f^*(S|s)\right] - s ,$$

to get the estimate of the average group size

$$\hat{\bar{S}} = \sum_s [s + c(s)] h(s) ,$$

which can also be written as:

$$\hat{\bar{S}} = \sum_s \left[s + \sum_S (S-s) f^*(S|s) \right] h(s) =$$
$$\sum_s h(s) \sum_S S f^*(S|s) = \sum_s h(s) E_{f^*}[S|s] .$$

Differences in adjustment values, $c(s)$, for different calibration data sets as reported in Rugh *et al.* (2008c) can result from differences in either $f^*(S)$ or $g(s|S)$. If the differences reported by Rugh *et al.* (2008c) are due to differences in $g(s|S)$ that may reflect inherent variability in observer ability or variability due to inherent differences in the calibration pods (e.g. frequency and timing of surfacing, proximity of whales in pod, distance from observer). However, if the differences are due to the selection of pods $f^*(S)$ during the different calibration experiments and $f(S)$ varies annually, substantial bias could result with the correction method of Reilly (1981).

The method of Reilly (1981) will be unbiased as long as $f^*(S) = f(S)$ (i.e. calibration distribution was selected to match the true distribution). That assumption could hold if passing pods could be selected randomly for calibration. However, use of the calibration data beyond the year in which they were collected would not be warranted unless $f(S)$ was the same in each year. While that may be possible, it is a strong assumption that is not necessary with the analysis method we describe here.

Instead of trying to ensure equality ($f^*(S) = f(S)$), the calibration data should be viewed like a regression problem in that pods should be selected to provide a best estimate of $g(s|S)$. In general, one would want the selection of pods to balance both $f(S)$ and the variance of $g(s|S)$ to minimise the uncertainty. For example, if $g(1|1)$ was nearly 1.0, then one would not need many calibration pods of size 1 and instead may select more pods of size 2 or more even if most pods were of size 1 (e.g. mode of $f(S)$ was at $S = 1$).

Matching and linking criterion

Two observers searched for gray whales at the same time and recorded their data independently to provide a measure of how many pods were missed during the watch. From the separate independent data records, we needed to decide which pods were seen by both observers and which were missed by one or the other. We have used the term 'matching' for this process of comparing observer records. The observers had a working definition for a gray whale pod as a group of whales that were within a body length of each other. However, errors were quite possible with whales in a pod surfacing at different times, and what one observer treated as a single pod could have been recorded as more than one pod by the other observer. Thus, the matching process also had to consider this possibility, so prior to matching we used a 'linking' process whereby the proximity of all sightings from a given observer were compared to each other, and any pods that were sufficiently close were merged. The records of these 'linked' (merged) pods were then 'matched' by comparing their proximity and pod size. For instance, if one observer recorded a pod of two whales and a second observer saw the same whales but recorded them as two pods of single whales each, then the linking process would merge the two whales, providing a good match between the two observers' records. An underlying assumption in this system is that there are no false positives, that is, no one records a sighting unless there truly is a whale there, and the sighting data (time and location) are accurate enough to make a match.

We used a linking/matching criterion that was a modified version of the criterion described by Rugh *et al.* (1993). The criterion constructs a score based on a comparison of crossing times (t241), distance offshore (d241), and pod sizes (s) (Fig. A1). The time and distance computations assume that whales travelled parallel to the coast at a constant speed of 6km/hour. The t241 is the time the pod would cross an imaginary line perpendicular to the location of the observer on shore (241° magnetic). It is computed from the last (most southerly) time and location of the pod by projecting, either forward or backward, the time needed to travel the distance from the last location to the 241° line. The d241 is the perpendicular distance from shore to the projected point on the 241° line where the whale pod crossed; this is estimated via a simple trigonometric calculation from the distance and angle to the most southerly location. The score function can be represented as:

$$score_{ij} = f\left[W_t |t241_i - t241_j|, \frac{W_d |d241_i - d241_j|}{\max(d241_i, d241_j)} \right]$$
$$+ W_s |s_i - s_j| ,$$

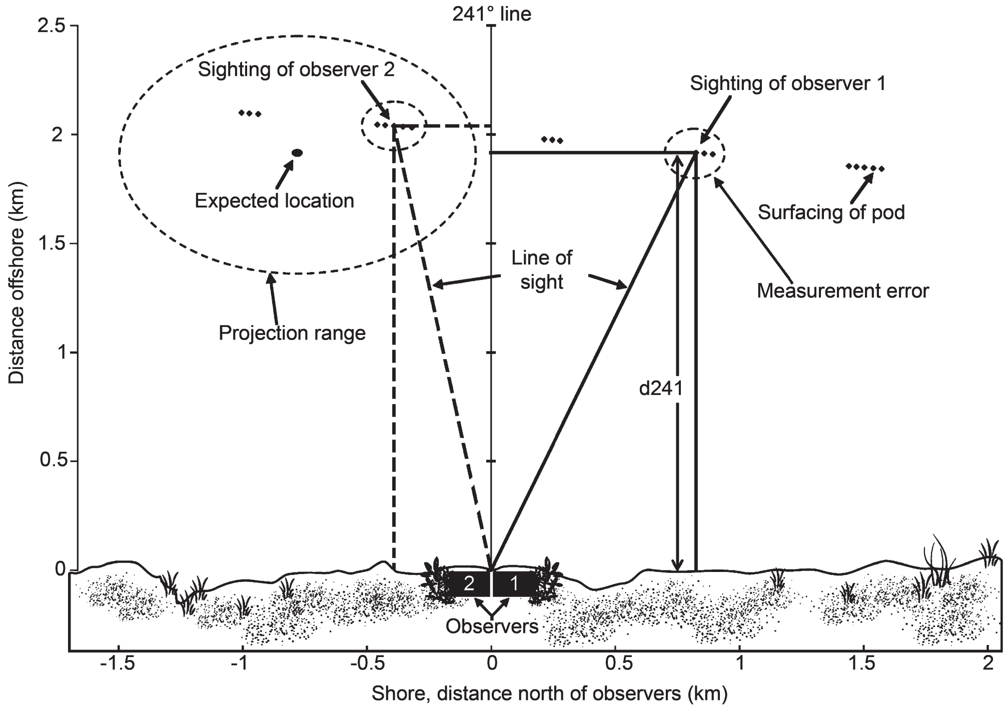

Fig. A1. Observers search from adjacent sheds (#2 and #1). As a pod passes offshore, each observer independently records time, magnetic angle, and vertical reticle. From these data, the sighting distance is calculated. The distance from shore and travel distance are calculated using trigonometry. The expected location at the time of the second sighting is estimated from the time difference and the assumption of parallel travel at 6Km/hr and the difference in t241 times is the parallel distance between these points divided by 6 km/hour. The projection range ellipse is a 95% probability area calculated from the fitted distributions for speed and deviation from parallel travel using the time difference.

where

(1) *i* and *j* are the indexes of the i^{th} and j^{th} pods of a single observer record for linking or the i^{th} and j^{th} pods recorded by independent observers for matching,

(2) the function *f* was a sum in Rugh *et al*. (1993) but here we have used a square root of the sum of the squared arguments, and

(3) W_t, W_d and W_s are defined weights for the time difference, distance difference, and pod size (*s*) difference.

All pods were scored against all other pods within an effort period. If the score was less than a maximum allowable score value, then the sightings met the criterion for linking/matching.

For linking, the pod size weight was set to zero. Pods were linked iteratively to allow for the potential that a pod was split into more than two separate pods. The pair of pods with the lowest score was merged into a single pod with the average t241 and d241 and the pod sizes summed to create a single pod replacing each subset. This was then repeated until no pair of pods met the criterion. For matching, the candidate matches were ranked by score with the lowest being the best match. The best match was recorded and the two pods in the match were removed from further matching. This process continued until there were no more candidate matches that met the criterion. The weights were scaled so that the matching maximum score was set to 1.0. The linking criterion was set to a lower value to limit the risk that a legitimate match could be lost due to the averaging of distance and time in merging pods.

The weights account for two types of errors involved in estimation of t241 and d241, measurement errors and projection errors. Measurement errors result from errors in measuring the horizontal angle, the angle below the horizon (via reticles), and the event time. These errors were estimated from comparisons between tracking teams and standard watch observers (Rugh *et al.*, 2008c). The frequencies reported in table 2 of Rugh *et al.* (2008c) were fitted by integrating the normal distribution between +0.5 and –0.5 of the horizontal degree difference and minimising the squared difference between the reported and the predicted frequency. The standard deviation for the error was estimated at 2.23°, which is consistent with the statement in Rugh *et al.* (2008c) that 95% of measurements differed by 3° or less. Reported frequencies of discrepancies in reticle measurements (Table 3 of Rugh *et al.*, 2008c) were fitted by integrating the normal distribution between +0.05 and –0.05 of the reticle difference and minimising the squared difference between the reported frequency and the predicted frequency. The standard deviation for the error was estimated at 0.14 reticles, which is consistent with the statement in Rugh *et al.* (2008c) that 95% of measurements differed by 0.4 reticles or less. Rugh *et al.* (2008c) found time precision to be limited to 45 seconds for the same surfacing of a pod which may include sequential surfacings of the pod members. Rugh *et al*. (2008c) reported time differences of less than 10 seconds for matches between tracked whales and standard watch data where the locations matched exactly (same angle and reticle), suggesting that it was the same whale surfacing. Transforming these measurement errors, the standard deviation for the error in t241 was 0.55 minutes at 1km offshore and 1.35 minutes at 3km of shore, and the standard deviations for the error in d241 were 0.032km and 0.319km respectively. When the d241 was compared between pods, this resulted in a 3.2% difference at 1km and 10.6% difference at 3km.

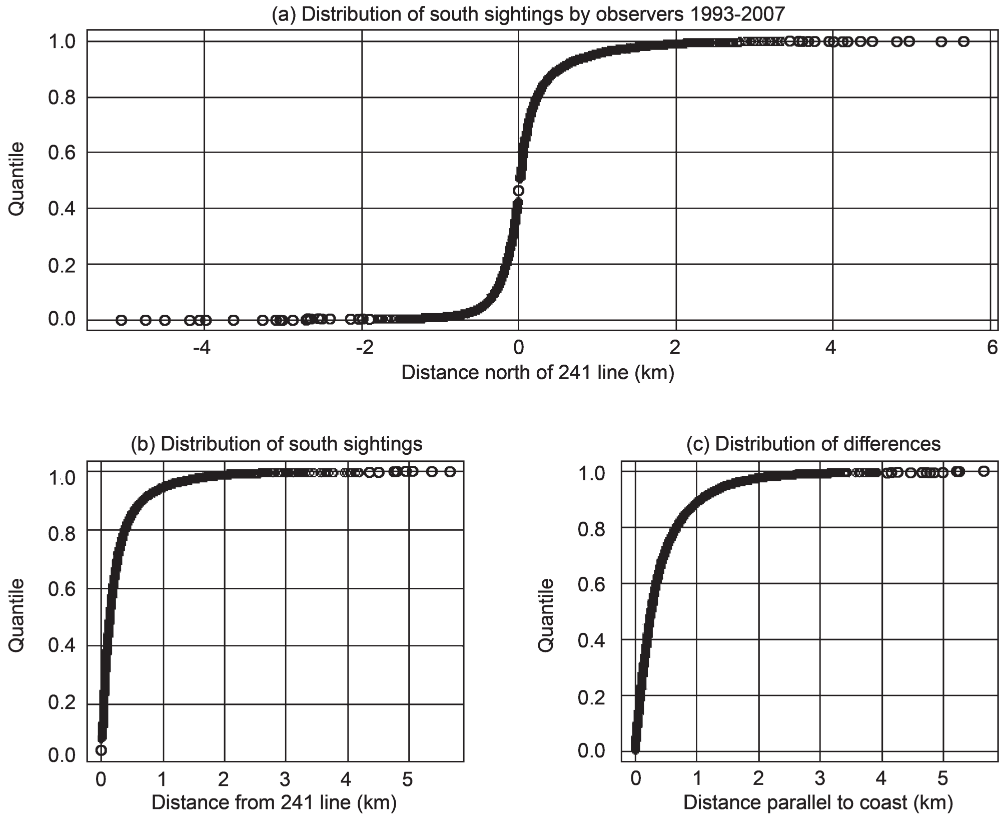

Fig. A2. (a) Distance north from the 241° line to the location of south sightings for all observers 1993–2007. (b) Absolute distance from 241° line. Note that 95% of south sightings fall between within 1 km and 99% within 2 km. (c) Distribution of differences between random pairs of sightings when sightings were drawn at random from the distribution of south sightings. Note that 90% of expected comparison distances between sightings were 1 km or less.

Projection errors resulted from differences between the actual speed and direction of a pod and the assumptions of 6km/hour and parallel travel (Fig. A1). The most southerly sightings were clustered around the 241° line with the median = 0.00km, mean = 0.079km (north) and standard deviation = 0.488 (Fig. A2a). Projection distance regardless of direction was zero (on the 241° line) for 8% of south sightings and 95% within 1km and 99% within 2km (Fig. A2b).

Travel speed was estimated directly from the sighting data using the travel time between north and south sightings. The sighting data incorporates the measurement error into the projection error. A subset of sightings was selected that have both north and south data, with a south sighting between –1.0km and +0.5km and a travel distance from north to south of 1.0 to 2.5km with a minimum time difference of 6 minutes and no other pods with t241 within 5 minutes. The south distance was chosen to insure that the travel occurred near the 241° line, the travel distance and minimum time were chosen to limit the effect of measurement errors. Only pods with no other recorded pods near were chosen to limit the effect of improperly linked sightings. Significant relations between speed and survey date and speed and pod size were found, but neither contributed significantly to reducing the variance. The average speed was 6.19km/hour (sd = 1.55, var = 2.41). The distribution of bearings relative to the 241° line was estimated from a similar data set except that all sightings with a minimum time difference of 3 minutes and travel distance between 0.02 and 2.5km were used. These were binned into 0.2km travel distance bins centered on the even tenths of a km and the mean deviation and variance about the track perpendicular to the 241° line were calculated. A linear fit of the mean deviation with the distance travelled yielded a significant but small trend shoreward of less than 30 meters/km travelled (Table A1). Two models for the change in variance were considered: (1) a ‘random walk’ in which the whales continually made small changes in heading as they proceeded south so that variance would increase linearly with distance, and (2) a fixed heading in which the square root of the variance would increase linearly with distance travelled. Of the two, the fixed heading model provided a better fit (Table A1).

The probability that a sighting by one observer was correctly matched to a sighting of the same pod by a second observer was estimated from the distribution of bearing and speed and applying the matching to the distribution of possible distances between sightings of the same group. Assuming that the distance between the sighting locations was the result of chance and observer behaviour rather than whale behaviour (e.g. sightings of faster pods are more likely to be farther apart), then the cumulative distribution of possible distances between sightings was determined by random draws of pairs from the distribution of south sightings (Fig. A2c). The projection errors were much greater than the measurement errors; consequently, it was not necessary to include the measurement errors explicitly in the choice of the weights.

While there are three measurements involved with each sighting, the determination of a match is reduced to a two dimensional comparison by relating the difference in time and distance parallel to the coast (and perpendicular to the 241° line) assuming a fixed speed of 6km/h and accepting a range of difference in the t241 times to allow for variation

Table A1

Parameter estimates for deviation from travel parallel to the coastline (perpendicular to the 241° line) in kilometres difference in d241 per kilometre of travel parallel to the coast.

Model	Mean(deviation km) = a + b(travel dist km)		Variance(deviation km) = a + b(travel dist km)		SD(deviation km) = a + b(travel dist km)	
Parameter	a	b	a	B	a	b
Estimate	0.037	-0.029	0.006	0.050	0.139	0.092
SE	0.011	0.007	0.014	0.009	0.020	0.014
t	3.41	-3.89	0.47	5.33	6.83	6.68
Pr(>|t|)	0.00665	0.00299	0.65201	0.00034	0.00005	0.00005
R-squared	0.56		0.71		0.80	
F-statistic:	15.2	P = 0.0030	28.4	P = 0.00034	44.6	P = 0.00006

Table A2

Comparison table for weights used in matching criterion. Weights were scaled so that the probability of matching in each dimension was equal.

				Standard model		Alternate model	
Probability of matched by t241	Probability of matched by d241	Probability of matched	W_t	W_d	Probability of one other pod	W_d	Probability of one other pod
99%	99%	98%	0.11	3.02	79	1.9	60%
98%	98%	96%	0.16	3.66	66	2.25	44%
97%	97%	95%	0.18	3.95	61	2.38	40%
95%	95%	90%	0.27	5.06	45	2.86	27%
89%	89%	80%	0.46	6.66	27	3.56	15%

in speed. The range of time differences and consequently speeds that meet the criteria can be related to the distribution of distances between sightings (ignoring pod size and assuming travel parallel to the coast) by rewriting the difference in the t241 times in terms of the difference in time and difference in distance to the 241° line. Likewise the extremes of the deviations from parallel travel can be estimated assuming that speed was 6 km/hour.

$$S_{slow} = \frac{\Delta x}{\frac{\Delta x}{s} + \frac{K}{W_t}}$$

$$S_{fast} = \begin{cases} \dfrac{\Delta x}{\frac{\Delta x}{s} - \frac{K}{W_t}} & if\, \Delta x > \dfrac{Ks}{W_t} \\ \infty & otherwise \end{cases}$$

$$\text{Standard: } \Delta y_{near} = \frac{K}{W_d} y_1; y_1 \geq y_2,$$

$$\Delta y_{off} = \frac{\frac{K}{W_d} y_1}{1 - \frac{K}{W_d}}; y_1 < y_2, \text{ Alternative: } \Delta y = \pm \frac{K}{W_d},$$

where, S_{slow} and S_{fast} are the extremes of the distribution speed perpendicular to the 241° line; Δx is the difference in the distance perpendicular to the 241° line between the two sightings, note that S_{fast} is undefined until Δx is sufficient to make the denominator positive; K is the maximum allowable score for a match or link; and S is the speed used for the projection, in this case 6km/hour. Δy is the maximum allowable difference in the deviation distance parallel to the 241° line between the two sightings, with y_1 being the distance offshore of the northern of the two sightings and y_2 the southern. The standard version was described in Rugh *et al.* (1993) and was intended to account for the greater measurement error with distance offshore resulting from reticle measurements by allowing a larger deviation in the offshore direction and wider range with distance offshore. The alternative ignores the measurement error and uses a constant width.

The probability that two sightings of the same pod, at a given distance apart, are matched is estimated as the product of the probabilities that the speed and deviation fall into each of these ranges. Integrating over the distribution of distances gives the approximate probability that a match will be made. Note that this analysis ignores the discrete nature of the measurement errors and as a consequence will favour the alternative to some extent. However, it is satisfactory to optimise the parameters for the standard method and to estimate the potential for improvement of matching efficiency by using the alternative.

The probability of overmatching or mismatching is approximated by the likelihood that at least one other sighting falls within that range. The linking algorithm is modified to count the number of groups that could be matched. To fully estimate the probability of mismatching we would need to include a model of the probability of a second sighting of the pod being matched having a higher score as well, and the probability of overmatching would include the probability that the pod was missed by the second observer.

While there clearly is a trade off between the certainty of correctly matching the same pod and the risk of overmatching, the risk of under matching has the potential to result in an overestimate of abundance and a conservative analysis would limit this risk. We used the weights at the 95% probability of a match (0.18 and 3.95) as the best compromise while acknowledging that the rate of missed pods may be underestimated by 50%. This analysis suggests that the alternate model would reduce the risk of overmatching by about one-third; however simulations with a discrete measurement error structure are required to determine the actual matching rate.

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Research Article

Population Growth and Status of California Sea Lions

JEFFREY L. LAAKE, *National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115, USA*

MARK S. LOWRY, *National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center, 8901 La Jolla Shores Drive, La Jolla, CA 92037, USA*

ROBERT L. DELONG, *National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115, USA*

SHARON R. MELIN,[1] *National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115, USA*

JAMES V. CARRETTA, *National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center, 8901 La Jolla Shores Drive, La Jolla, CA 92037, USA*

ABSTRACT The California sea lion (*Zalophus californianus*) population in the United States has increased steadily since the early 1970s. The Marine Mammal Protection Act of 1972 (MMPA) established criteria for management of marine mammals based on the concept of managing populations within the optimal sustainable population (OSP), defined as a range of abundance from the maximum net productivity level (MNPL) to carrying capacity (*K*). Recent declines in California sea lion pup production and survival suggest that the population may have stopped growing, but the status of the population relative to OSP and MNPL is unknown. We used a time series of pup counts from 1975 to 2014 and a time series of mark-release-resight-recovery data from 1987 to 2015 for survival estimates to numerically reconstruct the population and evaluate the current population status relative to OSP using a generalized logistic model. We demonstrated that the population size in 2014 was above MNPL and within its OSP range. However, we also showed that population growth can be dramatically decreased by increasing sea surface temperature associated with El Niño events or similar regional ocean temperature anomalies. In this analysis we developed a critical tool for management of California sea lions that provides a better understanding of the population dynamics and a scientific foundation upon which to base management decisions related to complex resource issues involving this species. Published 2018. This article is a U.S. Government work and is in the public domain in the USA.

KEY WORDS birth rates, California sea lion, El Niño, generalized logistic, population growth, population status, survival, *Zalophus californianus*.

After centuries of exploitation of marine mammals, the Marine Mammal Protection Act of 1972 (MMPA) provided protection of all marine mammals in United States waters. The MMPA established criteria for management of marine mammals by the National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS). The MMPA states that marine mammal populations “should not be permitted to diminish beyond the point at which they cease to be a significant functioning element in the ecosystem of which they are a part, and, consistent with this major objective, they should not be permitted to diminish below their optimum sustainable population” (16 U. S. C. 1361 Sec 2:5). The intent of the MMPA was to recover marine mammal populations to levels that ensured healthy and robust populations; however, translating the language into management actions presented numerous challenges.

The first challenge was defining optimum sustainable population (OSP). Eberhardt (1977) suggested that the OSP should be interpreted as the range of population sizes from the maximum size (*K*) to the size which gives maximum productivity or maximum sustainable yield (MSY). The NMFS adopted the definition for OSP as a population level between *K* and the population size that provided the maximum net productivity level (MNPL; i.e., greatest net change in the population; Federal Register, 21 Dec 1976, 41FR55536). A population can be designated as depleted under the MMPA if it is below the MNPL. Depleted populations are afforded more protection under the MMPA; consequently, determining OSP and MNPL is an important objective of agencies responsible for the management of marine mammals.

In practice, it is difficult to estimate MNPL for marine mammals because it requires substantial population data that

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[1]*E-mail: sharon.melin@noaa.gov*

are not available for most species (Gerrodette and DeMaster 1990, Ragen 1995), but it is thought to be between 50% and 80% of *K* (Read and Wade 2000). There are some examples in which MNPL and OSP has been estimated for marine mammals. Jeffries et al. (2003) and Brown et al. (2005) fitted generalized logistic models to the counts of harbor seal (*Phoca vitulina*) pups and non-pups on land during the pupping seasons. The OSP (MNPL/*K*) was 0.56 and 0.60 for Washington populations (Jeffries et al. 2003) and 0.61 for the Oregon population (Brown et al. 2005). For northern fur seals (*Callorhinus ursinus*), Ragen (1995) estimated that the mode of MNPL/K was 0.65 with a range of 0.5–0.8. In an assessment of gray whales (*Eschrichtius robustus*), Punt and Wade (2010) integrated across the range of 0.4–0.8 for MNPL, with a resulting MNPL point estimate in their baseline analysis of 0.656. Similarly, in an assessment of spinner (*Stenella longirostris*) and spotted dolphins (*Stenella frontalis*), Wade et al. (2007) integrated across a prior distribution of 0.5–0.8 for MNPL in a generalized logistic model, although in that case there was not enough information in the data to update or change the prior distribution.

Following historical reductions in the population from harvesting and bounties, the California sea lion (*Zalophus californianus*) population in the United States has been steadily increasing since the early 1970s when it was protected under the MMPA (Carretta et al. 2016*b*). Although the growth of the population is a conservation success, the status of the population relative to the MMPA criteria has not been determined. As the population has increased and expanded its range, California sea lions have increasingly been involved in resource conflicts with humans and endangered fish along the west coast of the United States that have resulted in some controversial management actions (e.g., lethal removal of adult male sea lions that feed on endangered salmonids at the Bonneville Dam on the Columbia River, Oregon; Weise and Harvey 2005, Wright et al. 2010). Determination of the status of the population relative to the MMPA criteria will provide support for management decisions that address these complex resource conflicts.

For the United States population of California sea lions (Carretta et al. 2016*b*), pup production (Lowry et al. 2017), and survival (DeLong et al. 2017) have recently declined, suggesting that the population may have stopped growing. For California sea lions, only counts of pups are available for a sufficient period (1975–2014) to evaluate population growth, MNPL, and OSP (Lowry et al. 2017). Berkson and DeMaster (1985) determined that pup counts alone could be used to assess a population status relative to OSP, but they did not consider situations in which the production of pups varied widely from density-independent factors like El Niño events, which can result in low numbers of births and high mortality of pups (DeLong et al. 1991). When pup counts fluctuate widely because of increased pre-census pup mortality or reduced birth rates, the number of pups does not immediately reflect the same magnitude change in the population size. Thus, an analysis based solely on pup counts could be misleading with large reductions in pup numbers at the end of the time series. However, in lieu of a better method, the status of California sea lions is currently determined by a correction factor applied to annual pup counts (Carretta et al. 2016*b*).

As an alternative to assessing the status of the population from pup counts, we developed a model that numerically reconstructs the California sea lion population by integrating multiple data sources and that accounts for variability in birth rates. Our primary objectives were to assess the population growth of California sea lions since the mid-1970s, evaluate the current population status relative to MNPL, and describe environmental and density-dependent impacts on survival, population growth rate, and realized at-census birth rates.

STUDY AREA

Five genetically distinct populations of California sea lions have been identified and include the United States population (U.S. or Pacific Temperate), which breeds on offshore islands in California; the western Baja California population, which breeds offshore along the west coast of Baja California, Mexico; and 3 populations (southern, central, and northern) that breed in the Gulf of California, Mexico (Carretta et al. 2016*b*). Our study applies only to the U.S. population that inhabits coastal waters from the United States-Mexico border, along the west coasts of the United States, British Columbia, Canada, and southeast Alaska, USA (Fig. 1). During the breeding season from May through August each year, most of this population returns to offshore rookery islands along the California coast (Fig. 1). Most of the breeding (99.7%) occurs on 4 islands in the California Channel Islands: San Miguel, San Nicolas, Santa Barbara, and San Clemente. The data used in this study included summer pup censuses of the California Channel Islands and other offshore breeding areas, and survival estimates derived from a single colony at San Miguel Island, which represents about 45% of the United States population.

Pupping occurs over 6 weeks from late May to early July on uninhabited sandy beaches, rocky coves, or rocky points. Sea lion females give birth to a single pup and remain in constant attendance of the pup for 5–8 days postpartum. After the perinatal period, females begin an attendance cycle in which they alternate 2- to 4-day foraging trips at sea with 1- to 2-day nursing visits ashore until the pup is weaned at about 11 months of age (Antonelis et al. 1990, Melin et al. 2000). Breeding occurs about 4 weeks postpartum, beginning in late June and ending in early August. Adult females are nonmigratory and visit the rookery regularly throughout the year, particularly if they have dependent pups (Melin et al. 2000). Adult males arrive at the rookery islands in May, but peak numbers occur in July during the peak of breeding. A small proportion of adult males establish and maintain reproductive territories for 1–60 days. Nonreproductive males haul out in areas outside of the breeding territories. After the reproductive season, adult males migrate from the rookery islands to foraging areas and hauling sites along the California, Oregon, and Washington coasts, the islands of British Columbia, Canada, and southeast Alaska (Maniscalco et al.

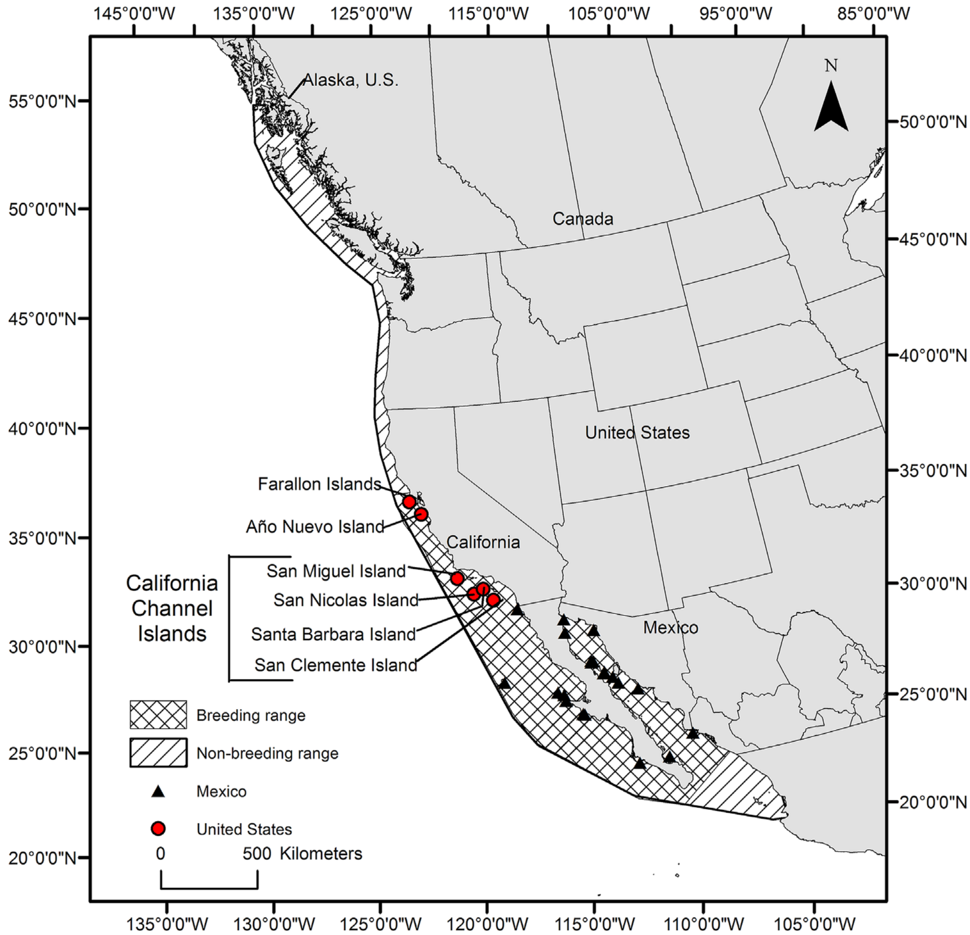

Figure 1. Range of male and female California sea lions and locations of breeding areas in the United States (circles) and Mexico (triangles). We used California sea lions branded at San Miguel Island, California between 1987 and 2014 to estimate survival rates.

2004). Juvenile (1–3 years old) females and males are present at the California Channel Islands throughout the year but also frequent hauling areas and feed along the central California coast during winter (Orr 2011).

California sea lion breeding colonies along the Pacific coast are regularly affected by the El Niño Southern Oscillation (ENSO), a global ocean-atmospheric pattern that consists of a warm El Niño phase followed by a cold La Niña phase. El Niño or La Niña conditions begin at the equator in the central Pacific ocean and then propagate northward along the west coasts of South America and North America dramatically affecting the productivity patterns of the California eastern boundary current (California Current) that the U.S. population of California sea lions relies on for food. El Niño conditions produce strong depressions of the thermocline, higher sea surface height anomalies, and warmer sea surface temperature anomalies in the California Current (King et al. 2011). These oceanographic changes result in reduced biomass of phytoplankton and zooplankton, which leads to changes in the abundance or distribution of fishes and invertebrates throughout the California Current (Bograd and Lynn, 2003). Sea lions feed on fishes and cephalopods, and during the El Niño phase of ENSO, these prey are redistributed northward or deeper in the water column in response to the warmer sea surface temperatures and the deepened thermocline. Consequently, prey become less available to sea lions, particularly nursing sea lions that are biologically tied to the colonies during the 11-month lactation period and have a limited foraging range (DeLong et al. 1991, Lowry et al. 1991, Melin et al. 2008). Pregnant and nursing sea lions travel farther and dive deeper during El Niño conditions, presumably in response to the changes in prey availability (Melin et al. 2008), resulting in significant declines in pup births and survival (Boness et al. 1991, DeLong et al. 1991, Francis and Heath 1991, DeLong and Melin 2000, Melin et al. 2012*a*).

METHODS

As an alternative to assessing the status of the population from pup counts, we numerically reconstructed the California sea lion population by integrating multiple data sources including 1) total pup counts for the U.S. population over a period from 1975 to 2014 (Lowry et al. 2017); 2) age- and sex-specific survival estimates derived from branding, resighting, and recovery data collected from 1987 to 2015 from a colony at San Miguel Island, California (DeLong et al. 2017); and 3) estimates of human-caused mortality (Carretta and Enriquez 2012; Carretta et al. 2016*a*, 2017).

We fitted a generalized logistic population growth curve to the annual reconstructed population sizes from which we could estimate MNPL and the status of the current population size relative to MNPL and OSP.

Our analysis involved 6 partially intertwined steps.

1. We imputed any missing values from available pup count data to construct an entire time series of annual pup counts for the United States population for 1975–2014.
2. We derived sex- and age-specific estimates of annual survival for 1975–2013.
3. With an initial population structure based on a stable age-distribution and the annual pup counts, we projected the abundances using survival estimates to reconstruct the age- and sex-specific population structure and total annual population size for 1975–2014.
4. We estimated annual sea lion bycatch from the halibut (*Paralichthys californicus*) set net fishery data as a minimal estimate of human-caused mortality for 1975–2014.
5. Using the bycatch estimates, we fit a generalized logistic growth curve to the time series of population size each year to estimate MNPL, K, and the status of the population in 2014 (N_{2014}/MNPL).
6. We conducted an analysis of realized birth rates derived from the sex- and age-specific population reconstruction.

These steps were partially recursive because we estimated missing survival rates using a density-dependence term derived from the population reconstruction that was, in part, based upon the survival estimates. This required a few iterations for convergence. Likewise, the analysis of birth rates contained a density-dependence term that was also derived from the generalized logistic fit. As described later, we propagated errors in the survival estimation and imputation of missing pup counts through each step using a bootstrap analysis.

Pup Counts

Pup counts for the entire United States population were available for 1975–1977, 1981–2008, and 2011–2014 using counts from Lowry et al. (2017) and for San Nicolas Island during 1985–1989 from previous reports (Bonnell et al. 1980, Stewart et al. 1993, Lowry and Maravilla-Chavez 2005). To accomplish the population reconstruction, we needed complete pup counts for each year (P_y). For missing years, we imputed values for 1978–1980 from predictions of a temporal trend using linear regression of the log of counts for 1975–2001. Lowry et al. (2017) describes how we imputed values for 2009–2010 from a complete ground count at San Miguel Island and a partial ground count at San Nicolas Island during those years. We assumed pup counts were known without error, but we propagated error from the missing imputed counts.

Age- and Sex-Specific Survival

Age- and sex-specific survival estimates from a mark-release-resight recovery model of branded California sea lions on San Miguel Island were available from 1987 to 2014 (DeLong et al. 2017). We used the annual survival estimates from the best model in DeLong et al. (2017). Pups were branded in fall at 3–4 months of age, but pup survival rates accounted for survival from the time of the pup counts in late July to branding by assuming a constant survival rate for that period as measured from 1 October to the following 1 July. Very early pup mortality can be higher, but it occurs before the pup count. Only pups were marked and released each year, so age-specific estimates were missing in year y for ages $a > y - 1987$ (e.g., only pup survival was available for 1987, only pup and yearling survival for 1988). Also, estimates of survival were not available for sea lions of any ages for 1975–1986. To provide estimates for these missing values, we fitted a linear mixed effects model to the logits (μ_{say}) of the set of survival estimates (S_{say}) for each sex ($s = m$ or f), age ($a = 0$–24), and year ($y = 1987$–2013), $\mu_{say} = log\left(S_{say}/\left(1 - S_{say}\right)\right)$. Predictive variables for fixed effects included sex, age, and annual covariates including average sea surface temperature (SST) anomaly, average pup weight, and N_y/K as a measure of density dependence in survival. For pup survival, we used the average SST anomaly from 1 October to 30 June and for juveniles and adults, we used the average SST anomaly from 1 July to 30 June to correspond to the survival periods in our models. In addition, for pup survival we also evaluated an average SST anomaly from 1 April to 30 September, which could affect pup weights at branding by affecting pregnant and lactating females. We used the local SST anomaly as a measure of environmental conditions during the study period and to identify years affected by El Niño conditions. Warmer SSTs are usually associated with lower productivity and prey availability, whereas cooler SSTs are associated with high productivity and good foraging conditions for sea lions. We used the average SST anomaly measured at 4 National Oceanic and Atmospheric Administration (NOAA) data buoys (stations: 46054, 46218, 46011, pslc1; NOAA National Data Buoy Center, http://www.ndbc.noaa.gov) located 26 km to 128 km north of San Miguel Island, California in the area where females from the colony primarily forage (Melin and DeLong 2000, Melin et al. 2008).

Annual estimates of pup and yearling survival were quite variable, so we included an annual random effect for those ages. From the fitted model, we predicted missing estimates of survival (e.g., for years <1987) with the fixed effect estimates, and where survival estimates were available from capture-recapture analysis (1987–2013), the estimated predictions included the fixed and random effect estimates.

The density-dependence term N_y/K in the mixed effects model for survival was only available after reconstructing the population and fitting the generalized logistic. Thus, we needed to iterate the model fitting for survival estimates, population reconstruction, and fitting of the logistic model. Carrying capacity in the mixed-effects model for survival primarily acts as a scalar for abundance N_y in N_y/K. With some reasonable starting values for N_y and K, we fitted the mixed-effects model, constructed the population size, predicted K, and repeated the process until the estimated parameters converged.

Human-Caused Mortality

To account partially for human-caused mortality in the population, we used data collected from the halibut set gillnet fishery, which is a primary cause of fishery entanglement and mortality for California sea lions (Carretta and Enriquez 2012). Total fishing effort data for the set gillnet fishery was available for 1981–2014 and the sea lion bycatch was observed in a sample of trips in 1990–1994, 1999–2000, 2006–2007, and 2010–2012 to estimate the average bycatch per unit effort. A gillnet closure area implemented in 1994 resulted in the halibut fishery being excluded from within 5.6 km of the southern California mainland. Consequently, we estimated 2 average bycatch rates: for years before and including 1994 and for years after 1994. We estimated the sea lion bycatch in a year (H_y) by multiplying the total annual fishing effort by the average bycatch rate for that year. The fishery was active from 1975 to 1980, but the amount of effort was not available, so we used a generalized additive model to predict the amount of fishing effort in those years using the log of fishing effort with a smoother across year.

Population Reconstruction

Population reconstruction for a set of years indexed by y is simply a series of estimates of the number of animals alive for each age a for females ($N_{f,a,y}$) and for males ($N_{m,a,y}$). The size of the total population in year y (N_y) is simply the sum of all the animals in each age for both sexes alive in that year, $N_y = \sum_{a=0}^{A} N_{f,a,y} + \sum_{a=0}^{A} N_{m,a,y}$, where A is the maximum age. From the number of pups in a year (P_y) and annual age- and sex-specific survival estimates ($S_{s,a,y}$) we can project forward to predict the number of animals in the population at each age over time for each sex. The population reconstruction assumes the population is geographically closed and only births add to the population. Assuming a 50:50 sex ratio of pups, $N_{f,0,y} = N_{m,0,y} = P_y/2$. For example, the expected number of yearling females in year $y+1$ is $N_{f,1,y+1} = N_{f,0,y}S_{f,0,y}$, where $S_{f,0,y}$ is female pup survival in year y and likewise for males using the male pup survival rate. In general, for any age and sex the equations are $N_{s,a+1,y+1} = N_{s,a,y}S_{s,a,y}$, where s is either f or m for females or males, respectively.

However, to initiate the reconstruction in the initial year (i.e., 1975), we also needed estimates of $N_{f,a,y}$ and $N_{m,a,y}$ for yearlings and older animals ($1 \leq a \leq A$) to estimate the population size for years 1975 to 1975+A-1. To develop estimates of the sex- and age-specific population sizes in 1975, we used the stable age-distribution equations of Cole (1954) as described by Eberhardt (1985). Let c_a be the proportion at age a. Assuming an instantaneous constant growth rate r, the proportion at age a is $c_a = e^{-ra} l_a / B_a$, where $l_a = \prod_{a=0}^{a-1} S_a$ and $B_a = \sum_{a=0}^{A} e^{-ra} l_a$. We used a value of r derived from the slope of a linear regression from the log of the pup count from the first 7 years (1975–1981) and computed separate age-distributions (c_a) for each sex using the estimated survival rates for 1975. Using the pup count in 1975, we estimated the number of females and males in the population as $N_{f,1975} = P_{1975}/2/c_{f,0}$ and $N_{m,1975} = P_{1975}/2/c_{m,0}$, respectively. Then we estimated the number at each age from the age-distribution formula (e.g., $N_{f,a,1975} = c_{f,a} N_{f,1975}$).

Birth Rates

California sea lion birth rate estimates were only available for a few cohorts over a short time frame within the population reconstruction period (Melin et al. 2012*a*), so we could not include them in the model fitting, but we computed implied birth rates (B_y) at the census time from the population reconstruction values for females >4 years old (Melin et al. 2012*a*), $B_y = P_y / F_y$, where $F_y = \sum_{a=4}^{A} N_{f,a,y}$. These values will be lower and likely more variable than true birth rates because of early pup mortality prior to the pup count.

Previous studies reported that birth rates in the 1970s and possibly later were lower because of premature births associated with high levels of total dichlorodiphenyltrichloroethane (DDT) and polychlorinated biphenyl (PCB) concentrations in the blubber of reproductive females (DeLong et al. 1973, Gilmartin et al. 1976). Also, the birth rate is often lower during El Niño conditions (DeLong et al. 1991, Melin et al. 2012*a*, Lowry et al. 2017) and as the population increased density-dependent reductions in birth rates may have occurred. To examine these potential effects, we fitted models for B_y using covariates allowing for density-dependent effects in birth rate (N_y/K), El Niño conditions as reflected by the local SST anomaly from 1 July to 30 June (DeLong et al. 2017), and impacts of DDT concentrations (lipid weight ppm) that declined from the early 1970s to the present.

Values of DDT concentration from adult female blubber tissue samples were available for only a few years including 1970 and 1972 (DeLong et al. 1973, Gilmartin et al. 1976), 1991 (R. L. DeLong, NMFS, unpublished data), and 2001–2003 (Randhawa et al. 2015). Values in 1970, 1972, and 1991 were taken from fixed sample sizes of premature parturient and full-term parturient females but not in proportion to their occurrence in the population. Thus, we computed a weighted average of the 2 means based on the proportion of premature parturient and full-term females in the population (R. L. DeLong, unpublished data). An average of DDT concentration for a sample of females was available for 2001–2003 (Randhawa et al. 2015), so we used the single average with a year of 2002. We derived yearly values of the DDT concentration covariate with predictions from a linear regression of the log of observed DDT concentration values (273, 268, 10.5, and 10.8) over time (1970, 1972, 1991, and 2002). For the model fitting of birth rates (B_y), we assumed that B_y was approximately normal with mean μ_y and variance $\tilde{B}_y \times (1 - \tilde{B}_y) \times (e^{\gamma} + 1)$, where $\tilde{B}_y$ is the predicted birth rate and the parameter γ inflates the binomial variance ($\tilde{B}_y \times (1 - \tilde{B}_y)$) for over-dispersion. We used linear combinations of the DDT, SST, and density-dependent (N_y/K) covariates to model μ_y with a logit link function. We estimated the parameters via maximum likelihood and selected from among models with various combinations of covariates based on Akaike's Information Criterion with small sample size correction (AIC_c).

Generalized Logistic Growth Model

In a discrete logistic model of population growth, $N_{y+1} = N_y[1 + R(1 - N_y/K)]$, where N_y is the population size in year y, R is the maximum growth rate, K is the carrying capacity of the population, and the derived value of MNPL is $K/2$. A generalized logistic model, $N_{y+1} = N_y[1 + R(1 - (N_y/K)^z))]$ has an additional exponent z with values >1, which allows MNPL/K to be >0.5 because MNPL/K is $(1+z)^{-(1/z)}$. To estimate K and MNPL of the California sea lion population, we used a generalized discrete logistic population growth curve fitted to the annual reconstructed population sizes (N_y). The basic equation for the growth curve is $N_{y+1} = N_y + N_y \times R \times (1 - (N_y/K)^z)) - H_y$, where R is the maximum rate of increase, K is carrying capacity, and H_y are the human-caused mortalities (bycatch) in year y. We expanded this equation to allow for variation in the population growth rate due to El Niño conditions as reflected by changes in the annual SST anomaly. Adding the SST anomaly in year y, the growth curve equation is $N_{y+1} = N_y + N_y \times (R + b \times SST_y)(1 - (N_y/K)^z) - H_y$, where b is an estimated slope for the effect of SST on the population growth rate and R is now the maximum rate of increase in years of average SST (anomaly = 0). We estimated the parameters (K, R, z, and b) using non-linear least squares with the function nls in R (R Core Team 2016). We used the reconstructed population size in 2014 divided by the estimate of MNPL as the measure of population status relative to OSP. If N_{2014}/MNPL >1, the population is within the OSP range.

To provide confidence intervals for parameter estimates and an evaluation of certainty about the population status relative to OSP, we used a parametric bootstrap approach with 1,000 bootstraps from which we computed 95% intervals, which were the 25th smallest and 975th largest value of the parameter estimates or derived statistics. We included all known sources of uncertainty including survival estimates derived from DeLong et al. (2017), imputed values of pup counts for missing values, estimates of human caused mortality, and DDT concentration values used in analysis of birth rates. For the latter 3 sources, we allowed the predictions to vary using the assumed error model in the regression or ratio estimation. For each bootstrap replicate, we completed 4 steps.

1. From the survival analysis, we assumed the logit of the sex- and age-specific survival estimates were distributed as a multi-variate normal with the mean vector computed from the estimated values and the variance-covariance matrix from the estimated model. The annual survival estimate for males >2 years old in 1996 was at a boundary of 1 with no valid variance estimate, which precluded evaluation of the multi-variate normal distribution, so we replaced it with the estimate from 1995 to allow the use of the parametric bootstrap. From the multi-variate distribution for the parameters, we drew a new sample of parameter estimates for the survival mode.
2. We generated a new set of imputed pup counts using the regression models described above and in Lowry et al. (2017).
3. We fitted the mixed-effects model to predict the complete set of age- and sex-specific survival estimates and reconstructed the population sizes from 1975 to 2014. In reconstructing the population size for the bootstraps, we used a binomial distribution to allow for stochastic variation in the proportion that survive from age a at time t to age $a+1$ at time $t+1$ rather than the deterministic equation.
4. After reconstructing the population over time, we fitted the logistic growth curve with one bootstrap set of human-caused mortality estimates and the fit of the model for birth rates using a bootstrap set of DDT concentration values.

This process provided 1,000 estimates of each parameter in the logistic growth curve, a ratio of predicted population size for 2014 divided by the MNPL estimate, and confidence intervals for the birth rate parameters. In the bootstrap process, we conducted model selection for the mixed-effects model of survival and the birth rate for each bootstrap to incorporate model selection uncertainty.

The research described in this paper was reviewed and approved by the National Atmospheric and Oceanic Administration, National Marine Fisheries Service, Alaska Fisheries Science Center/Northwest Fisheries Science Center Institutional Animal Care and Use Committee (IACUC) under approved protocol numbers A/NW 2010-7, A/NW 2013-5, and National Marine Fisheries Service MMPA Permit Numbers 717, 736, 782, 782-1812, 783-977, 1613, 16087, 16087-2 issued to the NMFS Alaska Fisheries Science Center, Marine Mammal Laboratory. The methods for marking and observing California sea lions for estimating survival are described in DeLong et al. (2017) and were approved under the permits and IACUC-approved protocols. Protocols for data collected prior to 2010 were not reviewed by the NMFS IACUC because the IACUC did not exist; however, protocols for pup censusing and the sea lion marking program have not changed since they began in the 1970s and 1980s. Research conducted by the NMFS Southwest Fisheries Science Center was authorized under MMPA Permit Numbers 347, 404, 684, 704, 774-1437, 774-1714, and 14097 and National Marine Sanctuary Permits GFNMS/MBNMS/CINMS-04-98, MULTI-2002-003, MULTI-2003-003, and MULTI-2008-003.

RESULTS

The California sea lion pup count in the United States population has increased steadily since 1975 except for

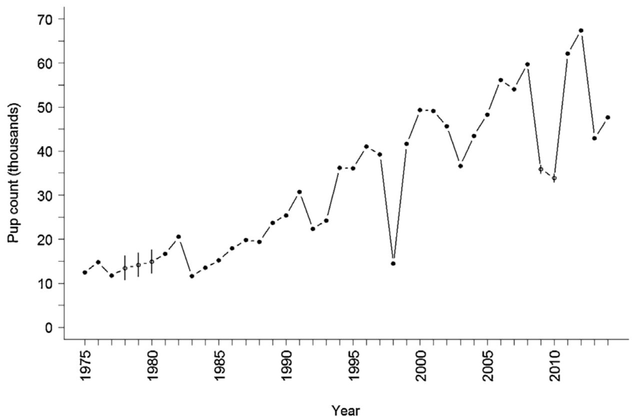

Figure 2. California sea lion population pup counts in the United States, 1975–2014. Open circles are imputed estimated values with vertical lines representing 95% bootstrap confidence intervals.

abrupt significant declines associated with El Niño events and recent declines in 2009, 2010, 2013, and 2014 (Fig. 2). These shifts in annual pup production are reflected throughout the age structure, which is dynamic over time (Fig. 3).

In addition to changes in the number of births, there has been significant annual variation in survival of pups and yearlings (DeLong et al. 2017). A recent decline in yearling and pup survival has resulted in low recruitment of females reaching age 2 and age 4 (Fig. 3). Even though the pup count in 2012 was the highest recorded (Fig. 2), the number of males and females reaching age 2 from this cohort was the lowest since the 1998 cohort (Fig. 3) when pup production was severely curtailed because of the strong 1997–1998 El Niño event.

The declines in pup births and juvenile survival from 2011 to 2014 have led to a leveling of the number of females ≥4 years old that comprise the reproductive age class (Fig. 4). This may have consequences for future population growth by depressing recruitment of reproductive females. Similar leveling occurred during other periods in the time series and followed the occurrence of El Niño events in 1982–1983 and 1997–1998 (Fig. 4). In each of these occasions, the high mortality of birth cohorts and poor survival of juveniles led to the leveling period, but each was followed by a period of strong population growth.

The reconstructed total population sizes (Fig. 5) are more variable over time than the reconstructed population sizes of females ≥4 years old (Fig. 4) because of the high degree of annual variability in pup and yearling numbers (Fig. 3). The sex- and age-partitioned population sizes (Table 1, Fig. 3) demonstrate the shifts in age structure with the number of sea lions <8 years old in recent years being lower than their peak abundance earlier in the time series and sea lions ≥8 years old being at their peak abundance. The sex- and age- partitioned population sizes also show the change in sex structure across age due to the sex-differential in survival at older ages (Tables S1 and S2, available online in Supporting Information). The abundance of males and females are similar up to age 8 but then diverge at older ages with females predominating because of lower survival of males of the same ages. From the population reconstruction values, we computed the multiplier that would be needed to derive the correct population size from the pup count in each year. The multiplier values ranged from 3.88 in 2000 to 10.06 in 1998 (Table 1). When the birth rate was >0.8 the average correction factor was 4.26, but the birth rate estimates were >0.8 in only 15% of the 39 years. For the remaining years, except 1999, the correction factor was >4.26.

The model-averaged estimates of parameters fitted to the annual birth rates computed from the reconstructed population sizes demonstrated a decline in birth rate from higher DDT concentrations in adult female blubber and

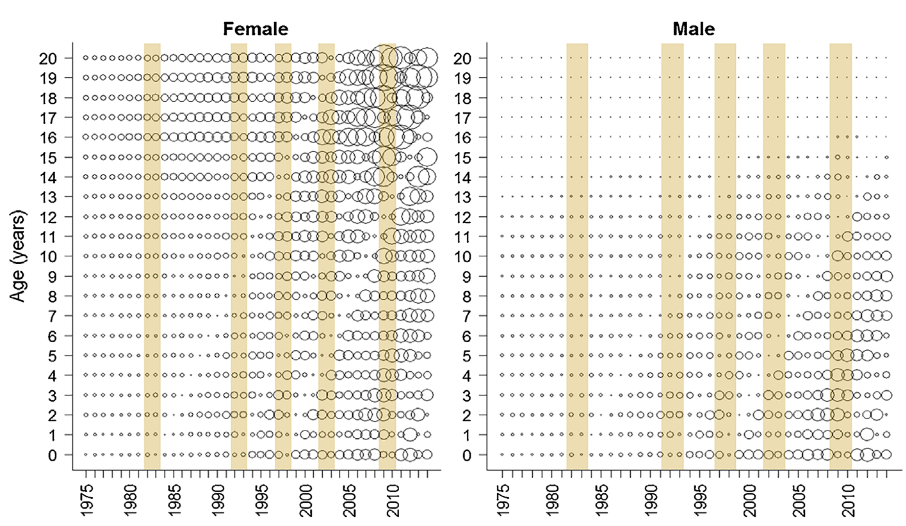

Figure 3. Relative abundance for female and male California sea lions in the United States, 1975–2014, for ages 0 to 20 years. Bubble size represents the proportion for age (a) in year (y) of females or males relative to the maximum number of animals (females+males) of age a among all years. Age axis is restricted to age 20 to improve visual for younger ages; most of the population (99.8%) was younger than age 21. Gold bars identify years affected by El Niño conditions.

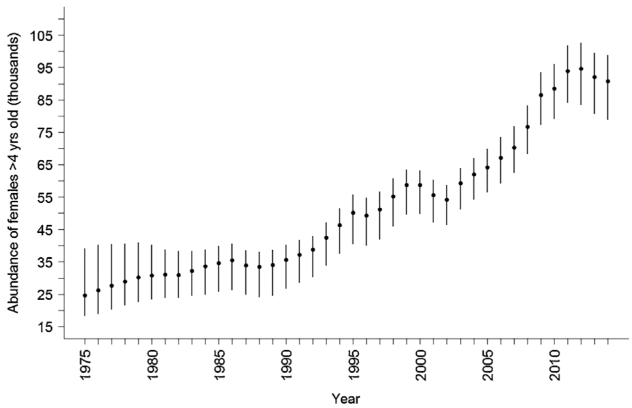

Figure 4. Predicted abundance of female California sea lions ages 4 and older in the United States population, 1975–2014, and 95% confidence intervals from parametric bootstrap.

higher SST anomalies associated with El Niño events and a possible density-dependent response in recent years (Table 2, Fig. 6). The birth rate odds $(B_y/(1-B_y))$ decline by 0.129 (95% CI = 0.004–0.563) for every 10 ppm DDT concentration increase, by 0.570 (95% CI = 0.491–0.702) for every 1°C of SST above normal, and by 0.155 (95% CI = 0.003–0.314) for each 0.1 N/K increase in abundance. The estimate of the SST effect was much more precise than either the DDT concentration or density-dependent responses.

For most of the period from 1974 to 2014, the estimated percentage of the California sea lion population killed as bycatch in the halibut set gillnet fishery was <2%, but during the period of highest fishing effort in the 1980s, it reached about 8.5%. In the past decade, it declined to <0.2%. Most of the bycaught California sea lions in the fishery were juveniles. If the bycatch is assumed to consist only of sea lions of age 0–3, those ages would represent a greater proportion of the total, but the pattern across time would be similar.

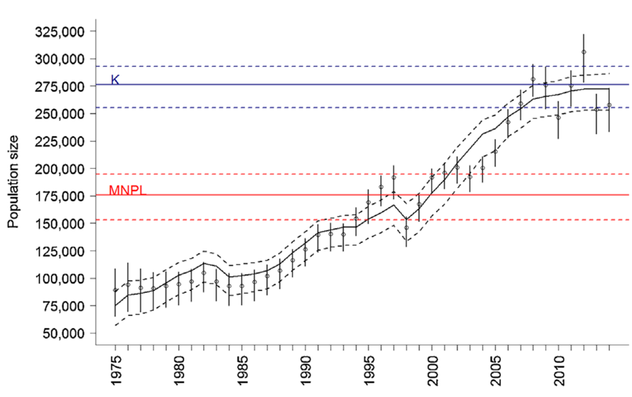

Figure 5. Fitted logistic growth curve (solid line) and 95% bootstrap intervals (dashed line) for reconstructed California sea lion annual population sizes in the United States, 1975–2014. Vertical lines are 95% bootstrap confidence intervals for reconstructed annual population sizes. We also present estimated carrying capacity (K; solid blue line) with 95% confidence intervals (dashed blue line) and maximum net productivity level (MNPL; red solid line) with 95% confidence intervals (dashed red line).

Table 1. Annual California sea lion pup counts from breeding areas in the United States and population sizes of female (F) and male (M) California sea lions from 1975 to 2014 estimated from a population reconstruction model. The multiplier is the correction factor for pup counts to derive the total population size.

		Population estimate			
Yr	Pup count	F	M	Total	Multiplier
1975	12,499	49,136	39,788	88,924	7.12
1976	14,749	51,944	42,226	94,170	6.39
1977	11,712	50,784	40,415	91,199	7.79
1978[a]	13,449	50,942	39,971	90,913	6.76
1979[a]	14,145	52,151	40,661	92,812	6.56
1980[a]	14,878	53,180	41,153	94,333	6.34
1981	16,701	54,748	42,249	96,997	5.81
1982	20,540	58,881	45,899	104,780	5.10
1983	11,595	55,342	41,465	96,807	8.35
1984	13,550	53,657	39,354	93,011	6.86
1985	15,224	53,753	39,259	93,012	6.11
1986	17,896	55,489	41,187	96,676	5.40
1987	19,796	58,017	43,827	101,844	5.14
1988	19,452	60,513	46,337	106,850	5.49
1989	23,757	65,162	51,021	116,183	4.89
1990	25,422	70,281	56,040	126,321	4.97
1991	30,747	76,840	62,383	139,223	4.53
1992	22,364	77,663	62,675	140,338	6.28
1993	24,274	77,681	62,178	139,859	5.76
1994	36,184	85,138	68,990	154,128	4.26
1995	36,073	93,031	76,067	169,098	4.69
1996	41,044	100,531	82,570	183,101	4.46
1997	39,245	105,432	86,367	191,799	4.89
1998	14,506	83,352	62,559	145,911	10.06
1999	41,695	94,426	72,932	167,358	4.01
2000	49,372	107,358	84,274	191,632	3.88
2001	49,078	110,679	85,126	195,805	3.99
2002	45,658	114,253	86,612	200,865	4.40
2003	36,659	110,691	81,384	192,075	5.24
2004	43,490	114,985	85,342	200,327	4.61
2005	48,331	122,423	92,825	215,248	4.45
2006	56,144	135,829	106,364	242,193	4.31
2007	54,088	144,443	114,561	259,004	4.79
2008	59,774	156,091	125,359	281,450	4.71
2009[a]	35,914	154,229	121,926	276,155	7.69
2010[a]	33,873	139,983	106,348	246,331	7.27
2011	62,109	155,174	120,315	275,489	4.44
2012	67,396	171,149	135,071	306,220	4.54
2013	42,913	146,010	107,652	253,662	5.91
2014	47,691	148,499	109,107	257,606	5.40

[a] Pup count estimated from imputed values from partial censuses or regression (Lowry et al. 2017).

From the fitted logistic growth model of the total reconstructed population size (Table 3, Fig. 5), the estimated maximum growth rate (R) for the California sea lion population was 0.07 under a normal SST regime. The California sea lion population size in 2014 (257,631) was estimated to be about 40% greater than MNPL (183,481) and the 95% confidence limit for N/MNPL (95% CI = 1.22–1.58) shows that the population is currently well within OSP (Table 3). Carrying capacity was estimated to be at 275,298 animals. Even with a substantial reduction in N, the population is expected to remain at OSP for the foreseeable future. However, an increase of 1° C SST was estimated to reduce the population growth rate by 0.07, thereby halting growth (Table 3). During strong El Niño events the SST anomaly can be ≥2° C resulting in a negative growth rate

Table 2. Model-averaged estimates of the logit of parameters for the California sea lion birth rate function computed from population reconstruction values for sea lions in the United States, 1975–2014. The 95% confidence intervals are from bootstrap replicates.

		95% CI	
Parameter[a]	Estimate	Lower limit	Upper limit
γ	8.02	7.88	8.61
Intercept	2.13	0.601	4.69
SST	−0.843	−1.21	−0.675
DDT	−0.0138	−0.0827	−0.000348
N/K	−1.68	−3.78	−0.0302

[a] γ is inflation value for binomial variance for over-dispersion, SST is sea surface temperature anomaly, DDT is concentration of dichlorodiphenyltrichloroethane in blubber of reproductive females, and *N*/K represents density dependence where *N* is abundance and *K* is carrying capacity.

Table 3. Logistic growth curve parameters used to estimate the size of the United States California sea lion population in 2014. The 95% confidence intervals are from 1,000 bootstrap replicates.

		95% CI	
Parameter[a]	Estimate	Lower limit	Upper limit
z	3.93	2.09	7.79
R	0.0695	0.056	0.0947
N_{1975}	75,102	56,874	87,756
K	275,298	255,332	291,360
b	−0.0696	−0.101	−0.0493
MNPL	183,481	160,156	207,649
MNPL/K	0.666	0.583	0.756
N_{2014}	257,631	233,515	273,211
N_{2014}/MNPL	1.4	1.22	1.58

[a] N_y is population size in year *y*, *K* is the population carrying capacity, *R* is the maximum growth rate, *z* is the generalized logistic exponent, MNPL is maximum net productivity level, and *b* is the slope of the sea surface temperature covariate for growth rate.

from decreases in pup births and pup and juvenile survival. Thus, rapid declines in abundance could occur with persistent ocean warming.

DISCUSSION

We have proposed a conceptually simple population reconstruction approach to estimate the total population size and population growth of California sea lions in the United States, resulting in the first age- and sex- specific population growth model for the species. The method has a side benefit of providing complete sex- and age-structure of the population over time and provides derived estimates of birth rates. However, this approach does require a long-term data set with counts of pups and age- and sex-specific survival estimates. We used 39 years of pup counts and 28 years of survival estimates, which allowed us to identify factors contributing to the dynamic nature of the population.

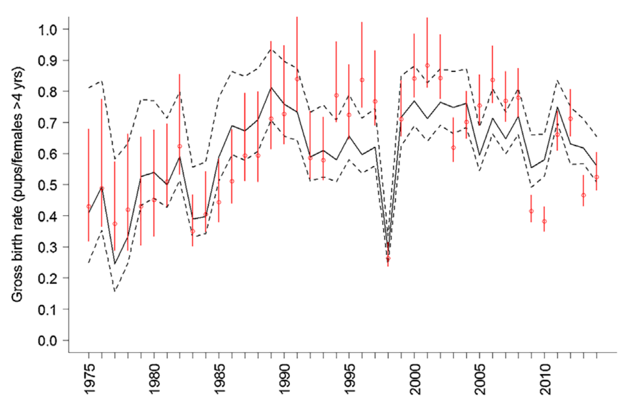

Figure 6. Model-averaged predicted birth rate function (solid line) for female California sea lions in the United States, 1975–2014, and 95% bootstrap confidence interval (dashed line). Model covariates included sea surface temperature anomaly in female foraging area, predicted dichlorodiphenyltrichloroethane (DDT) concentration in female blubber, and a density-dependence covariate (*N/K*) (abundance/carrying capacity). Points are the implicit gross birth rates computed from population reconstructions by dividing number of pups by number of females ≥4 years old. Error bars around points are 95% confidence intervals for birth rate computation from population reconstruction.

For this method, the population must be geographically closed with no immigration or emigration. Permanent emigration may be subsumed into the survival estimates so it was not a large concern. Immigration of California sea lions from Mexico's Pacific coast populations cannot be completely ruled out. If there is immigration, particularly of juvenile animals, then our estimates of population size derived from pup births will be too low in years when immigration occurred. Immigration that resulted in increased abundance of mature females not accounted for in our model could also affect our assessment of birth rates by making them higher than our model estimates.

Birth rates were very low during the first decade of the study in part because adult females suffered reproductive failure associated with high levels of DDT concentrations in their blubber (DeLong et al. 1973, Gilmartin et al. 1976). The effect of DDT concentrations on birth rates appeared to become less important after 1986, probably because of reduced levels of the contaminants in the southern California marine environment. Significant decreases in birth rates were clearly associated with warmer SSTs that occur during El Niño conditions, but elevated SSTs do occur outside El Niño events. Warmer SSTs negatively affect sea lion births because they are usually associated with other physical and biological oceanographic changes that occur in the California Current Ecosystem that lead to decreased prey availability to California sea lions (Chavez et al. 2002). The decreased prey availability leads to low pup growth rates, decreased birth rates, and higher mortality among sea lions (DeLong et al. 1991; Melin et al. 2010, 2012*a*,*b*). In some cases, the population response to warmer SSTs may span multiple years or may lag the event by months or years as indicated by the substantial variability in the abundance of pups and yearling age classes in our model. The relationships of SST, birth rates, and animal condition are sensitive to small- and large-scale changes in the marine environment and are likely not always a simple linear relationship nor the only environmental factor affecting changes in birth rates, animal condition, or survival. However, the strong relationship between warmer SSTs and changes in birth rates provides insight into the potential impacts of warming oceans on sea lion population trends due to climate change.

The very large estimate of the parameter γ to allow for over-dispersion from binomial variance, suggests the birth rate model is incomplete and other factors not included in our model are causing additional variation in either the reconstructed population sizes or the true birth rates. One such factor is early pup mortality that occurs prior to the pup census in mid- to late July. The 2009 birth rate was far below the long-term average and the predicted value from the birth rate model because of high pup mortality prior to the pup census (Melin et al. 2010). Many reproductive females left the rookery early during the 2009 breeding season because foraging conditions were poor owing to an oceanographic upwelling relaxation along the central California coast during summer (Bjorkstedt et al. 2010). Consequently, reproductive females were either not impregnated, did not implant, or prematurely aborted leading to a similarly low birth rate value in 2010.

Even with the large data sets we used, they were still incomplete. In our application, we had only a partial set of age- and sex-specific survival rates limited to San Miguel Island from 1987 to 2014, but we devised a scheme to derive the missing estimates. Our approach assumes the survival estimates apply to the entire population of California sea lions breeding in the United States and the model for the derived survival estimates is unbiased. We also had to assume that the population had a stable age distribution in 1975 and we could accurately reconstruct it. By starting in 1975, any errors in the estimated age distribution would be largely diminished by 1990. Therefore, we do not believe that any possible problems are sufficient to invalidate our conclusion that the population has expanded past its MNPL and it is within the range of OSP. The location of MNPL relative to K (0.67) seems very sensible considering the assumed range of 0.5–0.8 that was used by Wade et al. (2007) and MNPL estimates for harbor seals (Jeffries et al. 2003, Brown et al. 2005). The California sea lion population growth model and the OSP conclusion were largely influenced by the data from the last 24 years when we had adequate survival estimates and accurate pup counts.

We cannot rule out the possibility that the population will increase again at some point in the future. If the California Current returns to a highly productive marine environment with ample prey for sea lions, the population will likely respond with higher survival and birth rates. However, what the population has experienced since 2009 is very different than what occurred in the late 1990s and early 2000s when the California Current was a productive ecosystem. The 1997–1998 El Niño event affected the birth cohorts of 1996–1998, resulting in a temporary leveling of population size, but it was short-lived because of the small number of cohorts affected. This was followed by a rapid growth period between 1999 and 2009. Decreases in the survival and birth rates since 2009 have been influenced by environmental anomalies in central and southern California (e.g., an oceanographic upwelling relaxation event in 2009 (Bjorkstedt et al. 2010), an El Niño in 2010 (Bjorkstedt et al. 2011), and an oceanic heat wave [i.e., The Blob] in 2013–2015 (Leising et al. 2015, McClatchie et al. 2016)) that have affected prey availability for juveniles and pregnant and lactating females that remain in the coastal California waters year round and influence population dynamics (Melin et al. 2010, 2012*b*). If the population had been much smaller during these events, like it was in the 1990s, *per capita* resources would have been greater, and the environmental effect may not have been as dramatic. Future monitoring of the population and its vital rates will allow a more robust assessment of whether density dependence is regulating growth of the population at current levels of population abundance.

All sources of mortality, including human-caused mortality, are reflected in the survival rates used in the model. We attempted to estimate human-caused mortality because the Potential Biological Removal (PBR) level is one of the criteria in the MMPA for determining a population's status. It is the maximum number of animals that can be removed from the population because of human-caused mortality while allowing the population to reach or maintain its OSP (Wade 1998). The default maximum rate of increase (R_{max}) for pinnipeds in the PBR scheme (Wade 1998) is 0.12; our R_{max} estimate was only 0.07 (95% CI = 0.06–0.09). Our estimate should not be treated as the potential maximum rate of increase for California sea lions because we have been able to include only a fraction of the human-caused mortality and because at the time that sea lions should have been increasing at their maximum (in the 1970s and 1980s), their reproductive rate was being hampered by the effects of DDT and PCB pollution (DeLong et al. 1973, Gilmartin et al. 1976). With respect to human-caused mortality of California sea lions, the largest estimates of mortality have historically been attributed to the halibut set gillnet fishery (Julian and Beeson 1998). However, this fishery represents only one source of human-caused mortality, and other sources include the swordfish (*Xiphias gladius*) and common thresher shark (*Alopias vulpinus*) large-mesh drift gillnet fishery (Carretta et al. 2017), fishery-related shootings (Greig et al. 2005), the ingestion of fishing hooks from recreational fisheries, and entrainment in power plant intake systems (Carretta et al. 2016*a*). Estimated bycatch in the California common thresher shark and swordfish drift gillnet fishery totaled approximately 1,400 animals between 1990 and 2015 (Carretta et al. 2017), a value that is less than some individual year bycatch estimates reported in the halibut set gillnet fishery by Julian and Beeson (1998). Hook-and-line fishery and shooting removals are based on opportunistic stranding reports, which represent minimum counts, because not all carcasses are documented and there is currently no way to correct for this bias. Greig et al. (2005) reported on the causes for 3,692 stranded sea lions over 10 years and concluded that 12% of the strandings were caused by human-induced trauma and 71% of those trauma cases resulted from gunshot wounds. If undocumented human-caused mortality is significant, then our estimates of maximum rates of increase for the population may be too low.

The dynamic age structure of the California sea lion population has implications for estimation of sea lion abundance. In lieu of species-specific life-history parameters, a correction factor (multiplier) constructed from northern fur seal life-history parameters has been used to scale up the pup count to a total population estimate. For example, a value of 4.32 was used for the multiplier on the 2008 count of pups (Carretta et al. 2016*b*). However, our analysis shows that the multiplier could range from 3.88 to a maximum of 10.06 because of changes in pup production. Thus, constructing an estimate of abundance from the pup count with a constant multiplier is not a viable approach for California sea lions.

The challenges of maintaining a high-quality data set over multiple decades needed to reconstruct a population history are many and varied. Such studies for marine mammals are uncommon, largely because of the challenges associated with this long-lived group that spends very little time in view, ranges over vast expanses of ocean, and is costly to monitor (Bowen et al. 2010). However, the method we used here will be a useful tool for estimating the abundance of other MMPA pinniped species for which there are sufficient time series for abundance and vital rates. For example, the status of California and Eastern Pacific stocks of northern fur seals are currently computed using pup counts and a single life-history multiplier (Carretta et al. 2016*b*, Muto et al. 2017). A time series of pup counts and data on survival are available for both populations, so the approach we used here could be used to estimate abundance of the populations with some modification to allow for less complete time series.

MANAGEMENT IMPLICATIONS

The determination that the United States California sea lion population is at OSP has several important management implications. First, it indicates that the management objectives of the MMPA are being met for this species. Second, the determination that a population is at OSP provides the opportunity for individual states to request a transfer of the authority for management and conservation under the MMPA from NMFS to the state. In the case of California sea lions, the states of California, Oregon, and Washington could request this authority, but they must meet various criteria stipulated in the MMPA, including a state management program that is consistent with the purposes, policies, and goals of the MMPA and international treaty obligations.

The influence of changes in SST on the population growth of California sea lions needs to be considered in management of the species. If SST in the California Current increases 1°C in response to climate changes, our model predicts the annual growth rate would fall to zero and if the SST increased 2°C, the annual population growth rate would decline 7%. If this occurred, the population could rapidly fall below the range of OSP, potentially changing the population's status under the MMPA. This could lead to changes in management strategies and options.

Finally, in developing this analysis we have provided a critical tool for current and future management of California sea lions. Along the west coast of the United States, there are various resource conflicts involving this robust population of sea lions: fisheries interactions that lead to sea lion mortality and economic losses for the fisheries (Weise and Harvey 2005), interactions with people on public beaches and at marinas creating human safety concerns and inflicting property damage, and interactions with endangered fish possibly impeding the recovery of the fish populations (NMFS 1997, 2008). Perhaps the most high-profile management issue is at the Bonneville Dam on the Columbia River, where a controversial lethal removal program authorized under the MMPA, and managed by the states of Oregon and Washington, has been conducted in an attempt to alleviate sea lion predation pressure that may be impeding recovery of endangered salmonids (NMFS 2008). The model we presented here highlights the value of long-term research in support of management needs to meet MMPA mandates and the need to continue the research as the California sea lion population responds to environmental and anthropogenic changes that may alter its status. It is only through a long-term approach that managers will have a sufficient understanding of the dynamics of the California sea lion population on which to base future management decisions related to complex resource conflicts involving this species.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article at the publisher's website.

Update on the use of a simulation-based approach to evaluate plausible levels of recruitment into the Pacific Coast Feeding Group of gray whales

Lang, A.R., and Martien, K. K.
Protected Resources Division, Southwest Fisheries Science Center, La Jolla, CA 92037

ABSTRACT

Previous genetic comparisons of the Pacific Coast Feeding Group (PCFG) of gray whales with whales feeding north of the Aleutians have shown significant levels of mitochondrial differentiation. The magnitude of the differentiation, along with the relatively high levels of genetic diversity identified within the PCFG, have raised questions about how much immigration into the group could occur before the signal of mtDNA differentiation is erased. Here we use a simulation-based approach to evaluate the range of plausible levels of immigration into the PCFG that could be occurring. The simulations incorporate annual immigration ranging from between 0 and 16 animals per year (once the larger ENP population reaches K), and simulations both with and without a pulse of +20 immigrants over two years are included. Results suggest that under the scenarios tested, current immigration into the PCFG of one migrant per year or less would produce levels of genetic diversity and differentiation that are inconsistent with the empirical data. The simulations were less informative with regard to placing an upper limit on the number of animals per year which could be immigrating into the PCFG, although comparison of F_{ST} and χ^2 (per degree of freedom) values between the simulated and empirical data suggests that immigration higher than 8 animals per year is unlikely. Comparisons between the observed and simulated values for the number of haplotypes, F_{ST}, and χ^2 (per df), which were the most informative measures, suggest that immigration of approximately 4 animals per year is most plausible.

INTRODUCTION

Genetic comparisons of samples collected from gray whales considered to be part of the Pacific Coast Feeding Group (PCFG) with those from animals that feed north of the Aleutians have revealed small but significant levels of mtDNA differentiation but no nuclear differentiation (Lang *et al.* 2011). In addition, a relatively large number of mtDNA haplotypes were identified within the PCFG (n=23 haplotypes, Lang *et al.* 2011), which is estimated to contain ~200 animals (IWC 2011). Analysis of photo-identification data indicates that on average, 10 animals per year were recruited[1] into the PCFG between 2004 and 2008, with larger numbers of recruits identified between 2000 and 2002 (IWC 2011). These recruits could be internal (i.e., calves born to PCFG mothers) or external (animals that previously fed north of the Aleutians and subsequently immigrated into the PCFG). An average of three calves per year were identified in the PCFG between 1998 and 2008 (Calambokidis *et al.* 2010), and it is presumed that at least half of the calves born each year may not have been identified as such (IWC 2011). Based on those assumptions, an estimated four animals per year may have recruited into the PCFG from northern feeding area(s) between 2004 and 2008, and a pulse of higher immigration may have occurred between 1999 and 2002, potentially in response to the increase in gray whale mortality that occurred in 1999 and 2000.

The results of these genetic and photo-id studies of the PCFG have raised questions about how much external recruitment into the PCFG could occur while still maintaining the observed level of mtDNA differentiation between the PCFG and animals feeding north of the Aleutians. The use of a simulation-based approach has the potential to provide information relevant to this question. As part of a previous IWC exercise (the Testing of Spatial Structure Methods, or TOSSM, project), simulated genetic datasets representing different population structure archetypes were created for performance testing of different analytical methods (Martien *et al.* 2009). The demographic parameters underlying the dataset generation model were based on the vital rates of

[1] Here a 'recruit' is defined as an individual first photographed in the PCFG seasonal range (within the area spanning 41-52°N and between June 1 and November 30) in a given year and resighted within the seasonal PCFG range in at least one subsequent year.

eastern gray whales (Martien *et al*. 2004, Martien 2006). In discussions with the IWC Stock Definition subcommittee, it was agreed that the TOSSM dataset generation model could be useful in creating simulated datasets that would allow the plausibility of different hypotheses (e.g., different immigration rates into the PCFG) to be evaluated.

METHODS

Rmetasim

Simulated datasets were produced using the *rmetasim* package (version 1.1.05, Strand 2002) as run in the R statistical environment (R 2.14.1). *Rmetasim* performs individual-based population genetic simulations utilizing stage-based matrix population models. The transition probabilities in the matrices are used to randomly assign births, stage transitions, and deaths of individuals over time. Density dependent growth is implemented by the linear interpolation between matrices representing survival and reproduction rates at carrying capacity (K) and at zero population density (ZPD). A pre-birth pulse model is used, such that at the end of each simulation year, the youngest animals in the population are one year old.

Stage-based matrices

As previously mentioned, vital rate estimates for eastern Pacific gray whales (as described in Martien *et al.* 2004, Martien 2006) were used to parameterize stage-based matrices for the TOSSM exercise. Since the construction of these matrices, additional information has become available on the life history of gray whales. This new information was utilized to update the stage-based matrices from TOSSM, and when possible the vital rates used in constructing the new matrices were chosen to be the same as those utilized in the IWC's Implementation Review of gray whales. The following changes were made:

1) Adult survival rate was increased to the median estimate from Punt & Wade 2010 (S_A=0.982)
2) A separate term for calf survival rate (set to S_c=0.732, the median estimate in Punt & Wade 2010) was utilized. In the previous matrices, calf survival was the same as juvenile survival.
3) The median estimate from Punt & Wade 2010 was utilized for the rate of increase at ZPD (λ =1.063)
4) The age of first reproduction (AFR) was increased to 7 years at ZPD based on the Bradford *et al.* 2010 review.
5) A third juvenile stage was added to provide better control of AFR.

In addition, three identical adult stages for each sex were included in the new matrices. In contrast, the matrices used in the TOSSM project included a single adult male stage and separate fertile and lactating stages for adult females. This change was implemented for two reasons. First, it allowed for better control of generation time and greatly reduced the proportion of individuals in the simulations that lived to unrealistic ages under the increased adult survival rate. Secondly, it reduced the number of multiple births by the same female in a given year. In *rmetasim*, the fertility term represents the mean number of calves produced per female based on a Poisson distribution (Strand 2002). This results in some females producing more than one calf per year. Eliminating the separate fertile and lactating stages allowed us to reduce the fertility term (since it was applied to all adult females, not just a subset in the lactating stage), thereby reducing the number of multiple births (Table 1). However, this change also eliminated the minimum two-year calving interval that had been enforced in the TOSSM matrices. As such, under the new matrices some females in the simulation will give birth in consecutive years (Table 2).

Given the number of changes implemented in the new matrices, we ran the simulations using both the updated nine-stage matrices as well as the original five-stage matrices (as described in Martien 2006) utilized in the TOSSM exercise. The vital rates used to construct the original matrices and those utilized in the updated 9-stage matrices are detailed in Table 3. The parameter for juvenile survival rate was not derived from the literature but was calculated from the matrices to produce the desired value of lambda. The

Maximum Sustainable Yield Rate (MSYR) calculated from the 9-stage matrices is ~3.3%, while MSYR for the 5-stage TOSSM matrices is ~3.6%.

These vital rates were used to construct stage-based matrices representing the demography of the population near carrying capacity (K) and near zero population density (ZPD). Transition probabilities were calculated according to Caswell (2001) and the resulting matrices are shown in Table 4.

Population Trajectories

Dataset generation followed the steps outlined in Martien 2006, with the exception that coalescent datasets were generated using FastSimcoal (Excoffier and Foll, 2011) rather than SimCoal 2.1.2 (Laval and Excoffier 2004) to establish the effective size (Ne). In all scenarios, a single population was simulated in *rmetasim* for 4000 years to provide datasets representing the equilibrium population. This time period was shown to be sufficient for reaching equilibrium in a similar exercise for bowhead whales (Archer *et al.* 2010), that have a markedly longer generation time.

The mutation parameter incorporated in the simulations was adjusted to produce genetic diversity levels (as measured by the number of haplotypes and the haplotypic diversity) that are similar to the values observed for the "North" strata in the Lang *et al.* 2011 study. A range of mutation parameters were explored before setting the mutation parameter to 3.8×10^{-3} per generation, which produced measures of genetic diversity that were the most consistent with the observed data.

Carrying capacity (K) for the larger ENP population of gray whales was set to 20,000 animals, similar to the most recent abundance estimate (19,126 animals in 2006/2007; Laake *et al.* 2009). Carrying capacity for the PCFG was set to 200 in accordance with the estimated abundance of 194 animals in 2008 (Annex F, IWC 2011).

For all population trajectories, depletion due to commercial whaling was simulated as having occurred between 1846 and 1930. Attempts were made to utilize the catch history (Annex E, IWC 2011) with a multiplier to produce the desired level of depletion in 1930 (10% of K). However, when this modification was incorporated it resulted in a high number of simulation runs that failed due to the simulated population(s) going extinct. As such, the depletion per year was set to a constant proportion of K, such that the population was depleted by 7.1% of K in each year for the duration of the simulated whaling period. This level of depletion allowed the population to reach the desired level (0.10 of K, or ~2000 animals) by 1930. Examples of the population trajectories produced are shown in Figure 5.

Given that little is known about the origin of the PCFG, two different population histories were simulated. The first scenario ("post-whaling split") assumes that the PCFG split from the larger ENP population following depletion. After reaching equilibrium a single population was projected forward through the 1846-1930 whaling period with depletion occurring as described above. In 1930, 20 animals (10% of K_{PCFG}) were split from the larger population to represent the PCFG. The two populations were then allowed to increase until reaching K. *Rmetasim* employs a "hard ceiling" to restrict population growth to K, such that individuals are killed off randomly after reaching levels >10% higher than K.

The second scenario ("pre-whaling split") assumes that the PCFG split from the larger ENP gray whale population prior to the depletion of gray whales due to commercial whaling. In this scenario, the equilibrium population was split into two feeding groups to represent the northern feeding ground (K_{ENP}=20,000) and the PCFG (K_{PCFG} = 200). The split was presumed to occur at the start of the Little Ice Age (considered here to be at 1540), a period in which it seems plausible that ice conditions would have been favorable for gray whales to begin using more southern feeding grounds. Both populations were projected forward until 1846, when the depletion due to commercial whaling was simulated as described above. After reaching 1930, the simulated depletion ceased and the two populations were allowed to grow until reaching K.

Immigration rates ranging from 0 to 0.0008 were simulated. These migration rates correspond to the immigration of between 0 and 16 animals per year into the PCFG from the larger ENP population once it has reached K (Figure 6). In addition, each population history and migration rate combination was also simulated with a migration "pulse" of 20 individuals over two years. This pulse is reflected in the abundance of the PCFG in 2000 and in 2001. Examples of abundance trajectories for the PCFG under the different immigration scenarios are shown in Figure 7.

Additional simulations were performed in which the value of K_{PCFG} was increased from 200 to between 500 and 5000. These simulations incorporated a post-whaling split of the PCFG from the larger ENP, with the pulse migration of +20 animals over two years but no annual immigration into the PCFG. As in the "post-whaling split" scenarios described above, the split of the PCFG from the larger ENP was modeled such that the number of animals colonizing the PCFG in 1930 was 10% of K.

A final set of simulations were performed that incorporated a more recent split (between 1940 and 1990) of the PCFG from the larger ENP population. The number of animals splitting off to form the PCFG in a given year was derived by taking an average (over ten replicates) of the simulated abundance of the PCFG in each year when the abundance trajectories were modeled under the scenario of a post-whaling split of the PCFG in 1930 with no annual immigration.

A list of scenarios that have been simulated to date is included in Table 7. Of note, the simulations incorporating a pre-whaling split of the PCFG from the larger ENP are in progress and have not yet been completed.

Sampling and Genetic Analyses:

To generate the simulated dataset, the number of simulated animals sampled per year was set to match the number of animals sampled per year and per stratum in the Lang *et al*. (2011) study (Table 8). In the empirical study, some animals were sampled multiple times, and only one sample per individual was retained for the data analysis. For the simulated sampling, the year of sampling for such individuals was assigned as the first year that the animal was sampled. A total of 103 samples were collected from simulated ENP individuals and 71 samples were collected from simulated PCFG individuals.

These sampled individuals were used to generate summary statistics for each group. Genetic diversity was characterized by the number of mtDNA haplotypes, the mtDNA haplotype diversity, and the mtDNA nucleotide diversity. Differentiation between the two simulated groups was measured using F_{ST}, χ^2 (per degree of freedom), and ϕ_{ST}. The summary statistics generated from the simulated datasets were then compared to the observed summary statistics generated for the PCFG and the North strata in Lang *et al.* 2011.

To further evaluate how well the shape of the haplotype frequency distribution for the simulated ENP population matched the shape of the distribution for the North stratum in the empirical data, a χ^2 test was used to compare the two haplotype frequency distributions, and the number of significant tests ($p<0.05$) was calculated. In addition, the frequency of the most common haplotype in each replicate simulation was calculated and compared to the frequency of the most common haplotype in the empirical data for the North stratum. Given that the mtDNA summary statistics produced for the simulated ENP population under all scenarios was similar, these tests were only conducted using the data for the simulated ENP population produced under the model with a post-whaling split with pulse migration but no annual immigration.

In addition to showing the proportion of simulations that had higher and lower values for each statistic than the values generated from the empirical data, we used interpolation to calculate the "crossover point" at which the 50% probability (median) was reached (i.e. the point at which the proportion of simulated runs had values higher than the observed reached 50%). For the number of haplotypes, the crossover point was calculated as the point at which the lines representing the proportion greater than and the proportion less than crossed (as for the other statistics), but because some simulation replicates had values equal to (rather than less than or greater than) the observed value, this point was slightly lower than the 50% probability.

RESULTS

Although the goal is to produce 500 replicates of each scenario, currently only 100 replicates of each scenario are complete and are utilized in the results shown here.

Comparison of simulated and observed data for ENP

Table 9 includes a summary of the number of haplotypes, haplotypic diversity and nucleotide diversity for the simulated ENP population for the model incorporating the 9-stage matrices with a post-whaling split and pulse immigration. Results were similar under all scenarios tested (data not shown). Overall, median values for both the haplotypic diversity and the number of haplotypes were similar among the simulated and empirical datasets. The haplotypic diversity values generated in the simulated data were slightly lower than that in the observed data, with median values for the simulated data ranging from 0.948 to 0.950 (as compared to the observed haplotypic diversity of 0.952) and with 52-64% of replicates under the different immigration scenarios having lower haplotypic diversity than found in the empirical data. In contrast, the median number of haplotypes generated in the simulated datasets (33 to 34 haplotypes) was slightly higher than that found in the observed data (32 haplotypes). Between 62 and 75% of replicates for the different immigration scenarios generated values higher than the number identified in the empirical dataset. Although the nucleotide diversity calculated from the empirical data fell within the 90% range of the simulated values, nucleotide diversity in the simulated data was higher than that found in the observed data.

To evaluate whether the shape of our simulated haplotype distributions matched the shape of the observed distribution, we used a χ^2 test to compare the observed (North stratum) versus the simulated haplotype frequency distributions for the ENP population. The χ^2 test evaluates whether the haplotype distributions representing the empirical and simulated data could have been generated by random sampling of a single population. The χ^2 test is particularly sensitive to the frequencies of the most common haplotypes, as those haplotypes are the most likely to be represented in the random draws that represent immigration events. In our comparison, 12% of tests showed significant ($p<0.05$) differences (Figure 10), suggesting that the shape of the observed and simulated distributions were similar in most cases. We also compared the frequency of the most common haplotype in the empirical data with the frequency of the most common haplotype in the simulations. We found that the frequency of the most common haplotype was higher than that found in the empirical data for 47% of the simulation replicates. This finding is consistent with the expectation that if two samples are drawn from the same distribution, the frequency of most common haplotype would be expected to be greater in one sample than the other 50% of the time.

Comparison of simulated and observed data for the PCFG

Figure 11 shows a graphical representation of the proportion of simulated values for each statistic that are lower (shown in black) or higher (shown in gray) than the observed value generated from the empirical data for one of the scenarios tested (post-whaling split with pulse immigration, nine-stage matrices). Summaries of the number of mtDNA haplotypes (Table 12), mtDNA haplotype diversity (Table 13), mtDNA nucleotide diversity (Table 14), F_{ST} (Table 15), ϕ_{ST} (Table 16), and χ^2/df (Table 17) produced by the simulations under all completed scenarios are shown below.

With regard to comparisons between the observed and simulated data, the statistics based on haplotype frequencies (haplotypic diversity, $F_{ST,}$ and χ^2/df) and haplotype numbers were the most informative. For all four of these statistics, scenarios based on annual immigration of one animal or less per year (at K) produced values that were inconsistent with the empirical data. The comparisons were less informative with regard to the highest level of immigration that could be occurring, although comparison of F_{ST} and χ^2/df values suggested that levels of immigration including > 8 animals/year (along with the pulse immigration) would produce values inconsistent with those produced by the empirical data.

Similar to the pattern seen in comparison of the observed and simulated data for the larger ENP population, the nucleotide diversity identified among the simulated datasets was higher than that seen in the empirical data. In the ϕ_{ST} comparisons, the value generated in the empirical comparison was more consistent with the lower range of values for annual immigration and indicated that more than 8 immigrants per year into the PCFG would produce values of ϕ_{ST} lower than that observed. Caution should be applied when interpreting this pattern, however, given the lower nucleotide diversities identified in the observed data when compared to the simulated datasets.

Table 18 shows the results of simulations evaluating scenarios in which the PCFG splits from the larger ENP population between 1940 and 1990. The results shown suggest that for no annual immigration into the PCFG to be plausible, the PCFG would have had to split from the larger population after 1950.

Table 19 shows the results of simulations evaluating scenarios in which the carrying capacity for the PCFG was set to between 500 and 5000. The results indicate that the carrying capacity for the PCFG would need to be higher than 500 animals for the simulated results to be consistent with the empirical data under a scenario of no annual immigration. Examples of the abundance trajectory of the PCFG for the K values tested are shown in Table 20. For all K values simulated, the abundance of the PCFG was close to carrying capacity by 2010 (Table 21).

DISCUSSION:

Comparison of the simulated and empirical datasets for the larger ENP population suggests that the simulations represent the empirical data reasonably well with regard to the number of haplotypes and their distribution. Although the simulations predict that we would find slightly higher number of haplotypes and a slightly lower haplotypic diversity than is present in the empirical data, the differences are small and the χ^2 test suggests that the two samples would be interpreted as being drawn from the same population in the majority (88%) of cases. The results of these comparisons suggest that similar frequency-based comparisons of the simulated and empirical data representing the PCFG should be informative.

The level of nucleotide diversity in the simulated data representing the larger ENP population is higher than that found in the empirical data, indicating that there are some aspects of the population's history that are not being captured by the simulations. It is likely that the gray whales in the North Pacific have experienced numerous fluctuations in abundance due to changing ice conditions in the past, and historic K may have been substantially larger than we have simulated here (e.g., Alter *et al*. 2007). Our simulations incorporate only a simplified version of the recent history of gray whales, and our results suggest that the statistics relying on nucleotide differences (e.g., nucleotide diversity and ϕ_{ST}) may be more sensitive to violations of our assumptions about past (pre-commercial whaling) population size and equilibrium. As such, the results derived from the comparisons of nucleotide diversity and ϕ_{ST} warrant further investigation and should be interpreted with caution.

The comparison of frequency-based statistics between the simulated and empirical datasets representing the PCFG suggests that annual immigration into the PCFG is likely to be higher than 1 immigrant per year under the scenarios tested. The simulations were less informative with regard to the upper bound on annual immigration that could be occurring. Although the F_{ST} and χ^2/df comparisons indicated that immigration of >8 animals/year would be inconsistent with the empirical data, the proportion of simulations with higher than the observed values for the number of haplotypes and the haplotypic diversity never exceeded 84% and 63%, respectively. For all four statistics, the proportion of simulations with higher (for the number of haplotypes and haplotypic diversity) or lower (for F_{ST} and χ^2/df) values than the observed appears to level off at the higher (8 -10 or more per year) levels of immigration. This pattern is particularly evident in the comparisons utilizing haplotypic diversity, where the proportion of simulations with higher or lower values than the observed levels off at ~50% for immigration of 8 or more animals per year. Haplotypic diversity is calculated based on the sum of squared allele frequencies. Given that relationship, as the number of haplotypes in a population increases, the addition of another haplotype, particularly one found in low frequencies as would be expected to be brought in by an immigrant, has little impact on diversity. As such, this statistic, and to a lesser extent the others, appear to have limited power to differentiate between the higher levels of immigration.

Although these statistics were limited in their ability to distinguish an absolute upper bound on how much immigration could be occurring, the calculation of the number of immigrants per year which corresponds to the "crossing point" provides some information on what the most plausible values of immigration could be (Table 22). The estimated number of migrants ranged from ~2 to 8 for the scenarios with pulse immigration under the updated matrices. For the reasons discussed above, the calculations based on ϕ_{ST} and haplotypic diversity may not provide the best estimates. Comparisons between the observed and simulated values for the number of haplotypes, F_{ST}, and χ^2/df, suggest that immigration of approximately 4 animals per year is most plausible. If the current abundance of the PCFG is approximately 200 animals, this represents immigration of ~ 2% per year. Of note, this estimate does not include the +20 animals which were simulated to immigrate into the PCFG in 2000 and 2001.

Although the simulation results could be sensitive to other parameters incorporated in the models, a limited evaluation of the effects of increased carrying capacity for the PCFG or a more recent founding time was conducted. These simulations suggested that to obtain the empirical results presented in Lang *et al.* 2011 under a scenario of no annual immigration, the abundance of the PCFG would have to be larger (>500 animals) than currently estimated. Gray whales have been observed feeding off of Kodiak Island, Alaska since at least 1999, with ~350-400 individuals counted during a single day in July 2000 (Moore *et al.* 2007). Approximately 20% of the animals photographically identified in this area between 2002 and 2005 are known to be animals that have also been photographed in the Pacific Northwest from northern California to southeast Alaska (Gosho *et al.* 2011). However, the median "crossing point" calculated from these comparisons suggest that values of K between 2000 (based on F_{ST}) and 3000 (based on the number of haplotypes) animals produce values that are most consistent with the empirical data, indicating that additional explanation may be needed.

The simulations exploring more recent founding times suggest that under a scenario with no annual immigration, the PCFG would have to have been founded after 1950, and more plausibly between the mid-1960s to mid-1970s, to produce simulated results that are consistent with the empirical data. Small numbers of gray whales have been sighted within the seasonal range of the PCFG since at least 1926 (Howell & Huey 1930, Gilmore 1960, Pike and MacAskie 1969, additional references in Rice & Wolman 1971), but photo-identification studies did not start until the 1970s, when the repeated return of individuals to the area was first documented (Hatler & Darling 1974, Darling 1984). Our simulations model an instantaneous colonization of the PCFG, such that for the scenarios modeling colonization in 1960 or later at least 60 whales become part of the PCFG in a given year. This aspect of our simulations is clearly an oversimplification. Given both the limited information available on use of the PCFG seasonal range prior to the 1970s and the limitations of our model, it is difficult to evaluate how the simulation results fit in with past records.

The simulations incorporating a pre-whaling split of the PCFG from the larger ENP population are in progress and are expected to be completed by the 2012 SC meeting. Future work will also include integrating the genetic data representing ENP gray whales in LeDuc *et al*. 2002 and Lang 2010 with the data represented in Lang *et al.* 2011 to ensure that the diversity values utilized here are as representative as possible of the larger ENP population. Simulations will also be performed to explore the effect of incorporating lower MSYR rates for the PCFG into the life history matrices underlying the models.

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Table 1. The proportion of birth events in the simulated data that resulted in multiple offspring for the same female in a given year.

	5-stage TOSSM matrices	9-stage matrices
Proportion of single offspring births:	64%	92%
Proportion of multiple offspring births:	36%	8%
Range of multiple offspring births:	2-7	2-3

Table 2. Calving intervals in the simulated datasets.

Measure	5-stage TOSSM matrices	9-stage matrices
Median	3	2
Mean	5.1	3.2
Variance	27.08	16.50
stdev	5.20	4.06
Min	2	1
Max	35	38

Table 3. Vital rates for gray whales. Generation time shown here is calculated based on a maximum age of 40 years (as in previous work).

	5-stage TOSSM matrices		9-stage matrices	
Vital Rate	At K	Near ZPD	At K	Near ZPD
Juvenile survival	0.925	0.94	0.905	0.935
Adult female survival	0.946	0.946	0.982	0.982
Adult male survival	0.954	0.954	0.982	0.982
Calf survival	0.925	0.94	0.732	0.732
Age of first reproduction	10	5	10	7
Rate of increase (λ)	1.003	1.072	1.000	1.064
Generation Time*	19.5	16.9	21.10	20.60

Table 4. The updated stage-based matrices for use at a) zero population density and b) carrying capacity are shown below.

a) Nine-stage matrices at ZPD:

	juv1	juv2	juv3	F1	F2	F3	M1	M2	M3
juv1	0.497	0.000	0.000	0.366	0.366	0.366	0.000	0.000	0.000
juv2	0.438	0.497	0.000	0.000	0.000	0.000	0.000	0.000	0.000
juv3	0.000	0.438	0.497	0.000	0.000	0.000	0.000	0.000	0.000
F1	0.000	0.000	0.219	0.942	0.000	0.000	0.000	0.000	0.000
F2	0.000	0.000	0.000	0.040	0.942	0.000	0.000	0.000	0.000
F3	0.000	0.000	0.000	0.000	0.040	0.942	0.000	0.000	0.000
M1	0.000	0.000	0.219	0.000	0.000	0.040	0.942	0.000	0.000
M2	0.000	0.000	0.000	0.000	0.000	0.000	0.040	0.942	0.000
M3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.040	0.942

b) Nine-stage matrices at K:

	juv1	juv2	juv3	F1	F2	F3	M1	M2	M3
juv1	0.633	0.000	0.000	0.176	0.176	0.176	0.000	0.000	0.000
juv2	0.272	0.633	0.000	0.000	0.000	0.000	0.000	0.000	0.000
juv3	0.000	0.272	0.633	0.000	0.000	0.000	0.000	0.000	0.000
F1	0.000	0.000	0.136	0.914	0.000	0.000	0.000	0.000	0.000
F2	0.000	0.000	0.000	0.068	0.914	0.000	0.000	0.000	0.000
F3	0.000	0.000	0.000	0.000	0.068	0.914	0.000	0.000	0.000
M1	0.000	0.000	0.136	0.000	0.000	0.068	0.914	0.000	0.000
M2	0.000	0.000	0.000	0.000	0.000	0.000	0.068	0.914	0.000
M3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.068	0.914

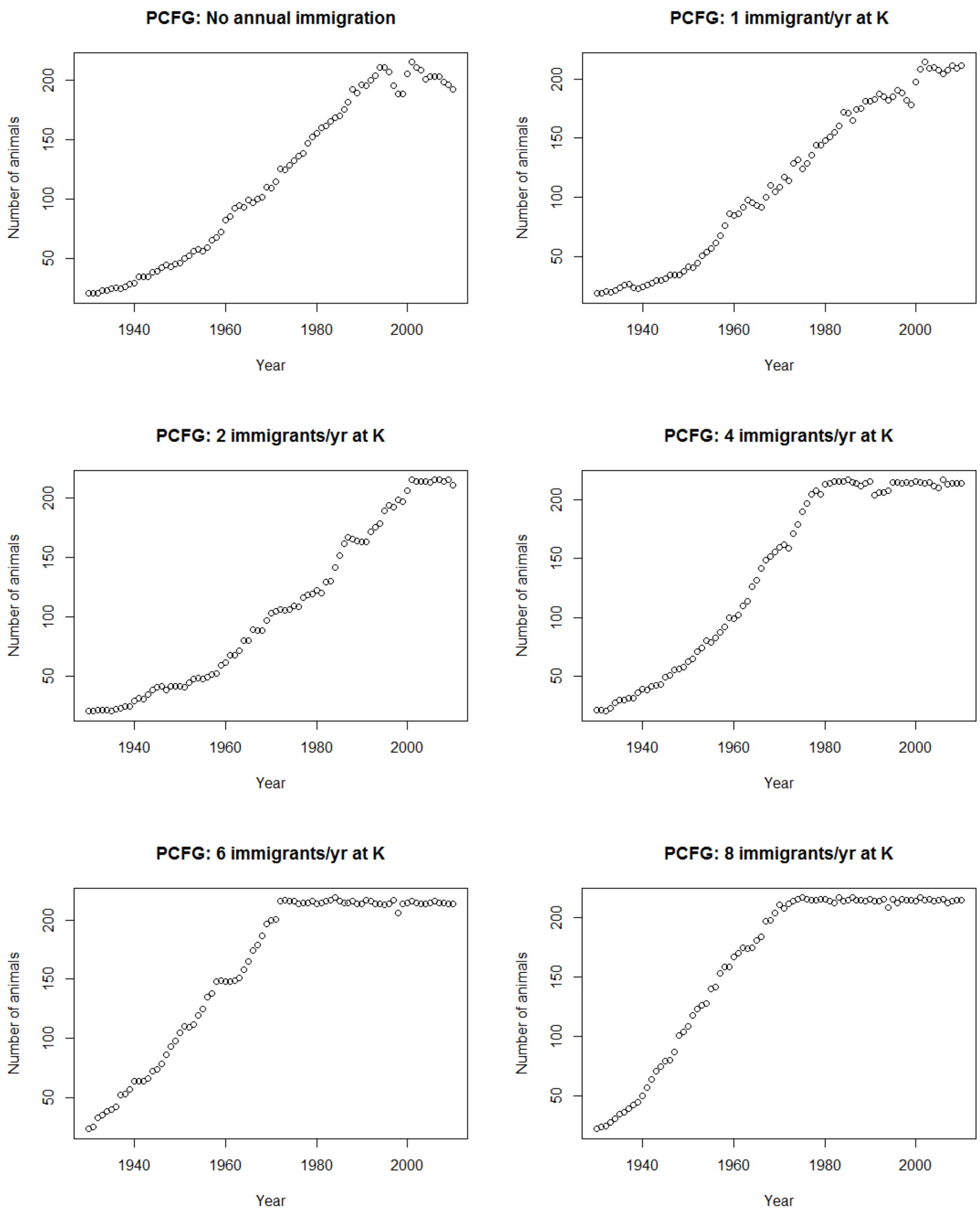
c) Five-stage(TOSSM) matrices at ZPD:

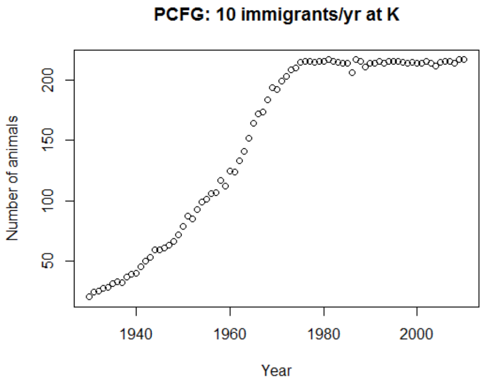
	juv1	juv2	fert	lact	male
juv1	0.730	0.000	0.000	0.940	0.000
juv2	0.210	0.000	0.000	0.000	0.000
fert	0.000	0.470	0.000	0.946	0.000
lact	0.000	0.000	0.946	0.000	0.000
male	0.000	0.470	0.000	0.000	0.954

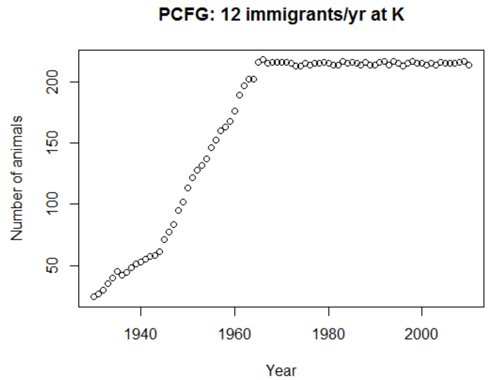
d) Five-stage (TOSSM) matrices at K:

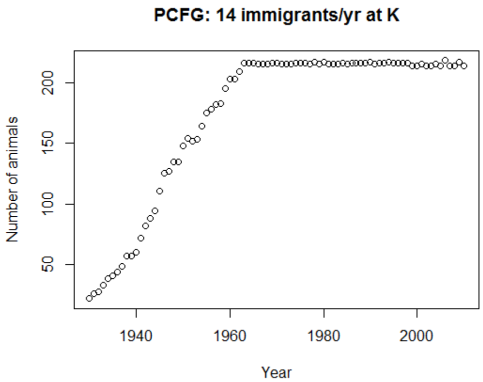
	juv1	juv2	fert	lact	male
juv1	0.768	0.000	0.000	0.925	0.000
juv2	0.157	0.720	0.000	0.000	0.000
fert	0.000	0.102	0.648	0.946	0.000
lact	0.000	0.000	0.298	0.000	0.000
male	0.000	0.102	0.000	0.000	0.954

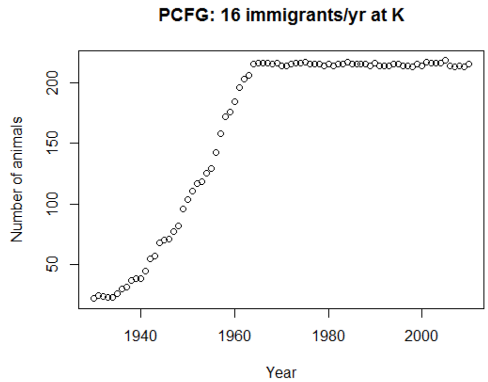
Figure 5. Examples of trajectories for PCFG, under a model incorporating a post-whaling split with pulse immigration. Plots for the abundance of the PCFG whales span 1930 to 2010, while the plot showing the abundance of the larger ENP population spans 1846 to 2010 to show the simulated depletion due to commercial whaling.




PCFG: 10 immigrants/yr at K
Number of animals
50
100
150
200
1940
1960
1980
2000
Year


PCFG: 12 immigrants/yr at K
Number of animals
50
100
150
200
1940
1960
1980
2000
Year


PCFG: 14 immigrants/yr at K
Number of animals
50
100
150
200
1940
1960
1980
2000
Year


PCFG: 16 immigrants/yr at K
Number of animals
50
100
150
200
1940
1960
1980
2000
Year

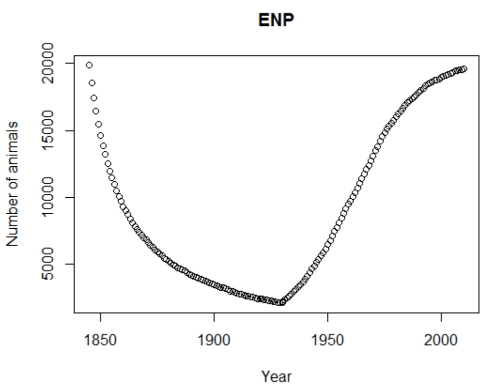
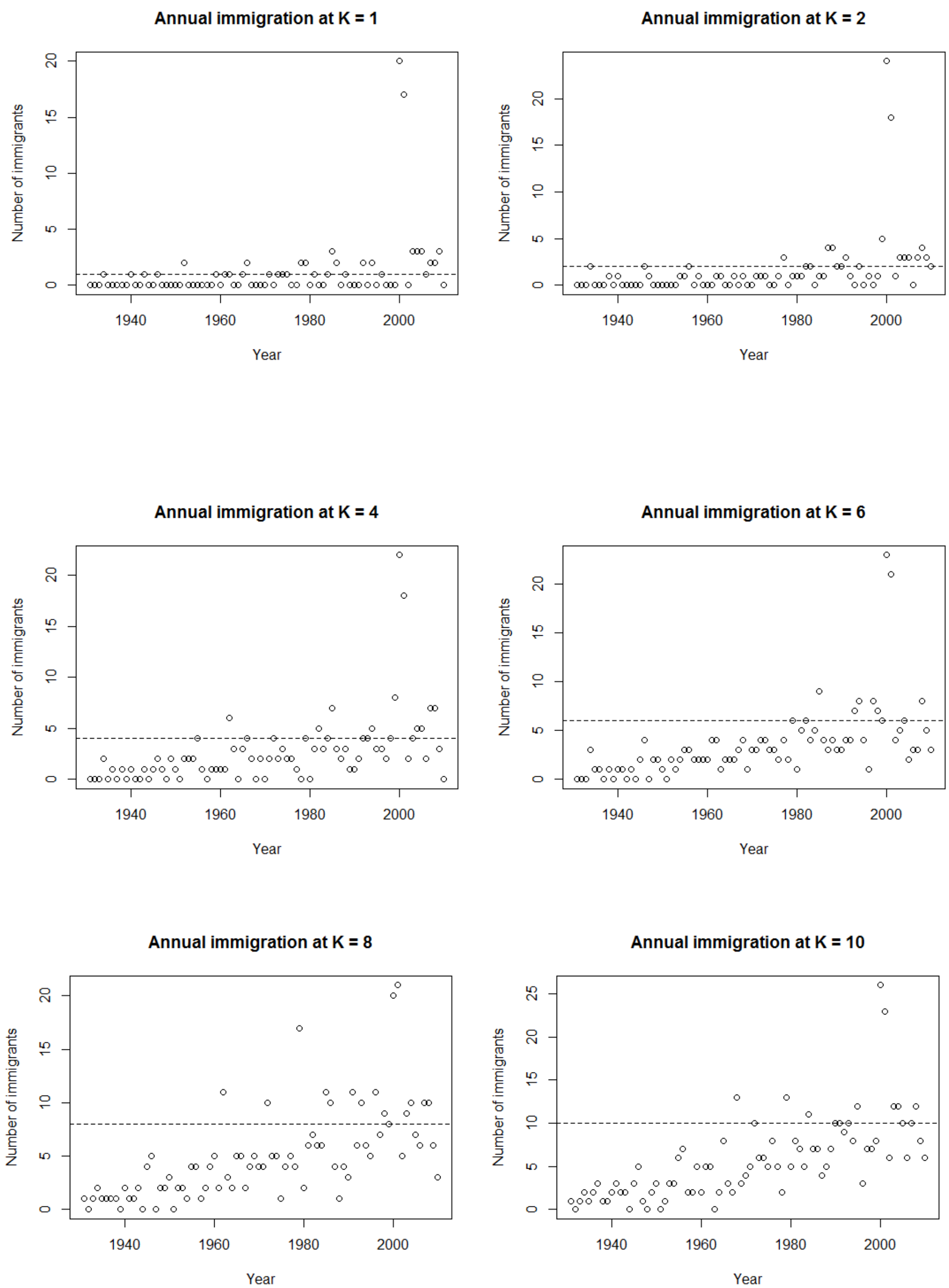
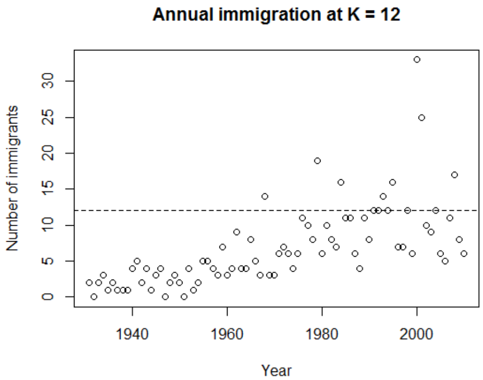
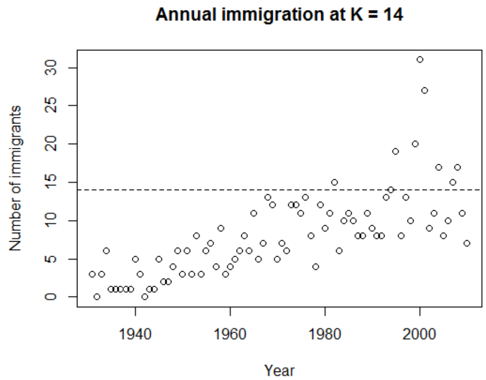

ENP
Number of animals
5000
10000
15000
20000
1850
1900
1950
2000
Year

Figure 6. Example of the number of immigrants per year generated for one replicate (9-stage matrices with pulse immigration). The dotted line represents the number of immigrants per year that would be expected when the ENP population reaches K.




Annual immigration at K = 12
Number of immigrants
0
5
10
15
20
25
30
1940
1960
1980
2000
Year


Annual immigration at K = 14
Number of immigrants
0
5
10
15
20
25
30
1940
1960
1980
2000
Year

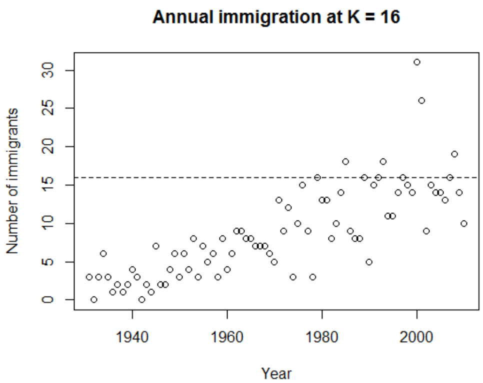

Annual immigration at K = 16
Number of immigrants
0
5
10
15
20
25
30
1940
1960
1980
2000
Year

Table 7. List of scenarios that have been completed for 100 replications.

Index	Matrices	Timing of split	Year of split	PCFG Carrying Capacity (K)	Immigrants/yr into the PCFG (at K)	Pulse immigration
1	9-stage	Post-whaling split	1930	200	0	Y
2	9-stage	Post-whaling split	1930	200	1	Y
3	9-stage	Post-whaling split	1930	200	2	Y
4	9-stage	Post-whaling split	1930	200	4	Y
5	9-stage	Post-whaling split	1930	200	6	Y
6	9-stage	Post-whaling split	1930	200	8	Y
7	9-stage	Post-whaling split	1930	200	10	Y
8	9-stage	Post-whaling split	1930	200	12	Y
9	9-stage	Post-whaling split	1930	200	14	Y
10	9-stage	Post-whaling split	1930	200	16	Y
11	9-stage	Post-whaling split	1930	200	0	N
12	9-stage	Post-whaling split	1930	200	1	N
13	9-stage	Post-whaling split	1930	200	2	N
14	9-stage	Post-whaling split	1930	200	4	N
15	9-stage	Post-whaling split	1930	200	6	N
16	9-stage	Post-whaling split	1930	200	8	N
17	9-stage	Post-whaling split	1930	200	10	N
18	9-stage	Post-whaling split	1930	200	12	N
19	9-stage	Post-whaling split	1930	200	14	N
20	9-stage	Post-whaling split	1930	200	16	N
21	5-stage	Post-whaling split	1930	200	0	Y
22	5-stage	Post-whaling split	1930	200	1	Y
23	5-stage	Post-whaling split	1930	200	2	Y
24	5-stage	Post-whaling split	1930	200	4	Y
25	5-stage	Post-whaling split	1930	200	6	Y
26	5-stage	Post-whaling split	1930	200	8	Y
27	5-stage	Post-whaling split	1930	200	10	Y
28	5-stage	Post-whaling split	1930	200	12	Y
29	5-stage	Post-whaling split	1930	200	14	Y
30	5-stage	Post-whaling split	1930	200	16	Y
31	9-stage	Post-whaling split	1940	200	0	Y
32	9-stage	Post-whaling split	1950	200	0	Y
33	9-stage	Post-whaling split	1960	200	0	Y
34	9-stage	Post-whaling split	1970	200	0	Y
35	9-stage	Post-whaling split	1980	200	0	Y
36	9-stage	Post-whaling split	1990	200	0	Y
37	9-stage	Post-whaling split	1930	500	0	Y
38	9-stage	Post-whaling split	1930	1000	0	Y
39	9-stage	Post-whaling split	1930	1500	0	Y
40	9-stage	Post-whaling split	1930	2000	0	Y
41	9-stage	Post-whaling split	1930	3000	0	Y
42	9-stage	Post-whaling split	1930	5000	0	Y

* Pulse immigration consists of +20 animals in per year as reflected in the abundance in 2000 and 2001

Table 8. The number of samples collected per year from each stratum in the Lang *et al*. 2011 study.

Year	North	PCFG
1994	11	0
1995	0	0
1996	0	3
1997	1	3
1998	0	7
1999	1	0
2000	1	2
2001	27	0
2002	0	1
2003	12	3
2004	12	3
2005	10	1
2006	0	0
2007	0	0
2008	0	0
2009	0	13
2010	28	35
Total	103	71

Table 9. Summary of the haplotypic diversity, number of mtDNA haplotypes, and nucleotide diversity generated in the simulated ENP population. Only the results from the post-whaling split with immigration pulse models are shown as results were similar under all other models.

Haplotypic diversity:
ENP: H_{obs} =0.952

Matrices	Scenario	Immigration (Inds/Yr at K)	With pulse?	Median_ENP	Min_ENP	Max_ENP	Prop < than ENP	Prop > than ENP
9-stage	Post-whaling split	0	Y	0.948	0.883	0.973	61	39
9-stage	Post-whaling split	1	Y	0.951	0.869	0.973	52	48
9-stage	Post-whaling split	2	Y	0.950	0.878	0.974	56	44
9-stage	Post-whaling split	4	Y	0.950	0.874	0.974	57	43
9-stage	Post-whaling split	6	Y	0.950	0.890	0.972	56	44
9-stage	Post-whaling split	8	Y	0.948	0.869	0.973	64	36
9-stage	Post-whaling split	10	Y	0.949	0.878	0.977	62	38
9-stage	Post-whaling split	12	Y	0.950	0.786	0.971	54	46
9-stage	Post-whaling split	14	Y	0.948	0.862	0.973	61	39
9-stage	Post-whaling split	16	Y	0.950	0.877	0.977	52	48

Number of haplotypes:
ENP: Nb_haps_{obs}=32

Matrices	Scenario	Immigration (Inds/Yr at K)	With pulse?	Median_ENP	Min_ENP	Max_ENP	Prop < than ENP	Prop > than ENP
9-stage	Post-whaling split	0	Y	33	25	47	36	52
9-stage	Post-whaling split	1	Y	33	24	44	33	57
9-stage	Post-whaling split	2	Y	33	23	46	40	54
9-stage	Post-whaling split	4	Y	33	22	44	37	54
9-stage	Post-whaling split	6	Y	34	24	42	25	62
9-stage	Post-whaling split	8	Y	33	22	45	38	55
9-stage	Post-whaling split	10	Y	33	20	45	38	54
9-stage	Post-whaling split	12	Y	33	20	43	37	57
9-stage	Post-whaling split	14	Y	33	23	44	38	52
9-stage	Post-whaling split	16	Y	33	25	45	31	56

Nucleotide diversity:
ENP: $\prod_{obs}$ = 0.0142

Matrices	Scenario	Immigration (Inds/Yr at K)	With pulse?	Median_ENP	Min_ENP	Max_ENP	Prop < than ENP	Prop > than ENP
9-stage	Post-whaling split	0	Y	0.026	0.012	0.065	7	93
9-stage	Post-whaling split	1	Y	0.025	0.011	0.060	10	90
9-stage	Post-whaling split	2	Y	0.024	0.012	0.056	9	91
9-stage	Post-whaling split	4	Y	0.025	0.011	0.059	9	91
9-stage	Post-whaling split	6	Y	0.025	0.011	0.060	10	90
9-stage	Post-whaling split	8	Y	0.025	0.011	0.067	8	92
9-stage	Post-whaling split	10	Y	0.024	0.011	0.059	8	92
9-stage	Post-whaling split	12	Y	0.025	0.010	0.057	9	91
9-stage	Post-whaling split	14	Y	0.025	0.011	0.071	7	93
9-stage	Post-whaling split	16	Y	0.025	0.011	0.066	9	91

Figure 10. Histogram showing the distribution of p-values for a χ^2 test comparing the observed to the simulated haplotype distributions for the larger ENP population.

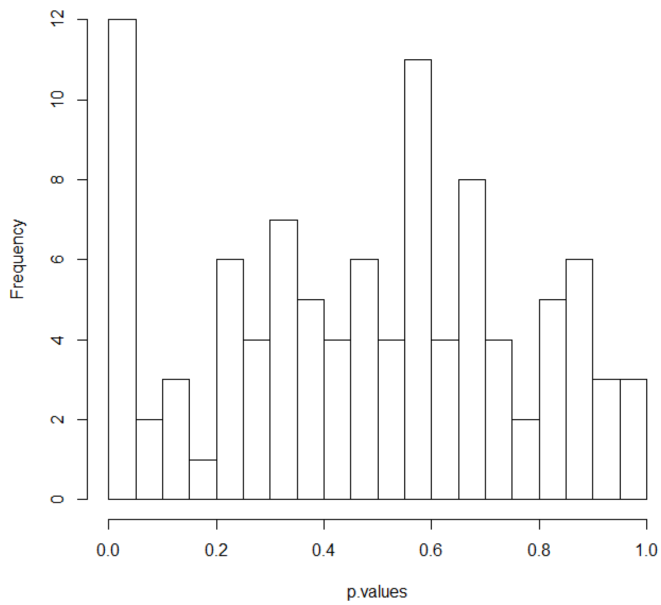
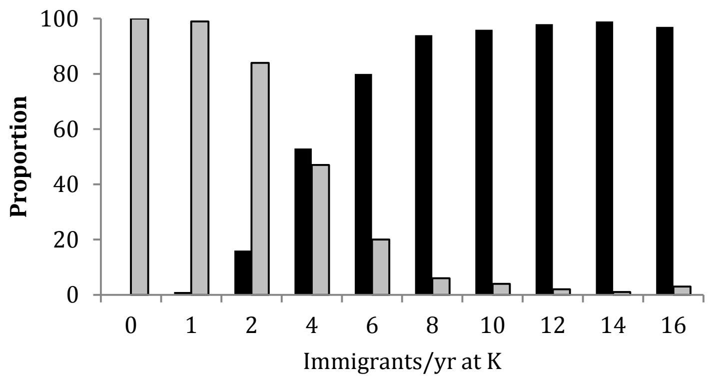
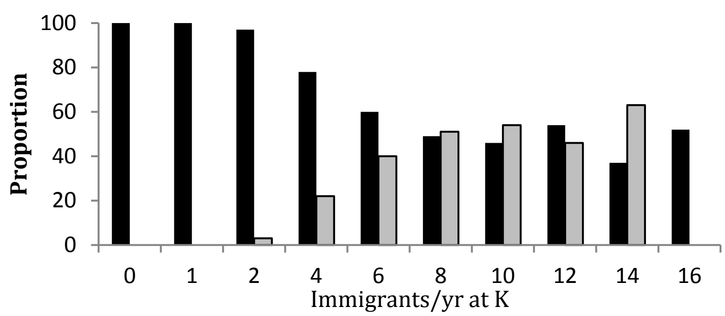


Figure 11. Graphical representation of the proportion of simulated values that are lower (shown in black) or higher (shown in gray) than the observed value generated from the empirical data. Simulated values are derived from the model incorporating a post-whaling split with pulse migration under the nine-stage matrices.

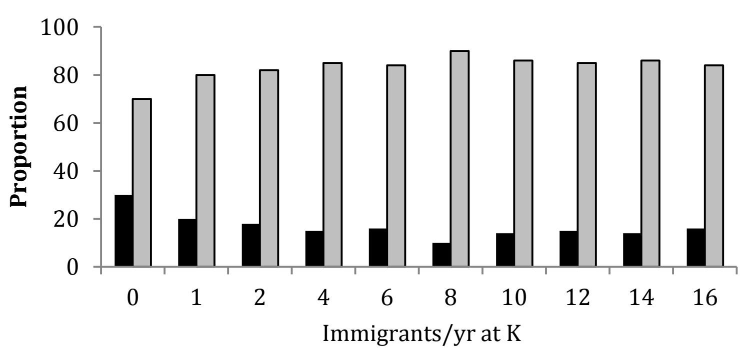
a.) Number of haplotypes:



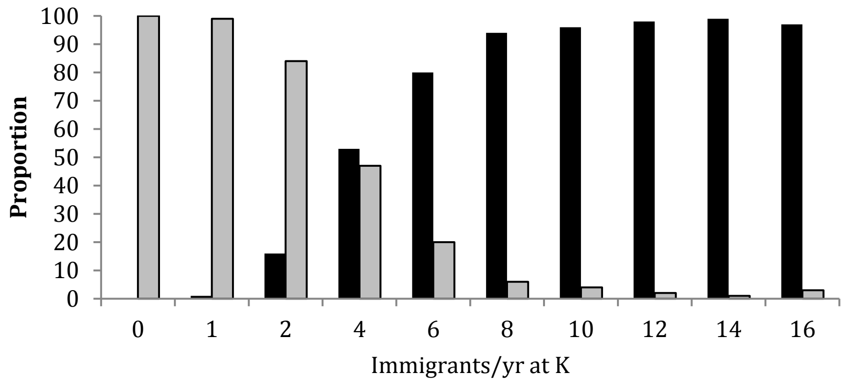
b.) Haplotypic diversity:



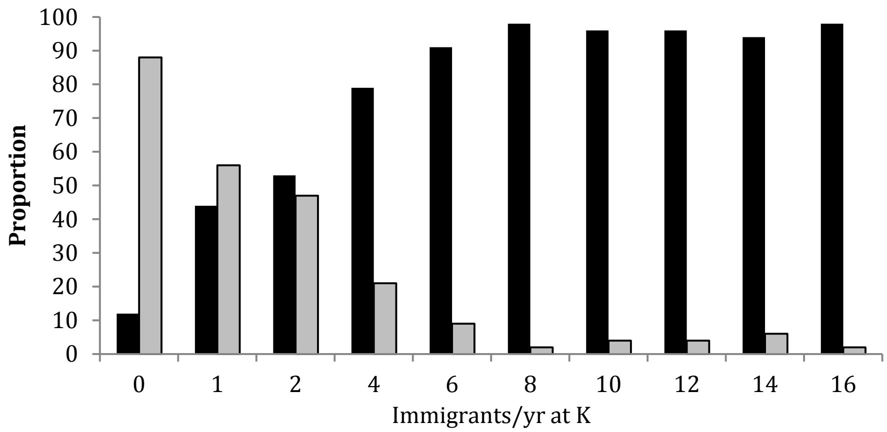
c.) Nucleotide diversity:



d.) F_{ST}:



e.) ϕ_{ST}:



f.) χ^2/df:

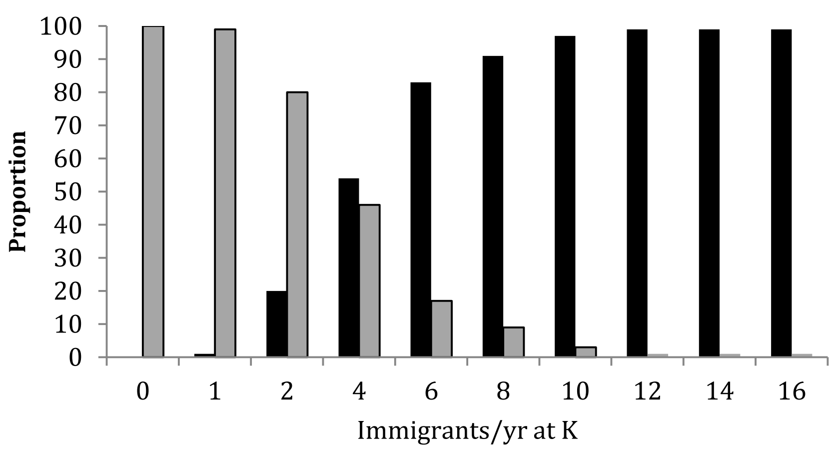


Table 12. Summary of number of mtDNA haplotypes in the simulated data for the PCFG. Scenarios highlighted in bold type produced results which were not consistent with those based on the empirical data.

PCFG: Nb_haps $_{obs}$=23

Matrices	Scenario	Immigrants/yr (at K)	With pulse?	Median_PCFG	Min_PCFG	Max_PCFG	Prop < PCFG	Prop > than obs
9-stage	**Post-whaling split**	**0**	**Y**	**12.0**	**6**	**19**	**100**	**0**
9-stage	**Post-whaling split**	**1**	**Y**	**16.6**	**11**	**26**	**96**	**2**
9-stage	Post-whaling split	2	Y	19.8	11	30	78	12
9-stage	Post-whaling split	4	Y	23.1	14	32	41	48
9-stage	Post-whaling split	6	Y	25.0	14	36	22	71
9-stage	Post-whaling split	8	Y	25.7	16	33	15	75
9-stage	Post-whaling split	10	Y	27.2	18	35	9	84
9-stage	Post-whaling split	12	Y	26.3	16	34	14	80
9-stage	Post-whaling split	14	Y	27.5	21	36	10	83
9-stage	Post-whaling split	16	Y	27.1	16	38	11	83
9-stage	**Post-whaling split**	**0**	**N**	**6.4**	**3**	**12**	**100**	**0**
9-stage	**Post-whaling split**	**1**	**N**	**12.5**	**6**	**20**	**100**	**0**
9-stage	**Post-whaling split**	**2**	**N**	**17.1**	**8**	**24**	**97**	**1**
9-stage	Post-whaling split	4	N	22.5	15	40	49	38
9-stage	Post-whaling split	6	N	23.9	12	32	36	52
9-stage	Post-whaling split	8	N	25.4	14	38	22	73
9-stage	Post-whaling split	10	N	25.8	17	37	27	66
9-stage	Post-whaling split	12	N	26.6	17	33	11	86
9-stage	Post-whaling split	14	N	27.0	17	36	11	84
9-stage	Post-whaling split	16	N	26.7	18	38	16	76
5-stage	**Post-whaling split**	**0**	**Y**	**10.4**	**6**	**16**	**100**	**0**
5-stage	**Post-whaling split**	**1**	**Y**	**15.0**	**7**	**23**	**99**	**0**
5-stage	Post-whaling split	2	Y	18.1	9	26	88	8
5-stage	Post-whaling split	4	Y	21.5	15	30	60	29
5-stage	Post-whaling split	6	Y	22.9	15	30	49	38
5-stage	Post-whaling split	8	Y	24.1	18	35	33	56
5-stage	Post-whaling split	10	Y	24.6	17	37	29	61
5-stage	Post-whaling split	12	Y	25.0	17	35	28	65
5-stage	Post-whaling split	14	Y	24.8	18	34	30	63
5-stage	Post-whaling split	16	Y	25.4	17	37	21	67

Table 13. Summary of haplotypic diversity in the simulated data for the PCFG. Scenarios highlighted in bold type produced results which were not consistent with those based on the empirical data.

PCFG: Hobs = 0.945

Matrices	Scenario	Immigration (Inds/Yr at K)	With pulse?	Median_ PCFG	Min_PCFG	Max_PCFG	Prop < than PCFG	Prop > than PCFG
9-stage	**Post-whaling split**	**0**	**Y**	**0.804**	**0.137**	**0.896**	**100**	**0**
9-stage	**Post-whaling split**	**1**	**Y**	**0.869**	**0.334**	**0.940**	**100**	**0**
9-stage	**Post-whaling split**	**2**	**Y**	**0.907**	**0.722**	**0.949**	**97**	**3**
9-stage	Post-whaling split	4	Y	0.933	0.699	0.970	78	22
9-stage	Post-whaling split	6	Y	0.939	0.810	0.971	60	40
9-stage	Post-whaling split	8	Y	0.945	0.848	0.972	49	51
9-stage	Post-whaling split	10	Y	0.948	0.857	0.974	46	54
9-stage	Post-whaling split	12	Y	0.943	0.825	0.969	54	46
9-stage	Post-whaling split	14	Y	0.951	0.842	0.972	37	63
9-stage	Post-whaling split	16	Y	0.944	0.866	0.979	52	48
9-stage	**Post-whaling split**	**0**	**N**	**0.754**	**0.344**	**0.867**	**100**	**0**
9-stage	**Post-whaling split**	**1**	**N**	**0.841**	**0.608**	**0.928**	**100**	**0**
9-stage	**Post-whaling split**	**2**	**N**	**0.888**	**0.748**	**0.946**	**99**	**1**
9-stage	Post-whaling split	4	N	0.932	0.788	0.974	84	16
9-stage	Post-whaling split	6	N	0.936	0.840	0.965	67	33
9-stage	Post-whaling split	8	N	0.941	0.835	0.974	59	41
9-stage	Post-whaling split	10	N	0.944	0.842	0.977	51	49
9-stage	Post-whaling split	12	N	0.946	0.870	0.971	45	55
9-stage	Post-whaling split	14	N	0.946	0.878	0.976	43	57
9-stage	Post-whaling split	16	N	0.947	0.841	0.976	48	52
5-stage	**Post-whaling split**	**0**	**Y**	**0.734**	**0.259**	**0.883**	**100**	**0**
5-stage	**Post-whaling split**	**1**	**Y**	**0.854**	**0.600**	**0.930**	**100**	**0**
5-stage	**Post-whaling split**	**2**	**Y**	**0.890**	**0.717**	**0.949**	**97**	**3**
5-stage	Post-whaling split	4	Y	0.915	0.752	0.958	92	8
5-stage	Post-whaling split	6	Y	0.929	0.768	0.963	79	21
5-stage	Post-whaling split	8	Y	0.931	0.796	0.965	74	26
5-stage	Post-whaling split	10	Y	0.934	0.720	0.973	78	22
5-stage	Post-whaling split	12	Y	0.935	0.747	0.968	64	36
5-stage	Post-whaling split	14	Y	0.937	0.823	0.965	67	33
5-stage	Post-whaling split	16	Y	0.934	0.834	0.971	68	32

Table 14. Summary of the mtDNA nucleotide diversity in the simulated data for the PCFG. Scenarios highlighted in bold type produced results which were not consistent with those based on the empirical data.

PCFG: ∏ obs = 0.0148

Matrices	Scenario	Immigration (Inds/Yr at K)	With pulse?	Median_PCFG	Min_PCFG	Max_PCFG	Prop < than PCFG	Prop > than PCFG
9-stage	Post-whaling split	0	Y	0.021	0.004	0.059	30	70
9-stage	Post-whaling split	1	Y	0.022	0.005	0.056	20	80
9-stage	Post-whaling split	2	Y	0.022	0.010	0.063	18	82
9-stage	Post-whaling split	4	Y	0.025	0.010	0.062	15	85
9-stage	Post-whaling split	6	Y	0.025	0.010	0.062	16	84
9-stage	Post-whaling split	8	Y	0.025	0.012	0.066	10	90
9-stage	Post-whaling split	10	Y	0.025	0.010	0.058	14	86
9-stage	Post-whaling split	12	Y	0.025	0.011	0.059	15	85
9-stage	Post-whaling split	14	Y	0.025	0.011	0.059	14	86
9-stage	Post-whaling split	16	Y	0.024	0.010	0.067	16	84
9-stage	Post-whaling split	0	N	0.020	0.002	0.080	32	68
9-stage	Post-whaling split	1	N	0.022	0.007	0.051	27	73
9-stage	Post-whaling split	2	N	0.023	0.007	0.064	18	82
9-stage	Post-whaling split	4	N	0.024	0.008	0.062	15	85
9-stage	Post-whaling split	6	N	0.025	0.010	0.064	13	87
9-stage	Post-whaling split	8	N	0.024	0.010	0.060	11	89
9-stage	Post-whaling split	10	N	0.026	0.010	0.074	14	86
9-stage	Post-whaling split	12	N	0.025	0.010	0.065	12	88
9-stage	Post-whaling split	14	N	0.025	0.011	0.059	12	88
9-stage	Post-whaling split	16	N	0.025	0.010	0.058	12	88
5-stage	Post-whaling split	0	Y	0.015	0.004	0.042	51	49
5-stage	Post-whaling split	1	Y	0.018	0.003	0.046	44	56
5-stage	Post-whaling split	2	Y	0.018	0.005	0.048	37	63
5-stage	Post-whaling split	4	Y	0.017	0.005	0.051	27	73
5-stage	Post-whaling split	6	Y	0.019	0.005	0.054	27	73
5-stage	Post-whaling split	8	Y	0.020	0.006	0.048	31	69
5-stage	Post-whaling split	10	Y	0.020	0.004	0.053	31	69
5-stage	Post-whaling split	12	Y	0.020	0.005	0.052	27	73
5-stage	Post-whaling split	14	Y	0.021	0.005	0.052	29	71
5-stage	Post-whaling split	16	Y	0.020	0.006	0.050	25	75

Table 15. Summary of F_{ST} values generated in the comparison of simulated data representing the PCFG and the larger ENP population. Scenarios highlighted in bold type produced results which were not consistent with those based on the empirical data.

$F_{ST\ obs}$ = 0.012

Matrices	Scenario	Immigration (Inds/Yr at K)	With pulse?	Median	Min	Max	Prop > than obseved	Prop > than observed
9-stage	**post-whaling split**	**0**	**Y**	**0.069**	**0.019**	**0.254**	**0**	**100**
9-stage	**post-whaling split**	**1**	**Y**	**0.040**	**0.005**	**0.189**	**1**	**99**
9-stage	post-whaling split	2	Y	0.023	0.002	0.096	16	84
9-stage	post-whaling split	4	Y	0.011	-0.004	0.033	53	47
9-stage	post-whaling split	6	Y	0.005	-0.005	0.030	80	20
9-stage	post-whaling split	8	Y	0.002	-0.004	0.017	94	6
9-stage	**post-whaling split**	**10**	**Y**	**0.002**	**-0.007**	**0.021**	**96**	**4**
9-stage	**post-whaling split**	**12**	**Y**	**0.001**	**-0.006**	**0.019**	**98**	**2**
9-stage	**post-whaling split**	**14**	**Y**	**0.001**	**-0.007**	**0.013**	**99**	**1**
9-stage	**post-whaling split**	**16**	**Y**	**0.001**	**-0.007**	**0.020**	**97**	**3**
9-stage	**post-whaling split**	**0**	**N**	**0.099**	**0.029**	**0.295**	**0**	**100**
9-stage	**post-whaling split**	**1**	**N**	**0.051**	**0.020**	**0.146**	**0**	**100**
9-stage	post-whaling split	2	N	0.032	0.006	0.098	9	91
9-stage	post-whaling split	4	N	0.012	-0.004	0.058	47	53
9-stage	post-whaling split	6	N	0.008	-0.003	0.035	71	29
9-stage	post-whaling split	8	N	0.003	-0.004	0.025	91	9
9-stage	post-whaling split	10	N	0.003	-0.006	0.022	93	7
9-stage	**post-whaling split**	**12**	**N**	**0.001**	**-0.007**	**0.015**	**98**	**2**
9-stage	**post-whaling split**	**14**	**N**	**0.002**	**-0.007**	**0.016**	**98**	**2**
9-stage	**post-whaling split**	**16**	**N**	**0.001**	**-0.006**	**0.048**	**92**	**8**
5-stage	**post-whaling split**	**0**	**Y**	**0.101**	**0.018**	**0.323**	**0**	**100**
5-stage	post-whaling split	1	Y	0.044	0.007	0.150	6	94
5-stage	post-whaling split	2	Y	0.025	-0.002	0.097	18	82
5-stage	post-whaling split	4	Y	0.009	-0.004	0.045	64	36
5-stage	post-whaling split	6	Y	0.004	-0.008	0.040	87	13
5-stage	post-whaling split	8	Y	0.002	-0.004	0.021	90	10
5-stage	post-whaling split	10	Y	0.003	-0.005	0.025	94	6
5-stage	**post-whaling split**	**12**	**Y**	**0.001**	**-0.007**	**0.014**	**96**	**4**
5-stage	**post-whaling split**	**14**	**Y**	**0.001**	**-0.006**	**0.016**	**98**	**2**
5-stage	**post-whaling split**	**16**	**Y**	**0.000**	**-0.006**	**0.019**	**97**	**3**

Table 16. Summary of ϕ_{ST} values generated in the comparison of simulated data representing the PCFG and the larger ENP population. Scenarios highlighted in bold type produced results which were not consistent with those based on the empirical data.

ϕ_{STobs}=0.023

Matrices	Scenario	Immigration (Inds/Yr at K)	With pulse?	Median	Min	Max	Prop > than observed	Prop < than observed
9-stage	Arch1_sc1	0	Y	0.065	0.000	0.332	12	88
9-stage	Arch1_sc2	1	Y	0.030	-0.002	0.240	44	56
9-stage	Arch1_sc3	2	Y	0.021	-0.004	0.080	53	47
9-stage	Arch1_sc4	4	Y	0.007	-0.009	0.074	79	21
9-stage	Arch1_sc5	6	Y	0.000	-0.011	0.062	91	9
9-stage	**Arch1_sc6**	**8**	**Y**	**-0.001**	**-0.011**	**0.036**	**98**	**2**
9-stage	**Arch1_sc7**	**10**	**Y**	**0.000**	**-0.011**	**0.028**	**96**	**4**
9-stage	**Arch1_sc8**	**12**	**Y**	**-0.003**	**-0.011**	**0.055**	**96**	**4**
9-stage	Arch1_sc9	14	Y	0.000	-0.011	0.044	94	6
9-stage	**Arch1_sc9**	**16**	**Y**	**-0.001**	**-0.010**	**0.032**	**98**	**2**
9-stage	Arch1_sc1	0	N	0.090	0.005	0.439	7	93
9-stage	Arch1_sc2	1	N	0.043	0.002	0.237	23	77
9-stage	Arch1_sc3	2	N	0.026	-0.008	0.187	48	52
9-stage	Arch1_sc4	4	N	0.009	-0.010	0.064	84	16
9-stage	Arch1_sc5	6	N	0.007	-0.009	0.087	86	14
9-stage	Arch1_sc6	8	N	0.001	-0.011	0.071	87	13
9-stage	Arch1_sc7	10	N	-0.002	-0.011	0.051	93	7
9-stage	Arch1_sc8	12	N	-0.002	-0.011	0.037	93	7
9-stage	Arch1_sc9	14	N	-0.001	-0.010	0.040	93	7
9-stage	Arch1_sc10	16	N	-0.002	-0.010	0.092	94	6
5-stage	Arch1_sc1	0	Y	0.099	0.007	0.501	7	93
5-stage	Arch1_sc2	1	Y	0.032	-0.004	0.321	40	60
5-stage	Arch1_sc3	2	Y	0.014	-0.008	0.181	67	33
5-stage	Arch1_sc4	4	Y	0.005	-0.007	0.068	83	17
5-stage	Arch1_sc5	6	Y	0.002	-0.010	0.044	95	5
5-stage	Arch1_sc6	8	Y	0.000	-0.010	0.108	88	12
5-stage	**Arch1_sc7**	**10**	**Y**	**0.001**	**-0.010**	**0.051**	**95**	**5**
5-stage	**Arch1_sc8**	**12**	**Y**	**-0.003**	**-0.011**	**0.045**	**99**	**1**
5-stage	Arch1_sc9	14	Y	-0.002	-0.010	0.044	94	6
5-stage	Arch1_sc9	16	Y	-0.002	-0.011	0.042	94	6

Table 17. Summary of χ^2/df values generated in the comparison of simulated data representing the PCFG and the larger ENP population. Scenarios highlighted in bold type produced results which were not consistent with those based on the empirical data.

χ^2/df_{obs} = 1.42

Matrices	Scenario	Immigration (Inds/Yr at K)	With pulse?	Median	Min	Max	Prop.< than observed	Prop.> than observed
9-stage	**Arch1_sc1**	**0**	**Y**	**2.65**	**1.57**	**3.66**	**0**	**100**
9-stage	**Arch1_sc2**	**1**	**Y**	**2.05**	**1.41**	**3.49**	**1**	**99**
9-stage	Arch1_sc3	2	Y	1.70	1.00	2.87	20	80
9-stage	Arch1_sc4	4	Y	1.41	0.85	2.13	54	46
9-stage	Arch1_sc5	6	Y	1.19	0.74	1.71	83	17
9-stage	Arch1_sc6	8	Y	1.11	0.77	1.69	91	9
9-stage	**Arch1_sc7**	**10**	**Y**	**1.07**	**0.66**	**1.51**	**97**	**3**
9-stage	**Arch1_sc8**	**12**	**Y**	**1.05**	**0.63**	**1.53**	**99**	**1**
9-stage	**Arch1_sc9**	**14**	**Y**	**1.06**	**0.59**	**1.43**	**99**	**1**
9-stage	**Arch1_sc9**	**16**	**Y**	**1.03**	**0.74**	**1.55**	**99**	**1**
9-stage	**Arch1_sc1**	**0**	**N**	**3.23**	**1.87**	**4.73**	**0**	**100**
9-stage	**Arch1_sc2**	**1**	**N**	**2.38**	**1.52**	**3.74**	**0**	**100**
9-stage	Arch1_sc3	2	N	1.93	1.25	3.21	9	91
9-stage	Arch1_sc4	4	N	1.47	0.94	2.12	43	57
9-stage	Arch1_sc5	6	N	1.30	0.81	2.02	73	27
9-stage	Arch1_sc6	8	N	1.16	0.71	1.76	84	16
9-stage	Arch1_sc7	10	N	1.14	0.71	1.62	91	9
9-stage	**Arch1_sc8**	**12**	**N**	**1.07**	**0.70**	**1.80**	**95**	**5**
9-stage	**Arch1_sc9**	**14**	**N**	**1.08**	**0.76**	**1.58**	**96**	**4**
9-stage	**Arch1_sc10**	**16**	**N**	**1.04**	**0.71**	**1.77**	**95**	**5**
5-stage	**Arch1_sc1**	**0**	**Y**	**2.87**	**1.50**	**4.41**	**0**	**100**
5-stage	**Arch1_sc2**	**1**	**Y**	**2.16**	**1.07**	**3.90**	**5**	**95**
5-stage	Arch1_sc3	2	Y	1.71	0.92	2.62	18	82
5-stage	Arch1_sc4	4	Y	1.32	0.82	1.89	64	36
5-stage	Arch1_sc5	6	Y	1.20	0.55	1.64	93	7
5-stage	Arch1_sc6	8	Y	1.12	0.68	1.67	94	6
5-stage	Arch1_sc7	10	Y	1.12	0.71	1.67	92	8
5-stage	**Arch1_sc8**	**12**	**Y**	**1.04**	**0.69**	**1.59**	**97**	**3**
5-stage	**Arch1_sc9**	**14**	**Y**	**1.02**	**0.64**	**1.47**	**98**	**2**
5-stage	**Arch1_sc9**	**16**	**Y**	**1.01**	**0.70**	**1.48**	**99**	**1**

Table 18. Measures of haplotypic diversity, number of haplotypes, and F_{ST} values produced in simulations incorporating a split of the PCFG between 1940 and 1990. These simulations utilized a model incorporating pulse migration and no annual immigration into the PCFG. Scenarios highlighted in bold type produced results which were not consistent with those based on the empirical data.

Haplotypic diversity:
PCFG: H_{obs} = 0.945

Year of split	Median_PCFG	Min_PCFG	Max_PCFG	Prop < than PCFG	Prop > than PCFG
1940	**0.863**	**0.591**	**0.925**	**100**	**0**
1950	**0.884**	**0.721**	**0.932**	**100**	**0**
1960	**0.905**	**0.766**	**0.950**	**98**	**2**
1970	0.927	0.821	0.963	80	20
1980	0.939	0.804	0.969	68	32
1990	0.942	0.883	0.969	55	45

Number of haplotypes
PCFG: Nb_{obs}=23

1940	**14**	**7**	**20**	**100**	**0**
1950	**16**	**10**	**23**	**99**	**0**
1960	**17**	**11**	**23**	**96**	**0**
1970	21.5	12	28	65	22
1980	24	15	33	33	57
1990	25	17	34	25	68

F_{ST}
$F_{ST\ obs}$ = 0.012

1940	**0.046**	**0.008**	**0.177**	**1**	**99**
1950	**0.036**	**0.011**	**0.104**	**1**	**99**
1960	0.022	0.003	0.077	16	84
1970	0.009	-0.005	0.029	64	36
1980	0.006	-0.003	0.035	84	16
1990	**0.003**	**-0.005**	**0.015**	**97**	**3**

Table 19. Measures of haplotypic diversity, number of haplotypes, and F_{ST} values produced in simulations incorporating a carrying capacity for the PCFG ranging from 500 to 5000 animals. These simulations utilized a model incorporating pulse migration and no annual immigration into the PCFG. Scenarios highlighted in bold type produced results which were not consistent with those based on the empirical data.

Haplotypic diversity:
PCFG: H_{obs} = 0.945

K-PCFG	Median_PCFG	Min_PCFG	Max_PCFG	Prop < than PCFG	Prop > than PCFG
500	**0.876**	**0.714**	**0.937**	**100**	**0**
1000	**0.911**	**0.808**	**0.949**	**96**	**4**
1500	0.922	0.818	0.959	90	10
2000	0.932	0.765	0.966	72	28
3000	0.934	0.841	0.965	73	27
5000	0.945	0.849	0.967	47	53

Number of haplotypes
PCFG: Nb_{obs}=23

K-PCFG	Median_PCFG	Min_PCFG	Max_PCFG	Prop < than PCFG	Prop > than PCFG
500	**14**	**7**	**24**	**99**	**1**
1000	**17**	**9**	**23**	**98**	**0**
1500	20	12	27	90	5
2000	20.5	15	28	69	21
3000	22	15	32	51	40
5000	26	16	34	20	73

F_{ST}
F_{ST}obs = 0.012

K-PCFG	Median_PCFG	Min_PCFG	Max_PCFG	Prop < than PCFG	Prop > than PCFG
500	**0.037**	**0.013**	**0.111**	**0**	**100**
1000	0.021	0.006	0.058	21	79
1500	0.015	0.002	0.044	39	61
2000	0.012	-0.002	0.041	52	48
3000	0.007	-0.003	0.025	74	26
5000	0.006	-0.004	0.019	91	9

Table 20. Example trajectories for simulations with K_{PCFG} set between 500 and 5000. Note that scale of y-axis differs across figures.

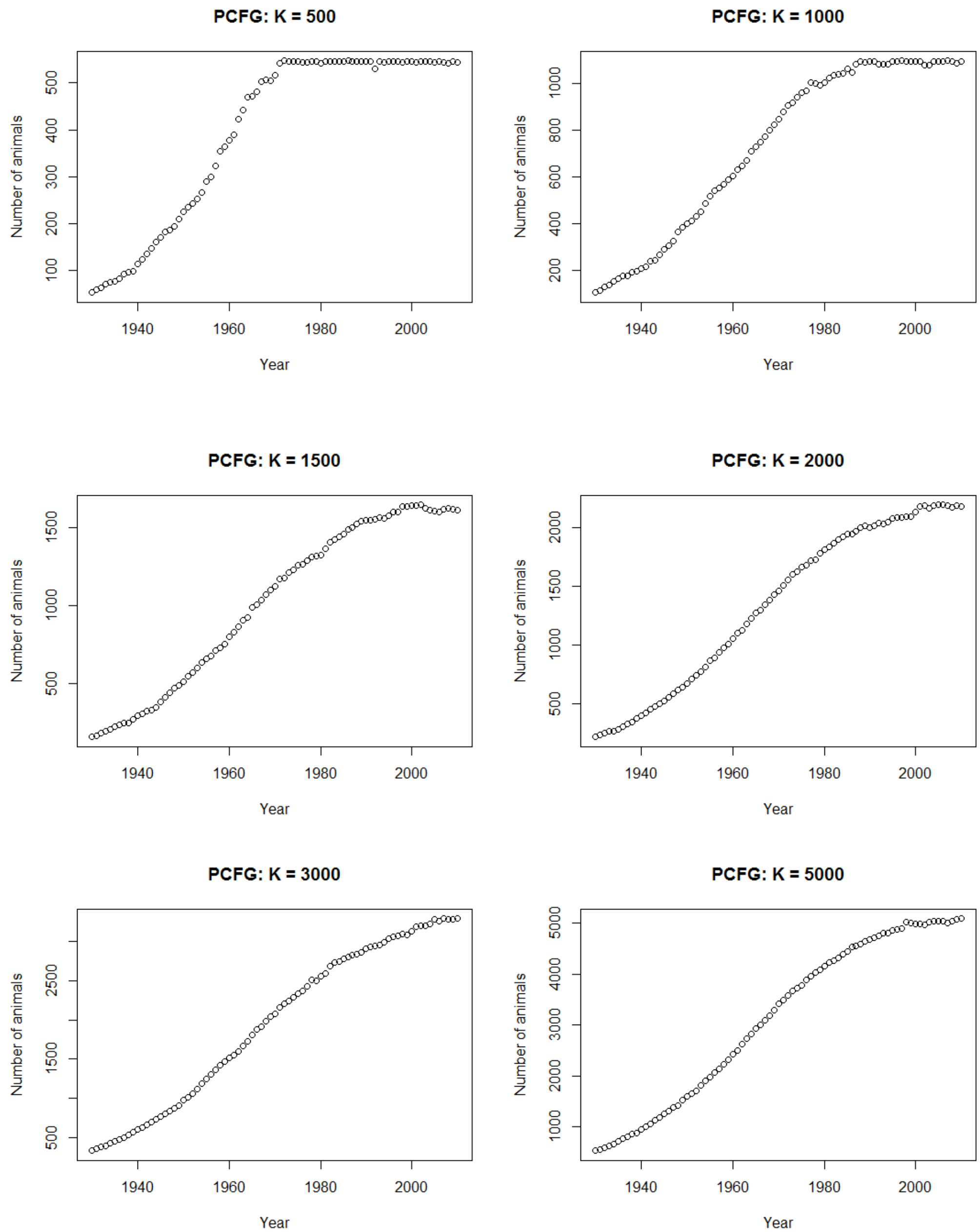


Table 21. Median PCFG abundance in 2010 for scenarios with K_{PCFG} set between 500 and 5000.

K_{PCFG}	N_{2010} (median and 90% range)
500	501 (466 – 542)
1000	998 (923-1063)
1500	1496 (1391-1588)
2000	1994(1864-2080)
3000	3002(2831-3128)
5000	4945 (4790-5095)

Table 22. The expected number of immigrants/year at the cross-over point under the scenarios with and without pulse immigration. The cross-over is derived by calculating the point at which 50% of the simulation replicates produce values for each summary statistic that are higher than that for the empirical data.

Matrices	Timing of split	Pulse migration	Number of haplotypes	Haplotypic diversity	F_{ST}	Φ_{ST}	χ^2/df
9-stage	Post-whaling split	Y	3.77	7.82	3.84	1.67	3.76
9-stage	Post-whaling split	N	4.35	10.25	4.25	2.11	4.47
5-stage	Post-whaling split	Y	6.76	-----	3.39	1.37	3.39

Appendix:

This appendix includes additional tables and figures aimed at understanding how well the model underlying our simulations is mimicking reality and/or the IR trial structure.

Table A1. Generation time estimates as calculated using different maximum ages for both 5-stage TOSSM and 9-stage matrices.

	5-stage matrices		9-stage matrices	
Max Age	K	ZPD	K	ZPD
40	19.52	16.92	21.05	20.59
50	21.68	18.74	23.65	23.86
100	26.04	22.25	28.29	32.87
150	26.64	22.69	28.61	34.93
1000	26.71	22.74	28.63	35.27

Table A2. The number of calves produced per year in simulated datasets at K as compared to data derived from photo-identification studies

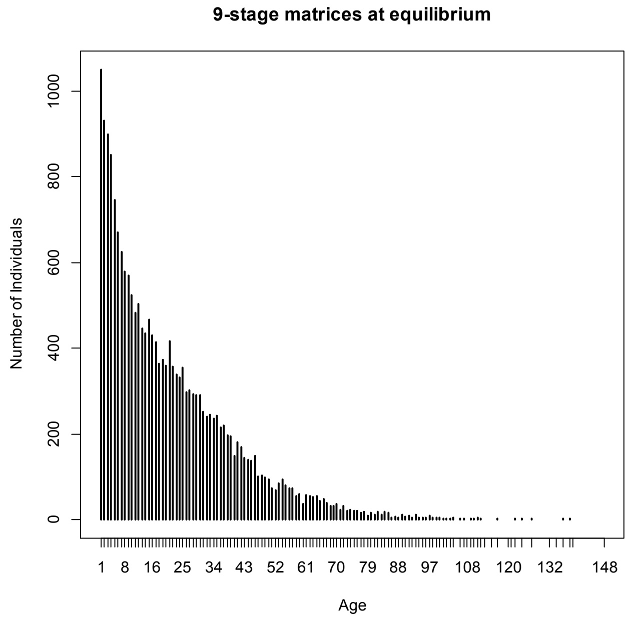
Source	Abundance (median with range):	Number of calves/yr	% Calves
5-stage matrices:	197(156-218)	11 (2-31)	6%
9-stage matrices:	195 (161-217)	10 (2-23)	5%
Photo-identification estimates	194 †	3 (0-9)††	2%

†Annex F, IWC 2011

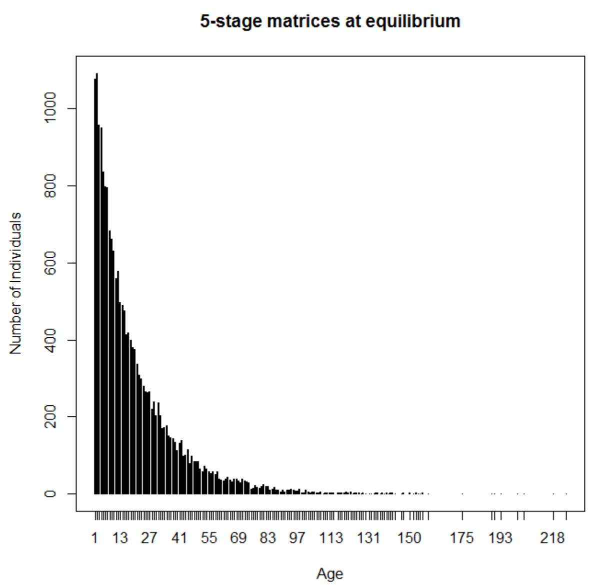
†† Calambokidis *et al.* 2008 (data from 1998-2008)

Figure A1. Age distribution in simulated datasets (note different x-axis scales):

a) Nine-stage matrices:



a.) Five-stage matrices:



Late-Feeding Season Movements of a Western North Pacific Gray Whale off Sakhalin Island, Russia and Subsequent Migration into the Eastern North Pacific

MATE, B.[1], A. BRADFORD[2], G. TSIDULKO[3], V. VERTYANKIN[4], AND V. ILYASHENKO[3] ,

[1]Marine Mammal Institute, Fisheries and Wildlife, Coastal Oregon Marine Experiment Station, Oregon State University, Hatfield Marine Science Center, Newport, OR 97365 USA. bruce.mate@oregonstate.edu

[2]School of Aquatic and Fishery Sciences, University of Washington, Box 355020, Seattle, WA 98195-5020, USA

[3]A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, Moscow, Russia.

[4]Kronotsky State Biosphere Reserve

ABSTRACT
The western population of North Pacific gray whales (WGW), once thought extinct, is now estimated at 130 individuals and feeds primarily off northeastern Sakhalin Island, Russia, during summer. The population is critically endangered, facing anthropogenic threats throughout its range from nets, ships, and oil development, but present migration routes and wintering areas remain unknown. On 4 October 2010, a subcutaneous Argos tag was applied following protocols established by the International Whaling Commission to a 13-year-old male (named "Flex") in good body condition off Piltun Lagoon, northeastern Sakhalin Island. Flex was first seen as a calf off Sakhalin in 1997. State-space modeling of fall near-shore movements for 68 days post-tagging identified a small home range foraging area within 45km of the tagging site. These data are unique as local weather conditions during this time generally prevent other forms of whale observation. On 11 December, Flex departed Sakhalin and began migrating across the Okhotsk Sea, Bering Sea, and Gulf of Alaska. By 5 February, Flex was within 20 km of the central Oregon coast, overlapping spatially and temporally with the last few weeks of the usual eastern gray whale southbound migration. Flex's migration segments were linear, high speed (averaging 6.5 km/h), and included deep water far offshore, suggesting open-water navigation skills not previously attributed to gray whales, who are considered coastal and shallow-water oriented. State-space modeling (considering directionality and speed) identified the basin-wide movements as "migration" rather than "wanderings" associated with foraging behavior. Flex's movements do not preclude other migration routes or winter destinations for WGWs. Additional WGW tagging is needed to identify other areas of use. The resulting data will have high conservation value and be useful in potential mitigation of anthropogenic activities.

BACKGROUND

The western population of North Pacific gray whales (Eschrichtius robustus, WGW) once thought to be extinct was re-discovery off northeastern Sakhalin Island, Russia and is critically endangered (IUCN, 2008). The population is estimated to contain about 130 individuals age one or older, of which only about 25 are reproductive females (Cooke et al., 2008), and it faces a number of anthropogenic threats throughout its range, including fatal interactions with coastal net fisheries off Japan (Weller et al., 2008; Bradford et al., 2009) along its presumed migration route(s) and oil development in and near its principal summer feeding area (IUCN, 2009). The wintering area of the present population is unknown but, based on the limited available information, has been suggested as south of Honshu, Japan, off the coast of southern China in the South China Sea and the Gulf of Tonkin (Weller et al., 2002), or possibly off North America (Ilyashenko, 2009).

Satellite telemetry has been proposed repeatedly as an efficient way to investigate the migratory routes and wintering grounds of western gray whales and scientists have been cautious about tagging because of the population's very low numbers. After considerable discussion by the IWC Scientific Committee from 2006-10 and various panels convened under the auspices of IUCN from 2006-8 (summarized for the U.S. Marine Mammal Commission and IUCN by Weller, 2008), the research tagging effort reported here was undertaken to tag and track up to 12 of whales during the late summer of 2010 to ascertain winter migration route(s) and reproductive area(s).

METHODS

We used Wildlife Computers Spot-5 Argos transmitters epoxy-cast in Stainless steel cylinders for nearly complete implantation. Insertion blades and attachments for WGWs were similar to those used on 18 eastern NP gray whales (EGW) in 2009/10 (Mate, 2010). The latter field study was an efficacy test prior to using the tags on WGWs. The tags were applied by using a modified air-powered ARTS applicator and specialty pushrods (Mate et al. 2007).

The research was based from the 50 m M/V Igor Maximov, which was at sea from 3 September to 7 October 2010. Although we encountered technical difficulties with the supplied small tagging vessel and significant weather problems (including remnants of two typhoons and two gales), we tagged a whale on the last field-operational day of the extended cruise.

We followed the protocols established by the IWC special steering committee on western North Pacific Gray whale telemetry, which required tagging only known adult males in good body condition. On 4 October 2011, we tagged a13 year old male known as Flex off the northeast coast of Sakhalin Island, Russia (Figure 1 inset), where the whale had first been seen as a calf in 1997. Although the tag was not completely deployed, it provided location data for 124 days.

RESULTS

Flex stayed along the Sakhalin Island coast within 45 km of the tagging site and within 5 km of shore for 68 days (Figure 1). These near shore movements suggest foraging behavior. In mid-December Flex crossed the Sea of Okhotsk to the west side of the Kamchatka Peninsula, went around the southern end of the peninsula and departed the east coast in early January. The tagged whale crossed the western and central Bering Sea in one week to arrive at the shallow shelf break near a major canyon and then proceeded south passed the Pribilof Islands and through the eastern Aleutian Islands before crossing the Gulf of Alaska and heading south 20-25 Km off the Washington and Oregon Coasts (Figure 2). He was last located by satellite 20 Km off Siletz Bay, Oregon (~45*N) on 5 February, which over-lapped with the last few weeks of the usual ENP gray whale southbound migration through this same area.

Despite ambiguities in the accuracy of many Argos location classes, the course heading across the western Bering Sea varied within just a few degrees for a week. Such linearity in the Argos track makes significant errors in the actual distance traveled unlikely compared to the Argos-derived path. The Argos track length may actually be a conservative estimate, but still resulted in sustained swimming speed estimates for various segments of travel (Table1) substantially higher than those normally observed for EGWs during their southbound migration (Herzing and Mate, 1989; Granite Canyon ref).

CONCLUSIONS AND DISCUSSIONS

The very liner movement of Flex so far from shore suggests good open water navigation skills not previously attributed to gray whales. ENP gray whales have been considered more coastal or shallow-water oriented. State-space modeling suggests the long-range movements of Flex across the Sea of Okhotsk, Bering Sea, and Gulf of Alaska are directed migration movements rather than “wanderings", usually indicative of foraging behavior. During the Bering Sea and North Pacific travel segments, the whale's average speeds were >6.5 km/h, 50% higher than average speeds observed for six 2009-tagged EGWs migrating south in 2010 (Mate, 2010).

Flex has previously visited the eastern North Pacific, confirmed by photo matching (Weller et al., IWC/SC63/BRG6) and two other WGWs have been genetically matched to southern California (Lang et al., IWC/S63/BRG10). The results demonstrated by this whale do not preclude other migratory destinations for other WGWs or even this whale during other winters. The possibilities identified from the tagging, genetics, and the photo-ID papers suggest additional WGW taggings would be useful to identify other possible winter migratory routes and/or destinations. We took 13 tags to Russia in anticipation of tagging 12 whales in 2010. The remaining 12 tags are still in Russia. We suggest tagging 12 more WG whales to increase the total sample size to 10% of the estimated population. The use of a mother ship would help assure our ability to move more widely if necessary to find adequate candidate whales for tagging. An improved tagging boat would increase the probability of success. An earlier tagging season would avoid seasonally predictable bad weather. Being able to tag both males and females would dramatically improve the probability of successfully deploying additional tags and develop information about possible sexual differences in: winter migratory routes; foraging area departure timings; reproductive destinations; wintering area arrival timings; the amount of time spent in wintering areas; turnover rates in wintering areas, and spring migration re-entry routes and timing back into the summer feeding areas. All of these issues might identify areas or specific anthropogenic activities that could be risks to WGWs, as well as mitigation possibilities.

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Table 1. The durations, estimated distances, and speeds of Flex, a western gray whale, during the late summer and early fall feeding season near Sakhalin Island, Russia and subsequent migratory movements to the eastern North Pacific.

Waypoint	Date	Distance-km	Days	Avg. Speed	Cumulative Distance-km	Cumulative Days	Cumulative Avg. Speed
Deploy	10/4/2010 0:22:00						
Depart Sakhalin	12/11/2010 21:44:00	1018	68.9	0.6			
Arrival W Kamchatka	12/16/2010 23:59:00	899	6.0	6.2	899	6.0	6.2
Depart E Kamchatka	1/2/2011 6:04:00	1185	16.4	3.0	2084	22.4	3.9
Arrival Bering Shelf	1/9/2011 21:28:00	1324	7.7	7.1	3408	30.1	4.7
Arrival Shumagin Islands	1/18/2011 21:44:00	1540	10.0	6.4	4948	40.1	5.1
Arrival west coast U.S.	2/2/2011 23:33:23	2520	14.9	7.1	7468	55.0	5.7

Figure 1. The study area at the northeast end of Sakhalin Island in the southern Sea of Okhotsk (inset), showing the near shore movements of “Flex” for 69 days within the traditional summer feeding area (4 October to 11 December 2010) just east of Piltun Lagoon.

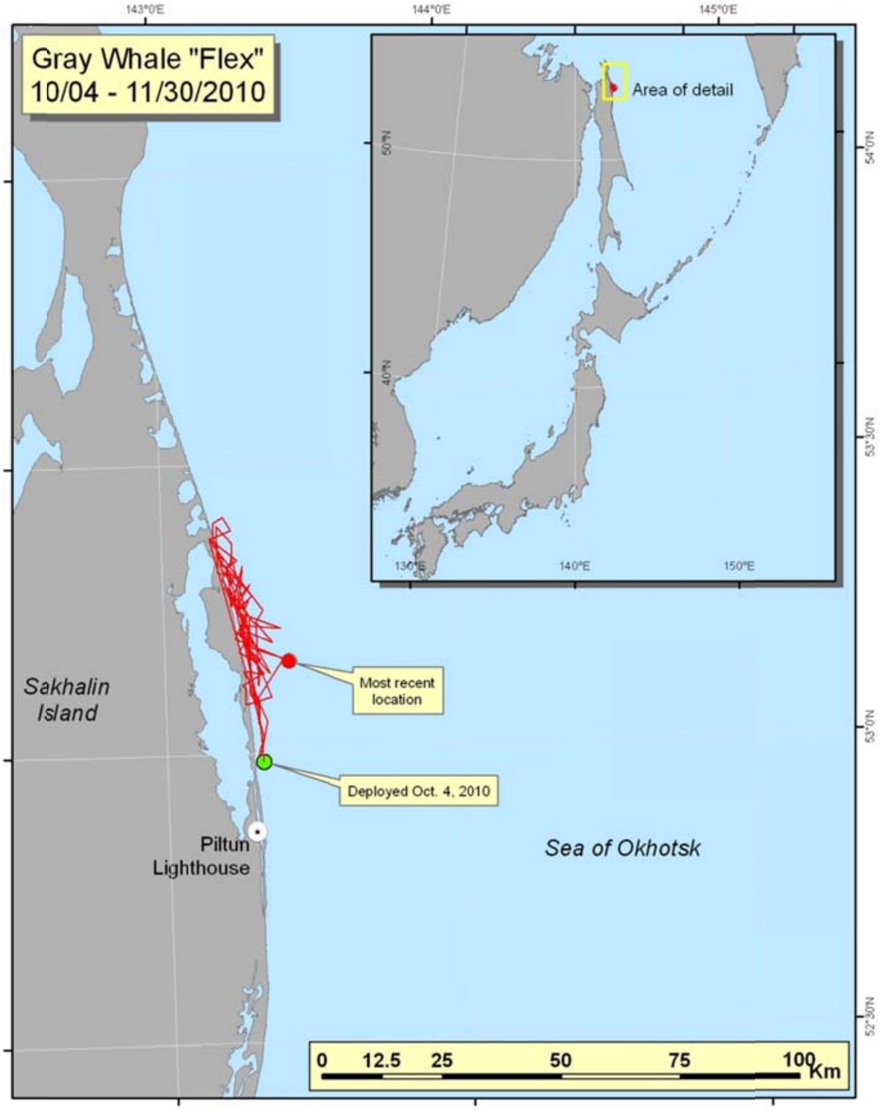

Figure 2. The 124 day movements of a 14 year old male western North Pacific gray whale "Flex" from 4 October 2010 to 5 February 2011.

Probability of taking a western North Pacific gray whale during the proposed Makah hunt

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U.S. Department of Commerce
National Oceanic and Atmospheric Administration
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Jeffery E. Moore and David W. Weller

Protected Resources Division
Southwest Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
8901 La Jolla Shores Drive
La Jolla, CA 92037-1022 USA

U.S. Department of Commerce
Rebecca M. Blank, Acting Secretary

National Oceanic and Atmospheric Administration
Jane Lubchenco, Undersecretary for Oceans and Atmosphere

National Marine Fisheries Service
Samuel D. Rauch, Acting Assistant Administrator for Fisheries

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Protected Resources Division
Southwest Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
8901 La Jolla Shores Drive
La Jolla, CA 92037-1022 USA

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EXECUTIVE SUMMARY

Recent observations of gray whales (*Eschrichtius robustus*) identified in the western North Pacific (WNP) migrating to areas off the coast of North America (Alaska to Mexico) raise concern about the possibility of the small western population being subjected to the gray whale hunt proposed by the Makah Indian Tribe in northern Washington, USA. To address this concern, we estimated the probability of striking (i.e. killing or seriously injuring) a WNP whale during the Makah hunt using six models from 4 model sets that varied based on the assumptions and types of data used for estimation. Model set 1 used WNP and ENP abundance estimates. Model set 2 used these abundance estimates, as well as sightings data from the proposed hunt area. Model sets 3 and 4 used only the sightings data. Within model sets 1 and 2, two models (A and B) differed based upon whether migrating ENP and WNP whales were assumed to be equally available to the hunt per capita (A) or whether this assumption is relaxed (B). We consider Model 2B the most plausible of all models because model set 2 makes use of all available information and 2B contains fewer assumptions than 2A. Based on model 2B, the probability of striking ≥1 WNP whale in a single season ranges from 0.007 to 0.036, depending on if the median or upper 95th percentile estimate is used and on which maximum is used for the total number of whales struck. The probability of striking ≥1 WNP whale out of 5 seasons ranges from 0.036 to 0.170 across the same scenarios. The expected number to be struck in a single year ranges from 0.01 to 0.04 and from 0.04 to 0.19 across 5 years. For context, these strike estimates were compared to different possible values of Potential Biological Removal (PBR). We also summarized analogous estimates for the number of WNP whales that would be "taken" non-lethally, in terms of the number of attempted but unsuccessful strikes as well as the number of animals approached and pursued during the hunt.

INTRODUCTION

Gray whales (*Eschrichtius robustus*) are recognized as comprising two populations in the North Pacific Ocean. Significant mitochondrial and nuclear genetic differences have been found between whales in the western North Pacific (WNP) and those in the eastern North Pacific (ENP) (Lang *et al*., 2011). The ENP population ranges from wintering areas in Baja California, Mexico, to feeding areas in the Bering, Beaufort, and Chukchi Seas (Fig. 1). An exception to this generality is the relatively small number (100s) of whales that summer and feed along the Pacific coast between Kodiak Island, Alaska, and northern California (Calambokidis *et al*. 2012). These whales are collectively called the Pacific Coast Feeding Group (PCFG). U.S. domestic policy defines the PCFG as gray whales observed between 1 June and 30 November from Northern California through Northern British Columbia. The International Whaling Commission (IWC) has refined this definition to be: PCFG whales are those observed between 1 June and 30 November from 41°N to 52°N in two or more years (IWC, 2012). The WNP population feeds in the Okhotsk Sea off Sakhalin Island, Russia (Weller *et al*., 1999; Weller *et al*. 2012), and in nearshore waters of the southwestern Bering Sea off the southeastern Kamchatka Peninsula (Tyurneva *et al*., 2010).

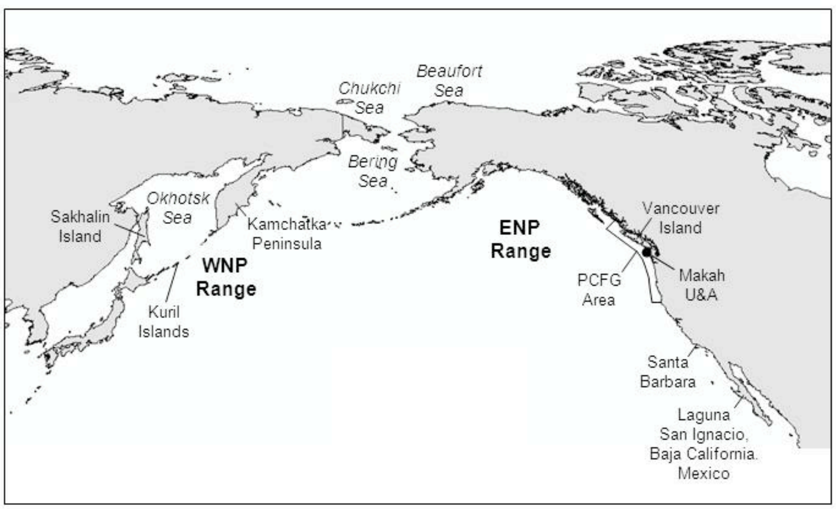

Figure 1. Areas in the western and eastern North Pacific mentioned in the report.

The historical distribution of gray whales in the Okhotsk Sea greatly exceeded what is found today (Reeves *et al*., 2008). Whales associated with the Sakhalin feeding area can be absent for all or part of a given feeding season (Bradford *et al*., 2008), indicating they use other areas during the summer and fall feeding period. Some of the whales identified feeding in the coastal waters off Sakhalin, including reproductive females and calves, have also been documented off the southern and eastern coast of Kamchatka (Tyurneva *et al*., 2010). Whales observed off Sakhalin have also been sighted off the northern Kuril Islands in the eastern Okhotsk Sea and Bering Island in the western Bering Sea (Weller *et al*., 2003).

Recently, mixing of whales identified in the WNP and ENP has been observed (Weller *et al*., 2012). Lang (2010) reported that two adult individuals from the WNP, sampled off Sakhalin in 1998 and 2004, matched the microsatellite genotypes, mtDNA haplotypes, and sexes (one male, one female) of two whales sampled off Santa Barbara, California in March 1995. Mate and colleagues (Mate *et al*., 2011) satellite-tracked three whales from the WNP to the ENP (Mate *et al*., 2011; IWC, 2012). Finally, photographic matches between the WNP and ENP, including resightings between Sakhalin and Vancouver Island and Laguna San Ignacio, have further confirmed use of areas in the ENP by whales identified in the WNP (Weller *et al*., 2012, Urbán *et al*., 2012). Despite this level of mixing, significant mtDNA and nuclear genetic differences between whales in the WNP and ENP have been found (Lang *et al*., 2011).

Observations of gray whales identified in the WNP migrating to areas off the coast of North America (Alaska to Mexico) raise concern about placing the WNP population at potential risk of being harmed or killed incidental to the ENP gray whale hunt proposed by the Makah Indian Tribe off northern Washington, USA (IWC, 2012). Given the ongoing concern about conservation of the WNP population, in 2011 the Scientific Committee of the International Whaling Commission (IWC) emphasized the need to estimate the probability of a western gray whale being killed during aboriginal gray whale hunts (IWC, 2012). Additionally, NOAA is required to prepare an Environmental Impact Statement (EIS) pertaining to the Makah's request for a waiver under the U.S. Marine Mammal Protection Act (MMPA) in order to hunt gray whales (NOAA, 2008). The EIS will include an estimate of the likelihood of Makah hunters approaching, pursuing, and attempting to strike a WNP whale in addition to the likelihood of actual strikes (assumed to result in death or serious injury).

The objective of this analysis was therefore to estimate the probability that one or more whales identified in the WNP might be lethally or non-lethally "taken[1]" during the hunt proposed by the Makah Indian Tribe. This report updates the analysis of mortality risk provided by Moore and Weller (2012), by incorporating feedback from the IWC Scientific Committee on that report and by including an analysis of the likelihood of non-lethal as well as lethal take.

METHODS

The probability of striking or taking a WNP whale during the proposed Makah hunt was estimated using four different sets of models (6 models total). Models were based on the following information: (1) the most recent estimates of WNP and ENP population abundance; (2) sightings data from spring 1999-2010 off the coast of northern Washington (NWA) in the Makah Usual and Accustomed (MUA) fishing grounds, where the proposed hunt would take place; and (3) minimum estimates of the proportion of the WNP population that migrate to ENP areas along the North American coast.

Data

Abundance estimates

The most recent WNP abundance estimate (for 2012) is 155, with 95% CI = 142 – 165 (IUCN, 2012). The most recent ENP estimate (for 2007) is 19,126, with CV = 0.071 (Laake *et al*., 2009). In the models, these estimates were expressed as log-normally distributed random variables with parameters $\mu_{WNP} = 5.043$, $\sigma_{WNP} = 0.0387$, and $\mu_{ENP} = 9.856$, $\sigma_{ENP} = 0.0709$.

[1] Under the U.S. Marine Mammal Protection Act, "take" is defined as "harass, hunt, capture, kill or collect, or attempt to harass, hunt, capture, kill or collect."

Sightings in the Makah Usual and Accustomed (MUA) Fishing Grounds
During spring surveys (1 March to 31 May) in 1999-2009, there were 118 "whale-days" in the MUA off the NWA coast (Calambokidis *et al*., 2012), where all sightings of an individual on a particular day collectively count as 1 "whale-day" (e.g., multiple sightings of the same individual on the same day count as just 1 whale-day, but the same individual seen the next day would count as a second whale-day). There were 9 gray whale sightings in March. All other sightings were in April or May. None of the 118 whale-days observed included WNP whales[2]; 35 (29.7%) were considered "Pacific Coast Feeding Group" (PCFG) whales; and the rest (83, or 70.3%) were assumed to be migrating ENP whales. The photo-identification catalog for whales identified in the WNP off Sakhalin Island is characterized by extremely high (> 95%) resighting rates since 2002 (Burdin *et al*., 2012). Therefore, we assumed in this analysis that the absence of WNP sightings is not likely due to false negative identification (although it is possible that WNP whales were missed during days when MUA surveys were or were not conducted).

Proportion of WNP whales migrating with ENP whales
The proportion of the WNP population that migrates along the North American coast is unknown but based on recent photo-identification, telemetry, and genetic matches of WNP whales to ENP areas, we estimate the value to be at least 0.15, based on there being 23 known matches out of an estimated population size of 155 (Mate *et al*., 2011; IWC, 2012; Urbán *et al*., 2012; Weller *et al*. 2012).

Models
Model set 1
Model set 1 makes use of the ENP and WNP abundance estimates but ignores information obtained from sightings in the MUA off the NWA coast. The potential justification for ignoring the sightings data is that these may not be representative of the whale compositions that would be encountered by hunters, perhaps because of a timing mismatch (if hunt does not occur in April/May) or if whales approached by field researchers in motorized boats behave fundamentally differently than those approached by hunters in non-motorized boats.

Model 1A - All whales migrating through the MUA area -- WNP and ENP -- are assumed to be equally available to the hunt, so that the probability of taking a WNP whale is:

$$P_{WNP} = mN_{WNP}/N_{ENP}$$
$$m \sim \text{uniform}(0.15, 1)$$
$$N_{WNP} \sim \text{log-normal}(\mu_{WNP}, \sigma_{WNP})$$
$$N_{ENP} \sim \text{log-normal}(\mu_{ENP}, \sigma_{ENP}),$$

where m is the proportion of WNP whales that migrate with ENP whales along the North American coast and abundance parameters are as above (see Data section). The lower limit for m, 0.15, is based on genetic and photo-identification matching data (see Data section). The upper limit of 1 for m is precautionary, as the true value is unknown but could be high. We used Monte Carlo simulation based on drawing 100,000 random samples from the above distributions to estimate the distribution for P_{WNP}.

Model 1B – Rather than assuming P_{WNP} to be directly proportional to the ratio of abundances (N_{WNP}/N_{ENP}), we express our uncertainty in P_{WNP} as a uniform distribution with the upper limit

[2] Although not in the MUA, Weller *et al*. 2012 report observing three WNP whales on 2 May 2004 and three more on 25 April 2008 near Barkley Sound off the west coast of southern Vancouver Island, British Columbia, Canada.

for P_{WNP} based on the maximum (99^{th} percentile) estimate for the number of WNP whales available to the hunt divided by a minimum (1^{st} percentile) estimate for the ENP population, i.e.,

$$P_{WNP} \sim \text{uniform}(0, P_{max})$$
$$P_{max} = m \cdot N_{99,WNP}/N_{01,ENP}.$$

The interpretation of this model is that, within some plausible upper bound (defined as P_{max}), we have no information about the per capita probability of taking a WNP whale, given unknown differences in migration patterns between WNP and ENP animals. Just as for Model 1A, we use a Monte Carlo approach (100,000 samples) to estimate a distribution for P_{WNP}. For each sample, P_{WNP} is drawn from the uniform distribution specified by P_{max}. P_{max} varies with each sample based on the draw for m, while the ratio $N_{99,WNP}/N_{01,ENP}$ is fixed. Analysis for Model set 1 was conducted in R.

Model set 2

Model sets 2, 3, and 4 differ from Model set 1 in that they use the information from the sightings data in the MUA. In these models, it is assumed that the sightings data from the MUA are representative of the composition of whales (three groups: ENP, WNP, PCFG) that would be available to the hunt. In other words, whales that are most likely to be photographed (i.e., approachable in a small boat) are also the most likely to be approached by hunters.

Model set 2 makes use of the MUA sightings data, as well as WNP and ENP abundance estimates. WNP whales are assumed to be moving with the ENP migrants, so that the marginal probability of a WNP whale being taken is the probability of being a migrant, P_{mig} (i.e., probability of not being a whale from the PCFG), multiplied by the conditional probability of being a WNP whale given that it is a migrant ($P_{WNP|mig}$), i.e., $P_{WNP} = P_{mig}P_{WNP|mig}$. P_{mig} is estimated using Bayesian MCMC methods assuming that $n_{mig} \sim$ Binomial (N, P_{mig}), where n_{mig} is the number of non-PCFG migrants (83) out of N (118) sightings in the MUA sightings data set. Models 2A and 2B differ in how the conditional probability $P_{WNP|mig}$ is estimated.

<u>Model 2A</u> - The distribution for $P_{WNP|mig}$ is given by the estimator for P_{WNP} in Model 1A. Thus, it is assumed the per capita probabilities of an ENP or WNP whale being taken are the same.

<u>Model 2B</u> - The distribution for $P_{WNP|mig}$ is given by the estimator for P_{WNP} in 1B. Thus, this model asserts that we have no information (apart from specifying a reasonable upper bound) about the per capita likelihood of a WNP whale being killed relative to that of an ENP whale.

Model 3

This uses the MUA sightings data but does not make use of information about WNP population size or the proportion of WNP whales that migrate with ENP whales. Thus, P_{WNP} estimates are solely based on the proportion of animals in the MUA sightings data set that are from the WNP. The posterior distribution for P_{WNP} is estimated using MCMC methods assuming that $n_{WNP} \sim$ Binomial (N, P_{WNP}), where $n_{WNP} = 0$, and N = 118. The justification for this model (i.e., for ignoring information about WNP abundance) would be that the relative per capita probability of taking WNP vs. ENP animals is totally unknown apart from the information contained in the sightings data set. For example, WNP whales could be much more (or less) available to the hunt than ENP whales due to differences in migration timing or behavior, such that our knowledge about the WNP population being very small is irrelevant to the estimates.

Model 4
Model 4 is a variant of Model 3, explained below.

Bayesian estimation
Analyses for Models 2, 3, and 4 were conducted in WinBUGS. Posterior distributions for parameters were summarized from two MCMC chains, each 50,000 samples in length (100,000 samples total) following a burn-in of 20,000 samples. These simple models converged quickly and clearly (chains well mixed) in all cases (Fig. 2). A uniform [0, 1] prior was used for P_{mig} in model set 2 and for P_{WNP} in model 3 and 4; these are the only parameters for which the prior is updated by data (the MUA sightings data) to obtain a new posterior. The posterior distributions for $P_{WNP|mig}$ in Models 2A and 2B were not informed by the sightings data and thus are essentially determined by informative priors given by the above estimators for these parameters.

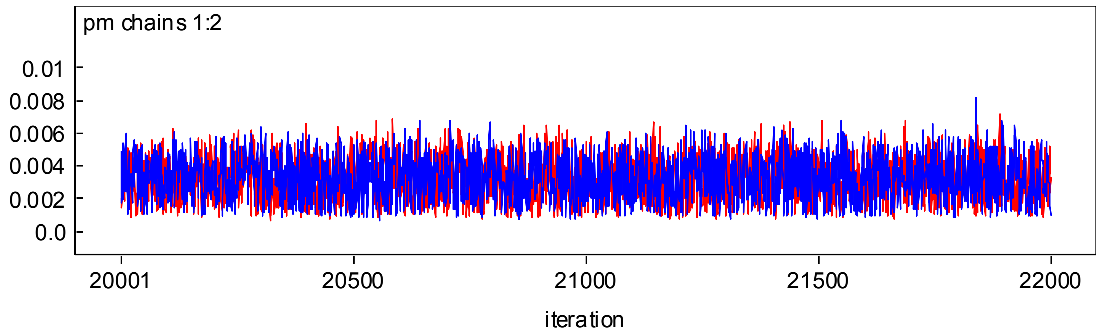

Figure. 2. Example from Model 2A of two MCMC chains (red and blue) mixing for the parameter P_{WNP}.

Estimated parameters
Based on estimates of P_{WNP} for each model, we calculated the probability of striking at least one WNP whale (i.e., P(x>0)) out of X total strikes (strikes are treated as lethal takes), the probability of non-lethally taking at least one WNP whale out of Y strike attempts (P(y>0)), or the probability of non-lethally taking at least one WNP whale out of Z approaches (P(z>0)). We also estimated the expected number of WNP takes out of X, Y or Z total takes. These are calculated as follows:

$$P(x > 0) = 1 - (1 - P_{WNP})^X$$
$$P(y > 0) = 1 - (1 - P_{WNP})^Y$$
$$P(z > 0) = 1 - (1 - P_{WNP})^Z$$
$$E(x) = P_{WNP}X$$
$$E(y) = P_{WNP}Y$$
$$E(z) = P_{WNP}Z$$

For model sets 1, 2, and 3, let X = X* = 5, 7, 20, and 35 gray whale strikes. These were based on the description of the Makah Tribe's proposed gray whale hunt (IWC, 2012 Annex D), which states the following: 5 is the maximum allowable number of landed whales per year; 7 is the maximum number of struck whales allowed per year; 20 is the maximum number allowed to be landed over a 5-year period; and 35 is the maximum number that could be struck over a 5-year period.

For model sets 1, 2, and 4, let X = X** = 3 or 4 strikes in one year and 15 or 20 strikes in 5 years of *non-PCFG whales*. The justification for considering this scenario is that, given other management measures within the Makah plan – most importantly the provision to cease the annual hunt if a certain number of PCFG whales are struck – it may be unlikely that the maximum strike limits in the proposal will be achieved. Implementation trials conducted by the Aboriginal Whaling Management Procedure (AWMP) subgroup of the IWC scientific committee suggest that, when management measures are considered, the expected number of strikes per year *to non-PCFG whales* would typically be between 3 and 4 (J. Scordino, pers. comm.).

For Model set 1, estimates for when X = X** are calculated the same as for when X = X*. For Model set 2, since it is given that X** are for *non-PCFG* whales (i.e., migrant whales), then it follows that P_{mig} = 1, so the model 2 estimators for P_{WNP} reduce from $P_{mig}P_{WNP|mig}$ to just $P_{WNP|mig}$, which are the same estimators as for Model set 1. When X = X**, we use Model 4 as a variant of Model 3 (which is for X = X*). In Model 3, n_{WNP} ~ Binomial (N_{tot}, P_{WNP}), where n_{WNP} = 0, and N_{tot} = 118 total whale-day sightings, 35 of which were PCFG whales and 83 of which were migrating ENP whales. In Model 4, n_{WNP} ~ Binomial (N_{mig}, $P_{WNP|mig}$), where N_{mig} = 83 whale-day sightings of non-PCFG migrant whales (i.e., we are only evaluating conditional probability of being a WNP whale given being migrant whale.

Values of Y for each model were calculated as 4X, and values for Z were calculated as 20X. In other words, for every struck whale, there are an estimated 4 strike attempts and 20 whales approached in attempt to strike. These numbers are based on the Makah tribe's experience in the 1999 and 2000 hunts, for which they stated that for every struck whale, there would be approximately 4 attempted strikes and 10 individuals pursued, which are assumed to affect 20 whales, given an average pod size of two whales (NOAA, 2008).

Comparison to Potential Biological Removal (PBR)
To contextualize the Table 1 estimates of lethal takes, we provide 5-year estimates of PBR[3]) for comparison. PBR is conventionally calculated as $0.5R_{max}N_{min}F_R$, where R_{max} is the maximum productivity rate estimate for the population (we used 0.062 based on the 2012 Draft Stock Assessment Report; NMFS, 2012), N_{min} is the 20th percentile abundance estimate (we used 150 based on WNP abundance parameters), and F_R is a recovery factor. We provide PBR estimates for F_R = 0.1, 0.5, and 1.0. F_R = 0.1 is typically used for stocks of endangered species, noting that the WNP gray whale stock is listed as Endangered under the U.S. Endangered Species Act and Critically Endangered on the IUCN Red List. F_R = 0.5 is a recommended default for most stocks (NMFS 2005), whereas F_R = 1.0 may be appropriate for stocks with known and favorable population status. The PBR estimate is also supposed to take into the account (be discounted by) the proportion of the stock using US waters and the proportion of time it is there (NMFS, 2005). The proportion of the WNP migrating in the ENP range is unknown but characterized in our models by a uniform (0.15, 1) distribution. The proportion of time spent in US waters is difficult to estimate for migratory animals but is probably on the order of 3 months or 0.25 years. Thus, for each value of F_R, we calculated a distribution for the 5-year PBR estimate, by multiplying the standard equation by 0.25 and by a uniform (0.15, 1) distribution.

[3] Under the U.S. Marine Mammal Protection Act, PBR level is defined as "the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population."

a b

RESULTS

Take estimates

Estimated parameters from all model sets are in Tables 1 – 3. Table 1 presents estimates for the probability of striking a WNP whale during a single strike event (P_{WNP}), and of striking at least one WNP whale (P(x>0)) and the expected number of WNP whales (E(x)) that would be struck given X = X* (number of gray whales struck) or X** (number of *non-PCFG* whales struck). Table 2 presents the analogous estimates for the number of attempted strikes (Y = Y* or Y**), and Table 3 presents the analogous estimates for the number of whales approached (Z = Z* or Z**). We present median estimates and, for precautionary purposes, 95th percentile estimates from the Monte Carlo or Bayesian posterior distributions.

For X = X*, Y = Y*, and Z = Z* (i.e., out of the total number of events affecting gray whales, irrespective of the putative stock affected), parameter estimates were higher for Model set 1 than Model set 2. Within these models sets, median parameter estimates were higher for version A than B, although upper (95th percentile) estimates were similar. Estimates for Model 3 were higher than for the other models, particularly when looking at upper bound (95th percentile) estimates, because of the highly skewed and unconstrained posterior for P_{WNP} (Fig. 3).

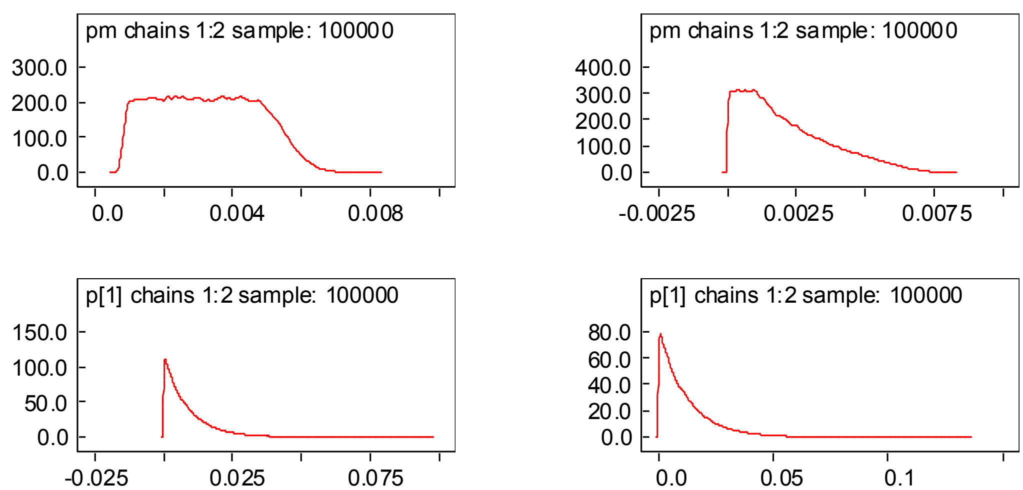

Figure 3. Comparison of Bayesian posterior distributions for P_{WNP} for Models 2A (a), 2B (b), 3 (c), and 4 (d).

For X = X**, Y = Y**, Z = Z** (i.e., out of the total number of events affecting *non-PCFG* whales), model set 1 and model set 2 results are the same (because the estimators are the same), but median estimates were higher for version A than B in these model sets (although 95th percentile estimates were similar). Estimates for Model 4 were higher than for the other models.

In Tables 1 – 3, we highlight (bold) estimates from Model 2B because Model set 2 makes the greatest use of available information (i.e., uses all datasets), and model 2B is based on fewer assumptions than 2A, and thus we favor Model 2B estimates as the most plausible (see Discussion). Estimates from this model for the proposed 5-year hunt period are as follows. The median (and 95th percentile) probability of striking a WNP whale within the 5-year permit period ranged from 0.036 (0.107) to 0.058 (0.170) as X increased from 15 *non-PCFG* whales to 35 whales of any putative stock, and the expected number of whales that would be struck ranged from 0.04 (0.11) to 0.06 (0.19). The probability of an attempted strike on a WNP whale ranged from 0.136 (0.365) to 0.212 (0.524), and the expected number of attempts on WNP whales ranged from 0.15 (0.45) to 0.24 (0.74). Finally, the probability that a WNP whale would be pursued or approached by a hunter ranged from 0.519 (0.897) to 0.697 (0.976), and the expected number of WNP whales that would be approached ranged from 0.73 (2.26) to 1.19 (3.70).

In summary, we estimate based on Model 2B a fairly high probability that at least one WNP would be taken in the broadest sense of being pursued or approached by Makah hunters (i.e., $P(z>0) = 0.52 – 0.98$, depending on Z and whether the median or upper estimate is used). The probability of an attempted strike on least one WNP whale in 5 years was relatively moderate (i.e., $P(y>0) = 0.14 – 0.52$). The probability of actually striking at least one WNP whale during the 5-year period was relatively low but non-trivial (i.e., $P(z>0) = 0.04 – 0.17$).

Table 1. Summary statistics for six models from four model sets. P_{WNP} is probability of taking (striking) a WNP whale during a given take event. $P(x>0)_X$ are probabilities of striking at least 1 WNP whale out of X events. $E(x)_X$ is the expected number of struck WNP whales out of X total events. X=X** indicates that events are known to affect *non-PCFG* whales (otherwise X = X*, the number of events to gray whales in general). Cell entries are median and upper (95th percentile) probabilities.

	Model 1A	Model 1B	Model 2A	**Model 2B**	Model 3	Model 4
P_{WNP}	0.005 (0.008)	0.002 (0.008)	for X = X* 0.003 (0.006) for X = X** 0.005 (0.007)	**for X = X* 0.002 (0.005) for X = X** 0.002 (0.008)**	0.006 (0.025)	0.008 (0.035)
1 year						
$P(x>0)_{3**}$	0.014 (0.024)	0.007 (0.023)	0.014 (0.023)	**0.007 (0.022)**	NA	0.024 (0.102)
$P(x>0)_{4**}$	0.018 (0.031)	0.010 (0.030)	0.018 (0.031)	**0.010 (0.030)**	NA	0.033 (0.134)
$P(x>0)_5$	0.023 (0.039)	0.012 (0.037)	0.016 (0.028)	**0.008 (0.026)**	0.029 (0.119)	NA
$P(x>0)_7$	0.032 (0.054)	0.017 (0.052)	0.022 (0.039)	**0.012 (0.036)**	0.040 (0.162)	NA
$E(x)_{3**}$	0.01 (0.02)	0.01 (0.02)	0.01 (0.02)	**0.01 (0.02)**	NA	0.03 (0.11)
$E(x)_{4**}$	0.02 (0.03)	0.01 (0.03)	0.02 (0.03)	**0.01 (0.03)**	NA	0.03 (0.14)
$E(x)_5$	0.02 (0.04)	0.01 (0.04)	0.02 (0.03)	**0.01 (0.03)**	0.03 (0.13)	NA
$E(x)_7$	0.03 (0.06)	0.02 (0.05)	0.02 (0.04)	**0.01 (0.04)**	0.04 (0.18)	NA
5 year						
$P(x>0)_{15**}$	0.067 (0.113)	0.036 (0.108)	0.067 (0.112)	**0.036 (0.107)**	NA	0.117 (0.416)
$P(x>0)_{20**}$	0.089 (0.147)	0.048 (0.141)	0.089 (0.146)	**0.048 (0.141)**	NA	0.152 (0.512)
$P(x>0)_{20}$	0.089 (0.147)	0.048 (0.141)	0.063 (0.106)	**0.034 (0.101)**	0.110 (0.397)	NA
$P(x>0)_{35}$	0.151 (0.244)	0.082 (0.233)	0.107 (0.178)	**0.058 (0.170)**	0.185 (0.587)	NA
$E(x)_{15**}$	0.07 (0.12)	0.04 (0.11)	0.07 (0.12)	**0.04 (0.11)**	NA	0.12 (0.53)
$E(x)_{20**}$	0.09 (0.16)	0.05 (0.15)	0.09 (0.16)	**0.05 (0.15)**	NA	0.17 (0.70)
$E(x)_{20}$	0.09 (0.16)	0.05 (0.15)	0.06 (0.11)	**0.03 (0.11)**	0.12 (0.50)	NA
$E(x)_{35}$	0.16 (0.28)	0.09 (0.26)	0.11 (0.20)	**0.06 (0.19)**	0.20 (0.87)	NA

Table 2. Summary statistics for six models from four model sets. P_{WNP} is probability of taking (attempted strike) a WNP whale during a given take event. $P(y>0)_Y$ are probabilities of attempting to strike at least 1 WNP whale out of Y events. $E(y)_Y$ is the expected number of attempted-struck WNP whales out of Y total events. Y=Y** indicates that events are known to affect *non-PCFG* whales (otherwise Y = Y*, the number of events to gray whales in general). Cell entries are median and upper (95th percentile) probabilities.

	Model 1A	Model 1B	Model 2A	**Model 2B**	Model 3	Model 4
P_{WNP}	0.005 (0.008)	0.002 (0.008)	for Y = Y 0.003 (0.006) for Y = Y* 0.005 (0.007)	**for Y = Y** **0.002 (0.005)** **for Y = Y*** **0.002 (0.008)**	0.006 (0.025)	0.008 (0.035)
1 year						
$P(y>0)_{12**}$	0.054 (0.091)	0.029 (0.087)	0.054 (0.090)	**0.029 (0.087)**	NA	0.094 (0.349)
$P(y>0)_{16**}$	0.072 (0.120)	0.039 (0.114)	0.072 (0.119)	**0.038 (0.114)**	NA	0.124 (0.436)
$P(y>0)_{20}$	0.089 (0.147)	0.048 (0.141)	0.063 (0.106)	**0.034 (0.101)**	0.110 (0.397)	NA
$P(y>0)_{28}$	0.122 (0.200)	0.066 (0.192)	0.086 (0.145)	**0.047 (0.138)**	0.151 (0.507)	NA
$E(y)_{12**}$	0.06 (0.10)	0.03 (0.09)	0.06 (0.09)	**0.03 (0.09)**	NA	0.10 (0.42)
$E(y)_{16**}$	0.07 (0.13)	0.04 (0.12)	0.07 (0.13)	**0.04 (0.12)**	NA	0.13 (0.56)
$E(y)_{20}$	0.09 (0.16)	0.05 (0.15)	0.06 (0.11)	**0.03 (0.11)**	0.12 (0.50)	NA
$E(y)_{28}$	0.13 (0.22)	0.07 (0.21)	0.09 (0.16)	**0.05 (0.15)**	0.16 (0.70)	NA
5 year						
$P(y>0)_{60**}$	0.244 (0.380)	0.137 (0.366)	0.243 (0.377)	**0.136 (0.365)**	NA	0.391 (0.883)
$P(y>0)_{80**}$	0.311 (0.472)	0.178 (0.455)	0.310 (0.468)	**0.178 (0.454)**	NA	0.484 (0.943)
$P(y>0)_{80}$	0.311 (0.472)	0.178 (0.455)	0.228 (0.360)	**0.127 (0.346)**	0.373 (0.877)	NA
$P(y>0)_{140}$	0.479 (0.673)	0.291 (0.655)	0.364 (0.543)	**0.212 (0.524)**	0.558 (0.971)	NA
$E(y)_{60**}$	0.28 (0.48)	0.15 (0.45)	0.28 (0.47)	**0.15 (0.45)**	NA	0.49 (2.11)
$E(y)_{80**}$	0.37 (0.64)	0.20 (0.61)	0.37 (0.63)	**0.20 (0.60)**	NA	0.66 (2.82)
$E(y)_{80}$	0.37 (0.64)	0.20 (0.61)	0.26 (0.45)	**0.14 (0.42)**	0.47 (2.00)	NA
$E(y)_{140}$	0.65 (1.11)	0.34 (1.06)	0.45 (0.78)	**0.24 (0.74)**	0.82 (3.49)	NA

Table 3. Summary statistics for six models from four model sets. P_{WNP} is probability of taking (approaching) a WNP whale during a given take event. $P(z>0)_Z$ are probabilities of approaching at least 1 WNP whale out of Z events. $E(z)_Z$ is the expected number of approached WNP whales out of Z total events. Z=Z** indicates that events are known to affect *non-PCFG* whales (otherwise Z = Z*, the number of events to gray whales in general). Cell entries are median and upper (95th percentile) probabilities.

	Model 1A	Model 1B	Model 2A	**Model 2B**	Model 3	Model 4
P_{WNP}	0.005 (0.008)	0.002 (0.008)	for Z = Z 0.003 (0.006) for Z = Z* 0.005 (0.007)	**for Z = Z 0.002 (0.005) for Z = Z* 0.002 (0.008)**	0.006 (0.025)	0.008 (0.035)
1 year						
$P(z>0)_{60**}$	0.244 (0.380)	0.137 (0.366)	0.243 (0.377)	**0.136 (0.365)**	NA	0.391 (0.883)
$P(z>0)_{80**}$	0.311 (0.472)	0.178 (0.455)	0.310 (0.468)	**0.178 (0.455)**	NA	0.484 (0.943)
$P(z>0)_{100}$	0.373 (0.550)	0.218 (0.532)	0.276 (0.428)	**0.157 (0.412)**	0.442 (0.920)	NA
$P(z>0)_{140}$	0.479 (0.673)	0.291 (0.655)	0.364 (0.543)	**0.212 (0.524)**	0.558 (0.971)	NA
$E(z)_{60**}$	0.28 (0.48)	0.15 (0.45)	0.28 (0.47)	**0.15 (0.45)**	NA	0.49 (2.11)
$E(z)_{80**}$	0.37 (0.64)	0.20 (0.61)	0.37 (0.63)	**0.20 (0.60)**	NA	0.66 (2.82)
$E(z)_{100}$	0.47 (0.79)	0.25 (0.76)	0.32 (0.56)	**0.17 (0.53)**	0.58 (2.50)	NA
$E(z)_{140}$	0.65 (1.11)	0.34 (1.06)	0.45 (0.78)	**0.24 (0.74)**	0.81 (3.49)	NA
5 year						
$P(z>0)_{300**}$	0.753 (0.909)	0.521 (0.898)	0.752 (0.906)	**0.519 (0.897)**	NA	0.916 (1.000)
$P(z>0)_{400**}$	0.845 (0.959)	0.625 (0.952)	0.844 (0.958)	**0.624 (0.952)**	NA	0.963 (1.000)
$P(z>0)_{400}$	0.845 (0.959)	0.625 (0.952)	0.725 (0.893)	**0.494 (0.880)**	0.903 (1.000)	NA
$P(z>0)_{700}$	0.962 (0.996)	0.821 (0.995)	0.896 (0.980)	**0.697 (0.976)**	0.983 (1.000)	NA
$E(z)_{300**}$	1.40 (2.48)	0.74 (2.27)	1.39 (2.36)	**0.73 (2.26)**	NA	2.47 (10.56)
$E(z)_{400**}$	1.86 (3.18)	0.98 (3.03)	1.85 (3.15)	**0.98 (3.02)**	NA	3.29 (14.07)
$E(z)_{400}$	1.86 (3.18)	0.98 (3.03)	1.29 (2.23)	**0.68 (2.12)**	2.33 (9.98)	NA
$E(z)_{700}$	3.26 (5.56)	1.72 (5.30)	2.26 (3.90)	**1.19 (3.70)**	4.07 (17.46)	NA

Comparison to PBR

Table 4 provides 5-year estimates of PBR based on F_R = 0.1, 0.5, and 1.0. Uncertainty in the estimates (e.g., 95% CI) reflects uncertainty in the proportion of the WNP stock that migrates with the ENP stock. For F_R = 0.1, striking one WNP whale in the 5-year period would exceed PBR. For F_R = 0.5, one WNP strike could exceed PBR, depending on how many WNP individuals migrate with the ENP stock. Fewer WNP whales in U.S. waters would mean higher chance that one strike would exceed PBR, but it would also translate into lower probability of there being a WNP strike in the first place (i.e., lower than reflected in the Table 1 estimates). For F_R = 1, striking one WNP whale in the 5-year period would not exceed PBR.

Table 4. Estimates of PBR (5-year total) for the WNP gray whale stock under three different values of F_R. Uncertainty in the estimates reflects uncertainty in the proportion of the WNP that uses U.S. waters; the lower estimate corresponds to a little more than 0.15 of the WNP stock migrating in ENP areas, whereas the upper estimate corresponds to nearly all WNP animals migrating in ENP areas.

	F_R = 0.1	F_R = 0.5	F_R = 1.0
2.5%	0.10	0.50	0.99
median	0.33	1.67	3.35
97.5%	0.57	2.85	5.69

DISCUSSION

In general, we consider Model set 2 the most plausible of the model sets used, because it makes use of information from sightings in the MUA from the NWA coast area as well as relative abundance of the WNP vs. ENP. In contrast, Model set 1 ignores the MUA sightings information, and Models 3 and 4 ignore our knowledge of the WNP being small relative to the ENP. We also feel that, within Model sets 1 and 2, the B-versions of each model are more appropriate than A-versions, because the B models make fewer assumptions. The B models assume no prior knowledge about $P_{WNP|mig}$, except to specify a reasonable upper bound, whereas the A models assume that WNP and ENP migrants are equally available to the hunt on a per capita basis. Therefore, Models 2A and 2B, but especially 2B, may be considered the most useful estimates.

Models 3 and 4 are probably the least justifiable, since by ignoring information about the WNP population size they allow for upper parameter estimates that are likely implausible. For example, if we assume that WNP and ENP animals are equally available to the hunt and there are 16,000-22,000 ENP animals, then the upper estimate for Model 4 of P_{WNP} = 0.035 corresponds to a WNP population estimate of nearly 560-770 animals, which far exceeds existing estimates. Alternatively, WNP animals would need to be far more available to hunters on per capita basis than ENP animals for behavioral reasons, and there is no reason presently to expect this is the case.

Estimates from our analysis are considered precautionary since they assume that the Makah will achieve their proposed maximum strike limits. That being said, the results herein offer a conservative initial step in assessing the potential risk of WNP gray whales incurring mortality incidental to the proposed hunt on the ENP population by the Makah Indian Tribe.

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UPDATED ESTIMATES OF THE PROBABILITY OF STRIKING A WESTERN NORTH PACIFIC GRAY WHALE DURING THE PROPOSED MAKAH HUNT

Jeffrey E. Moore and David W. Weller

Marine Mammal and Turtle Division, Southwest Fisheries Science Center
National Marine Fisheries Service, National Oceanic and Atmospheric Administration
8901 La Jolla Shores Drive, La Jolla, CA 92037 USA

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EXECUTIVE SUMMARY

Observations of gray whales (*Eschrichtius robustus*) from the western North Pacific (WNP) migrating to areas off the coast of North America (Alaska to Mexico) raised concerns that this small population could be encountered during a hunt of eastern North Pacific (ENP) gray whales proposed by the Makah Indian Tribe in northern Washington, USA. In 2013, an analysis was conducted to estimate the probability of striking (i.e. killing or seriously injuring) a WNP whale under the Makah Tribe's hunt proposal (Moore and Weller 2013). NOAA Fisheries is considering a draft proposal that would govern ENP gray whale hunts by the Makah for up to 10 years. Under the draft proposal, hunting seasons would alternate between winter-spring hunts in even-numbered years and summer hunts during odd-numbered years. It is presumed that only in even-numbered years (thus, for 5 of the 10 years) would WNP whales potentially be encountered during the hunt. In each of these years, the draft proposal would allow for up to 3 gray whales to be struck. Based on this alternative hunting scheme and the availability of updated gray whale data, this report re-estimates the probability of striking a WNP whale reported earlier (Moore and Weller 2013). One of the models from the 2013 analysis (Model 2A) was used to generate new estimates. We estimate that for an individual strike on a gray whale, the expected probability of it being a WNP whale is 0.004 (95% CRI: 0.002 – 0.007). For a single year's hunt (3 strikes), the expected probability of striking ≥1 WNP whale would be 0.012 (0.006 – 0.019). Across the 10-year hunt period (15 strikes), the probability of striking ≥1 WNP whale would be 0.058 (0.030 – 0.093).

INTRODUCTION

Two gray whale (*Eschrichtius robustus*) populations are recognized in the North Pacific Ocean. Significant mitochondrial and nuclear genetic differences have been found between whales in the western North Pacific (WNP) and those in the eastern North Pacific (ENP) (LeDuc *et al*., 2002, Lang *et al*. 2010, Lang *et al*., 2011). The ENP population ranges from wintering areas in Baja California, Mexico, to feeding areas in the Bering, Beaufort, and Chukchi Seas (Fig. 1). An exception to this generality is the relatively small number (100s) of whales that summer and feed along the Pacific coast between Kodiak Island, Alaska, and northern California (Weller *et al*., 2013). These whales are collectively called the Pacific Coast Feeding Group (PCFG). The International Whaling Commission (IWC) has defined PCFG whales as individuals observed between 1 June and 30 November from 41°N to 52°N in two or more years (IWC, 2012), and NOAA Fisheries has adopted this definition in recent assessments (Weller *et al.*, 2013). The usual and accustomed (U&A) fishing grounds of the Makah Indian Tribe are off the coast of northern Washington, USA, and overlap with a portion of the PCFG summering area (Fig. 1).

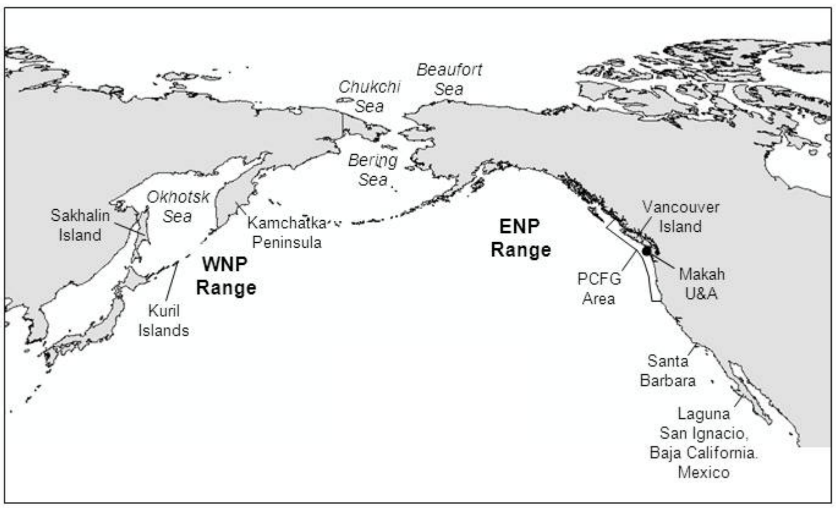

Figure 1. Areas in the western and eastern North Pacific mentioned in the report.

The WNP population feeds in the Okhotsk Sea off Sakhalin Island, Russia (Weller *et al*., 1999; Weller *et al*. 2012), and in nearshore waters of the southwestern Bering Sea off the southeastern Kamchatka Peninsula (Tyurneva *et al*., 2010). The historical distribution of gray whales in the Okhotsk Sea greatly exceeded what is found today (Reeves *et al*., 2008). Whales associated with the Sakhalin feeding area can be absent for all or part of a given feeding season (Bradford *et al*., 2008), indicating they use other areas during the summer and fall feeding period. Some of the whales identified feeding in the coastal waters off Sakhalin, including reproductive females and calves, have been documented off the southern and eastern coast of Kamchatka (Tyurneva *et al*., 2010). A small number of whales observed off Sakhalin have also been sighted off the northern Kuril Islands in the eastern Okhotsk Sea and Bering Island in the western Bering Sea (Weller *et al*., 2003).

Mixing of whales identified in the WNP and ENP has been observed (Weller *et al*., 2012). Lang (2010) reported that two adult individuals from the WNP, sampled off Sakhalin in 1998 and 2004, matched the microsatellite genotypes, mtDNA haplotypes, and sexes (one male, one female) of two whales sampled off Santa Barbara, California in March 1995. Between 2010 and 2012 three whales outfitted with satellite transmitters were tracked moving from Sakhalin in the WNP to the ENP (Mate *et al*., 2015). Finally, photographic matches between the WNP and ENP, including matches between Sakhalin, Vancouver Island and Laguna San Ignacio (Fig. 1), have further confirmed use of areas in the ENP by whales identified in the WNP (Weller *et al*., 2012, Urbán *et al*., 2012). Despite this level of mixing, significant mtDNA and nuclear genetic differences between whales in the WNP and ENP have been found (LeDuc *et al*. 2002, Lang *et al*., 2011).

In 1995, following the 1994 delisting of ENP gray whales under the U.S. Endangered Species Act, the Makah Indian Tribe notified NOAA Fisheries of its interest in re-establishing limited ceremonial and subsistence whale hunting. The decision-making history on this issue is complex and not described here except to note that in 2005, the Makah Tribe submitted a detailed proposal for hunting ENP gray whales in the coastal portion of its U&A off northern Washington, USA, as part of a request for a waiver of the U.S. Marine Mammal Protection Act's (MMPA) take moratorium (16 USC 1371(a)(3)(A)). Subsequently, observations of WNP gray whales migrating through areas off the coast of North America (Alaska to Mexico) emphasized the need to evaluate the probability of a WNP gray whale being encountered in aboriginal hunts for ENP gray whales (IWC, 2012). Following recommendations of the Scientific Committee of the International Whaling Commission (IWC), analyses were conducted to estimate such probability in the context of the Makah Tribe's hunt proposal (Moore and Weller, 2013). These analyses informed a draft Environmental Impact Statement (DEIS), completed in 2015 (NMFS, 2015), pertaining to the Makah Tribe's MMPA waiver request.

NOAA Fisheries is presently considering a MMPA waiver and associated draft proposal that would govern a modified version of the Tribe's hunt proposal. The objective of the analysis reported here was to provide updated estimates of the probability that one or more WNP whales might be subjected to strikes[1], unsuccessful strike attempts (i.e., harpoon throws that do not penetrate), and vessel approaches during hunts and hunt training exercises considered in the draft proposal. This report is based on the methods used by Moore and Weller (2013) and incorporates updated information about the population sizes of ENP and WNP gray whales and their occurrence within the proposed hunt area.

METHODS

Hunt proposal

NOAA Fisheries' draft proposal would govern a Makah Tribe hunt of ENP gray whales in the coastal portion of the U&A (i.e., the "hunt area") over a 10-year hunt period. In odd-numbered years, the hunt would take place from 1 July through 31 October, a period when no sightings of WNP whales have been recorded in the ENP, and when gray whales generally (apart from PCFG

[1] As described in NOAA Fisheries' DEIS (NMFS, 2015), the term "strike" is interpreted to be consistent with the IWC Schedule definition as meaning "to penetrate with a weapon used for whaling."

animals) are in northern feeding areas. Thus, hunted animals in these odd-numbered years would presumably belong to the PCFG and it is assumed that WNP whales would not be at risk from proposed hunt operations. In even-numbered years, the hunt would take place from 1 December through 31 May. This period coincides with both the southward (December to mid-February) and northward (mid-February to late May) migration of ENP whales and overlaps with the time when WNP gray whales have been sighted in the ENP. Thus, in even-numbered years there is a potential risk to WNP whales from proposed hunt operations. In each of the even-numbered years, a maximum of 3 gray whales per year could be struck (including "struck and lost" animals). Over the 10-year period of the proposed hunt, a maximum of 15 whales could be struck (in even-numbered years) that would have some probability of being WNP whales. We therefore evaluate the probability of striking at least one WNP whale per even-numbered year (out of 3 strikes) and for the 10-year period (out of 15 strikes). We also evaluate associated rates of WNP whales being subjected to aforementioned "unsuccessful strike attempts" (i.e., harpoon throws that do not penetrate) and "approaches" (i.e., whales approached by vessels during hunts and hunt training exercises).

Data

Abundance estimates - The most recent ENP abundance estimate (for 2015/2016) is 26,960 (CV = 0.05) (Durban *et al.*, 2017). The most recent WNP abundance estimate (for 2015) is 200 (CV = 0.03) for the 1+ population (i.e., excluding calves) (Cooke 2018). We then multiplied the WNP estimate by 1.099 to account for calves. This multiplier is based on the ratio of the population size with and without calves in 2012 (IUCN, 2012).

Mixing proportions based on sightings in the Makah Hunt Area - During spring surveys (March to May) in 1996-2012 there were 181 observed whale-days in the Makah hunt area (Calambokidis *et al*., 2014). To clarify the term "whale-day" – all sightings of an individual on a particular day collectively count as 1 whale-day (e.g., multiple sightings of the same individual on the same day count as just 1 whale-day, but the same individual seen the next day would count as a second whale-day). None of the 181 whale-days observed included WNP whales[2]; 73 (40.3%) were considered PCFG whales; and the rest (108, or 59.7%) were assumed to be migrating ENP whales.

However, rather than use 40.3% as the expected PCFG proportion in the hunt area during an even-year hunt, we use 28% for this mixing proportion (i.e. 72% of animals encountered during an even-year hunt are likely to be non-PCFG animals). This value is based on analyses summarized in a 2018 IWC workshop (IWC, 2018).

Proportion of WNP whales migrating with ENP whales - The proportion of the WNP population that migrates along the North American coast is unknown but estimated to be at least 0.37 based on analysis by Cooke (2015) and reported to a 2015 IWC workshop on gray whale population structure (IWC, 2016).

[2] Although not in the Makah hunt area, Weller *et al.* (2012) report observing three WNP whales on 2 May 2004 and three more on 25 April 2008 near Barkley Sound off the west coast of southern Vancouver Island, British Columbia, Canada.

Model

Moore and Weller (2013) considered four models in their analysis but they based final inferences on what they termed Model 2B. Here, we use Model 2A instead. Models 2A and 2B are similar. The difference is that for Model 2A, the conditional probability of a non-PCFG whale being a WNP (rather than ENP) whale is simply based on the ratio of WNP:ENP population size. This is an intuitive estimator, though it does rely on the assumption that WNP and ENP animals migrating together are using the same migration corridors and behaving similarly. For Model 2B, this assumption is relaxed and we allow for broader uncertainty by stating that the conditional probability varies uniformly from zero (if the WNP whales do not migrate through the Makah area at all) to some maximum value that is based on (but not equivalent to) the ratio of WNP:ENP population size. However, it is difficult to define that maximum value, and allowing a lower probability of zero is not precautionary and arguably should not be considered without supporting evidence.

Model 2 (A and B) makes use of the mixing proportion/sightings data for the Makah hunt area, as well as WNP and ENP abundance estimates. WNP whales are assumed to be moving with the ENP migrants, so that the marginal probability of a WNP whale being struck is the probability that the struck whale is a migrant, P_{mig} (i.e., probability of not being a PCFG whale), multiplied by the conditional probability of being a WNP whale given that it is a migrant ($P_{WNP|mig}$). Thus, $P_{WNP} = P_{mig}P_{WNP|mig}$.

P_{mig} is defined as 1 – P_{PCFG}, where P_{PCFG} is given by an informative prior: P_{PCFG} ~ Beta (5.3648, 13.7952) which has a mean of 0.28 and SD of 0.1 (IWC 2018).

We assume that the per-capita likelihood of a migrating (non-PCFG) whale in the hunt area being a WNP whale (i.e., $P_{WNP|mig}$) is simply given by the proportion of the migrating population made up of WNP whales. This proportion depends on what fraction of the WNP population migrates along the U.S. West Coast, which we call *m*, and the relative size of the WNP to the ENP population. Thus, $P_{WNP|mig} = mN_{WNP}/(mN_{WNP} + N_{ENP})$. Let m ~ Uniform (0.37, 1), based on Cooke *et al.* (2015). N_{WNP} and N_{ENP} are treated as lognormally distributed variables with means and CVs as given above.

Estimation

Earlier analyses (Moore and Weller, 2013) used Bayesian estimation. In the current exercise, analysis was conducted using OpenBUGS software, but estimation is not strictly Bayesian because there are no new data updating the informative prior inputs. Rather, the present analysis is essentially a Monte Carlo procedure, with distributions for the parameters of interest (e.g., probability of striking a WNP whale) being derived from random draws from informed prior distributions for the input parameters. Derived parameter distributions are summarized from two MCMC chains, each 25,000 samples in length (50,000 samples total).

Derived parameters

The key parameter of interest is the per-strike probability of striking a WNP whale. Derived from this parameter are the probabilities of striking at least one WNP out of 3 gray whale strikes (i.e., the annual probability of striking a WNP whale, for the even-numbered years) or out of 15 gray whale strikes (i.e., probability for the whole 10-year period). These are calculated as $P(x > 0) = 1 – (1 – P_{WNP})^X$, where X is 3 or 15. Additionally, we can derive the expected number of WNP strikes as $E(x) = P_{WNP}X$. Using data collected during previous hunts (NMFS, 2015), the following two assumptions were used to calculate analogous estimates for vessel approaches and unsuccessful strike attempts: (1) there will be 353 vessel approaches per year (3530 across all 10 years)[3], and (2) there will be 6 unsuccessful strike attempts for every strike in an even-year hunt[4].

RESULTS

Parameter estimates

Estimated parameters from all model sets are in Table 1. Figure 2 shows the distribution for P_{WNP}. It is straightforward to integrate across the uncertainty in P_{WNP} to obtain a single probability estimate. We did this for the probability of striking ≥ 1 WNP whale over the entire 10-year hunt period (i.e., out of 15 strikes). This probability was 0.058.

Table 1. Distribution summaries for key model parameters. "Prob(WNP)" is the probability of at least 1 WNP animal being struck or subjected to unsuccessful strike attempts or vessel approaches given the specified number of events.

Parameter	Posterior mean	2.5% CRI	Posterior median	97.5% CRI
Prob(WNP) for a single interaction, i.e., P_{WNP}	0.004	0.002	0.004	0.007
Prob(WNP|3 strikes in 1 yr)	0.012	0.006	0.012	0.019
Prob(WNP|15 strikes in 10 yrs)	0.058	0.030	0.057	0.093
Prob(WNP|18 unsuccessful strike attempts in 1 yr)	0.070	0.036	0.069	0.110
Prob(WNP|90 unsuccessful strike attempts in 10 yrs)	0.299	0.167	0.298	0.442
Prob(WNP|353 approaches in 1 yr)	0.735	0.511	0.751	0.899
Prob(WNP|3530 approaches in 10 yrs)	~ 1.0	0.999	~ 1.0	~ 1.0
Expected WNP|3 strikes in 1 yr	0.012	0.006	0.012	0.019
Expected WNP|15 strikes in 10 yrs	0.060	0.030	0.059	0.097
Expected WNP|18 unsuccessful strike attempts in 1 yr	0.072	0.036	0.071	0.116
Expected WNP|90 unsuccessful strike attempts in 10 yrs	0.361	0.182	0.353	0.582
Expected WNP|353 approaches in 1 yr	1.416	0.714	1.386	2.283
Expected WNP|3530 approaches in 10 yrs	14.160	7.141	13.860	22.830

[3] This number is conservative because it assumes that all approaches (hunting and training) in both even and odd years occur during the winter/spring period when WNP whales may be present. Realistically we would expect a substantial number of approaches to occur outside this period, i.e., during the summer when ocean conditions are more favorable and, in odd years, when hunting approaches are restricted to July - October.

[4] We expect zero in odd years because the draft proposal limits training strikes (which count as unsuccessful strike attempts) to the summer-fall hunting season, when WNP whales are not expected to be present.

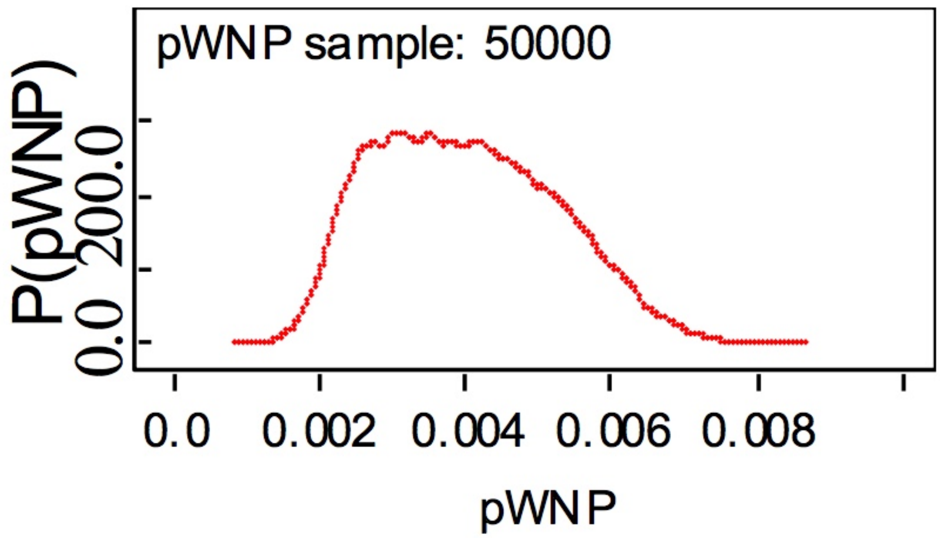

Figure 2. Posterior distribution for probability that any given strike is a WNP whale.

DISCUSSION

Estimates from our analysis may be precautionary since they assume that the Makah hunt will achieve proposed maximum strike limits, and because the assumption of Model 2A is that WNP whales are homogenously mixed with ENP whales. The likelihood of striking a WNP whale is overestimated if fewer total animals are struck or if in reality the WNP animals use a different migration corridor and are less likely to travel through the Makah hunt area. Given uncertainties associated with the model and scenario assumptions, these results serve as a rough approximation of the potential for WNP gray whales to be subjected to strikes, unsuccessful strike attempts and vessel approaches during a Makah hunt operating under a draft proposal currently being considered by NOAA Fisheries.

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Alaska Marine Mammal Stock Assessments, 2016

by
M. M. Muto, V. T. Helker, R. P. Angliss, B. A. Allen, P. L. Boveng,
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K. E. W. Shelden, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini

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Marine Mammal Laboratory
Alaska Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
7600 Sand Point Way NE
Seattle, WA 98115-6349

U.S. DEPARTMENT OF COMMERCE
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Benjamin Friedman, Acting Under Secretary and Administrator
National Marine Fisheries Service
Samuel D. Rauch III, Acting Assistant Administrator for Fisheries

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PREFACE

On 30 April 1994, Public Law 103-238 was enacted allowing significant changes to provisions within the Marine Mammal Protection Act (MMPA). Interactions between marine mammals and commercial fisheries are addressed under three new sections. This new regime replaced the interim exemption that has regulated fisheries-related incidental takes since 1988. Section 117, Stock Assessments, required the establishment of three regional scientific review groups to advise and report on the status of marine mammal stocks within Alaska waters, along the Pacific Coast (including Hawaii), and the Atlantic Coast (including the Gulf of Mexico). This report provides information on the marine mammal stocks of Alaska under the jurisdiction of the National Marine Fisheries Service.

Each stock assessment includes, when available, a description of the stock's geographic range; a minimum population estimate; current population trends; current and maximum net productivity rates; optimum sustainable population levels and allowable removal levels; estimates of annual human-caused mortality and serious injury through interactions with commercial, recreational, and subsistence fisheries, takes by subsistence hunters, and other human-caused events (e.g., entanglement in marine debris, ship strikes); and habitat concerns. The commercial fishery interaction data will be used to evaluate the progress of each fishery towards achieving the MMPA's goal of zero fishery-related mortality and serious injury of marine mammals.

The Stock Assessment Reports should be considered working documents, as they are updated as new information becomes available. The Alaska Stock Assessment Reports were originally developed in 1995 (Small and DeMaster 1995). Revisions have been published for the following years: 1996 (Hill et al. 1997), 1998 (Hill and DeMaster 1998), 1999 (Hill and DeMaster 1999), 2000 (Ferrero et al. 2000), 2001 (Angliss et al. 2001), 2002 (Angliss and Lodge 2002), 2003 (Angliss and Lodge 2004), 2005 (Angliss and Outlaw 2005), 2006 (Angliss and Outlaw 2007), 2007 (Angliss and Outlaw 2008), 2008 (Angliss and Allen 2009), 2009 (Allen and Angliss 2010), 2010 (Allen and Angliss 2011), 2011 (Allen and Angliss 2012), 2012 (Allen and Angliss 2013), 2013 (Allen and Angliss 2014), 2014 (Allen and Angliss 2015), and 2015 (Muto et al. 2016). Each Stock Assessment Report is designed to stand alone and is updated as new information becomes available. The MMPA requires Stock Assessment Reports to be reviewed annually for stocks designated as strategic, annually for stocks where there is significant new information available, and at least once every 3 years for all other stocks. New information for all strategic stocks (Western U.S. Steller sea lions, northern fur seals, Cook Inlet beluga whales, AT1 Transient killer whales, harbor porpoise, sperm whales, humpback whales, fin whales, North Pacific right whales, and bowhead whales) was reviewed in 2015-2016. This review, and a review of other stocks, led to the revision of the following stock assessments for the 2016 document: Western U.S. and Eastern U.S. stocks of Steller sea lions; northern fur seals; bearded seals; ringed seals; Cook Inlet beluga whales; narwhals; Eastern North Pacific (ENP) Alaska Resident, ENP Gulf of Alaska, Aleutian Islands, and Bering Sea Transient, and AT1 Transient stocks of killer whales; Southeast Alaska, Gulf of Alaska, and Bering Sea stocks of harbor porpoise; sperm whales; Western North Pacific and Central North Pacific stocks of humpback whales; fin whales; North Pacific right whales, and bowhead whales. The Stock Assessment Reports for all stocks, however, are included in this document to provide a complete reference. Those sections of each Stock Assessment Report containing significant changes are listed in Appendix 1. The authors solicit any new information or comments which would improve future Stock Assessment Reports.

The U.S. Fish and Wildlife Service (USFWS) has management authority for polar bears, sea otters, and walruses. Copies of the stock assessments for these species are included in Appendix 8 of this NMFS Stock Assessment Report for your convenience.

Ideas and comments from the Alaska Scientific Review Group (SRG) have significantly improved this document from its draft form. The authors wish to express their gratitude for the thorough reviews and helpful guidance provided by the Alaska Scientific Review Group members: Karl Haflinger, Lloyd Lowry (Chair from 2012 to 2016), Beth Mathews, Craig Matkin, Mike Miller, Grey Pendleton, Robert Small, Kate Stafford, Robert Suydam, David Tallmon, and Kate Wynne. We would also like to acknowledge the contributions from the NMFS Alaska Region and the Communications Program of the Alaska Fisheries Science Center.

The information contained within the individual Stock Assessment Reports stems from a variety of sources. Where feasible, we have attempted to utilize only published material. When citing information contained in this document, authors are reminded to cite the original publications, when possible.

CONTENTS*

*NMFS Stock Assessment Reports and Appendices revised in 2016 are in boldface.

STELLER SEA LION (*Eumetopias jubatus*): Western U.S. Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Steller sea lions range along the North Pacific Rim from northern Japan to California (Loughlin et al. 1984), with centers of abundance and distribution in the Gulf of Alaska and Aleutian Islands (Fig. 1). Large numbers of individuals disperse widely outside of the breeding season (late May-early July), probably to access seasonally important prey resources. This results in marked seasonal patterns of abundance in some parts of the range and potential for intermixing in foraging areas of animals that were born in different areas (Sease and York 2003). Despite the wide-ranging movements of juveniles and adult males in particular, exchange between rookeries by breeding adult females and males (other than between adjoining rookeries) is low, although males have a higher tendency to disperse than females (NMFS 1995, Trujillo et al. 2004, Hoffman et al. 2006).

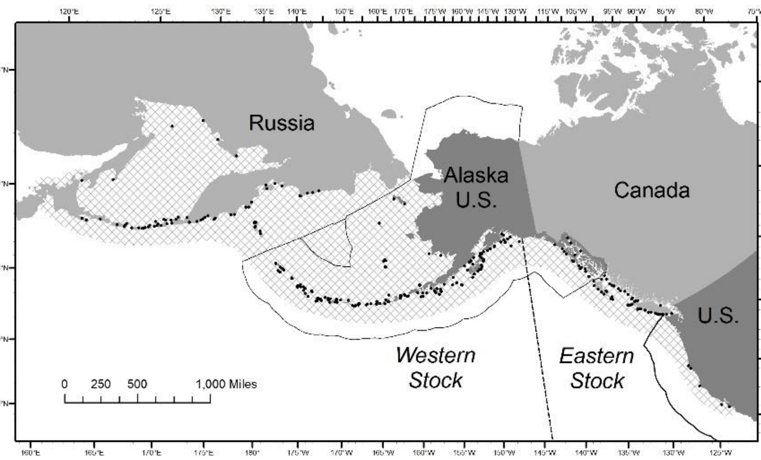

Figure 1. Generalized distribution (crosshatched area) of Steller sea lions in the North Pacific and major U.S. haulouts and rookeries (50 CFR 226.202, 27 August 1993), as well as active Asian and Canadian (British Columbia) haulouts and rookeries (points: Burkanov and Loughlin 2005; S. Majewski, Fisheries and Oceans Canada, pers. comm.). Black dashed line (144°W) indicates stock boundary (Loughlin 1997) and solid black line delineates U.S. Exclusive Economic Zone.

Loughlin (1997) considered the following information when classifying stock structure based on the phylogeographic approach of Dizon et al. (1992): 1) Distributional data: geographic distribution continuous, yet a high degree of natal site fidelity and low (<10%) exchange rate of breeding animals among rookeries; 2) Population response data: substantial differences in population dynamics (York et al. 1996); 3) Phenotypic data: differences in the length of pups (Merrick et al. 1995, Loughlin 1997); and 4) Genotypic data: substantial differences in mitochondrial DNA (Bickham et al. 1996). Based on this information, two separate stocks of Steller sea lions were recognized within U.S. waters: an Eastern U.S. stock, which includes animals born east of Cape Suckling, Alaska (144°W), and a Western U.S. stock, which includes animals born at and west of Cape Suckling (Loughlin 1997; Fig. 1). However, Jemison et al. (2013) summarized that there is regular movement of Steller sea lions from the western Distinct Population Segment (DPS) (males and females equally) and eastern DPS (almost exclusively males) across the DPS boundary.

Steller sea lions that breed in Asia are considered part of the western stock. Whereas Steller sea lions seasonally inhabit coastal waters of Japan in the winter, breeding rookeries outside of the U.S. are currently only located in Russia (Burkanov and Loughlin 2005). Analyses of genetic data differ in their interpretation of separation between Asian and Alaska sea lions. Based on analysis of mitochondrial DNA, Baker et al. (2005) found evidence of a genetic split between the Commander Islands (Russia) and Kamchatka that would include Commander Island sea lions within the Western U.S. stock and animals west of there in an Asian stock. However, Hoffman et al. (2006) did not support an Asian/western stock split based on their analysis of nuclear microsatellite markers indicating high rates of male gene flow. Berta and Churchill (2012) concluded that a putative Asian stock is "not substantiated by microsatellite data since the Asian stock groups with the western stock." All genetic analyses (Baker et al. 2005; Harlin-Cognato et al. 2006; Hoffman et al. 2006, 2009; O'Corry-Crowe et al. 2006) confirm a strong separation between western and eastern stocks, and there may be sufficient morphological differentiation to support elevating the two recognized stocks to subspecies (Phillips et al. 2009), although a recent review by Berta and Churchill (2012) characterized the status of these subspecies assignments as "tentative" and requiring further attention before their status can be determined. Recent work by Phillips et al. (2011) addressed the effect of climate change, in the form of glacial events, on the evolution of Steller sea lions and reported that the effective population size at the time of the event determines the impact of change on the population. The results suggested that during historic glacial periods, dispersal events were correlated with historically low effective population sizes, whereas range fragmentation type events were correlated with larger effective population sizes. This work again reinforced the stock delineation concept by noting that ancient population subdivision likely led to the sequestering of most mtDNA haplotypes as DPS or subspecies-specific (Phillips et al. 2011).

In 1998, a single Steller sea lion pup was observed on Graves Rock just north of Cross Sound in Southeast Alaska, and within 15 years (2013) pup counts had increased to 551 (DeMaster 2014). Mitochondrial and microsatellite analysis of pup tissue samples collected in 2002 revealed that approximately 70% of the pups had mtDNA haplotypes that were consistent with those found in the western stock (Gelatt et al. 2007). Similarly, a rookery to the south on the White Sisters Islands, where pups were first noted in 1990, was also sampled in 2002 and approximately 45% of those pups had western stock haplotypes. Collectively, this information demonstrates that these two most recently established rookeries in northern Southeast Alaska have been partially to predominately established by western stock females. While movements of animals marked as pups in both stocks support these genetic results (Jemison et al. 2013), overall the observations of marked sea lion movements corroborate the extensive genetic research findings for a strong separation between the two currently recognized stocks. O'Corry-Crowe et al. (2014) concluded that the results of their study of the genetic characteristics of pups born on these new rookeries "demonstrates that resource limitation may trigger an exodus of breeding animals from declining populations, with substantial impacts on distribution and patterns of genetic variation. It also revealed that this event is rare because colonists dispersed across an evolutionary boundary, suggesting that the causative factors behind recent declines are unusual or of larger magnitude than normally occur." Thus, although recent colonization events in the northern part of the eastern DPS indicate movement of western sea lions into this area, the mixed part of the range remains small (Jemison et al. 2013), and the overall discreteness of the eastern from the western stock remains distinct. Hybridization among subspecies and species along a contact zone such as now occurs near the stock boundary is not unexpected as the ability to interbreed is a primitive condition whereas reproductive isolation would be derived. In fact, as stated by NMFS and the U.S. Fish and Wildlife Service (USFWS) in a 1996 response to a previous comment regarding stock discreteness policy (61 FR 47222), "*The Services do not consider it appropriate to require absolute reproductive isolation as a prerequisite to recognizing a distinct population segment*" or stock. The fundamental concept overlying this distinctiveness is the collection of morphological, ecological and behavioral, and genetic evidence for stock differences initially described by Bickham et al. (1996) and Loughlin (1997) and supported by Baker et al. (2005), Harlin-Cognato et al. (2006), Hoffman et al. (2006, 2009), O'Corry-Crowe et al. (2006), and Phillips et al. (2009, 2011).

POPULATION SIZE

The western stock of Steller sea lions decreased from an estimated 220,000 to 265,000 animals in the late 1970s to less than 50,000 in 2000 (Loughlin et al. 1984, Loughlin and York 2000, Burkanov and Loughlin 2005). Since 2000, the abundance of the western stock has increased, but there has been considerable regional variation in trend (Sease and Gudmundson 2002, Burkanov and Loughlin 2005, Fritz et al. 2013). The most recent comprehensive aerial photographic and land-based surveys of western Steller sea lions in Alaska were conducted during the 2014 and 2015 breeding seasons (Fritz et al. 2015a, 2015b). Western Steller sea lion pup and non-pup counts in Alaska in 2015 were estimated to be 12,492 (95% credible interval of 11,480-13,612) and 38,491 (34,377-42,634), respectively, using agTrend (Johnson and Fritz 2014) and survey results through 2015 (Fritz et al. 2015a, 2015b). Demographic multipliers (e.g., pup production multiplied by 4.5) and proportions of each age-sex class that are hauled out during the day in the breeding season (when aerial surveys are conducted) have been proposed as methods to estimate total population size from pup and/or non-pup counts (Calkins and Pitcher 1982, Higgins et al. 1988, Milette and Trites 2003, Maniscalco et al. 2006). However, there are several factors which make using these methods problematic when applied to counts of western Steller sea lions in Alaska, including the lack of vital (survival and reproductive) rate information for the western and central Aleutian Islands, the large variability in abundance trends across the range (see Current Population Trend section below and Pitcher et al. 2007), and the large uncertainties related to reproductive status and foraging conditions that affect proportions hauled out (see review in Holmes et al. 2007).

Methods used to survey Steller sea lions in Russia differ from those used in Alaska, with less use of aerial photography and more use of skiff surveys and cliff counts for non-pups and ground counts for pups. The most recent counts of non-pup Steller sea lions in Russia were conducted in 2007-2011 and totaled ~12,700 (V. Burkanov, NMFS-AFSC-MML, pers. comm.). The most recent estimate of pup production in Russia is available from counts conducted in 2011 and 2012, which totaled 6,021 pups. Analysis of data collected in 2013 and 2015 is ongoing and results will be included in a future Stock Assessment Report.

Minimum Population Estimate

Because of the uncertainty regarding the use of a pup multiplier or haulout rate to estimate N, we will use the best estimate of the total count of western Steller sea lions in Alaska as the minimum population estimate (N_{MIN}). Western Steller sea lion pup and non-pup counts in 2015 in Alaska were estimated to be 12,492 and 38,491, respectively (Fritz et al. 2015b), which total 50,983 and will be used as the N_{MIN} for the U.S. portion of the western stock of Steller sea lions (Wade and Angliss 1997). This is considered a minimum estimate because it has not been corrected to account for animals that were at sea during the surveys.

Current Population Trend

The first reported trend counts (sums of counts at consistently surveyed, large sites used to examine population trends) of Steller sea lions in Alaska were made in 1956-1960. Those counts indicated that there were at least 140,000 (no correction factor applied) sea lions in the Gulf of Alaska and Aleutian Islands (Merrick et al. 1987). Subsequent surveys indicated a major population decrease, first detected in the eastern Aleutian Islands in the mid-1970s (Braham et al. 1980). Counts from 1976 to 1979 totaled about 110,000 sea lions (no correction factor applied). The decline appears to have spread eastward to Kodiak Island during the late 1970s and early 1980s, and then westward to the central and western Aleutian Islands during the early and mid-1980s (Merrick et al. 1987, Byrd 1989). During the late 1980s, counts in Alaska overall declined at ~15% per year (NMFS 2008) which prompted the listing (in 1990) of the species as threatened range-wide under the Endangered Species Act (ESA). Continued declines in counts of western Steller sea lions in Alaska in the 1990s (Sease et al. 2001) led NMFS to change the ESA listing status to endangered in 1997 (NMFS 2008). Surveys in Alaska in 2002, however, were the first to note an increase in counts, which suggested that the overall decline of western Steller sea lions stopped in 2000-2002 (Sease and Gudmundson 2002).

Johnson and Fritz (2014) estimated regional and overall trends in counts of pups and non-pups in Alaska using data collected at all sites with at least two non-zero counts, rather than relying solely on counts at "trend" sites (also see Fritz et al. 2013). Using data collected through 2015, there is strong evidence that non-pup and pup counts of western stock Steller sea lions in Alaska increased at ~2% y^{-1} between 2000 and 2015 (Table 1; Fritz et al. 2015b). However, there are strong regional differences across the range in Alaska, with positive trends east of Samalga Pass (~170°W) in the Gulf of Alaska and eastern Bering Sea and negative trends to the west in the Aleutian Islands (Table 1; Fig. 2).

Regional differences in pup trends cannot be explained by movement of pups during the breeding season. However, slower growth in pup counts in the central Gulf of Alaska than in the surrounding regions east of Samalga Pass could be due to movement of adult females out of the region (suggesting some level of permanent emigration), indicating that sea lions may have responded to meso-scale (on the order of 100s of kilometers) variability in their environment (O'Corry-Crowe et al. 2014).

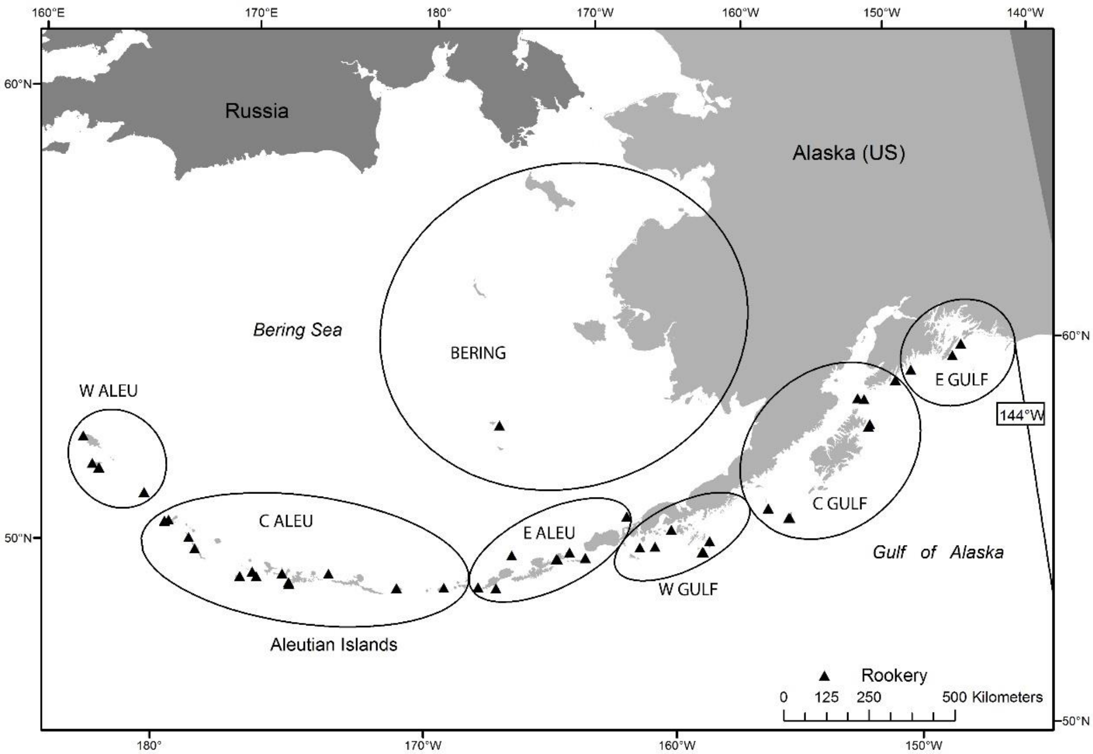

Figure 2. Regions of Alaska used for western Steller sea lion population trend estimation. E GULF, C GULF, and W GULF are eastern, central, and western Gulf of Alaska regions, respectively. E ALEU, C ALEU, and W ALEU are eastern, central, and western Aleutian Islands regions, respectively.

Table 1. Trends (annual rates of change expressed as % y^{-1} with 95% credible interval) in counts of western Steller sea lion non-pups (adults and juveniles) and pups in Alaska, by region, for the period 2000-2015 (Johnson and Fritz 2014; Fritz et al. 2013, 2015a, 2015b).

		Non-pups				**Pups**		
Region	**Latitude Range**	**Trend**	**-95%**	**+95%**		**Trend**	**-95%**	**+95%**
Western Stock in Alaska	144°W-172°E	1.94	1.35	2.58		1.87	1.30	2.40
E of Samalga Pass	144°-170°W	3.28	2.55	4.10		3.30	2.61	3.98
Eastern Gulf of Alaska	144°-150°W	5.07	2.35	7.87		4.31	2.54	6.00
Central Gulf of Alaska	150°-158°W	2.68	1.53	3.73		2.82	1.39	4.24
Western Gulf of Alaska	158°-163°W	3.95	2.75	5.11		3.28	1.86	4.61
Eastern Aleutian Islands	163°-170°W	2.08	0.69	3.44		3.35	2.29	4.37
W of Samalga Pass	170°W-172°E	-1.82	-2.62	-0.97		-1.62	-2.45	-0.82
Central Aleutian Islands	170°W-177°E	-0.84	-1.69	0.05		-0.68	-1.58	0.23
Western Aleutian Islands	172°-177°E	-8.71	-10.65	-6.83		-8.88	-10.00	-7.73

The distribution of sightings of branded animals during the breeding season indicates an average annual net movement of adult and juvenile sea lions from the central to the eastern Gulf of Alaska (Fritz et al. 2013). This could have depressed non-pup trend estimates in the central Gulf (2.68% y^{-1} between 2000 and 2015) and increased them in the eastern Gulf (5.07% y^{-1}; Table 1). Although less is known about inter-regional movement west of Samalga Pass, including Russia, sea lion dispersal during the breeding season may have had a smaller influence on non-pup trends here than in the eastern-central Gulf of Alaska given the much larger area over which regional non-pup (and pup) trends are declining (see discussion of Russia below).

The net magnitude of Steller sea lion movements during the breeding season between the eastern and western stocks appears to be relatively small and would have a negligible impact on non-pup trend estimates in either area (Fritz et al. 2013, Jemison et al. 2013). However, there were significant differences by sex in cross-boundary movements: for females, there was a net increase of ~600 in the east and very few moved from east to west, while males moved in both directions but with a net increase of ~500 males in the west. This pattern of movement is supported by mitochondrial DNA evidence that indicated that the newest rookeries in northern Southeast Alaska (eastern stock) were colonized in part by western females (Gelatt et al. 2007, O'Corry-Crowe et al. 2014).

Burkanov and Loughlin (2005) estimated that the Russian Steller sea lion population (pups and non-pups) declined from about 27,000 in the 1960s to 13,000 in the 1990s and increased to approximately 16,000 in 2005. Data collected through 2012 (V. Burkanov, NMFS-AFSC-MML, pers. comm.) indicate that overall Steller sea lion abundance in Russia increased back to levels observed in the 1960s (~27,100 based on life table multiplier of 4.5 on the most recent total pup count of 6,021). However, just as in the U.S. portion of the stock, there are significant regional differences in population trend in Russia, with increasing abundance in the Sea of Okhotsk and Kuril Islands and stable or declining trends in eastern Kamchatka, the Commander Islands, and the western Bering Sea. The largest decline in Steller sea lions in Russia has been in the western Bering Sea (which has no rookeries), where non-pup counts declined 98% between 1982 and 2010. Regions in Russia that have either stable or declining counts of pups and non-pups are adjacent to regions in the U.S. with similar trends (Aleutian Islands west of 170°W). Results from surveys conducted in 2013 and 2015 will be available soon and included in a future Stock Assessment Report.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

There are no estimates of the maximum net productivity rate for Steller sea lions. Hence, until additional data become available, it is recommended that the theoretical maximum net productivity rate (R_{MAX}) for pinnipeds of 12% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.1, the default value for stocks listed as endangered under the ESA (Wade and Angliss 1997). Thus, for the U.S. portion of the western stock of Steller sea lions, PBR = 306 animals (50,983 × 0.06 × 0.1).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

Between 2010 and 2014, mortality and serious injury of western Steller sea lions was observed in the following 8 fisheries of the 22 federally-regulated commercial fisheries in Alaska that are monitored for incidental mortality and serious injury by fisheries observers: Bering Sea/Aleutian Islands Atka mackerel trawl, Bering Sea/Aleutian Islands flatfish trawl, Bering Sea/Aleutian Islands Pacific cod trawl, Bering Sea/Aleutian Islands pollock trawl, Bering Sea/Aleutian Islands Pacific cod longline, Gulf of Alaska Pacific cod trawl, Gulf of Alaska Pacific cod longline, and Gulf of Alaska sablefish longline fisheries (Table 2; Breiwick 2013; MML, unpubl. data).

Observers also monitored the Alaska State-managed Prince William Sound salmon drift gillnet fishery in 1990 and 1991, recording two mortalities in 1991, extrapolated to 29 (95% CI: 1-108) for the entire fishery (Wynne et al. 1992). No mortality or serious injury was observed during 1990 for this fishery (Wynne et al. 1991), resulting in a mean annual mortality rate of 15 (CV = 1.0) sea lions for 1990 and 1991. It is not known whether this incidental mortality and serious injury rate is representative of the current rate in this fishery.

Combining the mortality and serious injury estimates from the Bering Sea/Aleutian Islands groundfish trawl, Bering Sea/Aleutian Islands longline, Gulf of Alaska groundfish trawl, and Gulf of Alaska longline fisheries (15) with the estimate from the Prince William Sound salmon drift gillnet fishery (15) results in an estimated mean annual mortality and serious injury rate of 30 sea lions from this stock in observed U.S. commercial fisheries (Table 2).

Table 2. Summary of incidental mortality and serious injury of Western U.S. Steller sea lions due to U.S. commercial fisheries in 2010-2014 (or the most recent data available) and calculation of the mean annual mortality and serious injury rate (Wynne et al. 1991, 1992; Breiwick 2013; MML, unpubl. data). N/A indicates that data are not available. Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Is. Atka mackerel trawl	2010 2011 2012 2013 2014	obs data	100 99 99 99 99	1 0 0 0 0	1 0 0 0 0	0.2 (CV = 0.05)
Bering Sea/Aleutian Is. flatfish trawl	2010 2011 2012 2013 2014	obs data	99 100 99 99 99	4 (+1)[a] 7 6 7 5	4 (+1)[b] 7 6.0 7.1 5.0	5.8 (+0.2)[c] (CV = 0.01)
Bering Sea/Aleutian Is. Pacific cod trawl	2010 2011 2012 2013 2014	obs data	66 60 68 80 80	1 1 0 1 0	1 1.0 0 1.9 0	0.8 (CV = 0.34)
Bering Sea/Aleutian Is. pollock trawl	2010 2011 2012 2013 2014	obs data	86 98 98 97 98	5 9 7 (+1)[d] 5 2	8.2 9.3 7 (+1)[e] 5.1 2.1	6.3 (+0.2)[f] (CV = 0.09)
Bering Sea/Aleutian Is. Pacific cod longline	2010 2011 2012 2013 2014	obs data	64 57 51 66 64	0 0 0 0 1	0 0 0 0 1.7	0.3 (CV = 0.64)
Gulf of Alaska Pacific cod longline	2010 2011 2012 2013 2014	obs data	29 30 13 29 31	1 0 0 0 0	1.1 0 0 0 0	0.2 (CV = 0.33)
Gulf of Alaska Pacific cod trawl	2010 2011 2012 2013 2014	obs data	31 41 25 10 12	0 0 1 0 0	0 0 1 0 0	0.2 (CV = 0)
Gulf of Alaska sablefish longline	2010 2011 2012 2013 2014	obs data	15 14 14 14 19	0 0 1 0 0	0 0 5.5 0 0	1.1 (CV = 0.89)

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Prince William Sound salmon drift gillnet	1990 1991	obs data	4 5	0 2	0 29	15 (CV = 1.0)
Minimum total estimated annual mortality						30 (CV = 0.50)

[a]Total mortality and serious injury observed in 2010: 4 sea lions in sampled hauls + 1 sea lion in an unsampled haul.
[b]Total estimate of mortality and serious injury in 2010: 4 sea lions (extrapolated estimate from 4 sea lions observed in sampled hauls) + 1 sea lion (1 sea lion observed in an unsampled haul).
[c]Mean annual mortality and serious injury for fishery: 5.8 sea lions (mean of extrapolated estimates from sampled hauls) + 0.2 sea lions (mean of number observed in unsampled hauls).
[d]Total mortality and serious injury observed in 2012: 7 sea lions in sampled hauls + 1 sea lion in an unsampled haul.
[e]Total estimate of mortality and serious injury in 2012: 7 sea lions (extrapolated estimate from 7 sea lions observed in sampled hauls) + 1 sea lion (1 sea lion observed in an unsampled haul).
[f]Mean annual mortality and serious injury for fishery: 6.3 sea lions (mean of extrapolated estimates from sampled hauls) + 0.2 sea lions (mean of number observed in unsampled hauls).

Reports from the NMFS Alaska Region stranding network of Steller sea lions entangled in fishing gear or with injuries caused by interactions with gear are another source of mortality and serious injury data (Table 3; Helker et al. 2016). During 2010 to 2014, there were five reports of a Steller sea lion in poor body condition with a flasher lure hanging from its mouth and, in each case, the animal was believed to have ingested the hook (Table 3). An additional animal was hooked by longline gear and two animals were entangled in unidentified fishing gear. Fishery-related strandings in these unknown (commercial, recreational, or subsistence) fisheries during 2010-2014 resulted in a minimum mean annual mortality and serious injury rate of 1.6 animals from this stock (Table 3). This estimate is considered a minimum because not all entangled animals strand and not all stranded animals are found or reported. Additionally, since Steller sea lions from parts of the western stock are known to travel to parts of Southeast Alaska to forage, and higher rates of entanglement of Steller sea lions have been observed in this area (e.g., Raum-Suryan et al. 2009), estimates based solely on stranding reports in areas west of 144°W longitude may underestimate the total entanglement of western stock animals in fishery-related and other marine debris.

Table 3. Summary of Western U.S. Steller sea lion mortality and serious injury, by year and type, reported to the NMFS Alaska Region marine mammal stranding network and Alaska Department of Fish and Game in 2010-2014 (Helker et al. 2016).

Cause of injury	2010	2011	2012	2013	2014	Mean annual mortality
Hooked by Gulf of Alaska longline gear*	1	0	0	0	0	0.2
Hooked by Southcentral Alaska salmon troll gear*	0	1	0	0	1	0.4
Hooked by Alaska Peninsula troll gear*	0	0	0	1	0	0.2
Hooked by troll gear*	0	0	2	0	0	0.4
Entangled in unidentified fishing gear*	0	0	1	0	1	0.4
Entangled in marine debris	5	1	2	0	3	2.2
Struck by arrow	0	0	0	1	0	0.2
Entangled in commercial Kodiak salmon hatchery net	0	0	0	1	0	0.2
*Total in unknown (commercial, recreational, or subsistence) fisheries						1.6
Total in marine debris						2.2
Total due to other causes (arrow strike, entangled in hatchery net)						0.4

NMFS studies using satellite-tracking devices attached to juvenile and adult female Steller sea lions suggest that these two age/sex classes rarely go beyond the U.S. Exclusive Economic Zone into international waters (Merrick and Loughlin 1997; Lander et al. 2009, 2011a, 2011b). Little is known about the at-sea distribution of sub-adult and adult males, however, since there have been no satellite-tracking devices attached to them. In the 1980s and 1990s, Steller sea lions of unknown sex and age were observed in international waters of the North Pacific Ocean and Bering Sea, but it is unclear how important these areas are for foraging (Himes-Boor and Small 2012).

The minimum average annual estimated mortality and serious injury rate incidental to U.S. commercial fisheries is 30 Steller sea lions. The minimum average annual mortality and serious injury rate for all fisheries, based on observer data (30 sea lions) for commercial fisheries and stranding data (1.6 sea lions) for unknown (commercial, recreational, or subsistence) fisheries is 32 western Steller sea lions. Observer data for state fisheries are from 1990-1991; however, these are the best data available to estimate takes in these fisheries. No observers have been assigned to several fisheries that are known to interact with this stock, thus, the estimated mortality and serious injury is likely an underestimate of the actual level.

Alaska Native Subsistence/Harvest Information

Information on the subsistence harvest of Steller sea lions comes via two sources: the Alaska Department of Fish and Game (ADF&G) and the Ecosystem Conservation Office (ECO) of the Aleut Community of St. Paul. The ADF&G conducted systematic interviews with hunters and users of marine mammals in approximately 2,100 households in about 60 coastal communities within the geographic range of the Steller sea lion in Alaska (Wolfe et al. 2005, 2006, 2008, 2009a, 2009b). The interviews were conducted once per year in the winter (January to March) and covered hunter activities for the previous calendar year. As of 2009, annual statewide data on community subsistence harvests are no longer being consistently collected. Data are being collected periodically in subareas. Data were collected on the Alaska Native harvest of Western U.S. Steller sea lions for 7 communities on Kodiak Island in 2011 and 15 communities in Southcentral Alaska in 2014. The Alaska Native Harbor Seal Commission (ANHSC) and ADF&G estimated a total of 20 adult sea lions were harvested on Kodiak Island in 2011, with a 95% confidence range between 15 and 28 animals (Wolfe et al. 2012), and 7.9 sea lions (CI = 6-15.3) were harvested in Southcentral Alaska in 2014, with adults comprising 84% of the harvest (ANHSC 2015). These estimates do not represent a comprehensive statewide estimate; therefore, the best available statewide subsistence harvest estimates for a 5-year period are those from 2004 to 2008. Therefore, the most recent 5 years of data available (2004-2008) will be retained and used for calculating an annual mortality and serious injury estimate for all areas except St. Paul. Data from St. Paul are still being collected and will be updated with the most recent 5 years of data available. The ECO collects data on the harvest in near real-time on St. Paul Island and records hunter activities within 36 hours of the harvest (Lestenkof 2011). Information on subsistence harvest levels is provided in Table 4; data from ECO (e.g., Lestenkof 2011) are relied upon as the source of data for St. Paul Island and all other data are from the ADF&G (e.g., Wolfe et al. 2005). The most recent 5 years of data from St. Paul are from 2010 to 2014 (Lestenkof 2011, 2012).

The mean annual subsistence take from this stock for all areas except St. Paul in 2004-2008 (172) combined with the mean annual take for St. Paul in 2010-2014 (29) is 201 western Steller sea lions (Table 4).

Table 4. Summary of the subsistence harvest data for Western U.S. Steller sea lions. As of 2009, data on community subsistence harvests are no longer being consistently collected. Therefore, the most recent 5 years of data (2004-2008) will be retained and used for calculating an annual mortality and serious injury estimate for all areas except St. Paul. Data from St. Paul are still being collected and will be updated with the most recent 5 years of data available (2010-2014). N/A indicates that data are not available.

	All areas except St. Paul Island			St. Paul Island
Year	**Number harvested**	**Number struck and lost**	**Total**	**Number harvested + Number struck and lost**
2004	136.8	49.1	185.9[a]	
2005	153.2	27.6	180.8[b]	
2006	114.3	33.1	147.4[c]	
2007	165.7	45.2	210.9[d]	
2008	114.7	21.6	136.3[e]	
2009	N/A	N/A	N/A	
2010	N/A	N/A	N/A	20[f]
2011	N/A	N/A	N/A	32[g]

	All areas except St. Paul Island			St. Paul Island
Year	**Number harvested**	**Number struck and lost**	**Total**	**Number harvested + Number struck and lost**
2012	N/A	N/A	N/A	24[h]
2013	N/A	N/A	N/A	34[h]
2014	N/A	N/A	N/A	35[h]
Mean annual take	136.9	35.3	172.3	29

[a]Wolfe et al. (2005); [b]Wolfe et al. (2006); [c]Wolfe et al. (2008); [d]Wolfe et al. (2009a); [e]Wolfe et al. (2009b); [f]Lestenkof (2011); [g]Lestenkof (2012); [h]ADF&G, unpubl. data.

Other Mortality

Reports from the NMFS Alaska Region stranding network of Steller sea lions entangled in marine debris or with injuries caused by other types of human interaction are another source of mortality and serious injury data. From 2010 to 2014, 11 animals were observed entangled in marine debris, 1 animal was struck by an arrow, and 1 entangled in a commercial Kodiak salmon hatchery net (Table 3; Helker et al. 2016). The minimum mean annual mortality and serious injury rate from these sources of human interactions in 2010-2014 is 2.6 sea lions from this stock.

Mortality and serious injury may occasionally occur incidental to marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. In 2011, there were two reports of mortality incidental to research on the Western U.S. stock of Steller sea lions (Division of Permits and Conservation, Office of Protected Resources, NMFS, 1315 East-West Highway, Silver Spring, MD 20910), resulting in a mean annual mortality and serious injury rate of 0.4 sea lions from this stock in 2010-2014.

STATUS OF STOCK

The current mean annual U.S. commercial fishery-related mortality and serious injury rate (30 sea lions) is less than 10% of the PBR (10% of PBR = 31) and, therefore, can be considered insignificant and approaching a zero mortality and serious injury rate. Based on available data, the total estimated annual level of human-caused mortality and serious injury (236 sea lions) is below the PBR level (306) for this stock. The Western U.S. stock of Steller sea lions is currently listed as endangered under the ESA and, therefore, designated as depleted under the MMPA. As a result, the stock is classified as a strategic stock. However, the population previously declined for unknown reasons that are not explained by the documented level of direct human-caused mortality and serious injury.

HABITAT CONCERNS

Many factors have been suggested as causes of the steep decline in abundance of western Steller sea lions observed in the 1980s, including competitive effects of fishing, environmental change, disease, contaminants, killer whale predation, incidental take, and illegal and legal shooting (Atkinson et al. 2008, NMFS 2008). Potential threats to Steller sea lion recovery are shown in Table 5. A number of management actions have been implemented since 1990 to promote the recovery of the Western U.S. stock of Steller sea lions, including 3 nautical mile no-entry zones around rookeries, prohibition of shooting at or near sea lions, and regulation of fisheries for sea lion prey species (e.g., walleye pollock, Pacific cod, and Atka mackerel; see reviews by Fritz et al. 1995, McBeath 2004, Atkinson et al. 2008, NMFS 2008).

Table 5. Potential threats and impacts to Steller sea lion recovery and associated references. Threats and impacts to recovery as described by the Revised Steller Sea Lion Recovery Plan (NMFS 2008). Reference examples identify research related to corresponding threats and may or may not support the underlying hypotheses.

Threat	Impact on Recovery	Level of Uncertainty	Reference Examples
Environmental variability	Potentially high	High	Trites and Donnelly 2003, Fritz and Hinckley 2005
Competition with fisheries	Potentially high	High	Fritz and Ferrero 1998, Hennen 2004, Fritz and Brown 2005, Dillingham et al. 2006
Predation by killer whales	Potentially high	High	Springer et al. 2003, Williams et al. 2004, DeMaster et al. 2006, Trites et al. 2007
Toxic substances	Medium	High	Calkins et al. 1994, Lee et al. 1996, Albers and Loughlin 2003
Incidental take by fisheries	Low	High	Wynne et al. 1992, Nikulin and Burkanov 2000, Perez 2006
Subsistence harvest	Low	Low	Haynes and Mishler 1991, Loughlin and York 2000, Wolfe et al. 2005
Illegal shooting	Low	Medium	Loughlin and York 2000, NMFS 2001
Entanglement in marine debris	Low	Medium	Calkins 1985
Disease and parasitism	Low	Medium	Burek et al. 2005
Disturbance from vessel traffic and tourism	Low	Medium	Kucey and Trites 2006
Disturbance or mortality due to research activities	Low	Low	Calkins and Pitcher 1982, Loughlin and York 2000, Kucey 2005, Kucey and Trites 2006, Atkinson et al. 2008, Wilson et al. 2012

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STELLER SEA LION (*Eumetopias jubatus*): Eastern U.S. Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Steller sea lions range along the North Pacific Rim from northern Japan to California (Loughlin et al. 1984), with centers of abundance and distribution in the Gulf of Alaska and Aleutian Islands (Fig. 1). Individual sea lions disperse widely outside of the breeding season (late May-early July), probably to access seasonally important prey resources. This results in marked seasonal patterns of abundance in some parts of the range and potential for intermixing of eastern and western stock sea lions in foraging areas (Sease and York 2003). Despite the wide-ranging movements of juveniles and adult males in particular, exchange between rookeries by breeding adult females and males (other than between adjoining rookeries) is low, although males have a higher tendency to disperse than females (NMFS 1995, Trujillo et al. 2004, Hoffman et al. 2006, Jemison et al. 2013). A northward shift in the overall breeding distribution has occurred, with a contraction of the range in southern California and new rookeries established in Southeast Alaska (Pitcher et al. 2007).

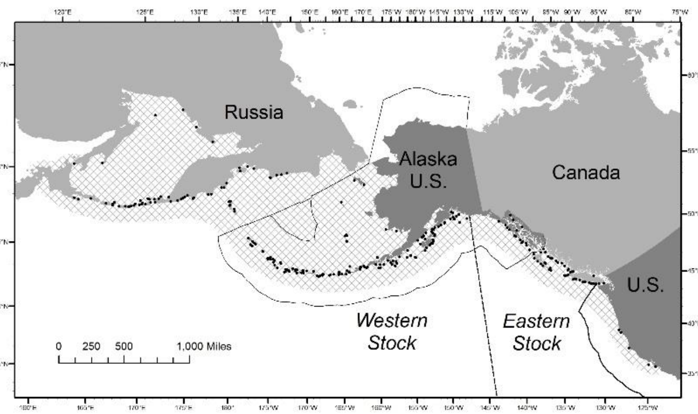

Figure 1. Generalized distribution (crosshatched area) of Steller sea lions in the North Pacific and major U.S. haulouts and rookeries (50 CFR 226.202, 27 August 1993), as well as active Asian and Canadian (British Columbia) haulouts and rookeries (points: Burkanov and Loughlin 2005; S. Majewski, Fisheries and Oceans Canada, pers. comm.). Black dashed line (144°W) indicates stock boundary (Loughlin 1997) and solid black line delineates U.S. Exclusive Economic Zone.

Loughlin (1997) considered the following information when classifying stock structure based on the phylogeographic approach of Dizon et al. (1992): 1) Distributional data: geographic distribution continuous, yet a high degree of natal site fidelity and low (<10%) exchange rate of breeding animals among rookeries; 2) Population response data: substantial differences in population dynamics (York et al. 1996); 3) Phenotypic data: differences in the length of pups (Merrick et al. 1995, Loughlin 1997); and 4) Genotypic data: substantial differences in mitochondrial DNA (Bickham et al. 1996). Based on this information, two separate stocks of Steller sea lions were recognized within U.S. waters: an Eastern U.S. stock, which includes animals born east of Cape Suckling, Alaska (144°W), and a Western U.S. stock, which includes animals born at and west of Cape Suckling (Loughlin 1997; Fig. 1). However, Jemison et al. (2013) summarized that there is regular movement of Steller sea lions from the western Distinct Population Segment (DPS) (males and females equally) and eastern DPS (almost exclusively males) across the DPS boundary. Most of this movement, but not all, is likely to access seasonally available, but important, prey resources as discussed above.

All genetic analyses (Baker et al. 2005; Harlin-Cognato et al. 2006; Hoffman et al. 2006, 2009; O'Corry-Crowe et al. 2006) confirm a strong separation between western and eastern stocks and there may be sufficient morphological differentiation to support elevating the two recognized stocks to subspecies (Phillips et al. 2009). However, a recent review by Berta and Churchill (2012) characterized the status of these subspecies assignments as "tentative" and requiring further attention before their status can be determined. Phillips et al. (2011) addressed the effect of climate change, in the form of glacial events, on the evolution of Steller sea lions and reported that the effective population size at the time of the event determines the impact of change on the population. The results suggested that during glacial periods, dispersal events were correlated with historically low effective population sizes, whereas range fragmentation type events were correlated with larger effective population sizes. This work again reinforced the stock delineation concept by noting that ancient population subdivision likely led to the sequestering of most mtDNA haplotypes as DPS or subspecies-specific (Phillips et al. 2011).

In 1998, a single Steller sea lion pup was observed on Graves Rock just north of Cross Sound in Southeast Alaska, and within 15 years (2013) pup counts had increased to 551 (DeMaster 2014). Mitochondrial and microsatellite analysis of pup tissue samples collected in 2002 revealed that approximately 70% of the pups had mtDNA haplotypes that were consistent with those found in the western stock (Gelatt et al. 2007). Similarly, a rookery to the south on the White Sisters Islands, where pups were first noted in 1990, was also sampled in 2002 and approximately 45% of those pups had western stock haplotypes. Collectively, this information demonstrates that these two most recently established rookeries in northern Southeast Alaska have been partially to predominately established by western stock females. While movements of animals marked as pups in both stocks support these genetic results (Jemison et al. 2013), overall the observations of marked sea lion movements corroborate the extensive genetic research findings for a strong separation between the two currently recognized stocks. O'Corry-Crowe et al. (2014) concluded that the results of their study of the genetic characteristics of pups born on these new rookeries "demonstrates that resource limitation may trigger an exodus of breeding animals from declining populations, with substantial impacts on distribution and patterns of genetic variation. It also revealed that this event is rare because colonists dispersed across an evolutionary boundary, suggesting that the causative factors behind recent declines are unusual or of larger magnitude than normally occur." Thus, although recent colonization events in the northern part of the eastern DPS indicate movement of western sea lions into this area, the mixed part of the range remains small (Jemison et al. 2013) and the overall discreteness of the eastern from the western stock remains distinct. Hybridization among subspecies and species along a contact zone such as now occurs near the stock boundary is not unexpected as the ability to interbreed is a primitive condition whereas reproductive isolation would be derived. In fact as stated by NMFS and the U.S. Fish and Wildlife Service (USFWS) in a 1996 response to a previous comment regarding stock discreteness policy (61 FR 47222), "*The Services do not consider it appropriate to require absolute reproductive isolation as a prerequisite to recognizing a distinct population segment*" or stock. The fundamental concept overlying this distinctiveness is the collection of morphological, ecological and behavioral, and genetic evidence for stock differences initially described by Bickham et al. (1996) and Loughlin (1997), and supported by Baker et al. (2005), Harlin-Cognato et al. (2006), Hoffman et al. (2006, 2009), O'Corry-Crowe et al. (2006), and Phillips et al. (2009, 2011).

POPULATION SIZE

The eastern stock of Steller sea lions has historically bred on rookeries located in Southeast Alaska, British Columbia, Oregon, and California. However, within the last several years a new rookery has become established on the outer Washington coast (at the Carroll Island and Sea Lion Rock complex), with >100 pups born there in 2015 (R. DeLong and P. Gearin, NMFS-AFSC-MML, pers. comm.). Counts of pups on rookeries conducted near the end of the birthing season are nearly complete counts of pup production. The dates of the most recent aerial photographic and land-based surveys of eastern Steller sea lions have varied by region. Southeast Alaska was surveyed in June-July 2015 (Fritz et al. 2015), while counts used in population analyses for the contiguous U.S. (i.e., Washington, Oregon, and California) are from 2013 surveys and counts from Canada (i.e., British Columbia) are from the 2010 survey effort (NMFS, Fisheries and Oceans Canada, Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, unpubl. data). For trend and population estimates, we used agTrend (Johnson and Fritz 2014) to augment missing counts in order to estimate 2015 counts. The 2015 estimated total eastern stock pup count is 19,423 (95% credible interval of 16,318-23,309). The 2015 estimated total eastern stock non-pup count is 52,139 (95% confidence interval of 45,428-59,711); this estimate does not account for animals at sea.

Minimum Population Estimate

Because of the uncertainty regarding the use of a pup multiplier or haulout rate to estimate N, we use the best estimate of the total count of eastern Steller sea lions as the minimum population estimate (N_{MIN}). The agTrend (Johnson and Fritz 2014) total count estimate of pups and non-pups for the entire eastern stock of Steller sea lions in 2015 is 71,562 (52,139 non-pups plus 19,423 pups). The estimated U.S. total count of the eastern stock of Steller sea lions is 41,638 (30,917 non-pups plus 10,721 pups; Table 1) and it will be used as the N_{MIN}. These counts are considered minimum estimates of population size because they have not been corrected for animals that are at sea during the surveys.

Current Population Trend

Using agTrend, we modeled the most recent count data to estimate annual trends from 1989 to 2015. This model indicates the eastern stock of Steller sea lions increased at a rate of 4.76% per year (95% confidence intervals of 4.09-5.45%) between 1989 and 2015 based on an analysis of pup counts in California, Oregon, British Columbia, and Southeast Alaska (Table 1, Figs. 2 and 3). A similar analysis of non-pup counts in the same regions plus Washington yielded an estimate of population increase of 2.84% per year (95% confidence intervals of 2.36-3.33%). Pitcher et al. (2007) reported that the Eastern U.S. stock increased at a rate of 3.1% per year during a 25-year time period from 1977 to 2002; however, they used a slightly different method to estimate population growth than the methods reported in NMFS (2013). The Eastern U.S. stock increase has been driven by growth in pup counts in all regions (NMFS 2013).

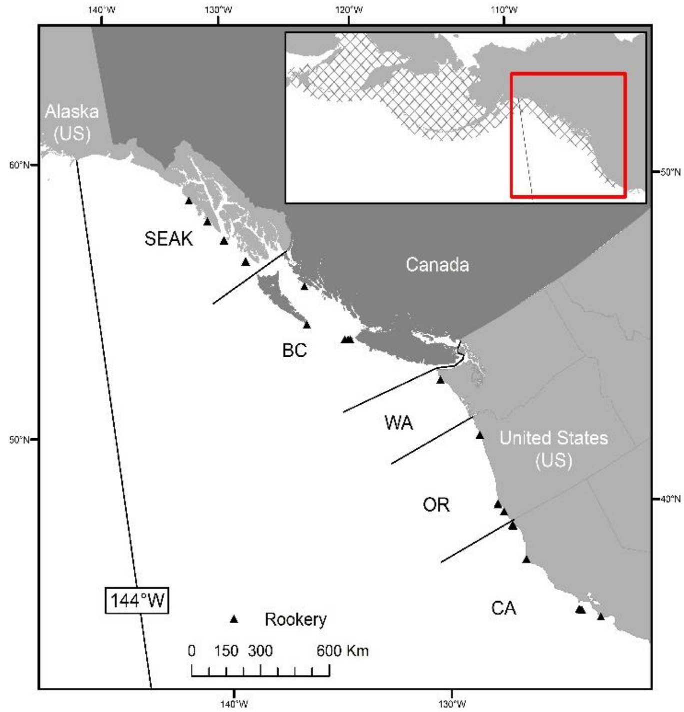

Figure 2. The eastern Steller sea lion rookery sites by region: SEAK (Southeast Alaska), BC (British Columbia, Canada), WA (Washington State), OR (Oregon State), and CA (California State).

Table 1. Trends (annual rates of change expressed as % y^{-1} with 95% credible interval) in estimated counts of eastern Steller sea lion non-pups (adults and juveniles) and pups, by region and total population, for the period 1989-2015 (Johnson and Fritz 2014, Fritz et al. 2015). The agTrend estimated counts of non-pups and pups by region and the overall counts in 2015 are also shown. Total eastern stock counts are slightly greater than the sums of the regional counts due to the modeling process.

	Non-pups					**Pups**			
Region	**Trend**	**-95%**	**+95%**	**2015**		**Trend**	**-95%**	**+95%**	**2015**
California, U.S.	1.95	0.36	3.53	3,120		3.82	2.47	5.05	936
Oregon, U.S.	2.39	1.08	3.54	5,634		3.80	2.58	5.03	1,946
Washington, U.S.*	8.77	6.00	11.37	1,407					
British Columbia, Canada	3.43	2.64	4.22	20,689		7.89	6.22	9.61	8,630
Southeast Alaska, U.S.	2.33	1.54	3.07	20,756		3.20	2.59	3.82	7,838
Total Eastern Stock	2.84	2.36	3.33	52,139		4.76	4.09	5.45	19,423
Total U.S. Eastern Stock				30,917					10,721

*NMFS has never observed Steller sea lion pups born on known sites in Washington except within the last several years. A new rookery has become established on the outer Washington coast (at the Carroll Island and Sea Lion Rock complex), with a confirmed count of 45 pups in 2013 and >100 pups born there in 2015 (R. DeLong and P. Gearin, NMFS-AFSC-MML, pers. comm.).

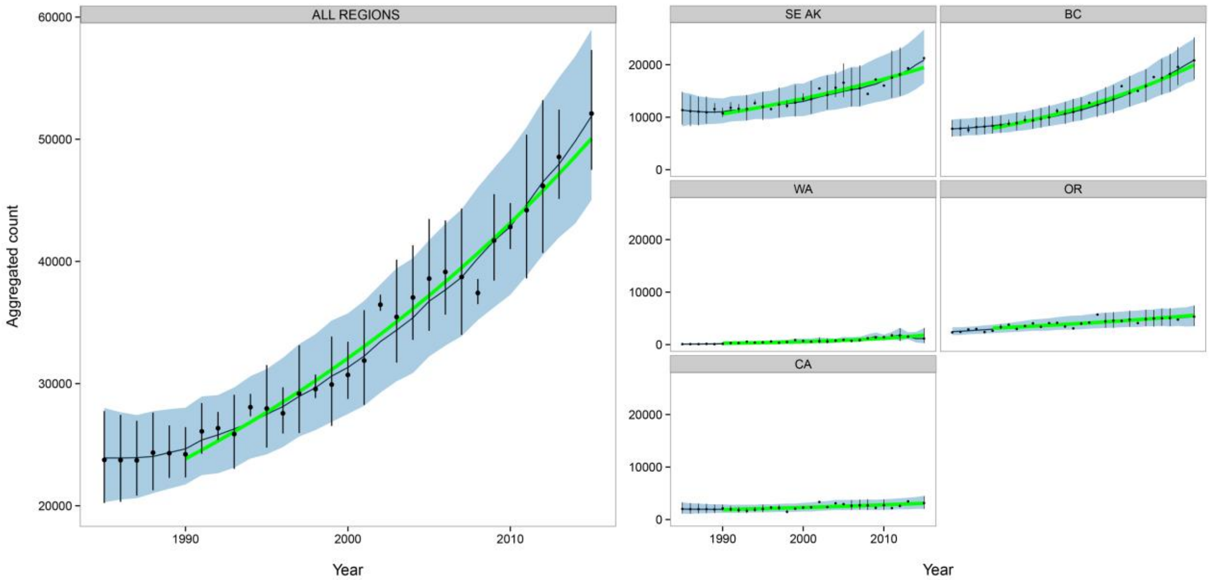

Figure 3. Estimated counts (modeled with agTrend) of eastern Steller sea lion non-pups (adults and juveniles) for the period from 1989 to 2015, with estimated trend (green line) from 1990 to 2015 for all regions and for the five separate regions: Southeast Alaska (SEAK), British Columbia (BC), Washington (WA), Oregon (OR), and California (CA) (Johnson and Fritz 2014, Fritz et al. 2015).

While the eastern stock of Steller sea lions has been increasing in all regions from 1990 to 2015, the most significant growth has been observed in Southeast Alaska and British Columbia, Canada (Fig. 3). These two regions comprise almost 85% of the total eastern stock count. Non-pups in Oregon and Washington have been increasing since 1990, though at a lower rate. Non-pup counts in California ranged between 4,000 and 6,000 with no apparent trend from 1927 to 1947 but subsequently declined. At Año Nuevo Island off central California, a steady decline in abundance began in 1970, and there was an 85% reduction in the breeding population by 1987 (LeBoeuf et al. 1991). Non-pup counts increased slightly from 1989 to 2015, ranging from approximately 2,000 to 3,100.

The net magnitude of Steller sea lion movements during the breeding season between the eastern and western stocks appears to be relatively small and would have a negligible impact on non-pup trend estimates in either area (Fritz et al. 2013, Jemison et al. 2013). However, there were significant differences by sex in cross-boundary movements: for females, there was a net increase of ~600 in the east and very few moved from east to west, while males moved in both directions but with a net increase of ~500 males in the west. This pattern of movement is supported by mitochondrial DNA evidence that indicated that the newest rookeries in northern Southeast Alaska (eastern stock) were colonized in part by western females (Gelatt et al. 2007, O'Corry-Crowe et al. 2014).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

There are no estimates of the maximum net productivity rate for Steller sea lions. Pitcher et al. (2007) observed a rate of population increase of 3.1% per year for the eastern stock but concluded this rate did not represent a maximum rate of increase. NMFS (2013) estimated that the eastern stock increased at rates of 4.18% per year using pup counts and 2.99% per year using non-pup counts between 1979 and 2009. Here, we estimated that counts of pups and non-pups increased at rates of 4.76% and 2.84% per year, respectively, between 1989 and 2015 (Table 1). Until additional data become available, it is recommended that the theoretical maximum net productivity rate (R_{MAX}) for pinnipeds of 12% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. On 4 December 2013, the eastern stock of Steller sea lions was removed from the list of threatened species under the Endangered Species Act (ESA; 78 FR 66140, 4 November 2013). NMFS' decision to delist this species was based on the information presented in the Status Review (NMFS 2013), the factors for delisting in section 4(a)(1) of the ESA, the biological and threats-based recovery criteria in the 2008 Recovery Plan (NMFS 2008), the continuing efforts to protect the species, and information received during public comment and peer review. NMFS' consideration of this information led to a determination that the eastern population has recovered and no longer meets the definition of a threatened species under the ESA. As recently noted within the humpback whale ESA listing final rule (81 FR 62259, 8 September 2016), in the case of a species or stock that achieved its depleted status solely on the basis of its ESA status, such as the eastern stock of Steller sea lions, the species or stock would cease to qualify as depleted under the terms of the definition set forth in MMPA Section 3(1) if the species or stock is no longer listed as threatened or endangered. Therefore, NMFS considers this stock not to be depleted; the recovery factor is 1.0 (recovery factor for a stock within its Optimum Sustainable Population), and the PBR = 2,498 (41,638 × 0.06 × 1.0).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries is presented in Appendices 3-6 of the Alaska Stock Assessment Reports (for fisheries in Alaska waters) and Appendix 1 of the U.S. Pacific Stock Assessment Reports (for fisheries in Washington, Oregon, and California waters).

During 2010-2014, no incidental mortality or serious injury of eastern Steller sea lions was observed in the 22 federally-regulated commercial fisheries in Alaska monitored for incidental mortality by fisheries observers (Breiwick 2013; MML, unpubl. data).

U.S. West Coast groundfish fishery observers monitored three federally-regulated commercial fisheries in 2010-2013 in which Steller sea lions from this stock were taken incidentally: the Washington/Oregon/California (WA/OR/CA) groundfish bottom trawl, WA/OR/CA groundfish midwater trawl (shoreside hake sector), and WA/OR/CA midwater trawl (at-sea hake sector) fisheries, resulting in a mean annual mortality and serious injury rate of 14 Steller sea lions from this stock (Table 2; Jannot et al. 2016).

The estimated mean annual mortality and serious injury rate incidental to U.S. commercial fisheries is 14 eastern Steller sea lions, based on observer data for 2010-2013 (Table 2). Due to limited observer program coverage, no data exist on the mortality of marine mammals incidental to Canadian commercial fisheries (i.e., those similar to U.S. fisheries known to take Steller sea lions). As a result, the number of Steller sea lions taken in Canadian waters is not known.

Table 2. Summary of incidental mortality and serious injury of Eastern U.S. Steller sea lions due to U.S. commercial fisheries in 2010-2013 (Jannot et al. 2016) and calculation of the mean annual mortality and serious injury rate.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
WA/OR/CA groundfish (bottom trawl)[a]	2010 2011 2012 2013	obs data	18 100 100 100	7 20 7 5	7[b] 20 7 5	9.8
WA/OR/CA groundfish (midwater trawl - shoreside hake sector)[c]	2011 2012 2013	obs data	100 100 100	1 0 0	1 0 0	0.3
WA/OR/CA groundfish (midwater trawl - at-sea hake sector)	2010 2011 2012 2013	obs data	100 100 100 100	9 2 1 2	9 2 1 2	3.5
Minimum total estimated annual mortality						14

[a]The bottom trawl fishery was a limited entry fishery in 2010 and a catch shares fishery in 2011-2013.
[b]The observed mortality and serious injury for this fishery will be used until published estimates are available.
[c]Fishery observers began monitoring the shoreside hake sector of the fishery in 2011.

Reports to the NMFS Alaska Region stranding network and the Alaska Department of Fish and Game (ADF&G) of Steller sea lions entangled in fishing gear or with injuries caused by interactions with gear provide additional information on fishery-related mortality and serious injury (Table 3; Helker et al. 2016). During 2010-2014, one Steller sea lion interaction with a recreational Southeast Alaska salmon troll fishery was reported, resulting in a minimum mean annual mortality and serious injury rate of 0.2 Steller sea lions per year in recreational troll fisheries. An additional 154 Steller sea lion interactions with troll fisheries were reported in 2010-2014 (including 11 that occurred in the Southeast Alaska salmon troll fishery and 99 that occurred in unidentified Southeast Alaska troll fisheries). In each case, animals had either ingested troll gear or were hooked in the mouth; however, it is not clear whether these interactions involved recreational or commercial components of the fisheries. Three of the animals that were seriously injured in the Southeast Alaska troll fisheries had dependent pups, so the pups were also considered seriously injured. Other fishery-related mortality and serious injury of eastern Steller sea lions in 2010-2014 was due to interactions with longline gear, monofilament gear, trawl gear, and unidentified fishing gear. The minimum mean annual mortality and serious injury rate due to all non-commercial fishery interactions reported to the NMFS Alaska Region and ADF&G in 2010-2014 is 38 eastern Steller sea lions: 0.2 in recreational fisheries + 38 in unknown (commercial, recreational, or subsistence) fisheries (Table 3; Helker et al. 2016). Estimates of fishery-related mortality and serious injury from stranding data are considered minimum estimates because not all entangled animals strand, and not all stranded animals are found or reported.

An additional four Steller sea lions initially considered seriously injured in a Yakutat salmon set gillnet (1 in 2011), Southeast Alaska pot gear (1 in 2012), Southeast Alaska salmon drift gillnet (1 in 2012), and marine debris (1 in 2014) were disentangled and released with non-serious injuries in Alaska waters, and one Steller sea lion pup with serious injuries caused by human harassment was rehabilitated and released with non-serious injuries in Washington waters in 2014 (Helker et al. 2016). None of these animals were included in the average annual mortality and serious injury rate for 2010-2014.

Table 3. Summary of Eastern U.S. Steller sea lion mortality and serious injury, by year and type, reported to the NMFS Alaska Region marine mammal stranding network and ADF&G in 2010-2014 (Helker et al. 2016).

Cause of injury	**2010**	**2011**	**2012**	**2013**	**2014**	**Mean annual mortality**
Hooked by recreational SE Alaska salmon troll gear	0	0	0	0	1	0.2
Hooked by Gulf of Alaska longline gear*	1	0	0	0	0	0.2
Entangled in SE Alaska halibut longline gear*	0	1	0	0	0	0.2
Entangled in SE Alaska longline gear*	0	1	0	0	0	0.2
Hooked by SE Alaska salmon troll gear*	0	0	0	3	8	2.2
Hooked by SE Alaska troll gear*	42	30	27	-	0	25[a]
Dependent pup of animal seriously injured by SE Alaska troll gear*	2	0	1	-	0	0.8[a]
Hooked by troll gear*	0	0	0	3	41	8.8
Entangled in SE Alaska monofilament gear*	1	1	0	0	0	0.4
Entangled in trawl gear*	0	0	0	0	1	0.2
Hooked by unidentified fishing gear*	0	0	2	0	0	0.4
Entangled in marine debris	25	32	24	-	26	27[b]
Dependent pup of animal seriously injured by marine debris	0	1	0	-	3	1[b]
Entangled in foreign high-seas gillnet	1	0	0	0	0	0.2
Gunshot[c]	-	-	15	16	14	15[d]
Struck by arrow	0	0	0	1	0	0.2
Explosives	0	0	0	0	1	0.2

Cause of injury	2010	2011	2012	2013	2014	Mean annual mortality
Total in recreational fisheries						0.2
*Total in unknown (commercial, recreational, or subsistence) fisheries						38
Total in marine debris						28
Total due to other sources (gunshot, arrow, foreign gillnet, explosives)						16

[a]A 4-year average (using the 2010-2012 and 2014 data) was calculated for this category, since we did not receive data on mortality and serious injury due to flasher entanglement (which is primarily assigned to SE Alaska troll gear) from the ADF&G in 2013. Although the NMFS Alaska Region did not assign any mortality and serious injury to SE Alaska troll gear in 2014, this mortality and serious injury is accounted for in the more general category of "troll gear" in 2014.
[b]A 4-year average (using 2010-2012 and 2014 data) was calculated for this category, since we did not receive data on mortality and serious injury due to marine debris entanglement from the ADF&G in 2013.
[c]Only animals reported to the NMFS West Coast Region are included in this table because animals reported to the NMFS Alaska Region are likely accounted for as "struck and lost" in the Alaska Native harvest.
[d]A 3-year average (using the 2012-2014 data) was calculated for this category, since we do not have gunshot data for 2010 and 2011.

The minimum estimated mean annual mortality and serious injury rate incidental to all fisheries in 2010-2014 is 52 Steller sea lions: 14 in U.S. commercial fisheries + 0.2 in recreational fisheries + 38 in unknown (commercial, recreational, or subsistence) fisheries.

Alaska Native Subsistence/Harvest Information

Information on the subsistence harvest of Steller sea lions is provided by the ADF&G. The ADF&G conducted systematic interviews with hunters and users of marine mammals in approximately 2,100 households in about 60 coastal communities within the geographic range of the Steller sea lion in Alaska in 2005-2008 (Wolfe et al. 2006, 2008, 2009a, 2009b). The interviews were conducted once per year in the winter (January to March) and covered hunter activities for the previous calendar year. Approximately 16 of the interviewed communities lie within the range of the Eastern U.S. stock. As of 2009, annual statewide data on community subsistence harvests are no longer being consistently collected. Data are being collected periodically in subareas. During 2010-2014, monitoring occurred only in 2012 (Wolfe et al. 2013), when one animal was landed and eight animals were struck and lost. Therefore, the most recent 5 years of data (2005-2008 and 2012) will be retained and used for calculating an annual mortality and serious injury estimate. The average number of animals harvested plus struck and lost is 11 animals per year during this 5-year period (Table 4).

An unknown number of Steller sea lions from this stock are harvested by subsistence hunters in Canada. The magnitude of the Canadian subsistence harvest is believed to be small (Fisheries and Oceans Canada 2010). Alaska Native subsistence hunters have initiated discussions with Canadian hunters to quantify their respective subsistence harvests, and to identify any effect these harvests may have on management of the stock.

Table 4. Summary of the subsistence harvest data for Eastern U.S. Steller sea lions in 2005-2008 and 2012. As of 2009, data on community subsistence harvests are no longer being consistently collected at a statewide level. Therefore, the most recent 5 years of data (2005-2008 and 2012) will be retained and used for calculating an annual mortality and serious injury estimate.

Year	Number harvested	Number struck and lost	Estimated total number taken
2005	0	19	19[a]
2006	2.5	10.1	12.6[b]
2007	0	6.1	6.1[c]
2008	1.7	8.0	9.7[d]
2012	1	8	9[e]
Mean annual take (2005-2008 and 2012)	1.0	10	11

[a]Wolfe et al. (2006); [b]Wolfe et al. (2008); [c]Wolfe et al. (2009a); [d]Wolfe et al. (2009b); [e]Wolfe et al. (2013).

Other Mortality

Illegal shooting of sea lions in U.S. waters was thought to be a potentially significant source of mortality prior to the listing of sea lions as threatened under the ESA in 1990. (Note: the 1994 amendments to the MMPA made intentional lethal take of any marine mammal illegal except for subsistence hunting by Alaska Natives or where imminently necessary to protect human life).

Steller sea lions were taken in British Columbia during commercial salmon farming operations. Preliminary figures from the British Columbia Aquaculture Predator Control Program indicated a mean annual mortality of 45.8 Steller sea lions from this stock over the period from 1999 to 2003 (Olesiuk 2004). Starting in 2004, aquaculture facilities were no longer permitted to shoot Steller sea lions (P. Olesiuk, Pacific Biological Station, Canada, pers. comm.). However, Fisheries and Oceans Canada (2010) summarized that "illegal and undocumented killing of Steller Sea Lions is likely to occur in B.C." and reported "[s]everal cases of illegal kills have been documented (Department of Fisheries and Oceans, Canada, unpubl. data), and mortality may also occur outside of the legal parameters assigned to permit holders (e.g., for predator control or subsistence harvest)" but "…data on these activities are currently lacking."

Steller sea lion mortality and serious injury caused by gunshot wounds is reported to the NMFS Alaska Region and the NMFS West Coast Region. During 2012-2014, 45 animals with gunshot wounds were reported to the NMFS West Coast Region stranding network, resulting in a minimum average annual mortality and serious injury rate of 15 Steller sea lions from this stock (Table 3; Helker et al. 2016). An additional two animals with gunshot wounds were reported to the NMFS Alaska Region in 2010. Although it is likely that illegal shooting does occur in Alaska, these events are not included in the estimate of the average annual mortality and serious injury rate due to gunshot wounds because it could not be confirmed that the deaths were due to illegal shooting and were not already accounted for in the estimate of animals struck and lost in the Alaska Native subsistence harvest. Other non-fishery human-caused mortality and serious injury reported to the NMFS Alaska Region stranding network in 2010-2014 (and the resulting minimum mean annual mortality and serious injury rates) were due to entanglement in marine debris (27), dependent pups of animals seriously injured by marine debris (1), entanglement in foreign gillnet (0.2), arrow strike (0.2), and explosives (0.2) (Table 3; Helker et al. 2016). These estimates are considered a minimum because not all stranded animals are found, reported, or cause of death determined (via necropsy by trained personnel), and human-related stranding data are not available for British Columbia.

Mortality and serious injury may occasionally occur incidental to marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. Three mortalities occurred incidental to research on the Eastern U.S. stock of Steller sea lions in 2011 (Division of Permits and Conservation, Office of Protected Resources, NMFS, 1315 East-West Highway, Silver Spring, MD 20910), resulting in a mean annual mortality and serious injury rate of 0.6 sea lions from this stock in 2010-2014.

The minimum mean annual human-caused mortality and serious injury rate in 2010-2014 from sources other than fisheries or Alaska Native harvest is 45 eastern Steller sea lions.

STATUS OF STOCK

Based on currently available data, the minimum estimated mean annual U.S. commercial fishery-related mortality and serious injury rate for this stock (14 sea lions) is less than 10% of the calculated PBR (10% of PBR = 250) and, therefore, can be considered to be insignificant and approaching a zero mortality and serious injury rate. The total estimated annual level of human-caused mortality and serious injury (108 sea lions) does not exceed the PBR (2,498) for this stock. The Eastern U.S. stock of Steller sea lions is currently not listed under the ESA and is not considered depleted under the MMPA. This stock is classified as a non-strategic stock. Because the counts of eastern Steller sea lions have steadily increased over a 30+ year period, this stock is likely within its Optimum Sustainable Population (OSP); however, no determination of its status relative to OSP has been made.

HABITAT CONCERNS

Unlike the Western U.S. stock of Steller sea lions, there has been a sustained and robust increase in abundance of the Eastern U.S. stock throughout its breeding range. In the southern end of its range (Channel Islands in southern California), it has declined considerably since the late 1930s and several rookeries and haulouts south of Año Nuevo Island have been abandoned. Changes in the ocean environment, particularly warmer temperatures, may be factors that have favored California sea lions over Steller sea lions in the southern portion of the Steller's range (NMFS 2008). The risk of oil spills to this stock may increase in the next several decades due to increased shipping, including tanker traffic, from ports in British Columbia and possibly Washington State (COSEWIC 2013, NMFS 2013, Wiles 2014) and LNG facility and pipeline construction (COSEWIC 2013).

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NORTHERN FUR SEAL (*Callorhinus ursinus*): Eastern Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

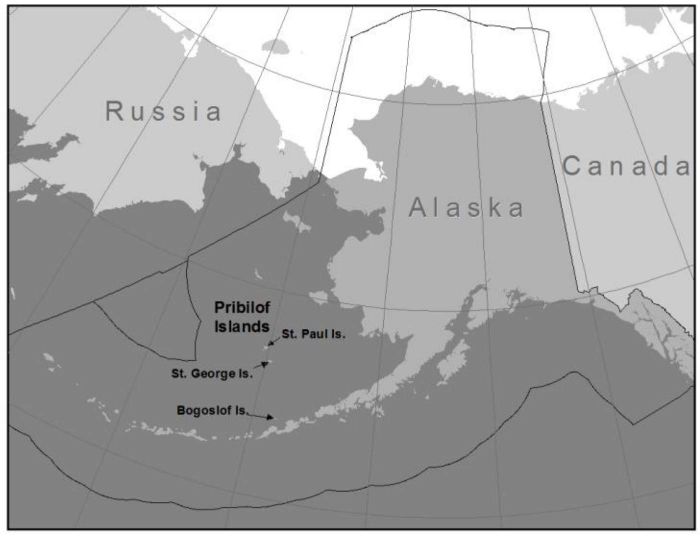

Figure 1. Approximate distribution of northern fur seals in the eastern North Pacific (dark shaded area).

Northern fur seals occur from southern California north to the Bering Sea (Fig. 1) and west to the Okhotsk Sea and Honshu Island, Japan. During the summer breeding season, most of the worldwide population is found on the Pribilof Islands in the southern Bering Sea, with the remaining animals on rookeries in Russia, on Bogoslof Island in the southern Bering Sea, on San Miguel Island off southern California (Lander and Kajimura 1982, NMFS 1993), and on the Farallon Islands off central California. Non-breeding northern fur seals may occasionally haul out on land at other sites in Alaska, British Columbia, and on islets along the west coast of the United States (Fiscus 1983).

During the reproductive season, adult males usually are on shore during the 4-month period from May to August, though some may be present until November (well after giving up their territories). Adult females are ashore during a 6-month period (June-November). Following their respective times ashore, fur seals of both genders then move south and remain at sea until the next breeding season (Roppel 1984). Adult females and pups from the Pribilof Islands move through the Aleutian Islands into the North Pacific Ocean, often to the waters offshore of Oregon and California. Adult males generally move only as far south as the Gulf of Alaska in the eastern North Pacific (Kajimura 1984) and the Kuril Islands in the western North Pacific (Loughlin et al. 1999). In Alaska, pups are born during summer months, leave the rookeries in the fall, on average around mid-November but ranging from late October to early December, and generally remain at sea for 22 months before returning to their rookery of birth. There is considerable interchange of individuals between rookeries.

Two separate stocks of northern fur seals are recognized within U.S. waters based on the distribution and population response factors of the Dizon et al. (1992) phylogeographic approach: 1) Distribution: continuous during non-breeding season and discontinuous during the breeding season, high natal site fidelity (DeLong 1982, Baker et al. 1995); 2) Population response: substantial differences in population dynamics between the Pribilof Islands and San Miguel Island (DeLong 1982, DeLong and Antonelis 1991, NMFS 1993); 3) Phenotypic differentiation: unknown; and 4) Genotypic differentiation: little evidence of genetic differentiation among breeding islands (Ream 2002, Dickerson et al. 2010). Thus, an Eastern Pacific stock and a California stock are recognized. The California stock is reported separately in the Stock Assessment Reports for the U.S. Pacific Region.

POPULATION SIZE

The population estimate for the Eastern Pacific stock of northern fur seals is calculated as the estimated number of pups born at rookeries in the eastern Bering Sea multiplied by a series of different expansion factors determined from a life table analysis to estimate the number of yearlings, 2-year-olds, 3-year-olds, and animals 4 or more years old (Lander 1981). The resulting population estimate is equal to the pup production estimate multiplied by 4.5. Juvenile northern fur seals are pelagic and are not included in the rookery counts. The expansion factor is based on a sex and age distribution estimated after the harvest of juvenile males was terminated. Coefficients of variation (CVs) are unavailable for the expansion factor. As the great majority of pups are born on St. Paul and St. George Islands, pup surveys are conducted biennially on these islands. Counts are available less frequently on Sea Lion Rock (adjacent to St. Paul Island) and Bogoslof Island (Table 1). The most recent estimate for the number of fur seals in the Eastern Pacific stock, based on pup counts on Sea Lion Rock (2014), on St. Paul and St. George

Islands (mean of 2010, 2012, and 2014), and on Bogoslof Island (2011), is 626,734 (4.47 × 140,209) northern fur seals.

Table 1. Estimates and/or counts of northern fur seal pups born on the Pribilof Islands and Bogoslof Island. Standard errors for pup estimates at rookery locations and the CV for total pup production estimates are provided in parentheses (direct counts do not have standard errors). The " symbol indicates that no new data are available for that year and, thus, the most recent prior estimate/count was used in determining total annual estimates.

	Rookery location				
Year	**St. Paul**	**Sea Lion Rock**	**St. George**	**Bogoslof**	**Total**
1992*	182,437 (8,919)	10,217 (568)	25,160 (707)	898 (N/A)	218,712 (0.041)
1994	192,104 (8,180)	12,891 (989)	22,244 (410)	1,472 (N/A)	228,711 (0.036)
1996	170,125 (21,244)	"	27,385 (294)	1,272 (N/A)	211,673 (0.10)
1998	179,149 (6,193)	"	22,090 (222)	5,096 (33)	219,226 (0.029)
2000	158,736 (17,284)	"	20,176 (271)	"	196,899 (0.089)
2002	145,716 (1,629)	8,262 (191)	17,593 (527)	"	176,667 (0.01)
2004	122,825 (1,290)	"	16,876 (239)	"	153,059 (0.01)
2005	"	"	"	12,631 (335)	160,594 (0.01)
2006	109, 961 (1,520)	"	17,072 (144)	"	147,900 (0.011)
2007	"	"	"	17,574 (843)	152,867 (0.011)
2008	102,674 (1,084)	6,741 (80)	18,160 (288)	"	145,149 (0.009)
2010	94,502 (1,259)	"	17,973 (323)	"	136,790 (0.011)
2011	"	"	"	22,905 (921.5)	142,121 (0.011)
2012	96,828 (1,260)	"	16,184 (155)	"	142,658 (0.011)
2014	91,737 (769)	5,250 (293)	18,937 (308)	"	138,829 (0.009)

*Incorporates the 1990 estimate for Sea Lion Rock and the 1993 count for Bogoslof Island.

Minimum Population Estimate

A CV(N) that incorporates the variance of the correction factor is not available. Consistent with a recommendation of the Alaska Scientific Review Group (SRG) in October 1997 (DeMaster 1998) and recommendations contained in Wade and Angliss (1997), a default CV(N) of 0.2 was used in the calculation of the minimum population estimate (N_{MIN}) for this stock. N_{MIN} is calculated using Equation 1 from the potential biological removal (PBR) guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the 3-year mean population estimate (N) of 626,734 and the default CV (0.2), N_{MIN} for the Eastern Pacific stock of northern fur seals is 530,474.

Current Population Trend

Estimates of the size of the Alaska population of northern fur seals increased to approximately 1.25 million in 1974 after the termination of commercial sealing on St. George in 1972 and pelagic sealing for science in 1974; commercial sealing on St. Paul continued until 1984. The population then began to decrease with pup production declining at a rate of 6.5-7.8% per year into the 1980s (York 1987). By 1983, the total stock estimate was 877,000

(Briggs and Fowler 1984). Annual pup production on St. Paul Island remained stable between 1981 and 1996 (Fig. 2; York and Fowler 1992). There has been a decline in pup production on St. Paul Island since the mid-1990s. Pup production at St. George Island had a less pronounced period of stabilization that was similarly followed by decline. However, pup production appeared to stabilize again on St. George Island beginning around 2002 (Fig. 3). During 1998-2014, pup production declined 4.25% per year (SE = 0.48%; P < 0.01) on St. Paul Island and 1.42% per year (SE = 0.54%; P = 0.04) on St. George Island. The estimated pup production in 2014 was below the 1917 level on both St. Paul and St. George Islands (MML, unpubl. data). Northern fur seal pup production at Bogoslof Island has grown at an exponential rate since the 1990s (Towell and Ream 2012). Despite continued growth at Bogoslof Island, recent estimates of pup production indicate that the rate of increase may be slowing. Between 2005 and 2011, pup production at Bogoslof Island increased 9.9% per year. Incorporation of the 2014 estimates from the Pribilofs shows a small and insignificant decline in pup production on the Pribilof Islands since 2010. Temporary increases in the overall stock size are observed when opportunistic estimates are conducted at Bogoslof, but declines at the larger Pribilof colony (specifically St. Paul) continue to drive the overall stock estimate down over time.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

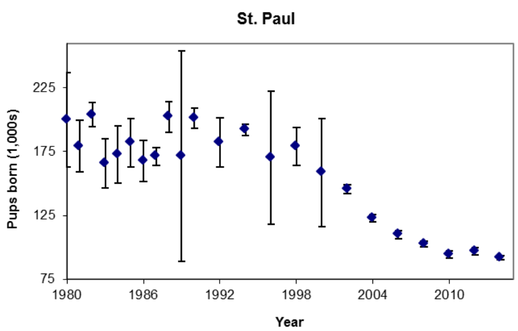

Figure 2. Estimated number of northern fur seal pups born on St. Paul Island, 1980-2014.

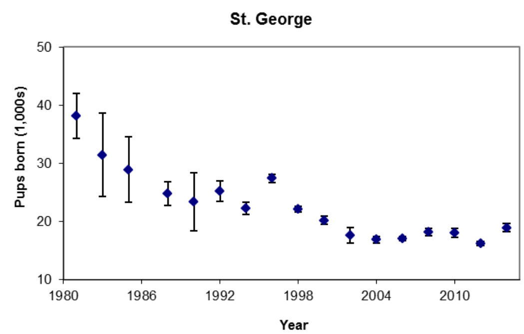

Figure 3. Estimated number of northern fur seal pups born on St. George Island, 1980-2014.

Pelagic sealing led to a decrease in the fur seal population; however, a moratorium on fur seal harvesting and termination of pelagic sealing resulted in a steady increase in the northern fur seal population during 1912-1924. During this period, the rate of population growth was approximately 8.6% (SE = 1.47) per year (A. York, NMFS-AFSC-MML (retired), unpubl. data), the maximum recorded for this species. This growth rate is similar and slightly higher than the 8.1% rate of increase (approximate SE = 1.29) estimated by Gerrodette et al. (1985). Though not as high as growth rates estimated for other fur seal species, the 8.6% rate of increase is considered a reliable estimate of R_{MAX} given the extremely low density of the population in the early 1900s.

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for depleted stocks under the MMPA (Wade and Angliss 1997). Thus, for the Eastern Pacific stock of northern fur seals, PBR = 11,405 (530,474 × 0.043 × 0.5) animals.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information on U.S. commercial fisheries in Alaska waters (including observer programs, observer coverage, and observed incidental takes of marine mammals) is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

During 2010-2014, incidental mortality and serious injury of northern fur seals was observed in the following 3 fisheries of the 22 federally-regulated commercial fisheries in Alaska monitored for incidental mortality and serious injury by fisheries observers: Bering Sea/Aleutian Islands flatfish trawl, Bering Sea/Aleutian Islands pollock trawl, and Bering Sea/Aleutian Islands Pacific cod longline fisheries (Table 2; Breiwick 2013; MML, unpubl. data). The estimated mean annual mortality and serious injury rate in these fisheries in 2010-2014 is 1.1 northern fur seals.

Observer programs for Alaska State-managed commercial fisheries have not documented any mortality or serious injury of northern fur seals (Wynne et al. 1991, 1992; Manly 2006, 2007).

Table 2. Summary of incidental mortality and serious injury of Eastern Pacific northern fur seals due to U.S. commercial fisheries in 2010-2014 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Is. flatfish trawl	2010 2011 2012 2013 2014	obs data	99 100 99 99 99	0 (+1)[a] 0 0 0 1	0 (+1)[b] 0 0 0 1	0.2 (+0.2)[c] (CV = 0.04)
Bering Sea/Aleutian Is. pollock trawl	2010 2011 2012 2013 2014	obs data	86 98 98 97 98	2 0 0 0 0	2.0 0 0 0 0	0.4 (CV = 0.07)
Bering Sea/Aleutian Is. Pacific cod longline	2010 2011 2012 2013 2014	obs data	64 57 51 67 64	1 0 0 0 0	1.4 0 0 0 0	0.3 (CV = 0.52)
Minimum total estimated annual mortality						1.1 (CV = 0.17)

[a]Total mortality and serious injury observed in 2010: 0 fur seals in sampled hauls + 1 fur seal in an unsampled haul.
[b]Total estimate of mortality and serious injury in 2010: 0 fur seals (extrapolated estimate from 0 fur seals observed in sampled hauls) + 1 fur seal (1 fur seal observed in an unsampled haul).
[c]Mean annual mortality and serious injury for fishery: 0.2 fur seals (mean of extrapolated estimates from sampled hauls) + 0.2 fur seals (mean of number observed in unsampled hauls).

Entanglement studies on the Pribilof Islands are another source of information on fishery-specific interactions with fur seals. Based on entanglement rates and sample sizes presented in Zavadil et al. (2003), an average of 1.1 fur seals per year on the rookeries were entangled in pieces of trawl netting and an average of 0.1 fur seals per year were entangled in monofilament net. Zavadil et al. (2007) determined the juvenile male entanglement rate for 2005-2006 to be between 0.15 and 0.35%. The mean entanglement rate in this 2-year period for pups on St. George Island was 0.06-0.08%, with a potential maximum rate of up to 0.11% in October prior to weaning. Female entanglement rate on St. George Island increased during the course of the 2005-2006 breeding seasons, reaching a rate of 0.13% in October; this rate increase coincided with the arrival of progressively younger females on the rookery throughout the season (Zavadil et al. 2007).

Entanglements of northern fur seals have been observed on St. Paul, St. George, and Bogoslof Islands. Since 2011, there has been an increased effort to include entanglement reports in the NMFS Alaska Region stranding database. A summary of entanglements in fishing gear that were reported in 2010-2014 is provided in Table 3 (Helker et al. 2016).

Three northern fur seals entangled in commercial Bering Sea/Aleutian Islands halibut longline gear and nine northern fur seals entangled in commercial Bering Sea/Aleutian Islands trawl gear were reported to the NMFS Alaska Region stranding network in 2010-2014, resulting in minimum mean annual mortality and serious injury rates of 0.6 and 1.8 fur seals, respectively, in these fisheries (Table 3; Helker et al. 2016).

An additional seven northern fur seals were initially considered to be seriously injured due to entanglement in commercial Bering Sea/Aleutian Islands trawl gear (2 in 2011, 2 in 2012, and 1 in 2014) and unidentified net (1 each in 2011 and 2012); however, since these animals were disentangled and released with non-serious injuries (Helker et al. 2016), they were not included in the mean annual mortality and serious injury rate for 2010-2014.

The total mean annual mortality and serious injury rate incidental to U.S. commercial fisheries in 2010-2014 is 3.5 northern fur seals (1.1 from observer data + 2.4 from stranding data).

The minimum mean annual mortality and serious injury rate due to entanglement in fishing line (0.2), pot gear (0.2), gillnet (0.2), and unidentified fishing net (0.8) in Alaska waters in 2010-2014 is 1.4 northern fur seals (Table 3; Helker et al. 2016). These entanglements cannot be assigned to a specific fishery, and it is unknown whether commercial, recreational, or subsistence fisheries are the source of the fishing debris. More thorough reporting of events has occurred since 2011, and there is significantly higher observation effort on the rookeries during the years of pup production (even years) than during odd numbered years, so this difference in the level of effort most likely affects estimates of entanglement based on opportunistic reports.

The Eastern Pacific stock can occur off the west coast of the continental U.S. in winter/spring; therefore, any mortality or serious injury of northern fur seals reported off the coasts of Washington, Oregon, or California during December through May will be assigned to both the Eastern Pacific and California stocks of northern fur seals. During 2010-2014, three northern fur seal entanglements in trawl gear occurred off the U.S. west coast in December through May (Carretta et al. 2016), resulting in an average annual mortality and serious injury rate of 0.6 Eastern Pacific northern fur seals in these waters (Table 3). An additional northern fur seal that stranded with a serious injury, due to an unidentified fishery interaction, in May 2012 in California was treated and released with a non-serious injury (Carretta et al. 2016); therefore, it was not included in the mean annual mortality and serious injury rate for 2010-2014.

Table 3. Summary of mortality and serious injury of Eastern Pacific northern fur seals, by year and type, reported to the NMFS Alaska Region (Helker et al. 2016) and NMFS U.S. West Coast Region (Carretta et al. 2016) marine mammal stranding networks in 2010-2014. Only cases of serious injuries are reported in this table; animals that were disentangled and released with non-serious injuries have been excluded.

Cause of injury	2010	2011	2012	2013	2014	Mean annual mortality
Entangled in commercial Bering Sea/Aleutian Is. halibut longline gear	0	0	0	0	3	0.6
Entangled in commercial Bering Sea/Aleutian Is. trawl gear	0	2	1	0	6	1.8
Entangled in Bering Sea crab pot gear*	0	1	0	0	0	0.2
Entangled in Bering Sea/Aleutian Is. monofilament hook and line gear*	0	1	0	0	0	0.2
Entangled in gillnet*	0	0	0	0	1	0.2
Entangled in unidentified net*	0	0	3	0	1	0.8
Entangled in trawl gear*	0	1[a]	0	0	2[a]	0.6
Entangled in marine debris	0	10	4	1	11	5.2
Entrained in power plant intake	0	0	1[a]	0	0	0.2
Sum of 2011, 2012, and 2014 events[b]		15	9		24	16
Total in commercial fisheries						2.4
*Total in unknown (commercial, recreational, or subsistence) fisheries						2.0
Total in marine debris						5.2
Total due to other sources (power plant entrainment)						0.2

[a]Mortality or serious injury that occurred off the coasts of Washington, Oregon, or California in December through May was assigned to both the Eastern Pacific and California stocks of northern fur seals.

[b]An increase in the number of reports is not necessarily an indication of an increase in occurrence of entanglements but rather is a reflection of more thorough reporting of these events in the NMFS Alaska Region stranding database as of 2011. The average of the sum of mortality/serious injury (M/SI) events reported in 2011, 2012, and 2014 may be a more accurate number of annual M/SI for management purposes due to more thorough reporting for those years.

Alaska Native Subsistence/Harvest Information

Alaska Natives residing on the Pribilof Islands are allowed an annual subsistence harvest of northern fur seals, with a 3-year take range based on historical local needs. Typically, only juvenile males are taken in the subsistence harvest, which results in a much smaller impact on population growth than a harvest that includes females. However, accidental harvesting of females and adult males does occur. Only juvenile males were harvested in 2010; no females were reported as accidentally killed. A single female was killed during the harvest on St. Paul Island in 2011 (Lestenkof et al. 2011), one female was killed on St. George Island in 2012 (Lekanof 2013), three females were killed on St. Paul in 2013 (Lestenkof et al. 2014), and four females were killed on St. Paul (Melovidov et al. 2014) and one was killed on St. George (Kashevarof 2014b) in 2014. During the inaugural pup harvest on St. George Island in 2014, 54 pups were killed (M. Williams, NMFS, Alaska Regional Office, Anchorage, AK, pers. comm). During 2010-2014, an average of 426 northern fur seals were harvested each year in the subsistence harvest on the Pribilof Islands (Table 4).

Table 4. Summary of the Alaska Native subsistence harvest of northern fur seals on St. Paul and St. George Islands in 2010-2014.

Year	St. Paul	St. George	Total harvested
2010	357[a]	78[b]	435
2011	323[c]	120[d]	443
2012	383[e]	64[f]	447
2013	301[g]	80[h]	381
2014	266[i]	158[j, k]	424
Mean annual take (2010-2014)			426

[a]Zavadil et al. (2011); [b]Merculief (2010); [c]Lestenkof et al. (2011); [d]Merculief (2011); [e]Lestenkof et al. (2012); [f]Lekanof (2013); [g]Lestenkof et al. (2014); [h]Kashevarof (2014a); [i]Melovidov et al. (2014); [j]Kashevarof (2014b); [k]M. Williams, NMFS, Alaska Regional Office, Anchorage, AK, pers. comm.

Other Mortality

Intentional killing of northern fur seals by commercial fishers, sport fishers, and others may occur, but the magnitude of that mortality is unknown. Such shooting has been illegal since the species was designated as depleted in 1988.

Since the Eastern Pacific and California stocks of northern fur seals overlap off the west coast of the continental U.S. during December through May, non-fishery mortality and serious injury reported off the coasts of Washington, Oregon, or California during that time will be assigned to both stocks. The mean annual mortality and serious injury rate due to entanglement in marine debris in Alaska waters in 2010-2014 is 5.2 Eastern Pacific northern fur seals (Table 3; Helker et al. 2016). A northern fur seal mortality in 2012 due to entrainment in the cooling water system of a California power plant resulted in an additional mean annual mortality and serious injury rate of 0.2 Eastern Pacific northern fur seals in 2010-2014 (Table 3; Carretta et al. 2016).

An additional 14 northern fur seals that were initially considered seriously injured due to entanglement in marine debris (3 in 2011, 7 in 2012, and 4 in 2014) were disentangled and released with non-serious injuries (Helker et al. 2016); therefore, these animals were not included in the mean annual mortality and serious injury rate for 2010-2104.

Mortality and serious injury may occasionally occur incidental to marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. In 2010-2014, no research-related mortality or serious injury was reported for the Eastern Pacific stock of northern fur seals (Division of Permits and Conservation, Office of Protected Resources, NMFS, 1315 East-West Highway, Silver Spring, MD 20910).

STATUS OF STOCK

Based on currently available data, the minimum estimate of the mean annual U.S. commercial fishery-related mortality and serious injury rate for this stock (3.5 fur seals) is less than 10% of the calculated PBR (10% of PBR = 1,140) and, therefore, can be considered to be insignificant and approaching a zero mortality and serious injury rate. The total estimated annual level of human-caused mortality and serious injury (437 fur seals) does not exceed the PBR (11,405) for this stock. However, given that the population is declining for unknown reasons, and this decline is not explained by the relatively low level of known direct human-caused mortality and serious injury, there is no reason to believe that limiting mortality and serious injury to the level of the PBR will reverse the decline. The northern fur seal was designated as depleted under the MMPA in 1988 because population levels had declined to less than 50% of levels observed in the late 1950s (1.8 million animals; 53 FR 17888, 18 May 1988) and there was no compelling evidence that carrying capacity (K, assumed to be 1.8 million animals) had changed substantially since the late 1950s. The Eastern Pacific stock of northern fur seals is classified as a strategic stock because it is designated as depleted under the MMPA.

HABITAT CONCERNS

Northern fur seals forage on a variety of fish species, including pollock. Some historically relevant prey items, such as capelin, have disappeared entirely from the fur seal diet and pollock consumption has increased (Sinclair et al. 1994, 1996; Antonelis et al. 1997). Analyses of scats collected from Pribilof Island rookeries during 1987-2000 found that pollock (46-75% by frequency of occurrence, FO) and gonatid squids dominated in the diet and that other primary prey (FO>5%) included Pacific sand lance, Pacific herring, northern smoothtongue, Atka mackerel, and Pacific salmon (Zeppelin and Ream 2006). These analyses also found that diets associated with rookery complexes reflected patterns associated with foraging in the specific hydrographic domains identified by Robson et al. (2004). Comparison of ingested prey sizes based on scat and spew analysis indicate a much larger overlap between sizes of pollock consumed by fur seals and those caught by the commercial trawl fishery than was previously known (Gudmundson et al. 2006). Call et al. (2008) found northern fur seals had three types of individual foraging route tactics at the rookery, which is important to consider in the context of adaptation to changes in environmental conditions and prey distributions.

Fishing effort displaced by Steller sea lion protection measures may have moved to areas important to fur seals; recent tagging studies have shown that lactating female fur seals and juvenile males from St. Paul and St. George Islands forage in specific and very different areas (Robson et al. 2004, Sterling and Ream 2004). From 1982 to 2002, pup production declined on St. Paul and St. George Islands (Figs. 2 and 3). However, it remains unclear whether the pattern of declines in fur seal pup production on the two Pribilof Islands is related to the relative distribution of pollock fishery effort in summer on the eastern Bering Sea shelf. Adult female fur seals spend approximately 8 months in varied regions of the North Pacific during winter, and forage in areas associated with eddies and the subarctic-subtropical transition region (Ream et al. 2005). Thus, environmental changes in the North Pacific could potentially be affecting abundance and productivity of fur seals breeding in Alaska.

There is concern that a variety of human activities other than commercial fishing, such as an increase in vessel traffic in Alaska waters and an increased potential for oil spills, may impact northern fur seals. A Conservation Plan for the Eastern Pacific stock was released in December of 2007 (NMFS 2007). This plan reviews known and potential threats to the recovery of fur seals in Alaska.

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HARBOR SEAL (*Phoca vitulina richardii*)

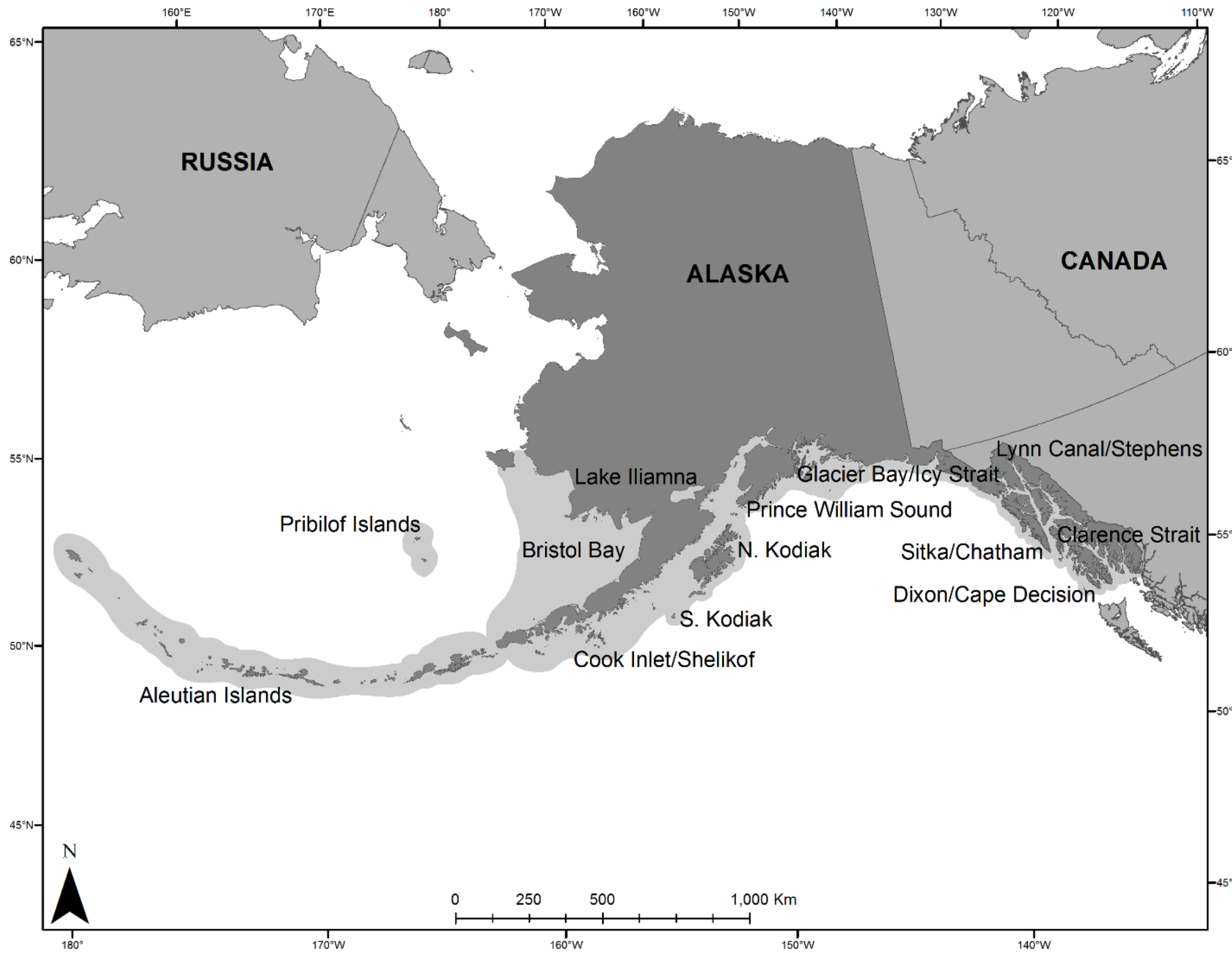

Figure 1. Approximate distribution of harbor seals in Alaska waters (shaded coastline area).

STOCK DEFINITION AND GEOGRAPHIC RANGE

Harbor seals inhabit coastal and estuarine waters off Baja California, north along the western coasts of the United States, British Columbia, and Southeast Alaska, west through the Gulf of Alaska and Aleutian Islands, and in the Bering Sea north to Cape Newenham and the Pribilof Islands. They haul out on rocks, reefs, beaches, and drifting glacial ice and feed in marine, estuarine, and occasionally fresh waters. Harbor seals generally are non-migratory, with local movements associated with such factors as tides, weather, season, food availability, and reproduction (Scheffer and Slipp 1944; Fisher 1952; Bigg 1969, 1981; Hastings et al. 2004). The results of past and recent satellite-tagging studies in Southeast Alaska, Prince William Sound, Kodiak Island, and Cook Inlet are also consistent with the conclusion that harbor seals are non-migratory (Swain et al. 1996, Lowry et al. 2001, Small et al. 2003, Boveng et al. 2012). However, some long-distance movements of tagged animals in Alaska have been recorded (Pitcher and McAllister 1981, Lowry et al. 2001, Small et al. 2003, Womble 2012, Womble and Gende 2013). Strong fidelity of individuals for haul-out sites during the breeding season has been documented in several populations (Härkönen and Harding 2001), including some harbor seal stocks in Alaska such as South Kodiak Island, Prince William Sound, Glacier Bay/Icy Strait, and Cook Inlet (Pitcher and McAllister 1981, Small et al. 2005, Boveng et al. 2012, Womble 2012, Womble and Gende 2013).

Local or regional trends in harbor seal numbers have been monitored at various time intervals since the 1970s, revealing diverse spatial patterns in apparent population trends. Where declines have been observed, they seem generally to have been strongest in the late 1970s or early 1980s to the 1990s. For example, counts of harbor seals declined by about 80% at Tugidak Island in the 1970s and 1980s (Pitcher 1990), and numbers at Nanvak Bay in northern Bristol Bay also declined at about the same time (Jemison et al. 2006). In Prince William Sound, harbor seal numbers declined by about 63% overall between 1984 and 1997, including a 40% decline prior to the *Exxon Valdez* oil spill that occurred in 1989 (Frost et al. 1999, Ver Hoef and Frost 2003). Harbor seal counts in Glacier Bay National Park, where the majority of seals haul out on floating ice calved from glaciers, declined by roughly 60% between 1992 and 2001 and continued to decline through 2008 (Mathews and Pendleton 2006, Womble et al. 2010). At Aialik Bay, a site in Kenai Fjords National Park where harbor seals also haul out on ice calved from a glacier, harbor seal numbers declined by 93% from 1979 to 2009 (Hoover-Miller et al. 2011). In the Aleutian Islands, counts declined by 67% between the early 1980s and 1999, with declines of about 86% in the western Aleutians (Small et al. 2008). Although there is evidence for recent stabilization or even partial recovery of harbor seal numbers in some areas of long-term harbor seal decline, such as Tugidak Island and Nanvak Bay (Jemison et al. 2006), most have not made substantial recoveries toward historical abundances. But these areas of declines in harbor seals contrast strongly with other large regions of Alaska where harbor seal numbers have remained stable or increased over the same period: trend monitoring regions around Ketchikan and the Kodiak area increased significantly in the 1980s and 1990s and were stable in around Sitka and Bristol Bay (Small et al. 2003). Differences in trend across the various regions of Alaska suggest some level of independent population dynamics (O'Corry-Crowe et al. 2003, O'Corry-Crowe 2012).

Westlake and O'Corry-Crowe's (2002) analysis of genetic information from 881 samples across 181 sites revealed population subdivisions on a scale of 600-820 km. These results suggest that genetic differences within Alaska, and most likely over their entire North Pacific range, increase with increasing geographic distance. New information revealed substantial genetic differences indicating that female dispersal occurs at region specific spatial scales of 150-540 km. This research identified 12 demographically independent clusters within the range of Alaskan harbor seals; however, significant geographic areas within the Alaskan harbor seal range remain unsampled (O'Corry-Crowe et al. 2003).

In 2010, NMFS and their co-management partners, the Alaska Native Harbor Seal Commission, identified 12 separate stocks of harbor seals based largely on genetic structure; this represents a significant increase in the number of harbor seal stocks from the three stocks (Bering Sea, Gulf of Alaska, Southeast Alaska) previously recognized. Given the genetic samples were not obtained continuously throughout the range, a total evidence approach was used to consider additional factors such as population trends, observed harbor seal movements, and traditional Alaska Native use areas in the final designation of stock boundaries. The 12 stocks of harbor seals currently identified in Alaska are 1) the Aleutian Islands stock – occurring along the entire Aleutian chain from Attu Island to Ugamak Island; 2) the Pribilof Islands stock – occurring on Saint Paul and Saint George Islands, as well as on Otter and Walrus Islands; 3) the Bristol Bay stock – ranging from Nunivak Island south to the west coast of Unimak Island and extending inland to Kvichak Bay and Lake Iliamna; 4) the North Kodiak stock – ranging from approximately Middle Cape on the west coast of Kodiak Island northeast to West Amatuli Island and south to Marmot and Spruce Islands; 5) the South Kodiak stock – ranging from Middle Cape on the west coast of Kodiak Island southwest to Chirikof Island and east along the south coast of Kodiak Island to Spruce Island, including the Trinity Islands, Tugidak Island, Sitkinak Island, Sundstrom Island, Aiaktalik Island, Geese Islands, Two Headed Island, Sitkalidak Island, Ugak Island, and Long Island; 6) the Prince William Sound stock – ranging from Elizabeth Island off the southwest tip of the Kenai Peninsula to Cape Fairweather, including Prince William Sound, the Copper River Delta, Icy Bay, and Yakutat Bay; 7) the Cook Inlet/Shelikof Strait stock – ranging from the southwest tip of Unimak Island east along the southern coast of the Alaska Peninsula to Elizabeth Island off the southwest tip of the Kenai Peninsula, including Cook Inlet, Knik Arm, and Turnagain Arm; 8) the Glacier Bay/Icy Strait stock – ranging from Cape Fairweather southeast to Column Point, extending inland to Glacier Bay, Icy Strait, and from Hanus Reef south to Tenakee Inlet; 9) the Lynn Canal/Stephens Passage stock – ranging north along the east and north coast of Admiralty Island from the north end of Kupreanof Island through Lynn Canal, including Taku Inlet, Tracy Arm, and Endicott Arm; 10) the Sitka/Chatham Strait stock – ranging from Cape Bingham south to Cape Ommaney, extending inland to Table Bay on the west side of Kuiu Island and north through Chatham Strait to Cube Point off the west coast of Admiralty Island, and as far east as Cape Bendel on the northeast tip of Kupreanof Island; 11) the Dixon/Cape Decision stock – ranging from Cape Decision on the southeast side of Kuiu Island north to Point Barrie on Kupreanof Island and extending south from Port Protection to Cape Chacon along the west coast of Prince of Wales Island and west to Cape Muzon on Dall Island, including Coronation Island, Forrester Island, and all the islands off the west coast of Prince of Wales Island; and 12) the Clarence Strait stock – ranging along the east coast of Prince of Wales Island from Cape Chacon north through Clarence Strait to Point Baker and along the east coast of Mitkof and Kupreanof Islands north to Bay Point, including Ernest Sound, Behm Canal, and Pearse Canal (Fig. 1). Individual stock distributions can be seen in Figures 2a-l.

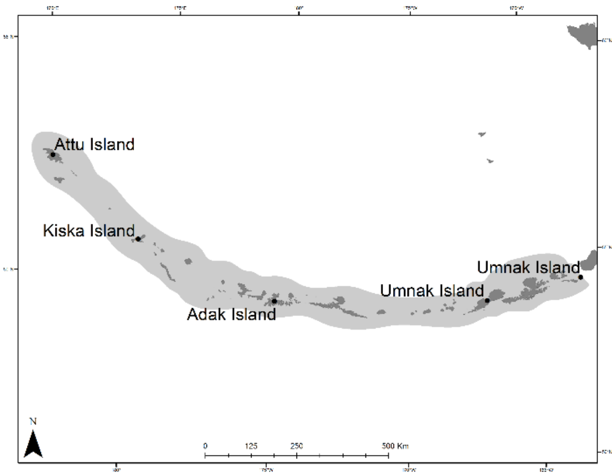

Figure 2a. Approximate distribution of Aleutian Islands harbor seal stock (shaded area).

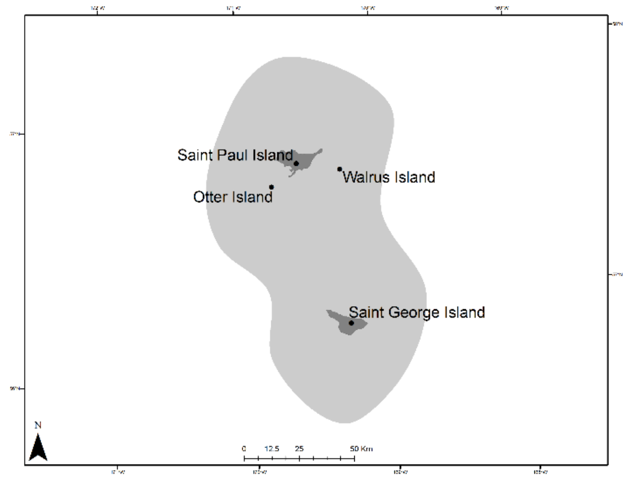

Figure 2b. Approximate distribution of Pribilof Islands harbor seal stock (shaded area).

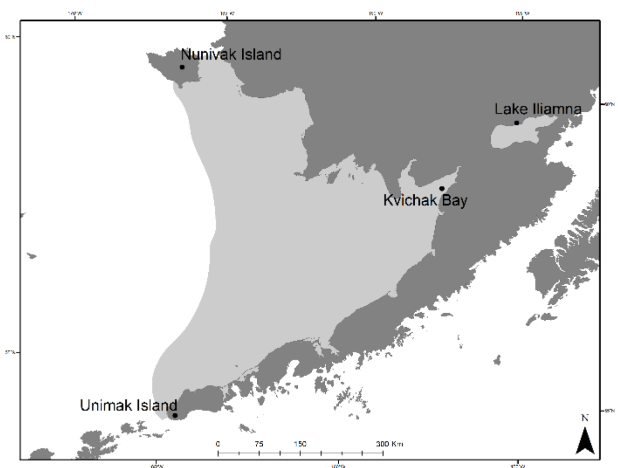

Figure 2c. Approximate distribution of Bristol Bay harbor seal stock (shaded area).

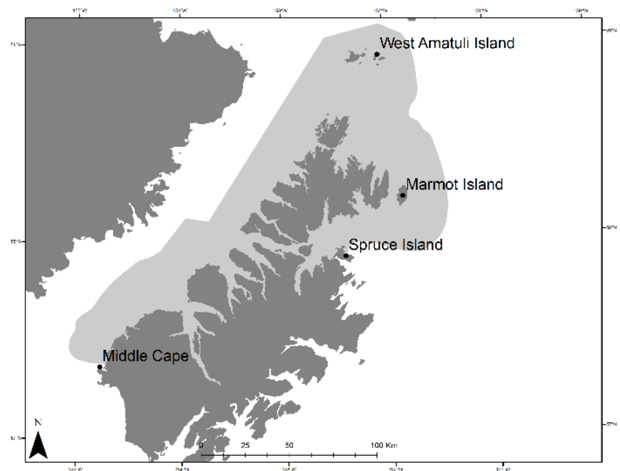

Figure 2d. Approximate distribution of North Kodiak harbor seal stock (shaded area).

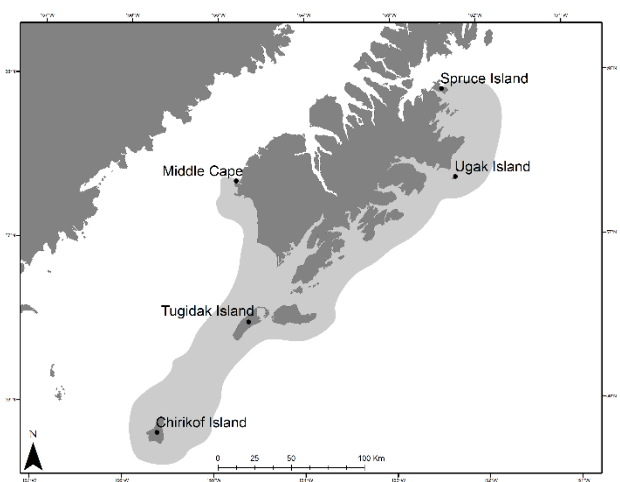

Figure 2e. Approximate distribution of South Kodiak harbor seal stock (shaded area).

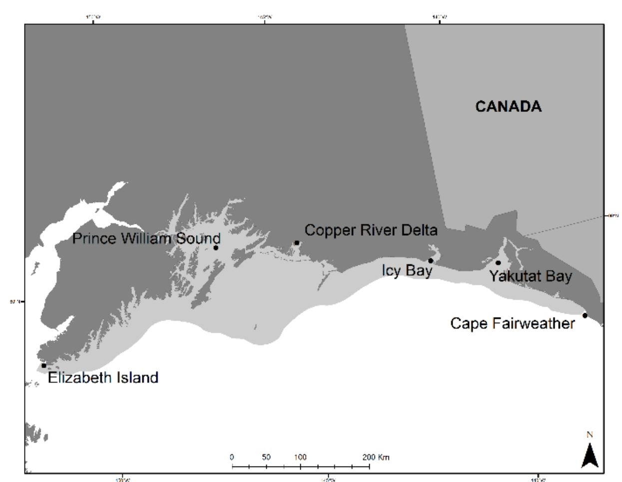

Figure 2f. Approximate distribution of Prince William Sound harbor seal stock (shaded area).

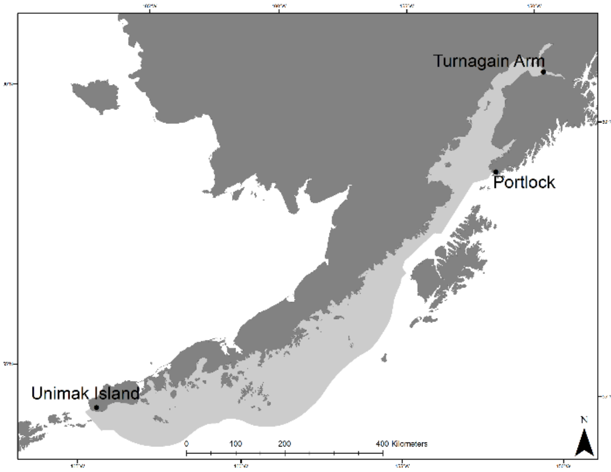

Figure 2g. Approximate distribution of Cook Inlet/Shelikof Strait harbor seal stock (shaded area).

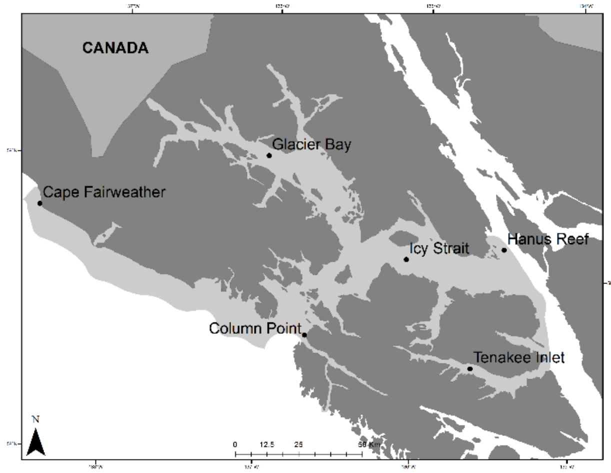

Figure 2h. Approximate distribution of Glacier Bay/Icy Strait harbor seal stock (shaded area).

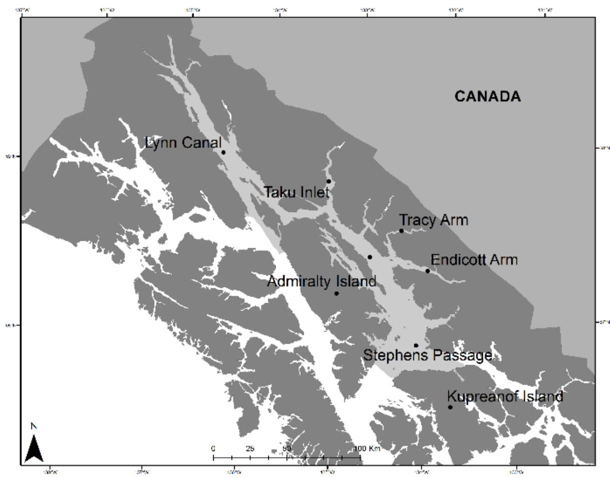

Figure 2i. Approximate distribution of Lynn Canal/Stephens Passage harbor seal stock (shaded area).

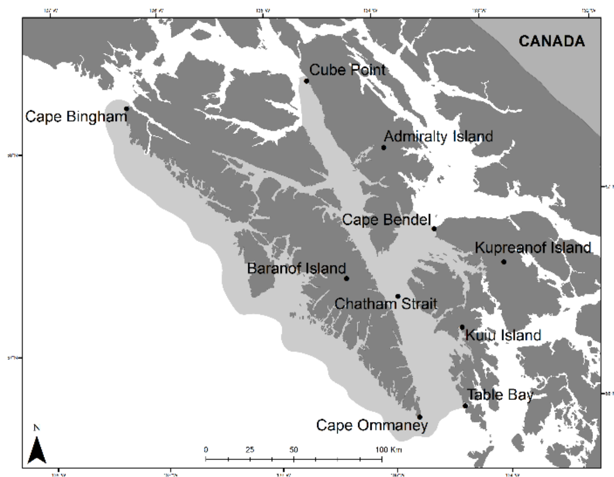

Figure 2j. Approximate distribution of Sitka/Chatham Strait harbor seal stock (shaded area).

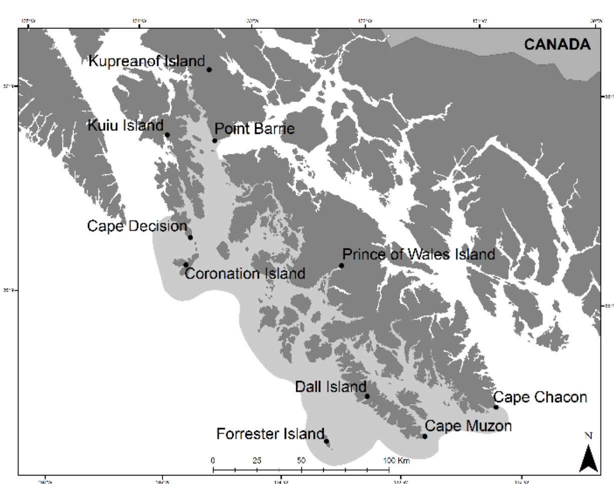

Figure 2k. Approximate distribution of Dixon/Cape Decision harbor seal stock (shaded area).

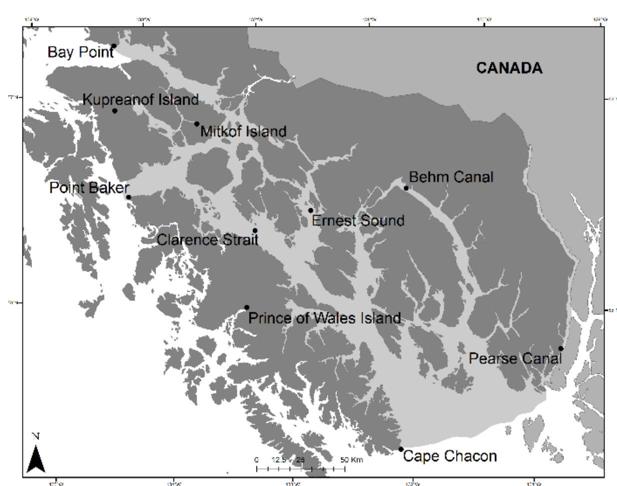

Figure 2l. Approximate distribution of Clarence Strait harbor seal stock (shaded area).

POPULATION SIZE

The Alaska Fisheries Science Center's National Marine Mammal Laboratory routinely conducts aerial surveys of harbor seals across their entire range in Alaska. Prior to 2008, Alaska was divided into five survey regions, with one region surveyed per year. In 2010, the survey sites were prioritized based on the newly defined harbor seal stock divisions, and annual aerial surveys attempt to sample the full geographic range of harbor seals in Alaska, with a focus on sites that make up a significant portion of each stock's population every year; sites with fewer seals are flown every 3 to 5 years. This site specific survey approach is designed to provide the counts necessary to estimate stock specific population abundance and trend for all 12 stocks annually. To derive an accurate estimate of population size from these surveys, a method was developed to address the influence of external conditions on the number of seals hauled out on shore, and counted, during the surveys. Many factors influence the propensity of seals to haul out, including tides, time of day, and date in the seals' annual life-history cycle. A statistical model defining the relationship between these factors and the number of seals hauled out was developed. Based on those models, the survey counts for each year were adjusted to the number of seals that would have been ashore during a hypothetical survey conducted under ideal conditions for hauling out (Boveng et al. 2003). In a separate analysis of radio-tagged seals, a similar statistical model was used to estimate the proportion of seals that were hauled out under those ideal conditions (Simpkins et al. 2003). The results from these two analyses were combined for each region to estimate the population size of each stock in Alaska.

Abundance Estimates and Minimum Population Estimates

The current statewide abundance estimate for Alaskan harbor seals is 205,090 (Boveng et al. in press a), based on aerial survey data collected during 1998-2011. See Table 1 for abundance estimates of the 12 stocks of harbor seals in Alaska. The minimum population estimate (N_{MIN}) for 11 of the 12 stocks of harbor seals in Alaska is calculated as the lower bound of the 80% credible interval obtained from the posterior distribution of abundance estimates. This approach is consistent with the definition of potential biological removal (PBR) in the current guidelines (Wade and Angliss 1997). The abundance estimate and N_{MIN} for the remaining stock, the Pribilof Islands stock, is simply the number counted in the most recent survey of this very small group.

Table 1. Abundance and 5-year trend estimates, by stock, for harbor seals in Alaska, along with respective estimates of standard error. The probability of decrease represents the proportion of the posterior probability distribution for the 5-year trend that fell below a value of 0 seals per year.

Stock	Year of last survey	Abundance estimate	SE	5-year trend estimate	SE	Probability of decrease	N_{MIN}
Aleutian Islands	2011	6,431	882	75	220	0.36	5,772
Pribilof Islands	2010	232	n/a	n/a	n/a	n/a	232
Bristol Bay	2011	32,350	6,882	1,209	1,941	0.25	28,146
North Kodiak	2011	8,321	1,619	531	590	0.16	7,096
South Kodiak	2011	19,199	2,429	-461	761	0.72	17,479
Prince William Sound	2011	29,889	13,846	26	3,498	0.56	27,936
Cook Inlet/Shelikof Strait	2011	27,386	3,328	313	1,115	0.38	25,651
Glacier Bay/Icy Strait	2011	7,210	1,866	179	438	0.40	5,647
Lynn Canal/Stephens Passage	2011	9,478	1,467	-176	388	0.71	8,605
Sitka/Chatham Strait	2011	14,855	2,106	411	568	0.23	13,212
Dixon/Cape Decision	2011	18,105	1,614	216	360	0.29	16,727
Clarence Strait	2011	31,634	4,518	921	1,246	0.21	29,093

Current Population Trend

Aerial surveys of harbor seal haulout sites throughout Alaska have been conducted annually and provide information on trends in abundance. The most current estimates of trend (Table 1) were estimated as the means of the slopes of 1,000 simple linear regressions over the most recent eight annual estimates in each of the 1,000 Markov Chain Monte Carlo (MCMC) samples from the posterior distributions for abundance. Thus, they are in units of seals per year, rather than the typical annual percent growth rate. There is no appropriate method for converting these estimates of trend to annual percent growth rate. As a reflection of uncertainty in trend estimates, the proportion of the posterior distribution for each stock's trend that lies below the value of 0 is used as an estimate of the probability that a stock is currently decreasing (Table 1). This allows a probabilistic determination of the qualitative trend status: a value greater than 0.5 means the evidence suggests that the stock is decreasing; less than 0.5 means the stock is increasing. Because there will typically be a 2-3 year lag between the most recent surveys and the Stock Assessment Report update, a 5-year interval was used for estimating trend. This ensures trend estimates are based on data no more than about 8 years old, which is considered to be the approximate threshold of reliability for Marine Mammal Protection Act (MMPA) stock assessment data. One caveat of this approach is that, due to the skewness inherent in the posterior distribution, it is possible for a stock to exhibit a positive trend while also having a probability of decrease greater than 0.5. The following summarizes historical and recent information on the population trend for each of the 12 stocks.

Aleutian Islands: A partial estimate of harbor seal abundance in the Aleutian Islands was determined from skiff surveys of 106 islands from 1977 to 1982 (8,601 seals). Small et al. (2008) compared counts from the same islands during a 1999 aerial survey (2,859 seals). Counts decreased at a majority of the islands. Islands with greater than 100 seals decreased by 70%. The overall estimates showed a 67% decline during the approximate 20-year period (Small et al. 2008). The current (2007-2011) estimate of the population trend in the Aleutian Islands is +75 seals per year, with a probability that the stock is decreasing of 0.36 (Table 1).

Pribilof Islands: Counts of harbor seals in the Pribilof Islands ranged from 250 to 1,224 in the 1970s. Counts in the 1980s and 1990s ranged between 119 and 232 harbor seals. Prior to July 2010, the most recent count was in 1995 when a total of 202 seals were counted. In July 2010, approximately 185 adults and 27 pups were observed on Otter Island plus approximately 20 on all the other islands combined for a total of 232 harbor seals. Maximum seal counts (all ages) are nearly identical to the 1995 counts (212 vs. 202), but 2010 pup numbers were slightly less (27 vs. 42). The current population trend in the Pribilof Islands is unknown.

Bristol Bay: At Nanvak Bay, the largest haulout in northern Bristol Bay, harbor seals declined in abundance from 1975 to 1990 and increased from 1990 to 2000 (Jemison et al. 2006). Land-based harbor seal counts at Nanvak Bay from 1990 to 2000 increased at 9.2% per year during the pupping period and 2.1% per year during the molting period (Jemison et al. 2006). The Iliamna Lake harbor seal population of about 400 seals, that forms a small portion of the Bristol Bay stock, likely increased through the 1990s and is now stable at around 400 animals (Boveng et al. in press b). The current (2007-2011) estimate of the population trend in the Bristol Bay stock is +1,209 seals per year, with a probability that the stock is decreasing of 0.25 (Table 1).

North Kodiak: The current (2007-2011) estimate of the North Kodiak population trend is +531 seals per year, with a probability that the stock is decreasing of 0.16 (Table 1).

South Kodiak: A significant portion of the harbor seal population within the South Kodiak stock is located at and around Tugidak Island off the southwest coast of Kodiak Island. Sharp declines in the number of seals present on Tugidak were observed between 1976 and 1998. The highest rate of decline was 21% per year between 1976 and 1979 (Pitcher 1990). While the number of seals on Tugidak has stabilized and shown some evidence of increase since the decline, the population in 2000 remained reduced by 80% compared to the levels in the 1970s (Jemison et al. 2006). The current (2007-2011) estimate of the South Kodiak population trend is -461 seals per year, with a probability that the stock is decreasing of 0.72 (Table 1).

Prince William Sound: The Prince William Sound stock includes harbor seals both within and adjacent to Prince William Sound proper. Within Prince William Sound proper, harbor seals declined in abundance by 63% between 1984 and 1997 (Frost et al. 1999). In Aialik Bay, adjacent to Prince William Sound proper, there has been a decline in pup production by 4.6% annually from 40 down to 32 pups born from 1994 to 2009 (Hoover-Miller et al. 2011). The current (2007–2011) estimate of the Prince William Sound population trend over a 5-year period is +26 seals per year, with a probability that the stock is decreasing of 0.56 (Table 1). As noted earlier, this is an example where the skewed nature of the posterior distribution of the abundance estimate has resulted in a higher than 0.5 probability of decrease while subsequently showing an increasing trend.

Cook Inlet/Shelikof Strait: A multi-year study of seasonal movements and abundance of harbor seals in Cook Inlet was conducted between 2004 and 2007. This study involved multiple aerial surveys throughout the year, and the data indicated a stable population of harbor seals during the August molting period (Boveng et al. 2011). Aerial surveys along the Alaska Peninsula present greater logistical challenges and have therefore been conducted less frequently. The current (2007-2011) estimate of the Cook Inlet/Shelikof Strait population trend is +313 seals per year, with a probability that the stock is decreasing of 0.38 (Table 1).

Glacier Bay/Icy Strait: The Glacier Bay/Icy Strait stock showed a negative population trend estimate for harbor seals from 1992 to 2008 in June and August for glacial (-7.7%/yr; -8.2%/yr) and terrestrial sites (-12.4%/yr, August only) (Womble et al. 2010). Trend estimates by Mathews and Pendleton (2006) were similarly negative for both glacial and terrestrial sites. Long-term monitoring of harbor seals on glacial ice has occurred in Glacier Bay since the 1970s (Mathews and Pendleton 2006) and has shown this area to support one of the largest breeding aggregations in Alaska (Steveler 1979, Calambokidis et al. 1987). After a dramatic retreat of Muir Glacier (more than 7 km), in the East Arm of Glacier Bay, between 1973 and 1986 and the subsequent grounding and cessation of calving in 1993, floating glacial ice was greatly reduced as a haul-out substrate for harbor seals and ultimately resulted in the abandonment of upper Muir Inlet by harbor seals (Calambokidis et al. 1987, Hall et al. 1995, Mathews 1995). Prior to 1993, seal counts were up to 1,347 in the East Arm of Glacier Bay; 2008 counts were fewer than 200 (Streveler 1979, Molnia 2007). The current (2007–2011) estimate of the Glacier Bay/Icy Strait population trend is +179 seals per year, with a probability that the stock is decreasing of 0.40 (Table 1).

Lynn Canal/Stephens Passage: The current (2007-2011) estimate of the Lynn Canal/Stephens Passage population trend is -176 seals per year, with a probability that the stock is decreasing of 0.71 (Table 1).

Sitka/Chatham Strait: The current (2007-2011) estimate of the Sitka/Chatham Strait population trend is +411 seals per year, with a probability that the stock is decreasing of 0.23 (Table 1).

Dixon/Cape Decision: The current (2007-2011) estimate of the Dixon/Cape Decision population trend is +216 seals per year, with a probability that the stock is decreasing of 0.29 (Table 1).

Clarence Strait: The current (2007-2011) estimate of the Clarence Strait population trend is +921 seals per year, with a probability that the stock is decreasing of 0.21 (Table 1).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Reliable rates of maximum net productivity have not been estimated directly from the 12 stocks of harbor seals identified in Alaska. Based on monitoring in Washington State from 1978 to 1999, Jeffries et al. (2003) estimated R_{MAX} to be 12.6% and 18.5% for harbor seals of the inland and coastal stocks, respectively. Harbor seals have been protected in British Columbia since 1970, and the monitored portion of that population responded with an annual rate of increase of approximately 12.5% through the late 1980s (Olesiuk et al. 1990), though a more recent evaluation suggested that 11.5% may be a more appropriate figure (DFO 2010). These empirical estimates of R_{MAX} indicate that the continued use of the pinniped maximum theoretical net productivity rate of 12% is appropriate for the Alaska stocks (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized MMPA, the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. Marine mammal stocks such as the harbor seal stocks in Alaska that are taken by subsistence hunting may be given F_R values up to 1.0, provided they are "known to be increasing" or "not known to be decreasing" and "there have not been recent increases in the levels of takes" (Wade and Angliss 1997). For harbor seals in Alaska, these guidelines were followed by assigning all harbor seal stocks an initial, default recovery factor of 0.5. The default value was adjusted up to 0.7 if the estimated probability of decrease was greater than 0.7. The value was adjusted down to 0.3 if the estimated probability of decrease was less than 0.3. This provides a simple, balanced approach for providing a recovery factor consistent with current guidelines while incorporating results from novel statistical methods. Table 2 summarizes the PBR levels for each stock of harbor seals in Alaska based on N_{MIN} estimates, R_{MAX} = 12%, and F_R values.

Table 2. PBR calculations by stock for harbor seals in Alaska. The N_{MIN} values are determined from the 20th percentile of the posterior distribution for stock-level abundance estimates, except for the Pribilof Islands. A default value of 0.5 was used as the recovery factor. Based on evaluation of the trend estimates and probability of decrease, the recovery factor for some stocks was increased to 0.7. For other stocks, the recovery factor was decreased to 0.3.

Stock	N_{MIN}	R_{MAX}	**Recovery Factor (F_R)** (default value = 0.5)	**PBR**
Aleutian Islands	5,772	0.12	0.5	173
Pribilof Islands	232	0.12	0.5	7
Bristol Bay	28,146	0.12	0.7	1,182
North Kodiak	7,096	0.12	0.7	298
South Kodiak	17,479	0.12	0.3	314
Prince William Sound	27,936	0.12	0.5	838
Cook Inlet/Shelikof Strait	25,651	0.12	0.5	770
Glacier Bay/Icy Strait	5,647	0.12	0.5	169
Lynn Canal/Stephens Passage	8,605	0.12	0.3	155
Sitka/Chatham Strait	13,212	0.12	0.7	555
Dixon/Cape Decision	16,727	0.12	0.7	703
Clarence Strait	29,093	0.12	0.7	1,222

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*." Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fisheries Information

Detailed information (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

Previous stock assessments for harbor seals indicated three observed commercial fisheries operated within the range of the Bering Sea stocks of harbor seals, three within the range of stocks in Southeast Alaska, and five within the range of harbor seal stocks in the Gulf of Alaska. As of 2003, changes in how fisheries are defined in the MMPA List of Fisheries have resulted in separating these fisheries into 14 fisheries in the Bering Sea, 9 fisheries in Southeast Alaska, and 22 fisheries in the Gulf of Alaska based on both gear type and target species (69 FR 70094, 2 December 2004). This change does not represent a change in fishing effort but provides managers with better information on the component of each fishery that is responsible for the incidental mortality or serious injury of marine mammal stocks in Alaska.

Observer programs have documented mortality and serious injury of harbor seals in the Bering Sea/Aleutian Islands (BSAI) flatfish trawl fishery (1 in 2011 and 2 in 2012), Gulf of Alaska (GOA) Pacific cod trawl fishery (1 in 2010), and GOA flatfish trawl fishery (1 in 2011 and 2 in 2013) in 2009-2013 (Breiwick 2013; NMML, unpubl. data) (Table 3).

Although a reliable estimate of the overall mortality and serious injury rate incidental to commercial fisheries is currently unavailable because of the absence of observer placements in salmon gillnet fisheries known to interact with several of these stocks, for the purposes of stock assessment, mean annual mortality and serious injury rates are assigned to the following harbor seal stocks based on the location of takes in observed fisheries in 2009-2013 (Table

3): Bristol Bay stock: 0.6 from the BSAI flatfish trawl fishery; South Kodiak stock: 0.6 from the GOA Pacific cod trawl fishery + 1.3 from the GOA flatfish trawl fishery; Cook Inlet/Shelikof Strait stock: 0.4 from the GOA flatfish trawl fishery mortality in 2011 (this seal could have been from either the South Kodiak or Cook Inlet/Shelikof Strait stock, so the mortality is assigned to both stocks).

Table 3. Summary of incidental mortality and serious injury of harbor seals in Alaska due to U.S. commercial fisheries in 2009-2013 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; NMML, unpubl. data).

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Is. flatfish trawl	2009 2010 2011 2012 2013	obs data	99 99 99 99 99	0 0 1 2 0	0 0 1 2 0	0.6 (CV = 0.02)
Gulf of Alaska Pacific cod trawl	2009 2010 2011 2012 2013	obs data	29 31 41 25 11	0 1 0 0 0	0 2.8 0 0 0	0.6 (CV = 0.81)
Gulf of Alaska flatfish trawl	2009 2010 2011 2012 2013	obs data	21 26 31 42 46	0 0 1 0 2[a]	0 0 1.9 0 4.7	1.3 (CV = 0.69)[b]
Minimum total estimated annual mortality						2.5 (CV = 0.41)

[a]Two pinnipeds incidentally caught in 2013 were recently genetically identified as harbor seals.
[b]The CV for this fishery does not accommodate the 2013 data.

Observer programs in Alaska State-managed salmon set gillnet and salmon drift gillnet fisheries have documented harbor seal mortality and serious injury (Table 4). The Prince William Sound salmon drift gillnet fishery is known to interact with harbor seals, although the most recent observer data available for this fishery are from 1990 and 1991. The minimum estimated average annual mortality and serious injury rate (24 seals) in this fishery will be applied to the Prince William Sound stock of harbor seals.

Table 4. Summary of incidental mortality and serious injury of harbor seals in Alaska due to U.S. commercial salmon drift and set gillnet fisheries in 1990 and 1991 and calculation of the mean annual mortality and serious injury rate based on the most recent observer program data available.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Prince William Sound salmon drift gillnet	1990 1991	obs data	4 5	2 1	36 12	24 (CV = 0.50)
Minimum total estimated annual mortality						24 (CV = 0.50)

Reports to the NMFS Alaska Region stranding database of harbor seals entangled in fishing gear or with injuries caused by interactions with gear are another source of mortality and serious injury data (Helker et al. 2015). During 2009-2013, harbor seal mortality and serious injury occurred due to interactions with unknown fisheries (1 Clarence Strait harbor seal was observed with a hook and weight in its mouth in 2010 and 1 Cook Inlet/Shelikof Strait harbor seal entangled in an unknown set net in 2011) and recreational fishing gear (1 Prince William Sound harbor seal was caught in hook and line gear and cut loose with trailing gear in 2009), resulting in mean annual mortality and serious injury rates of 0.2 harbor seals from each of these stocks due to fishery-related strandings.

Alaska Native Subsistence/Harvest Information

The Alaska Native subsistence harvest of harbor seals has been estimated by the Alaska Native Harbor Seal Commission (ANHSC) and the Alaska Department of Fish and Game (ADF&G). Information from the ADF&G indicates the average harvest levels for the 12 stocks of harbor seals identified in Alaska from 2004 to 2008, including struck and lost, as follows (see Table 5; average annual harvest column). In 2011 and 2012, data on community subsistence harvests were collected for Kodiak Island, Prince William Sound, and Southeast Alaska (see Table 5; annual harvest 2011-2012 column). The remaining stocks have no updated community subsistence data, therefore, the most recent 5-years of data (2004-2008) will be retained and used for estimating average annual mortality and serious injury for these stocks.

Table 5. Summary of the subsistence harvest data for all 12 harbor seal stocks in Alaska, 2004-2008 and 2011-2012. Data are from Wolfe et al. (2005, 2006, 2008, 2009a, 2009b, 2012, 2013).

Stock	Minimum annual harvest 2004-2008	Maximum annual harvest 2004-2008	Average annual harvest 2004-2008	Annual harvest 2011 or 2012
Aleutian Islands	50	146	90	N/A
Pribilof Islands	0	0	0	N/A
Bristol Bay	82	188	141	N/A
North Kodiak	66	260	131	37
South Kodiak	46	126	78	126
Prince William Sound	325	600	439	255
Cook Inlet/Shelikof Strait	177	288	233	N/A
Glacier Bay/Icy Strait	22	108	52	104
Lynn Canal/Stephens Passage	17	60	30	50
Sitka/Chatham Strait	97	314	222	77
Dixon/Cape Decision	100	203	157	69
Clarence Strait	71	208	164	40

Other Mortality

Reports to the NMFS Alaska Region stranding database of harbor seals entangled in marine debris or with injuries caused by other types of human interaction are another source of mortality and serious injury data (Helker et al. 2015). During 2009-2013, one harbor seal (observed towing a buoy in 2011) was determined to be seriously injured due to entanglement in marine debris and one harbor seal mortality due to a ship strike occurred in 2009, 2010, and 2012. The estimated average annual serious injury and mortality rates based on these stranding data are 0.6 Clarence Strait harbor seals (0.2 due to entanglement in marine debris/gear + 0.4 due to ship strikes in 2009 and 2012) and 0.2 Lynn Canal/Stephens Passage harbor seals (due to a ship strike in 2010) for 2009 to 2013. An additional average annual mortality and serious injury rate of 0.2 will be applied to the Prince William Sound stock for a harbor seal entanglement, observed (with a remotely operated vehicle) in the salmon seine net of a sunken fishing vessel in Prince William Sound in 2011, that was reported to the NMFS Alaska Region (Helker et al. 2015). Mortality and serious injury may occasionally occur incidental to marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. Between 2003 and 2007, there was no mortality or serious injury resulting from research on any stock of harbor seals in Alaska (Division of Permits and Conservation, Office of Protected Resources, NMFS, 1315 East-West Highway, Silver Spring, MD 20910).

STATUS OF STOCK

No harbor seal stocks in Alaska are designated as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act, and human-caused mortality does not exceed PBR for any of the stocks; therefore, none of the stocks are strategic. At present, average annual mortality and serious injury levels incidental to U.S. commercial fisheries that are less than 10% of PBR can be considered insignificant and approaching zero mortality and serious injury rate. A reliable estimate of the annual rate of mortality and serious injury incidental to commercial fisheries is unavailable. Therefore, it is unknown whether the mortality and serious injury rate due to commercial fishing is insignificant. The status of all 12 stocks of harbor seals identified in Alaska relative to their Optimum Sustainable Population is unknown.

Aleutian Islands: At present, U.S. commercial fishery-related annual mortality and serious injury levels less than 17 animals (i.e., 10% of PBR) can be considered insignificant and approaching zero mortality and serious injury rate. A reliable estimate of the annual rate of mortality and serious injury incidental to commercial fisheries is unavailable. Therefore, it is unknown whether the mortality and serious injury rate due to commercial fishing is insignificant. Based on the best scientific information available, the estimated level of human-caused mortality and serious injury (0 (commercial fisheries) + 90 (harvest) + 0 (other fisheries + other mortality) = 90) is not known to exceed the PBR (173). The Aleutian Islands stock of harbor seals is not classified as a strategic stock.

Pribilof Islands: At present, U.S. commercial fishery-related annual mortality and serious injury levels less than 0.7 animals (i.e., 10% of PBR) can be considered insignificant and approaching zero mortality and serious injury rate. A reliable estimate of the annual rate of mortality and serious injury incidental to commercial fisheries is unavailable. Therefore, it is unknown whether the mortality and serious injury rate due to commercial fishing is insignificant. Based on the best scientific information available, the estimated level of human-caused mortality and serious injury (0 + 0 + 0 = 0) is not known to exceed the PBR (7). The Pribilof Islands stock of harbor seals is not classified as a strategic stock.

Bristol Bay: At present, U.S. commercial fishery-related annual mortality and serious injury levels less than 118 animals (i.e., 10% of PBR) can be considered insignificant and approaching zero mortality and serious injury rate. A reliable estimate of the annual rate of mortality and serious injury incidental to commercial fisheries is unavailable. Therefore, it is unknown whether the mortality and serious injury rate due to commercial fishing is insignificant. Based on the best scientific information available, the estimated level of human-caused mortality and serious injury (0.6 + 141 + 0 = 142) is not known to exceed the PBR (1,182). The Bristol Bay stock of harbor seals is not classified as a strategic stock.

North Kodiak: At present, U.S. commercial fishery-related annual mortality and serious injury levels less than 30 animals (i.e., 10% of PBR) can be considered insignificant and approaching zero mortality and serious injury rate. A reliable estimate of the annual rate of mortality and serious injury incidental to commercial fisheries is unavailable. Therefore, it is unknown whether the mortality and serious injury rate due to commercial fishing is insignificant. Based on the best scientific information available, the estimated level of human-caused mortality and serious injury (0 + 37 + 0 = 37) is not known to exceed the PBR (298). The North Kodiak stock of harbor seals is not classified as a strategic stock.

South Kodiak: At present, U.S. commercial fishery-related annual mortality and serious injury levels less than 32 animals (i.e., 10% of PBR) can be considered insignificant and approaching zero mortality and serious injury rate. A reliable estimate of the annual rate of mortality and serious injury incidental to commercial fisheries is unavailable. Therefore, it is unknown whether the mortality and serious injury rate due to commercial fishing is insignificant. Based on the best scientific information available, the estimated level of human-caused mortality and serious injury (1.9 + 126 + 0 = 128) is not known to exceed the PBR (315). The South Kodiak stock of harbor seals is not classified as a strategic stock.

Prince William Sound: At present, U.S. commercial fishery-related annual mortality and serious injury levels less than 84 animals (i.e., 10% of PBR) can be considered insignificant and approaching zero mortality and serious injury rate. A reliable estimate of the annual rate of mortality and serious injury incidental to commercial fisheries is unavailable. Therefore, it is unknown whether the mortality and serious injury rate due to commercial fishing is insignificant. Based on the best scientific information available, the estimated level of human-caused mortality and serious injury (24 + 255 + 0.4 = 279) is not known to exceed the PBR (838). The Prince William Sound stock of harbor seals is not classified as a strategic stock.

Cook Inlet/Shelikof Strait: At present, U.S. commercial fishery-related annual mortality and serious injury levels less than 77 animals (i.e., 10% of PBR) can be considered insignificant and approaching zero mortality and serious injury rate. A reliable estimate of the annual rate of mortality and serious injury incidental to commercial fisheries is unavailable. Therefore, it is unknown whether the mortality and serious injury rate due to commercial fishing is insignificant. Based on the best scientific information available, the estimated level of human-caused mortality and serious injury (0.4 + 233 + 0.2 = 234) is not known to exceed the PBR (770). The Bristol Bay stock of harbor seals is not classified as a strategic stock.

Glacier Bay/Icy Strait: At present, U.S. commercial fishery-related annual mortality and serious injury levels less than 17 animals (i.e., 10% of PBR) can be considered insignificant and approaching zero mortality and serious injury rate. A reliable estimate of the annual rate of mortality and serious injury incidental to commercial fisheries is unavailable. Therefore, it is unknown whether the mortality and serious injury rate due to commercial fishing is insignificant. Based on the best scientific information available, the estimated level of human-caused mortality and serious injury (0 + 104 + 0 = 104) is not known to exceed the PBR (169). The Glacier Bay/Icy Strait stock of harbor seals is not classified as a strategic stock.

Lynn Canal/Stephens Passage: At present, U.S. commercial fishery-related annual mortality and serious injury levels less than 16 animals (i.e., 10% of PBR) can be considered insignificant and approaching zero mortality and serious injury rate. A reliable estimate of the annual rate of mortality and serious injury incidental to commercial fisheries is unavailable. Therefore, it is unknown whether the mortality and serious injury rate due to commercial fishing is insignificant. Based on the best scientific information available, the estimated level of human-caused mortality and serious injury (0 + 50 + 0.2 = 50) is not known to exceed the PBR (155). The Lynn Canal/Stephens Passage stock of harbor seals is not classified as a strategic stock.

Sitka/Chatham Strait: At present, U.S. commercial fishery-related annual mortality and serious injury levels less than 56 animals (i.e., 10% of PBR) can be considered insignificant and approaching zero mortality and serious injury rate. A reliable estimate of the annual rate of mortality and serious injury incidental to commercial fisheries is unavailable. Therefore, it is unknown whether the mortality and serious injury rate due to commercial fishing is insignificant. Based on the best scientific information available, the estimated level of human-caused mortality and serious injury (0 + 77 + 0 = 77) is not known to exceed the PBR (555). The Sitka/Chatham Strait stock of harbor seals is not classified as a strategic stock.

Dixon/Cape Decision: At present, U.S. commercial fishery-related annual mortality and serious injury levels less than 70 animals (i.e., 10% of PBR) can be considered insignificant and approaching zero mortality and serious injury rate. A reliable estimate of the annual rate of mortality and serious injury incidental to commercial fisheries is unavailable. Therefore, it is unknown whether the mortality and serious injury rate due to commercial fishing is insignificant. Based on the best scientific information available, the estimated level of human-caused mortality and serious injury (0 + 69 + 0 = 69) is not known to exceed the PBR (703). The Dixon/Cape Decision stock of harbor seals is not classified as a strategic stock.

Clarence Strait: At present, U.S. commercial fishery-related annual mortality and serious injury levels less than 122 animals (i.e., 10% of PBR) can be considered insignificant and approaching zero mortality and serious injury rate. A reliable estimate of the annual rate of mortality and serious injury incidental to commercial fisheries is unavailable. Therefore, it is unknown whether the mortality and serious injury rate due to commercial fishing is insignificant. Based on the best scientific information available, the estimated level of human-caused mortality and serious injury (0 + 40 + 0.8 = 41) is not known to exceed the PBR (1,222). The Clarence Strait stock of harbor seals is not classified as a strategic stock.

HABITAT CONCERNS

Glacial fjords in Alaska are critical for harbor seal whelping, nursing, and molting. Several of these areas have experienced a ten-fold increase in tour ship visitation since the 1980s. This increase in the presence of tour vessels has resulted in additional levels of disturbance to pups and adults (Jansen et al. 2015). The level of serious injury or mortality resulting from increased disturbance is not known.

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SPOTTED SEAL (*Phoca largha*): Alaska Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Spotted seals are distributed along the continental shelf of the Bering, Chukchi, and Beaufort seas, and the Sea of Okhotsk south to the western Sea of Japan and northern Yellow Sea (Fig. 1). Eight main areas of spotted seal breeding have been reported (Shaughnessy and Fay 1977). On the basis of small samples and preliminary analyses of genetic composition, potential geographic barriers, and significance of breeding groups Boveng et al. (2009) grouped those breeding areas into three Distinct Population Segments (DPSs): The Bering DPS, which includes breeding areas in the Bering Sea; the Okhotsk DPS; and the Southern DPS, which includes spotted seals breeding in the Yellow Sea and Peter the Great Bay in the Sea of Japan. For the purposes of this stock assessment the Bering DPS is considered the Alaska stock of the spotted seal.

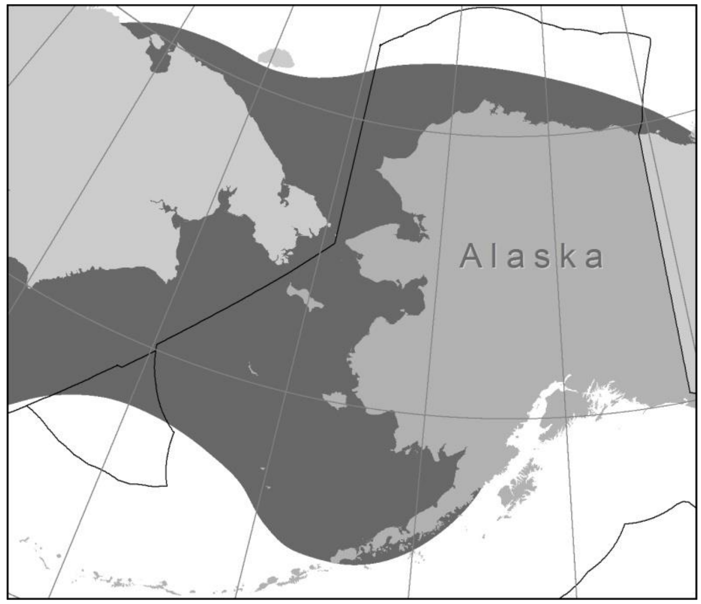

Figure 1. Approximate distribution of spotted seals (shaded area).

The distribution of spotted seals is seasonally related to specific life history events that can be broadly divided into two periods: late-fall through spring when whelping, nursing, breeding, and molting occur in association with the presence of sea ice on which the seals haul out, and summer through fall when seasonal sea ice has melted and most spotted seals use land for hauling out (Boveng et al. 2009). Satellite tagging studies showed that seals tagged in the northeastern Chukchi Sea moved south in October and passed through the Bering Strait in November. Seals overwintered in the Bering Sea along the ice edge and made east-west movements along the edge (Lowry et al. 1998). During spring they tend to prefer small floes (i.e., < 20 m in diameter), and inhabit mainly the southern margin of the ice in areas where water depth does not exceed 200 m, and move to coastal habitats after molting and the retreat of the sea ice (Fay 1974, Shaughnessy and Fay 1977, Lowry et al. 2000, Simpkins et al. 2003). In summer and fall, spotted seals use coastal haul-out sites regularly (Frost et al. 1993, Lowry et al. 1998), and may be found as far north as 69-72°N in the Chukchi and Beaufort Seas (Porsild 1945, Shaughnessy and Fay 1977). To the south, along the west coast of Alaska, spotted seals are known to occur around the Pribilof Islands, Bristol Bay, and the eastern Aleutian Islands. Spotted seals are closely related to and often mistaken for Pacific harbor seals (*Phoca vitulina richardii*). The two species are often seen together and are partially sympatric, as their ranges overlap in the southern part of the Bering Sea (Quakenbush 1988). Yet, spotted seals breed earlier and are less social during the breeding season, and only spotted seals are strongly associated with pack ice (Shaughnessy and Fay 1977). These and other ecological, behavioral, genetic, and morphological differences support their recognition as two separate species (Quakenbush 1988, O'Corry-Crowe and Westlake 1997).

The following information was considered in classifying stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution continuous; 2) Population response data: unknown; 3) Phenotypic data: unknown; 4) Genotypic data: unknown. Based on this limited information, and the absence of any significant fishery interactions, there is currently no strong evidence to suggest splitting Alaska spotted seals into more than one stock. Therefore, only one Alaska stock is recognized in U.S. waters.

POPULATION SIZE

Recent surveys and analyses have substantially improved the documentation of the spotted seal population breeding in the U.S. waters of the Bering Sea. A large segment (280,000 km^2) of the breeding area was surveyed by helicopter from an icebreaker in the spring of 2007; the abundance of spotted seals was estimated using a model that incorporated variation due to detectability, availability (proportion hauled out), and changes in extent and concentration of sea ice during the surveys. The modal estimate of abundance was 233,700 spotted seals with a 95% credible interval of 137,300-793,100 (Ver Hoef et al. 2014). A more extensive fixed-wing aerial survey (767,000 km^2) conducted during April-May of 2012 and 2013 encompassed the vast majority of the spotted seal breeding area. Analysis of a portion of the data, from 10 broadly-distributed survey flights during 20-27 April 2012, resulted in a mean estimate of 460,268 spotted seals, with a 95% CI of 391,000-559,993 (Conn et al. 2014). The method accounted for uncertainty in detection rate and species classification, as well as availability.

Other, previous surveys and estimates for spotted seals in the Bering Sea (e.g., Braham et al. 1984, Fedoseev et al. 1988, Fedoseev 2000, Rugh et al. 1995) are problematic to interpret and to compare with recent estimates because there is insufficient information available to assess detection rates, species mis-classification rates, area surveyed, extrapolation to unsurveyed areas, and other critical factors for estimating abundance and trends (Burkanov et al. 1988, Conn et al. 2013, Ver Hoef et al. 2014).

Minimum Population Estimate

The 2012 survey was used as the basis for the minimum population estimate because it was the most current survey, the survey tracks encompassed more of the spotted seal breeding area than did the 2007 tracks, and it was conducted at a substantially higher altitude (1,000 ft.) than the 2007 survey (400 ft.), reducing the potential for bias from disturbance. Conn et al. (2014) acknowledged potential upward bias resulting from the process of extrapolating to unsurveyed areas; consequently, the lower 95% confidence limit, rather than the lower 80% limit was used for the minimum population estimate, N_{MIN} = 391,000.

Current Population Trend

Frost et al. (1993) report that counts of spotted seals were relatively stable at Kasegaluk Lagoon from the mid-1970s through 1991. Because this represents only a fraction of the stock’s range and the data are outdated, reliable data on trends in population abundance for the Alaska stock of spotted seals are considered unavailable.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for the Alaska stock of spotted seals. Hence, until additional data become available, it is recommended that the pinniped maximum theoretical net productivity rate (R_{MAX}) of 12% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5 R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for pinniped stocks with unknown population status (Wade and Angliss 1997). Therefore, PBR for this stock is 391,000 × 0.06 × 0.5 = 11,730 individuals.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an “*injury that is more likely than not to result in mortality*”. Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fisheries Information

Prior to 2004, there were no reports of incidental serious injuries and mortalities of spotted seals in any of the observed fisheries. Between 2008 and 2012, incidental serious injuries and mortalities of spotted seals were reported in 3 of the 22 federally regulated commercial fisheries in Alaska monitored for incidental mortality by fisheries observers: the Bering Sea/Aleutian Islands flatfish trawl, Bering Sea/Aleutian Islands pollock trawl, and the Bering Sea/Aleutian Islands Pacific cod longline fisheries (Table 1). The total estimated minimum annual mortality rate incidental to commercial fisheries is 1.5 (CV = 0.13) spotted seals per year, based on observer data.

Serious injury and mortality of harbor seals incidental to commercial fisheries has occurred within the past five years and, because it is virtually impossible to distinguish between these two species, some of the reported harbor seal takes may actually have been spotted seals. Further, no observer programs have been done on nearshore Bristol Bay fisheries that are known to interact with this stock, making the total mortality due to fisheries unknown.

Table 1. Summary of incidental mortality of spotted seals (Alaska stock) due to commercial fisheries from 2008 through 2012 and calculation of the mean annual mortality rate (Breiwick 2013). Details of how percent observer coverage is measured are included in Appendix 6.

Fishery name	Years	Data type	Observer coverage	Reported mortality (in given yrs.)	Estimated mortality (in given yrs.)	Mean annual mortality
Bering Sea/Aleutian Islands flatfish trawl	2008 2009 2010 2011 2012	obs data	100 100 100 100 100	2 1 0 0 2	2.0 1.0 0 0 2.0	1.00 (CV = 0.01)
Bering Sea/Aleutian Islands pollock trawl	2008 2009 2010 2011 2012	obs data	85 86 86 98 98	0 0 1 0 0	0 0 1.0 0 0	0.20 (CV = 0.11)
Bering Sea/Aleutian Islands Pacific cod longline	2008 2009 2010 2011 2012	obs data	63 60 64 57 51	0 0 0 1 0	0 0 0 1.6 0	0.32 (CV = 0.61)
Minimum total annual mortality						1.52 (CV = 0.13)

Subsistence/Native Harvest Information

Spotted seals are an important species for Alaskan subsistence hunters, primarily in the Bering Strait and Yukon-Kuskokwim regions.

Few studies give a statewide estimate of subsistence take. The Division of Subsistence, Alaska Department of Fish and Game and the Alaska Native Harbor Seal Commission have reported subsistence harvest levels of harbor seals and sea lions annually (e.g., Wolfe et al. 2009). Harvest data were reported from 63 coastal communities, including 6 communities from northern Bristol Bay. Due to seasonal geographic overlap in spotted and harbor seal distribution in northern Bristol Bay in combination with the difficulty in distinguishing the two species from external morphology, reports of harvests of spotted seals were differentiated from harbor seals based on ecological features of the kill, primarily degree of association with seasonal ice (Wolfe et al. 2008). In 2008, six coastal villages in northern Bristol Bay reported a total of 271 spotted seals taken during for subsistence harvest (213 harvested, 58 struck and lost). As of 2009, data on community subsistence harvests are no longer being collected. Five Alaska Native communities in the Northwest Arctic region of Alaska voluntarily reported a total of 119 spotted seals were harvested during 2012 (Ice Seal Committee 2013). No complete data for the spotted seal harvest and struck and lost animals are available for the 2008-2012 period.

The Division of Subsistence, Alaska Department of Fish and Game, maintains a database that provides additional information on the subsistence harvest of ice seals in different regions of Alaska (ADFG 2000a, b). Information on subsistence harvest of spotted seals has been compiled for 135 villages from reports from the Division of Subsistence (Coffing et al. 1998, Georgette et al. 1998, Wolfe and Hutchinson-Scarbrough 1999) and a report from the Eskimo Walrus Commission (Sherrod 1982). Data were lacking for 22 villages; their harvests were estimated using the annual per capita rates of subsistence harvest from a nearby village. Harvest levels were estimated from data gathered in the 1980s for 16 villages; otherwise, data gathered from 1990-1998 were used. As of August 2000; the subsistence harvest database indicated that the estimated number of spotted seals harvested for subsistence use per year was 5,265.

At this time, there are no efforts to quantify the total statewide level of harvest of spotted seals by all Alaska communities.

A report on ice seal subsistence harvest in three Alaskan communities indicated that the number and species of ice seals harvested in a particular village may vary considerably among years (Coffing et al. 1999). These interannual differences are likely due to differences in ice and wind conditions that change the hunters' access to different ice habitats frequented by different types of seals. Although some of the more recent entries in the ADFG database have associated measures of uncertainty (Coffing et al. 1999, Georgette et al. 1998), the overall total does not. The estimate of 5,265 spotted seals is the best estimate of harvest level currently available.

STATUS OF STOCK

Spotted seals in Alaska are not designated as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act. Based on currently available data, the minimum estimated U.S. commercial fishery-related mortality and serious injury for this stock (1.52) is less than 10% of the calculated PBR (1,173) and, therefore, can be considered to be insignificant and approaching a zero mortality and serious injury rate. The estimated annual level of total human-caused mortality and serious injury is 1.52 (commercial fisheries) + 5,265 (Alaska Native harvest) = 5,267 does not exceed the PBR (11,730) for this stock. The Alaska stock of spotted seals is not considered a strategic stock.

On 28 March 2008, NMFS initiated a status review of the spotted seal (73 FR 16617). On 28 May 2008, NMFS received a petition to list spotted seals under the ESA, primarily due to concern about threats to this species' habitat from loss of sea ice and climate change in the Arctic. NMFS found that the petition presented sufficient information to consider listing and proceeded with the status review (73 FR 51615, 4 September 2008). After the status review was complete (Boveng et al. 2009), NMFS determined that listing the Bering and Okhotsk DPSs of spotted seals was not warranted at this time. The Southern DPS, however, was proposed for listing as "threatened" under the ESA (74 FR 53683, 20 October 2009). After fully considering comments from peer reviewers and the public, NMFS issued a final rule listing the Southern DPS as "threatened" on 22 October 2010 (75 FR 65239).

Habitat Concerns

The main concern about the conservation status of spotted seals stems from the likelihood that their sea-ice habitat has been modified by the warming climate and, more so, that the scientific consensus projections are for continued and perhaps accelerated warming in the foreseeable future (Boveng et al. 2009). Despite the recent dramatic reductions in Arctic Ocean ice extent during summer, the sea ice in the Bering Sea is expected to continue forming annually in winter for the foreseeable future. There will likely be more frequent years in which ice coverage is reduced, resulting in a decline in the long-term average ice extent, but Bering Sea spotted seals will likely continue to encounter sufficient ice to support adequate vital rates. Even if sea ice were to vanish completely from the Bering Sea, there may be prospects for spotted seals to adjust their breeding grounds to follow the northward shift of the annual ice front into the Chukchi Sea. Laidre et al. (2008) concluded that on a worldwide basis spotted seals were likely to be moderately sensitive to climate change based on an analysis of various life history features that could be affected by climate.

A second major concern, related by the common driver of carbon dioxide (CO_2) emissions, is the modification of habitat by ocean acidification, which may alter prey populations and other important aspects of the marine ecosystem. Ocean acidification, a result of increased CO_2 in the atmosphere, may impact spotted seal survival and recruitment through disruption of trophic regimes that are dependent on calcifying organisms. The nature and timing of such impacts are extremely uncertain. Because of spotted seals' apparent dietary flexibility, this threat should be of less immediate concern than the direct effects of sea-ice degradation (Boveng et al. 2009).

Additional habitat concerns include the potential effects from oil and gas exploration activities, particularly in the outer continental shelf leasing areas, such as disturbance from vessel traffic, seismic exploration noise, or the potential for oil spills.

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BEARDED SEAL (*Erignathus barbatus nauticus*): Alaska Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Bearded seals are a boreoarctic species with a circumpolar distribution (Fedoseev 1965; Johnson et al. 1966; Burns 1967, 1981; Burns and Frost 1979; Smith 1981; Kelly 1988). Their normal range extends from the Arctic Ocean (85°N) south to Sakhalin Island (45°N) in the Pacific and south to Hudson Bay (55°N) in the Atlantic (Allen 1880, Ognev 1935, King 1983). Bearded seals inhabit the seasonally ice-covered seas of the Northern Hemisphere, where they whelp and rear their pups and molt their coats on the ice in the spring and early summer. Bearded seals feed primarily on benthic organisms, including epifaunal and infaunal invertebrates, and demersal fishes and so are closely linked to areas where the seafloor is shallow (less than 200 m).

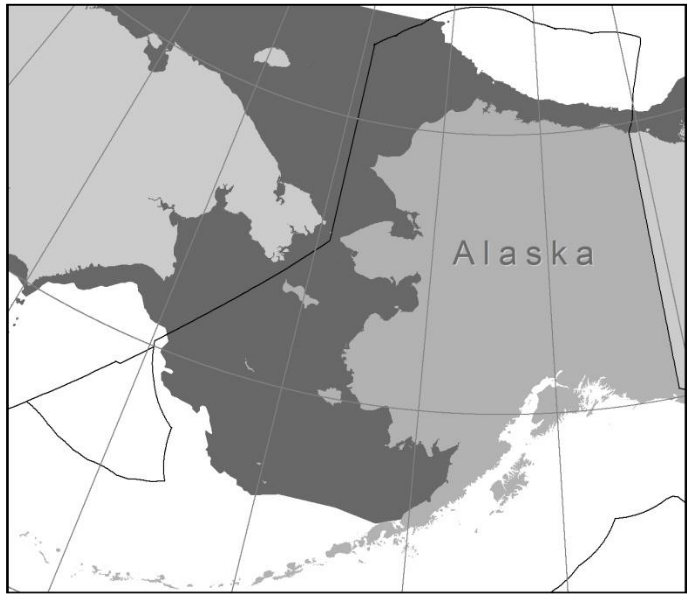

Figure 1. Approximate distribution of bearded seals (dark shaded area) in Alaska. The combined summer and winter distribution are depicted.

Two subspecies have been described: *E. b. barbatus* from the Laptev Sea, Barents Sea, North Atlantic Ocean, and Hudson Bay (Rice 1998); and *E. b. nauticus* from the remaining portions of the Arctic Ocean and the Bering and Okhotsk seas (Ognev 1935, Scheffer 1958, Manning 1974, Heptner et al. 1976). The geographic distributions of these subspecies are not separated by conspicuous gaps, and there are regions of intergrading generally described as somewhere along the northern Russian and central Canadian coasts. As part of a status review of the bearded seal for consideration of listing as threatened or endangered under the Endangered Species Act (ESA), Cameron et al. (2010) defined longitude 145°E as the Eurasian delineation between the two subspecies and 112°W in the Canadian Arctic Archipelago as the North American delineation between the two subspecies. Based on evidence for discreteness and ecological uniqueness of bearded seals in the Sea of Okhotsk, the *E. b. nauticus* subspecies was further divided into an Okhotsk Distinct Population Segment (DPS) and a Beringia DPS, so named because the continental shelf waters of the Bering, Chukchi, Beaufort, and East Siberian seas that are the bearded seals' range in this region overlie much of the land bridge that was exposed during the last glaciation, which has been referred to as Beringia. For the purposes of this stock assessment the Beringia DPS is considered the Alaska stock of the bearded seal (Fig. 1).

Spring surveys conducted in 1999-2000 along the Alaska coast indicate that bearded seals are typically more abundant 20-100 nmi from shore than within 20 nmi from shore, except for high concentrations nearshore to the south of Kivalina (Bengtson et al. 2000, 2005; Simpkins et al. 2003). Many seals that winter in the Bering Sea move north through the Bering Strait from late April through June and spend the summer in the Chukchi Sea (Burns 1967, 1981). Bearded seal sounds (produced by adult males) have been recorded nearly year-round (peak occurrence in December-June, when sea ice concentrations were >50%) at multiple locations in the Bering, Chukchi, and Beaufort seas, and calling behavior is closely related to the presence of sea ice (MacIntyre et al. 2013, 2015). The overall summer distribution is quite broad, with seals rarely hauled out on land, and some seals, mostly juveniles, may not follow the ice northward but remain near the coasts of the Bering and Chukchi seas (Burns 1967, 1981; Heptner et al. 1976; Nelson 1981). As the ice forms again in the fall and winter, most seals move south with the advancing ice edge through the Bering Strait into the Bering Sea where they spend the winter (Burns and Frost 1979; Frost et al. 2005, 2008; Cameron and Boveng 2007, 2009). This southward migration is less noticeable and predictable than the northward movements in late spring and early summer (Burns and Frost 1979, Burns 1981, Kelly 1988). During winter, the central and northern parts of the Bering Sea shelf have the highest densities of bearded seals (Fay 1974, Heptner et al. 1976, Burns and Frost 1979, Braham et al. 1981, Burns 1981, Nelson et al. 1984). In late winter and early spring, bearded seals are widely but not uniformly distributed in the broken, drifting pack ice ranging from the Chukchi Sea south to the ice front in the Bering Sea. In these areas, they tend to avoid the coasts and areas of fast ice (Burns 1967, Burns and Frost 1979).

POPULATION SIZE

A reliable population estimate for the entire stock is not available, but research programs have recently developed new survey methods and partial, but useful, abundance estimates. In spring of 2012 and 2013, U.S. and Russian researchers conducted aerial abundance and distribution surveys over the entire Bering Sea and Sea of Okhotsk (Moreland et al. 2013). The data from these image-based surveys are still being analyzed, but Conn et al. (2014), using a very limited sub-sample of the data collected from the U.S. portion of the Bering Sea in 2012, calculated an abundance estimate of approximately 299,174 (95% CI: 245,476-360,544) bearded seals in U.S. waters. These data do not include bearded seals that were in the Chukchi and Beaufort seas at the time of the surveys.

Minimum Population Estimate

The minimum population estimate (N_{MIN}) for a stock is calculated using Equation 1 from the potential biological removal (PBR) guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. An N_{MIN} for the entire stock cannot presently be determined because current reliable estimates of abundance are not available for the Chukchi and Beaufort seas. Using the 2012 Bering Sea abundance estimate by Conn et al. (2014), however, provides an N_{MIN} of 273,676 bearded seals in the U.S. sector of the Bering Sea.

Current Population Trend

At present, reliable data on trends in population abundance for the Alaska stock of bearded seals are unavailable.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for the Alaska stock of bearded seals. Hence, until additional data become available, it is recommended that the pinniped maximum theoretical net productivity rate (R_{MAX}) of 12% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for pinniped stocks with unknown population status (Wade and Angliss 1997). Using the N_{MIN} calculated for bearded seals in the Bering Sea, a PBR for bearded seals that overwinter and breed in the U.S. portion of the Bering Sea = 8,210 seals (273,676 × 0.06 × 0.5). However, this is not an estimate of PBR for the entire stock because a reliable estimate of N_{MIN} is currently not available for the entire stock; i.e., N_{MIN} is not available for the Chukchi and Beaufort seas.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

Of the 22 federally-regulated U.S. commercial fisheries in Alaska monitored for incidental mortality and serious injury by fisheries observers, 12 fisheries could potentially interact with bearded seals. During 2010-2014, incidental mortality and serious injury of bearded seals occurred in three fisheries: the Bering Sea/Aleutian Islands pollock trawl, Bering Sea/Aleutian Islands flatfish trawl, and Bering Sea/Aleutian Islands Pacific cod trawl fisheries (Table 1; Breiwick 2013; MML, unpubl. data). The estimated minimum mean annual mortality and serious injury rate incidental to U.S. commercial fisheries is 1.4 bearded seals, based exclusively on observer data.

Table 1. Summary of incidental mortality and serious injury of Alaska bearded seals due to U.S. commercial fisheries in 2010-2014 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Is. pollock trawl	2010 2011 2012 2013 2014	obs data	86 98 98 97 98	0 (+1)[a] 0 1 0 1	0 (+1)[b] 0 1.0 0 1.0	0.4 (+0.2)[c] (CV = 0.11)
Bering Sea/Aleutian Is. flatfish trawl	2010 2011 2012 2013 2014	obs data	99 100 99 99 99	0 1 1 0 1	0 1 1.0 0 1	0.6 (CV = 0.03)
Bering Sea/Aleutian Is. Pacific cod trawl	2010 2011 2012 2013 2014	obs data	66 60 68 80 80	0 0 0 1 0	0 0 0 1 0	0.2 (CV = 0)
Minimum total estimated annual mortality						1.4 (CV = 0.04)

[a]Total mortality and serious injury observed in 2010: 0 seals in sampled hauls + 1 seal in an unsampled haul.
[b]Total estimate of mortality and serious injury in 2010: 0 seals (extrapolated estimate from 0 seals observed in sampled hauls) + 1 seal (1 seal observed in an unsampled haul).
[c]Mean annual mortality and serious injury for fishery: 0.4 seals (mean of extrapolated estimates from sampled hauls) + 0.2 seals (mean of number observed in unsampled hauls).

Alaska Native Subsistence/Harvest Information

Bearded seals are an important resource for Alaska Native subsistence hunters. Approximately 64 Alaska Native communities in western and northern Alaska, from Bristol Bay to the Beaufort Sea, regularly harvest ice seals (Ice Seal Committee 2016). The Ice Seal Committee, as co-managers with NMFS, recognizes the importance of harvest information and has collected it since 2008, when funding and personnel have allowed. Annual household survey results compiled in a statewide harvest report include historical ice seal harvest information back to 1960 (Quakenbush et al. 2011). This report is used to determine where and how often harvest information was collected and where to focus in the future (Ice Seal Committee 2016). Information for 2009-2013 is available for 12 communities (Point Lay, Kivalina, Noatak, Buckland, Deering, Emmonak, Scammon Bay, Hooper Bay, Tununak, Quinhagak, Togiak, and Twin Hills) (Table 2); but more than 50 other communities harvest bearded seals and have not been surveyed in this time period or have never been surveyed. Harvest surveys are designed to estimate harvest within the surveyed community, but because of differences in seal availability, cultural hunting practices, and environmental conditions, extrapolating harvest numbers beyond that community is not appropriate. For example, during 2009-2013, only 12 of 64 coastal communities were surveyed for bearded seals; and, of those communities, only 6 were surveyed for two or more consecutive years (Ice Seal Committee 2016). Based on the harvest data from these 12 communities (Table 2), a minimum estimate of the average annual harvest of bearded seals in 2009-2013 is 390 seals. The Ice Seal Committee is working toward a better understanding of ice seal harvest by conducting more consecutive surveys in more communities with a goal to report a statewide ice seal harvest estimate.

Table 2. Alaska bearded seal harvest estimates in 2009-2013 (Ice Seal Committee 2016).

Community	**Estimated bearded seal harvest**				
	2009	**2010**	**2011**	**2012**	**2013**
Point Lay				55	
Kivalina			123		
Noatak			65		
Buckland			47		
Deering			49		
Emmonak			106		
Scammon Bay			82	51	
Hooper Bay	332	148	210	212	171
Tununak	21	40	42	44	
Quinhagak		29	26	44	49
Togiak	0	0	2		
Twin Hills	0	0			
Total	353	217	752	406	220

Other Mortality

Mortality and serious injury may occasionally occur incidental to marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. During 2010-2014, no research-related mortality or serious injury was reported for the Alaska stock of bearded seals (Division of Permits and Conservation, Office of Protected Resources, NMFS, 1315 East-West Highway, Silver Spring, MD 20910).

Beginning in mid-July 2011, elevated numbers of sick or dead seals, primarily ringed seals, with skin lesions were discovered in the Arctic and Bering Strait regions. By December 2011, there were more than 100 cases of affected pinnipeds, including bearded seals, ringed seals, spotted seals, and walruses in northern and western Alaska. Due to the unusual number of marine mammals discovered with similar symptoms across a wide geographic area, NMFS and USFWS declared a Northern Pinniped Unusual Mortality Event (UME) on December 20, 2011. Disease surveillance efforts in 2012-2013 detected few new cases similar to those observed in 2011, but the UME investigation remains open for bearded seals based on continuing reports in 2013-2014 of ice seals in the Bering Strait region with patchy hair loss (alopecia). To date, no specific cause for the disease has been identified.

STATUS OF STOCK

On December 28, 2012, NMFS listed the Beringia DPS bearded seal (*E. b. nauticus*): and, thus, the Alaska stock of bearded seals, as threatened under the ESA (77 FR 76740). The primary concern for this population is the ongoing and projected loss of sea-ice cover stemming from climate change, which is expected to pose a significant threat to the persistence of these seals in the foreseeable future (based on projections through the end of the 21st century; Cameron et al. 2010). On July 25, 2014, the U.S. District Court for the District of Alaska issued a memorandum decision in a lawsuit that challenged listing bearded seals under the ESA (Alaska Oil and Gas Association v. Pritzker, Case No. 4:13-cv-00018-RPB). The decision vacated NMFS' listing of the Beringia DPS of bearded seals as a threatened species. Consequently, it is also no longer designated as depleted or classified as a strategic stock. Because the PBR for the entire stock is unknown, the mean annual U.S. commercial fishery-related mortality and serious injury rate that can be considered insignificant and approaching zero mortality and serious injury rate is unknown. A PBR for only those bearded seals that overwinter and breed in the U.S. portion of the Bering Sea is 8,210 bearded seals. The total estimated annual level of human-caused mortality and serious injury is 391 bearded seals. Population trends and status of this stock relative to its Optimum Sustainable Population are currently unknown.

HABITAT CONCERNS

The main concern about the conservation status of bearded seals stems from the likelihood that their preferred sea-ice habitats are being modified by the warming climate. Future scientific projections are for continued and perhaps accelerated warming (Cameron et al. 2010). For bearded seals, the presence of sea ice is considered a requirement for whelping and nursing young. Similarly, the molt is believed to be promoted by elevated skin temperatures that, in polar regions, can only be achieved when seals haul out of the water. Thus, if suitable ice cover is absent from shallow feeding areas during times of peak whelping and nursing (April/May), or molting (May/June and sometimes through August), bearded seals would be forced to seek either sea-ice habitat over deeper waters (perhaps with poor access to food) or onshore haul-out sites (perhaps with increased risks of disturbance, predation, and competition). Both scenarios would require bearded seals to adapt to novel (i.e., potentially suboptimal) conditions, and to exploit habitats to which they may not be well adapted, likely compromising their reproduction and survival rates. A reliable assessment for the future conservation status of each bearded seal DPS requires a focus on projections of specific regional conditions, especially sea ice. End of century projections for the Bering Sea in April-May suggest that there will be sufficient ice only in small zones in the Gulf of Anadyr and in the area between St. Lawrence Island and the Bering Strait. Suitable ice in June in the Bering Sea is predicted to disappear as early as mid-century. To adapt to this regime, bearded seals would likely have to shift their nursing, rearing, and molting areas to the ice-covered seas north of the Bering Strait. Laidre et al. (2008) also concluded that on a worldwide basis bearded seals were likely to be highly sensitive to climate change based on an analysis of various life history features that could be affected by climate.

A second major concern, driven primarily by the production of carbon dioxide (CO_2) emissions, is the modification of habitat by ocean acidification, which may alter prey populations and other important aspects of the marine ecosystem. Ocean acidification, a result of increased CO_2 in the atmosphere, may affect bearded seal survival and recruitment through disruption of trophic regimes that are dependent on calcifying organisms. The nature and timing of such impacts are extremely uncertain. Changes in bearded seal prey, anticipated in response to ocean warming and loss of sea ice, have the potential for negative impacts, but the possibilities are complex. Ecosystem responses may have very long lags as they propagate through trophic webs. Because of bearded seals' apparent dietary flexibility, this threat may be of less immediate concern than the threats from sea-ice degradation.

Additional habitat concerns include the potential effects from increased shipping (particularly in the Bering Strait), and oil and gas exploration activities (particularly in the outer continental shelf leasing areas), such as disturbance from vessel traffic, seismic exploration noise, or the potential for oil spills.

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RINGED SEAL (*Pusa hispida hispida*): Alaska Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Ringed seals (*Pusa hispida*) have a circumpolar distribution and are found in all seasonally ice-covered seas of the Northern Hemisphere as well as in certain freshwater lakes (King 1983). Most taxonomists currently recognize five subspecies of ringed seals: *P. h. hispida* in the Arctic Ocean and Bering Sea; *P. h. ochotensis* in the Sea of Okhotsk and northern Sea of Japan; *P. h. botnica* in the northern Baltic Sea; *P. h. lagodensis* in Lake Ladoga, Russia; and *P. h. saimensis* in Lake Saimaa, Finland. Morphologically, the Baltic and Okhotsk subspecies are fairly well differentiated from the Arctic subspecies (Ognev 1935, Müller-Wille 1969, Rice 1998) and the Ladoga and Saimaa subspecies differ significantly from each other and from the Baltic subspecies (Müller-Wille 1969, Hyvärinen and Nieminen 1990, Amano et al. 2002). Genetic analyses support isolation of the lake-inhabiting populations (Palo 2003, Palo et al. 2003, Valtonen et al. 2012). Lack of differentiation between the Baltic and the Arctic subspecies may reflect recurrent gene flow (Martinez-Bakker et al. 2013) but is more likely due to retention of high diversity within the relatively large effective population size of the Baltic subspecies since separation from the Arctic subspecies (Nyman et al. 2014). Widespread mixing within the Arctic subspecies is the likely explanation for its high diversity and apparent lack of population structure (Palo et al. 2001, Davis et al. 2008, Kelly et al. 2009, Martinez-Bakker et al. 2013). Differences in body size, morphology, growth rates, and/or diet between Arctic ringed seals in shorefast versus pack ice have been taken as evidence of separate breeding populations in some locations (McLaren 1958, Fedoseev 1975, Finley et al. 1983). This has not been thoroughly examined, however, and the taxonomic status of the Arctic subspecies remains unresolved (Berta and Churchill 2012). For the purposes of this stock assessment, the Alaska stock of ringed seals is considered the portion of the Arctic subspecies (*P. h. hispida*) that occurs within the U.S. Exclusive Economic Zone of the Beaufort, Chukchi, and Bering seas (Fig. 1).

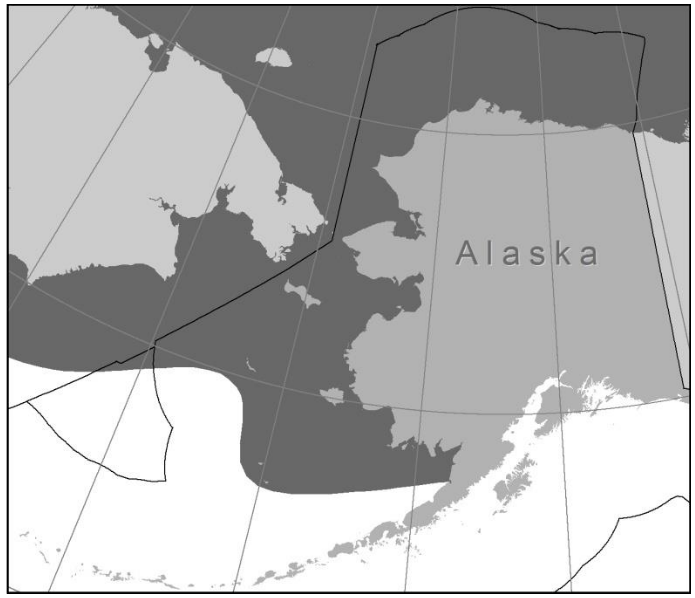

Figure 1. Approximate winter distribution of ringed seals (dark shaded area).

Throughout their range, ringed seals have an affinity for ice-covered waters and are well adapted to occupying both shorefast and pack ice (Kelly 1988a). They remain with the ice most of the year and use it as a platform for pupping and nursing in late winter to early spring, for molting in late spring to early summer, and for resting at other times of the year. This species rarely comes ashore in the Arctic; however, in more southerly portions of its range where sea or lake ice is absent during summer and fall, ringed seals are known to use isolated haul-out sites on land for molting and resting (Härkönen et al. 1998, Trukhin 2000, Kunnasranta 2001, Lukin et al. 2006). In Alaska waters, during winter and early spring when sea ice is at its maximal extent, ringed seals are abundant in the northern Bering Sea, Norton and Kotzebue Sounds, and throughout the Chukchi and Beaufort seas. They occur as far south as Bristol Bay in years of extensive ice coverage but generally are not abundant south of Norton Sound except in nearshore areas (Frost 1985). Although details of their seasonal movements have not been adequately documented, most ringed seals that winter in the Bering and Chukchi seas are thought to migrate north in spring as the seasonal ice melts and retreats (Burns 1970) and spend summers in the pack ice of the northern Chukchi and Beaufort seas, as well as in nearshore ice remnants in the Beaufort Sea (Frost 1985). During summer, ringed seals range hundreds to thousands of kilometers to forage along ice edges or in highly productive open-water areas (Harwood and Stirling 1992, Freitas et al. 2008, Kelly et al. 2010b, Harwood et al. 2015). With the onset of freeze-up in the fall, ringed seal movements become increasingly restricted. Seals that have summered in the Beaufort Sea are thought to move west and south with the advancing ice pack, with many seals dispersing throughout the Chukchi and Bering seas while some remain in the Beaufort Sea (Frost and Lowry 1984, Crawford et al. 2012, Harwood et al. 2012). Some adult ringed seals return to the same small home ranges they occupied during the previous winter (Kelly et al. 2010b).

POPULATION SIZE

Ringed seal population surveys in Alaska have used various methods and assumptions, incompletely covered their habitats and range, and were conducted more than a decade ago; therefore, current, comprehensive, and reliable abundance estimates or trends for the Alaska stock are not available. Frost et al. (2004) conducted aerial surveys within 40 km of shore in the Alaska Beaufort Sea during May-June 1996-1999 and observed ringed seal densities ranging from 0.81 seals/km^2 in 1996 to 1.17 seals/km^2 in 1999. Moulton et al. (2002) conducted similar, concurrent surveys in the Alaska Beaufort Sea during 1997-1999 but reported substantially lower ringed seal densities than Frost et al. (2004). The reason for this disparity was unclear (Frost et al. 2004). Bengtson et al. (2005) conducted aerial surveys in the Alaska Chukchi Sea during May-June 1999-2000. While the surveys were focused on the coastal zone within 37 km of shore, additional survey lines were flown up to 185 km offshore. Population estimates were derived from observed densities corrected for availability bias using a haul-out model from six tagged seals. Ringed seal abundance estimates for the entire survey area were 252,488 (SE = 47,204) in 1999 and 208,857 (SE = 25,502) in 2000. Using the most recent survey estimates from surveys by Bengtson et al. (2005) and Frost et al. (2004) in the late 1990s and 2000, for the purposes of an Endangered Species Act (ESA) status review, Kelly et al. (2010a) estimated the total population in the Alaska Chukchi and Beaufort seas to be at least 300,000 ringed seals. This estimate is likely an underestimate since the Beaufort Sea surveys were limited to within 40 km from shore.

Though a reliable population estimate for the entire Alaska stock is not available, research programs have recently developed new survey methods and partial, but useful, abundance estimates. In spring of 2012 and 2013, U.S. and Russian researchers conducted aerial abundance and distribution surveys of the entire Bering Sea and Sea of Okhotsk (Moreland et al. 2013). The data from these image-based surveys are still being analyzed, but Conn et al. (2014), using a very limited sub-sample of the data collected from the U.S. portion of the Bering Sea in 2012, calculated an abundance estimate of about 170,000 ringed seals. This estimate did not account for availability bias and did not include ringed seals in the shorefast ice zone, which were surveyed using a different method. Thus, the actual number of ringed seals in the U.S. sector of the Bering Sea is likely much higher, perhaps by a factor of two or more.

Minimum Population Estimate

A minimum population estimate (N_{MIN}) for the entire stock of ringed seals cannot presently be determined because current reliable estimates of abundance are not available for the Chukchi and Beaufort seas. The 2012 Bering Sea abundance estimate by Conn et al. (2014) of 170,000, however, can be considered an N_{MIN} for only those ringed seals in the U.S. sector of the Bering Sea.

Current Population Trend

Frost et al. (2002) reported that a trend analysis based on an ANOVA comparison of observed seal densities in the central Beaufort Sea suggested marginally significant but substantial declines of 50% on shorefast ice and 31% on all ice types combined from 1985-1987 to 1996-1999. A Poisson regression model indicated highly significant density declines of 72% on shorefast ice and 43% on pack ice during the 15-year period. However, the apparent decline between the mid-1980s and the late-1990s may have been due to a difference in the timing of surveys rather than an actual decline in abundance (Frost et al. 2002, Kelly et al. 2006). As these surveys represent only a fraction of the stock's range and occurred more than a decade ago, current and reliable data on trends in population abundance for the Alaska stock of ringed seals are considered unavailable.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for the Alaska stock of ringed seals. Hence, until additional data become available, it is recommended that the pinniped maximum theoretical net productivity rate (R_{MAX}) of 12% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for pinniped stocks with unknown population status (Wade and Angliss 1997). Using the N_{MIN} for ringed seals in the U.S. sector of the Bering Sea, a PBR for ringed seals in this area is 5,100 (170,000 × 0.06 × 0.5) seals. However, this is not an estimate of PBR for the entire stock because a reliable estimate of N_{MIN} is currently not available for the entire stock; i.e., N_{MIN} is not available for the Chukchi and Beaufort seas.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

During 2010-2014, incidental mortality and serious injury of ringed seals was reported in 4 of the 22 federally-regulated commercial fisheries in Alaska monitored for incidental mortality and serious injury by fisheries observers: the Bering Sea/Aleutian Islands flatfish trawl, Bering Sea/Aleutian Islands pollock trawl, Bering Sea/Aleutian Islands Pacific cod trawl, and Bering Sea/Aleutian Islands Pacific cod longline fisheries (Table 1; Breiwick 2013; MML, unpubl. data). An additional ringed seal mortality due to U.S. commercial fisheries was reported to the NMFS Alaska Region stranding network in 2011; however, because the seal was discovered during the offloading process, the resulting mean annual mortality and serious injury rate of 0.2 could not be assigned to a specific fishery (Table 2; Helker et al. 2016). Based on data from 2010 to 2014, the average annual rate of mortality and serious injury incidental to U.S. commercial fishing operations is 3.9 ringed seals (3.7 from observer data + 0.2 from stranding data).

In 2010, a ringed seal that was initially considered seriously injured due to entanglement in a subsistence salmon set gillnet in Nome, Alaska, was disentangled and released with non-serious injuries (Helker et al. 2016), so it was not included in the mean annual mortality and serious injury rate in this report.

Table 1. Summary of incidental mortality and serious injury of Alaska ringed seals due to U.S. commercial fisheries in 2010-2014 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Is. flatfish trawl	2010 2011 2012 2013 2014	obs data	99 100 99 99 99	0 6 (+1)[a] 3 3 0	0 6.0 (+1)[b] 3.0 3 0	2.4 (+0.2)[c] (CV = 0.02)
Bering Sea/Aleutian Is. pollock trawl	2010 2011 2012 2013 2014	obs data	86 98 98 97 98	0 3 0 0 0	0 3.0 0 0 0	0.6 (CV = 0.03)
Bering Sea/Aleutian Is. Pacific cod trawl	2010 2011 2012 2013 2014	obs data	66 60 68 80 80	0 1 0 0 0	0 1 0 0 0	0.2 (CV = 0)
Bering Sea/Aleutian Is. Pacific cod longline	2010 2011 2012 2013 2014	obs data	64 57 51 66 64	0 1 0 0 0	0 1.6 0 0 0	0.3 (CV = 0.61)

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Minimum total estimated annual mortality						3.7 (CV = 0.06)

[a]Total mortality and serious injury observed in 2011: 6 seals in sampled hauls + 1 seal in an unsampled haul.
[b]Total estimate of mortality and serious injury in 2011: 6 seals (extrapolated estimate from 6 seals observed in sampled hauls) + 1 seal (1 seal observed in an unsampled haul).
[c]Mean annual mortality and serious injury for fishery: 2.4 seals (mean of extrapolated estimates from sampled hauls) + 0.2 seals (mean of number observed in unsampled hauls).

Table 2. Summary of mortality and serious injury of Alaska ringed seals, by year and type, reported to the NMFS Alaska Region in 2010-2014 (Helker et al. 2016). Only cases of serious injuries are reported in this table; animals that were disentangled and released with non-serious injuries have been excluded.

Cause of injury	2010	2011	2012	2013	2014	Mean annual mortality
Unidentified commercial fishery	0	1	0	0	0	0.2
Total in commercial fisheries						0.2

Alaska Native Subsistence/Harvest Information

Ringed seals are an important resource for Alaska Native subsistence hunters. Approximately 64 Alaska Native communities in western and northern Alaska, from Bristol Bay to the Beaufort Sea, regularly harvest ice seals (Ice Seal Committee 2016). The Ice Seal Committee, as co-managers with NMFS, recognizes the importance of harvest information and has collected it since 2008, when funding and personnel have allowed. Annual household survey results compiled in a statewide harvest report include historical ice seal harvest information back to 1960 (Quakenbush et al. 2011). This report is used to determine where and how often harvest information was collected and where to focus in the future (Ice Seal Committee 2016). Information for 2009-2013 is available for 12 communities (Point Lay, Kivalina, Noatak, Buckland, Deering, Emmonak, Scammon Bay, Hooper Bay, Tununak, Quinhagak, Togiak, and Twin Hills) (Table 3), but more than 50 other communities harvest ringed seals and have not been surveyed in this time period or have never been surveyed. Harvest surveys are designed to estimate harvest within the surveyed community, but because of differences in seal availability, cultural hunting practices, and environmental conditions, extrapolating harvest numbers beyond that community is not appropriate. For example, during 2009-2013, only 12 of 64 coastal communities were surveyed for ringed seals; and, of those communities, only 6 were surveyed for two or more consecutive years (Ice Seal Committee 2016). Based on the harvest data from these 12 communities (Table 3), a minimum estimate of the average annual harvest of ringed seals in 2009-2013 is 1,050 seals. The Ice Seal Committee is working toward a better understanding of ice seal harvest by conducting more consecutive surveys in more communities with a goal to report a statewide ice seal harvest estimate.

Table 3. Alaska ringed seal harvest estimates in 2009-2013 (Ice Seal Committee 2016).

Community	Estimated ringed seal harvest				
	2009	2010	2011	2012	2013
Point Lay				51	
Kivalina			16		
Noatak			3		
Buckland			26		
Deering			0		
Emmonak			56		
Scammon Bay			137	169	
Hooper Bay	889	458	674	651	667
Tununak	232	162	257	219	

Community	Estimated ringed seal harvest				
	2009	2010	2011	2012	2013
Quinhagak		163	117	140	160
Togiak	1	1	0		
Twin Hills	0	0			
Total	1,122	784	1,286	1,230	827

Other Mortality

Beginning in mid-July 2011, elevated numbers of sick or dead seals, primarily ringed seals, with skin lesions were discovered in the Arctic and Bering Strait regions. By December 2011, there were more than 100 cases of affected pinnipeds, including ringed seals, bearded seals, spotted seals, and walruses, in northern and western Alaska. Due to the unusual number of marine mammals discovered with similar symptoms across a wide geographic area, NMFS and USFWS declared a Northern Pinniped Unusual Mortality Event (UME) on December 20, 2011. Disease surveillance efforts in 2012-2013 detected few new cases similar to those observed in 2011, but the UME investigation remains open for ringed seals based on continuing reports in 2013-2014 of ice seals in the Bering Strait region with patchy hair loss (alopecia). To date, no specific cause for the disease has been identified.

In 2011, a ringed seal mortality, due to a gunshot wound to the head, was reported to the NMFS Alaska Region stranding network (Helker et al. 2016). This seal was presumed to be a struck and lost animal from the Alaska Native subsistence hunt.

Mortality and serious injury may occasionally occur incidental to marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. In 2013, there was one report of a mortality incidental to research on the Alaska stock of ringed seals, resulting in a mean annual mortality and serious injury rate of 0.2 ringed seals from this stock in 2010-2014 (Division of Permits and Conservation, Office of Protected Resources, NMFS, 1315 East-West Highway, Silver Spring, MD 20910).

STATUS OF STOCK

On December 28, 2012, NMFS listed Arctic ringed seals (*P. h. hispida*) and, thus, the Alaska stock of ringed seals, as threatened under the ESA (77 FR 76706). The primary concern for this population is the ongoing and anticipated loss of sea ice and snow cover stemming from climate change, which is expected to pose a significant threat to the persistence of these seals in the foreseeable future (based on projections through the end of the 21st century; Kelly et al. 2010a). Because of its threatened status under the ESA, this stock was designated as depleted under the MMPA. As a result, the stock was classified as a strategic stock. On March 11, 2016, the U.S. District Court for the District of Alaska issued a memorandum decision in a lawsuit challenging the listing of ringed seals under the ESA (Alaska Oil and Gas Association et al. v. Pritzker, Case No. 4:14-cv-00029-RPB). The decision vacated NMFS' listing of Arctic ringed seals as a threatened species. Consequently, it is also no longer designated as depleted or classified as a strategic stock. Because the PBR for the entire stock is unknown, the mean annual U.S. commercial fishery-related mortality and serious injury rate that can be considered insignificant and approaching zero mortality and serious injury rate is unknown. A PBR for only those ringed seals in the U.S. portion of the Bering Sea is 5,100 ringed seals. The total estimated annual level of human-caused mortality and serious injury is 1,054 ringed seals. Population trends and status of this stock relative to its Optimum Sustainable Population are currently unknown.

HABITAT CONCERNS

The main concern about the conservation status of ringed seals stems from the likelihood that their preferred sea-ice and snow habitats are being modified by the warming climate. Future scientific projections are for continued and perhaps accelerated warming (Kelly et al. 2010a). Climate models consistently project overall diminishing ice and snow cover through the 21st century with regional variation in the timing and severity of those loses. Increasing atmospheric concentrations of greenhouse gases are driving climate warming and increasing acidification of the ringed seal's habitat. Changes in ocean temperature, acidification, and ice cover threaten prey communities on which ringed seals depend. Laidre et al. (2008) concluded that on a worldwide basis ringed seals were likely to be highly sensitive to climate change based on an analysis of various life history features that could be affected by climate.

The greatest impacts to ringed seals from diminished ice cover will be mediated through diminished snow accumulation. While winter precipitation is forecasted to increase in a warming Arctic (Walsh et al. 2005), the duration of ice cover will be substantially reduced, and the net effect will be lower snow accumulation on the ice (Hezel et al. 2012). Ringed seals excavate subnivean lairs (snow caves) in drifts over their breathing holes in the ice, in which they rest, give birth, and nurse their pups for 5-9 weeks during late winter and spring (Chapskii 1940, McLaren 1958, Smith and Stirling 1975). Snow depths of at least 50-65 cm are required for functional birth lairs (Smith and Stirling 1975, Lydersen and Gjertz 1986, Kelly 1988b, Lydersen 1998, Lukin et al. 2006). Such depths typically are found only where 20-30 cm or more of snow has accumulated on flat ice and then drifted along pressure ridges or ice hummocks (Lydersen et al. 1990, Hammill and Smith 1991, Lydersen and Ryg 1991, Smith and Lydersen 1991). According to climate model projections, snow cover is forecasted to be inadequate for the formation and occupation of birth lairs within this century over the Alaska stock's entire range (Kelly et al. 2010a). Without the protection of these lairs, ringed seals—especially newborns—are vulnerable to freezing and predation (Kumlien 1879, McLaren 1958, Lukin and Potelov 1978, Smith and Hammill 1980, Lydersen and Smith 1989, Stirling and Smith 2004). Changes in the ringed seal's habitat will be rapid relative to their generation time and, thereby, will limit adaptive responses. As ringed seal populations decline, the significance of currently lower-level threats—such as ocean acidification, increases in human activities, and changes in populations of predators, prey, competitors, and parasites—may increase.

A second major concern, driven primarily by the production of carbon dioxide (CO_2) emissions, is the modification of habitat by ocean acidification, which may alter prey populations and other important aspects of the marine ecosystem. Ocean acidification, a result of increased CO_2 in the atmosphere, may affect ringed seal survival and recruitment through disruption of trophic regimes that are dependent on calcifying organisms. The nature and timing of such impacts are extremely uncertain. Changes in ringed seal prey, anticipated in response to ocean warming and loss of sea ice, have the potential for negative impacts, but the possibilities are complex. Ecosystem responses may have very long lags as they propagate through trophic webs. Because of ringed seals' apparent dietary flexibility, this threat may be of less immediate concern than the threats from sea ice degradation

Additional habitat concerns include the potential effects from increased shipping (particularly in the Bering Strait) and oil and gas exploration activities (particularly in the outer continental shelf leasing areas), such as disturbance from vessel traffic, seismic exploration noise, or the potential for oil spills.

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RIBBON SEAL (*Histriophoca fasciata*): Alaska Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

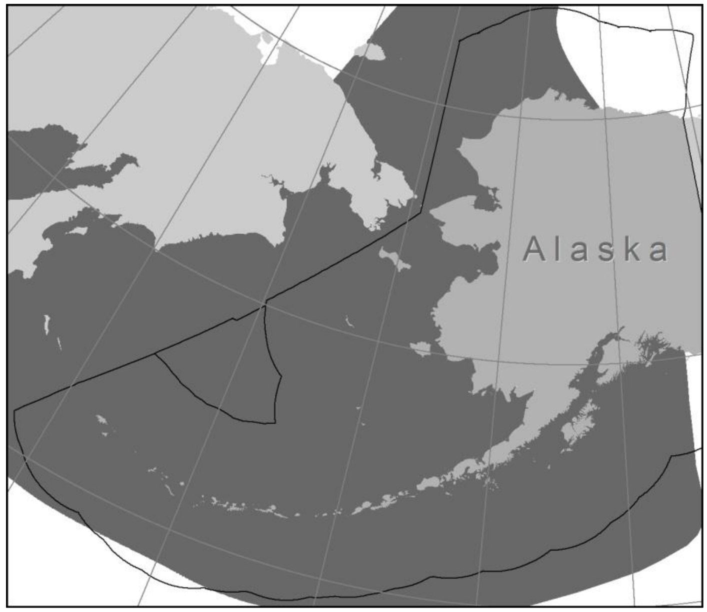

Figure 1. Approximate distribution of ribbon seals (dark shaded area) in Alaska waters. The combined summer and winter distribution is depicted.

Ribbon seals inhabit the North Pacific Ocean and adjacent parts of the Arctic Ocean. In Alaska waters, ribbon seals range from the North Pacific Ocean and Bering Sea into the Chukchi and western Beaufort seas (Fig. 1). From late March to early May, ribbon seals inhabit the Bering Sea ice front (Burns 1970, 1981; Braham et al. 1984). Ribbon seals are very rarely seen on shorefast ice or land. They are most abundant in the northern part of the ice front in the central and western parts of the Bering Sea (Burns 1970, Burns et al. 1981). As the ice recedes in May to mid-July, the seals move farther to the north in the Bering Sea, where they haul out on the receding ice edge and remnant ice (Burns 1970, 1981; Burns et al. 1981). As the ice melts, seals become more concentrated, with at least part of the Bering Sea population moving towards the Bering Strait and the southern part of the Chukchi Sea. By the time the Bering Sea ice recedes through the Bering Strait, there is usually only a small number of ribbon seals hauled out on the ice. Ten ribbon seals tagged in the spring of 2005 near the eastern coast of Kamchatka spent the summer and fall throughout the Bering Sea and Aleutian Islands. However, of 72 ribbon seals satellite tagged in the central Bering Sea during 2007-2010, only 21 (29%) moved to the Bering Strait, Chukchi Sea, or Arctic Basin as the ice retreated northward. About 9.5% of ribbon seals' time budget during July through October was in those areas. The majority of the seals tagged in the central Bering Sea did not pass north of the Bering Strait. These seals, and the 10 seals tagged in 2005 near Kamchatka, dispersed widely, occupying coastal areas as well as the interior of the Bering Sea, both on and off the continental shelf (Boveng et al. 2013). Year-long passive acoustic sampling on the Chukchi Plateau from autumn 2008-2009 detected ribbon seal calls only in October and November 2008 (Moore et al. 2012).

The following information was considered in classifying stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution continuous; 2) Population response data: unknown; 3) Phenotypic data: unknown; and 4) Genotypic data: unknown. Based on this limited information, and the absence of any significant fishery interactions, there is currently no strong evidence to suggest splitting the distribution of ribbon seals into more than one stock (Boveng et al. 2013). Therefore, only the Alaska stock of ribbon seal is recognized in U.S. waters.

POPULATION SIZE

A reliable population estimate for the entire stock is not available, but research programs have recently developed new survey methods and partial, but useful, abundance estimates. In spring of 2012 and 2013, U.S. and Russian researchers conducted aerial abundance and distribution surveys of the entire Bering Sea and Sea of Okhotsk (Moreland et al. 2013). The data from these image-based surveys are still being analyzed, but Conn et al. (2014), using a very limited sub-sample of the data collected from the U.S. portion of the Bering Sea in 2012, calculated an abundance estimate of approximately 184,000 (95% CI: 145,752-230,134) ribbon seals in those waters. Though this should be considered only a preliminary estimate, it is appropriate to consider this a reasonable estimate for the entire U.S. population of ribbon seals because few ribbon seals are expected to be north of the Bering Strait in the spring when these surveys were conducted. When the final analyses for both the Bering and Okhotsk seas are complete they should provide the first range-wide estimates of ribbon seal abundance.

Minimum Population Estimate

The minimum population estimate (N_{MIN}) for a stock is calculated using Equation 1 from the potential biological removal (PBR) guidelines (Wade and Angliss 1997): $N_{MIN} = N/exp(0.842\times[ln(1+[CV(N)]^2)]^{½})$. Using the 2012 Bering Sea abundance estimate by Conn et al. (2014) provides an N_{MIN} of 163,086 ribbon seals in this stock.

Current Population Trend

At present, reliable data on trends in population abundance for the Alaska stock of ribbon seals are unavailable. This stock is thought to occupy its entire historically-observed range (Boveng et al. 2013).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for the Alaska stock of ribbon seals. Hence, until additional data become available, it is recommended that the pinniped maximum theoretical net productivity rate (R_{MAX}) of 12% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the PBR is defined as the product of the minimum population estimate (N_{MIN}), one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 1.0, the value for stocks thought to be stable (Wade and Angliss 1997). Thus, the PBR for the Alaska stock of ribbon seals = 9,785 (163,086 × 0.06 × 1.0).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

Until 2003, there were three different federally regulated commercial fisheries in Alaska that could have interacted with ribbon seals and were monitored for incidental mortality and serious injury by fishery observers. As of 2003, changes in fishery definitions in the MMPA List of Fisheries have resulted in separating these 3 fisheries into 13 fisheries (69 FR 70094, 2 December 2004). This change does not represent a change in fishing effort but provides managers with better information on the component of each fishery that is responsible for the incidental serious injury or mortality of marine mammal stocks in Alaska. Between 2009 and 2013, incidental mortality and serious injury of ribbon seals occurred in the Bering Sea/Aleutian Islands flatfish trawl, Bering Sea/Aleutian Islands Atka mackerel trawl, and Bering Sea/Aleutian Islands pollock trawl fisheries (Table 1). The minimum estimated average annual mortality and serious injury rate incidental to U.S. commercial fisheries is 0.6 ribbon seals, based exclusively on observer data.

Table 1. Summary of incidental mortality and serious injury of the Alaska stock of ribbon seals due to U.S. commercial fisheries from 2009 to 2013 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; NMML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Is. flatfish trawl	2009 2010 2011 2012 2013	obs data	99 99 99 99 99	0 0 0 1 0	0 0 0 1 0	0.2 (CV = 0.01)
Bering Sea/Aleutian Is. Atka mackerel trawl	2009 2010 2011 2012 2013	obs data	99 99 99 99 99	1 0 0 0 0	1 0 0 0 0	0.2 (CV = 0.01)

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Is. pollock trawl	2009 2010 2011 2012 2013	obs data	86 86 98 98 97	1 0 0 0 0	1 0 0 0 0	0.2 (CV = 0.11)
Minimum total estimated annual mortality						0.6 (CV = 0.04)

Alaska Native Subsistence/Harvest Information

Ribbon seals are an important resource for Alaska Native subsistence hunters. Approximately 64 Alaska Native communities in western and northern Alaska, from Bristol Bay to Kaktovik, regularly harvest ice seals (Ice Seal Committee 2014). The Ice Seal Committee, as co-managers with NMFS, recognizes the importance of harvest information and has been collecting it since 2008 as funding and available personnel have allowed. Annual household survey results are compiled in a statewide harvest report that includes historical ice seal harvest information back to 1960. This report is used to determine where and how often harvest information has been collected and where efforts need to be focused in the future (Ice Seal Committee 2014). Current information, within the last 5 years, is available for 11 communities (Kivalina, Noatak, Buckland, Deering, Emmonak, Scammon Bay, Hooper Bay, Tununak, Quinhagak, Togiak, and Twin Hills) (Table 2), but more than 50 other communities harvest ribbon seals and have not been surveyed in the last 5 years or have never been surveyed. Harvest surveys are designed to confidently estimate harvest within the surveyed community, but because of differences in seal availability, cultural hunting practices, and environmental conditions, extrapolating harvest numbers beyond that community is misleading. For example, during the past 5 years (2009-2013), only 11 of the 64 coastal communities have been surveyed for ribbon seals and of those only 6 have been surveyed for two or more consecutive years (Ice Seal Committee 2015). Based on the harvest data from these 11 communities (Table 2), a minimum estimate of the average annual harvest of ribbon seals in 2009-2013 is 3.2 seals. The Ice Seal Committee is working toward a better understanding of ice seal harvest by conducting more consecutive surveys with the goal of being able to report a statewide ice seal harvest estimate in the future.

Table 2. Ribbon seal harvest estimates from 2009 to 2013 and the Alaska Native population for each community (Ice Seal Committee 2015).

Community	Alaska Native population (2013)	Estimated ribbon seal harvest				
		2009	2010	2011	2012	2013
Kivalina	352			0		
Noatak	514			1		
Buckland	519			0		
Deering	176			0		
Emmonak	782			0		
Scammon Bay	498			4	2	
Hooper Bay	1144	0	0	0	4	0
Tununak	342	0	0	0	0	
Quinhagak	694		2	3	0	0
Togiak	842	0	0	0		
Twin Hills	66	0	0			
Total		0	2	8	6	0

Other Mortality

Beginning in mid-July 2011, elevated numbers of sick or dead seals, primarily ringed seals, with skin lesions were discovered in the Arctic and Bering Strait regions of Alaska. By December 2011, there were more than 100 cases of affected pinnipeds, including ringed seals, spotted seals, bearded seals, and walrus, in northern and western Alaska. Due to the unusual number of marine mammals discovered with similar symptoms across a wide geographic area, NOAA and USFWS declared a Northern Pinniped Unusual Mortality Event (UME) on December 20, 2011. Disease surveillance efforts in 2012-2013 did not detect any new cases similar to those observed in 2011, but the UME investigation remains open for ice seals based on continuing reports in 2013 and 2014 of ice seals in the Bering Strait region with patchy hair loss. To date, no specific cause for the disease has been identified. No ribbon seal cases were reported but they are not a coastal species and are seldom observed.

STATUS OF STOCK

Ribbon seals are not designated as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act (ESA). The minimum population estimate of ribbon seals in U.S. waters is 163,086, with a PBR of 9,785. Because the estimated average annual level of U.S. commercial fishery-related mortality and serious injury (0.6) is less than 10% of PBR (979), it can be considered insignificant and approaching zero mortality and serious injury rate. The total estimated annual level of human-caused mortality and serious injury based on commercial fisheries observer data (0.6) and a minimum estimate of the Alaska Native harvest (3.2) is 3.8 ribbon seals. The Alaska stock of ribbon seals is not considered a strategic stock.

HABITAT CONCERNS

Evidence indicates that the Arctic climate is changing significantly and that one result of the change is a reduction in the extent of sea ice in at least some regions of the Arctic (ACIA 2004, Johannessen et al. 2004). Ribbon seals, along with other seals that are dependent on sea ice for at least part of their life history, will be vulnerable to reductions in sea ice. The main concern about the conservation status of ribbon seals stems from the likelihood that their sea-ice habitat has been modified by the warming climate and, more so, that the scientific consensus projections are for continued and perhaps accelerated warming in the foreseeable future (Boveng et al. 2013). A second major concern, related by the common driver of carbon dioxide (CO_2) emissions, is the modification of habitat by ocean acidification, which may alter prey populations and other important aspects of the marine ecosystem. Ocean acidification, a result of increased CO_2 in the atmosphere, may impact ribbon seal survival and recruitment through disruption of trophic regimes that are dependent on calcifying organisms. The nature and timing of such impacts are extremely uncertain. Laidre et al. (2008) concluded that on a worldwide basis ribbon seals were likely to be moderately sensitive to climate change based on an analysis of various life history features that could be affected by climate. Additional habitat concerns include the potential effects from increased shipping (particularly in the Bering Strait) and oil and gas exploration activities (particularly in the outer continental shelf leasing areas), such as disturbance from vessel traffic, seismic exploration noise, and the potential for oil spills.

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BELUGA WHALE (*Delphinapterus leucas*): Beaufort Sea Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Beluga whales are distributed throughout seasonally ice-covered arctic and subarctic waters of the Northern Hemisphere (Gurevich 1980), and are closely associated with open leads and polynyas in ice-covered regions (Hazard 1988). Depending on season and region, beluga whales may occur in both offshore and coastal waters, with summer concentrations in upper Cook Inlet, Bristol Bay, the eastern Bering Sea (i.e., Yukon Delta, Norton Sound), eastern Chukchi Sea, and the Mackenzie Delta (Hazard 1988). Satellite transmitters on a few whales from the Beaufort Sea, Chukchi Sea and Eastern Bering Sea stocks have lasted through the winter demonstrating that beluga whales from these summering areas overwinter in the Bering Sea and the stocks may use separate wintering locations (Suydam 2009; ABWC, unpublished data). Belugas found in Bristol Bay and the northern Gulf of Alaska/Cook Inlet remain in those areas throughout the year (Shelden 1994, Quakenbush 2003, NMFS and ADF&G unpublished data). Seasonal distribution is affected by ice cover, tidal conditions, access to prey, temperature, and human interaction (Lowry 1985).

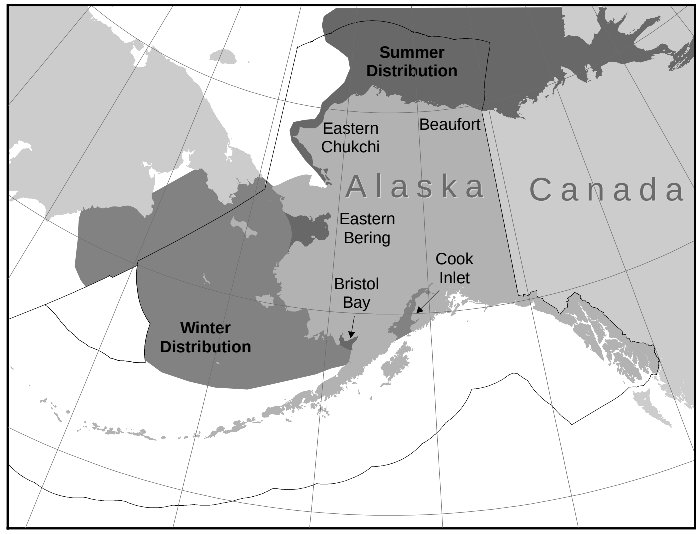

Figure 1. Approximate distribution of beluga whales in Alaska waters. The dark shading displays the summer distribution of the five stocks. Winter distributions are depicted with lighter shading.

The general distribution pattern for beluga whales shows major seasonal changes. During the winter, they occur in offshore waters associated with pack ice. In the spring, they migrate to warmer coastal estuaries, bays, and rivers where they may molt (Finley 1982, Suydam 2009) and give birth to and care for their calves (Sergeant and Brodie 1969). Annual migrations can be more than thousands of kilometers (Richard et al. 2001).

The following information was considered in classifying beluga whale stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution discontinuous in summer (Frost and Lowry 1990); 2) Population response data: distinct population trends between regions occupied in summer; 3) Phenotypic data: unknown; and 4) Genotypic data: mitochondrial DNA analyses indicate distinct differences among the five summering areas (O'Corry-Crowe et al. 1997). Based on this information, 5 beluga whale stocks are recognized within U.S. waters: 1) Cook Inlet, 2) Bristol Bay, 3) eastern Bering Sea, 4) eastern Chukchi Sea, and 5) Beaufort Sea (Fig. 1).

POPULATION SIZE

The sources of information to estimate abundance for belugas in the waters of northern Alaska and western Canada have included both opportunistic and systematic observations. Duval (1993) reported an estimate of 21,000 belugas for the Beaufort Sea stock, similar to that reported by Seaman et al. (1985). The most recent aerial survey was conducted in July 1992, and resulted in an estimate of 19,629 (CV = 0.229) beluga whales in the eastern Beaufort Sea (Harwood et al. 1996). To account for availability bias a correction factor (CF), which was not data-based, has been recommended for the Beaufort Sea beluga whale stock (Duval 1993), resulting in a population estimate of 39,258 (19,629 × 2) animals. A coefficient of variation (CV) for the CF is not available; however, this CF was considered negatively biased by the Alaska SRG considering that aerial survey CFs for this species have been estimated to be between 2.5 and 3.27 (Frost and Lowry 1995). Additionally, the 1992 surveys did not encompass the entire summer range of Beaufort Sea belugas (Richard et al. 2001), thus are negatively biased.

Minimum Population Estimate

For the Beaufort Sea beluga whale stock, the minimum population estimate (N_{MIN}) is calculated according to Equation 1 from the PBR Guidelines (Wade and Angliss 1997). Thus, $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the population estimate (N) of 39,258 whales and an associated CV(N) of 0.229, N_{MIN} for this stock is 32,453 whales. Because the survey data are more than 8 years old, it would not be considered a reliable minimum population estimate for calculating a PBR and N_{MIN} would be considered unknown. However, trend data from Harwood and Kingsley (2013) indicate the stock is at least stable or increasing; therefore, the Alaska SRG recommended at the 2014 meeting that NMFS retain the N_{MIN} estimate of 32,453 whales.

Current Population Trend

The current population trend of the Beaufort Sea stock of beluga whales is stable or increasing. Recent and historical aerial surveys off the Mackenzie River Delta indicate that the stock is at least stable or increasing (Harwood and Kingsley 2013). There are no data to suggest the stock is declining.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for the Beaufort Sea beluga whale stock. Hence, until additional data become available, it is recommended that the default maximum theoretical net productivity rate (R_{MAX}) for cetaceans of 4% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. As the stock trend is at least stable, the recovery factor (F_R) for this stock is 1 (Wade and Angliss 1997). Thus, using the abundance estimate calculated from 1992 surveys, the PBR for the Beaufort Sea beluga whale stock would be calculated to be 649 animals (32,453 × 0.02 × 1.0). The 2005 revisions to the SAR guidelines (Wade and Angliss 1997) state that abundance estimates older than 8 years should not be used to calculate PBR due to a decline in confidence in the reliability of an aged abundance estimate. However, the recent trend data suggest that the stock is at least as large as it was during the last estimate of N_{MIN}; thus the 1992 estimate of N_{MIN} = 32,452 whales is sufficient to use for a PBR calculation. Therefore, the PBR for this stock is 649 (NMFS 2005).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality.*" Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fisheries Information

The total fishery mortality and serious injury for this stock is estimated to be zero as there are no reports of mortality incidental to commercial fisheries.

Subsistence/Native Harvest Information

The subsistence take of beluga whales from this stock within U.S. waters is reported by the Alaska Beluga Whale Committee (ABWC). The most recent Alaska Native subsistence harvest estimates for the Beaufort Sea beluga stock are provided in Table 1 (Alaska Beluga Whale Committee, unpubl. data 2012). Given these data, the annual subsistence take by Alaska Native hunters averaged 65.6 belugas during the 5-year period from 2008 to 2012.

Table 1. Summary of beluga whales from the Beaufort Sea beluga whale stock landed by Alaska Native subsistence hunters, 2008-2012. Total taken includes landed and struck and lost in years 2010-2012; struck and lost data for 2008 and 2009 have not been quantified and are minimum counts.

Year	Harvested whales	Struck and lost whales	Reported total number taken
2008	48	N/A	48
2009	16	N/A	16
2010	71	1+	72
2011	42	6	48
2012	92	42+	144
Mean annual number of animals landed (2008-2012)			65.6+

The subsistence take of beluga whales within the Canadian waters of the Beaufort Sea is reported by the Fisheries Joint Management Committee (FJMC). The data are collected by on-site harvest monitors conducted by the FJMC at Inuvialuit communities in the Mackenzie Delta, Northwest Territories. The Canadian Inuvialuit subsistence harvest estimates for the Beaufort Sea beluga stock are provided in Table 2 (data for 2005 to 2009 from FJMC Beluga Monitor Program, Fisheries Joint Management Committee, Inuvik, NT, Canada). Given these data, the annual subsistence take in Canada averaged 100 belugas during the 5-year period from 2005 to 2009. Thus, the mean estimated subsistence take in Canadian (2005-2009) and U.S. (2008-2012) waters from the Beaufort Sea beluga stock is 166 (100 + 65.6) whales.

Table 2. Summary of the Canadian subsistence harvest from the Beaufort Sea stock of beluga whales, 2005-2009. N/A indicates the data are not available.

Year	Reported total number taken
2005	108
2006	126
2007	82
2008	81
2009	102
Mean annual landed (2005-2009)	100

STATUS OF STOCK

Beaufort Sea beluga whales are not designated as “depleted” under the MMPA or listed as “threatened” or “endangered” under the Endangered Species Act. There are no reported fisheries mortalities, thus the estimated annual U.S. commercial fishery-related mortality is zero (0). The total mean annual human-caused mortality estimate is 166 based on the known subsistence harvest in the United States (65.6) and Canada (100). Because the PBR is less than 10% of PBR (65), the level of annual U.S. commercial fishery-related mortality is considered insignificant and approaching zero mortality and serious injury rate. Although the abundance estimates are more than 8 years old, since there are no records of incidental mortality in commercial fisheries, the level of incidental mortality and serious injury is considered to be insignificant. The Beaufort Sea beluga stock is classified as a non-strategic stock. At this time it is not possible to assess the status of this stock relative to its Optimum Sustainable Population size.

HABITAT CONCERNS

Evidence indicates that the Arctic climate is changing rapidly and significantly, and one result of this change is a reduction in the extent of sea ice in at least some regions (ACIA 2004, Johannessen et al. 2004). These changes are likely to affect marine mammal species in the Arctic. Ice-associated animals, such as the beluga whale, may be sensitive to changes in Arctic weather, sea-surface temperatures, or ice extent, and the concomitant effect on prey availability. Currently, there are insufficient data to make reliable predictions of the effects from Arctic climate change on beluga whales, but Laidre et al. (2008) and Heide-Jørgensen (2010) concluded that on a worldwide basis belugas were likely to be less sensitive to climate change than other Arctic cetaceans because of their wide distribution and flexible behavior. Increased human activity in the Arctic, including increasing oil and gas exploration and development, and increased nearshore development, have the potential to impact beluga whale habitat (Moore et al. 2000, Lowry et al. 2006). However, predicting the type and magnitude of the impacts is difficult at this time.

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BELUGA WHALE (*Delphinapterus leucas*): Eastern Chukchi Sea Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Beluga whales are distributed throughout seasonally ice-covered arctic and subarctic waters of the Northern Hemisphere (Gurevich 1980), and are closely associated with open leads and polynyas in ice-covered regions (Hazard 1988). Depending on season and region, beluga whales may occur in both offshore and coastal waters, with summer concentrations in upper Cook Inlet, Bristol Bay, the eastern Bering Sea (i.e., Yukon Delta, Norton Sound), eastern Chukchi Sea, and the Mackenzie Delta (Hazard 1988). Satellite transmitters on a few whales from the Beaufort Sea, Chukchi Sea and eastern Bering Sea stocks have lasted through the winter demonstrating that beluga whales from these summering areas overwinter in the Bering Sea and the stocks may use separate wintering locations (Suydam 2009; Alaska Beluga Whale Committee, unpublished data). Belugas found in Bristol Bay and the northern Gulf of Alaska/Cook Inlet remain in those areas throughout the year (Shelden 1994; Quakenbush 2003; NMFS and ADF&G, unpublished data). Seasonal distribution is affected by ice cover, tidal conditions, access to prey, temperature, and human interaction (Lowry 1985).

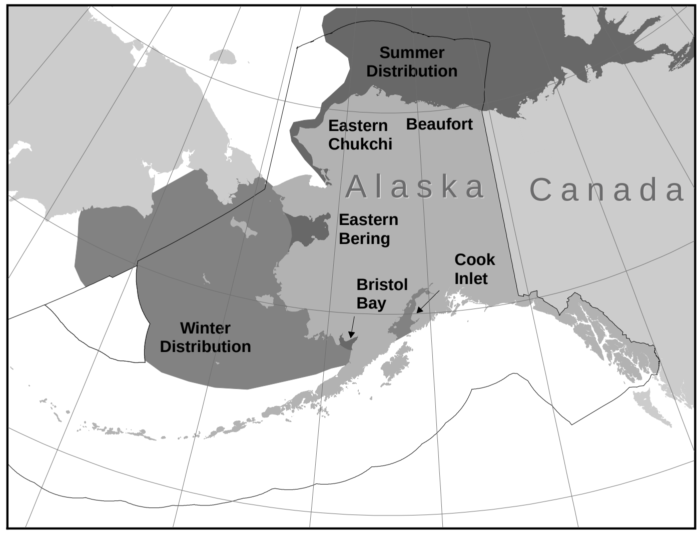

Figure 1. Approximate distribution of beluga whales in Alaska waters. The dark shading displays the summer distribution of the five stocks. Winter distributions are depicted with lighter shading.

The general distribution pattern for beluga whales shows major seasonal changes. During the winter, the Beaufort Sea, eastern Chukchi Sea, and Bering Sea stocks occur in offshore waters associated with pack ice. In the spring, they migrate to warmer coastal estuaries, bays, and rivers where they may molt (Finley 1982, Suydam 2009) and give birth to and care for their calves (Sergeant and Brodie 1969). Annual migrations can be more than thousands of kilometers (Richard et al. 2001).

Eastern Chukchi Sea belugas move into coastal areas, including Kasegaluk Lagoon, in late June and animals are sighted in the area until about mid-July (Frost and Lowry 1990, Frost et al. 1993). Satellite tags attached to eastern Chukchi belugas captured in Kasegaluk Lagoon during the summer showed these whales traveled 1,100 km north of the Alaska coastline, into the Canadian Beaufort Sea within 3 months (Suydam et al. 2001). This movement indicated some overlap in distribution with the Beaufort Sea beluga whale stock during late summer. Satellite telemetry data from 23 whales tagged during 1998-2007 suggest variation in movement patterns for different age and/or sex classes during July-September (Suydam et al. 2005). Adult males used deeper waters and remained there for the duration of the summer; all belugas that moved into the Arctic Ocean (north of 75°N) were males, and males traveled through 90% pack ice cover to reach deeper waters in the Beaufort Sea and Arctic Ocean (79-80°N) by late July/early August. Adult and immature female belugas remained at or near the shelf break in the Chukchi Sea. After October, only three tags continued to transmit, and those whales migrated south through the eastern Bering Strait into the northern Bering Sea, remaining north of Saint Lawrence Island over the winter. A whale tagged in the eastern Chukchi Sea in 2007 overwintered in the waters north of Saint Lawrence Island during 2007/2008 and moved to near King Island in April and May before moving north through the Bering Strait in late May and early June (Suydam 2009).

The following information was considered in classifying beluga whale stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution discontinuous in summer (Frost and Lowry 1990); 2) Population response data: distinct population trends between regions occupied in summer; 3) Phenotypic data: unknown; and 4) Genotypic data: mitochondrial DNA analyses indicate distinct differences among the five summering areas (O'Corry-Crowe et al. 1997). Based on this information, 5 beluga whale stocks are recognized within U.S. waters: 1) Cook Inlet, 2) Bristol Bay, 3) eastern Bering Sea, 4) eastern Chukchi Sea, and 5) Beaufort Sea (Fig. 1).

POPULATION SIZE

Frost et al. (1993) estimated the minimum size of the eastern Chukchi beluga stock at 1,200 whales, based on counts of animals from aerial surveys conducted during 1989-1991. Survey effort was concentrated along the sea side of the 170 km long Kasegaluk Lagoon, an area known to be regularly used by belugas during the open-water season. Other areas that these belugas are known to frequent (e.g., offshore) were not surveyed. Therefore, these surveys provided only a minimum raw count. If this count is corrected using radio telemetry data, for the proportion of animals that were diving and thus not visible at the surface (2.62; Frost and Lowry 1995), and for the proportion of newborns and yearlings not observed due to small size and dark coloration (1.18; Brodie 1971), the total corrected abundance estimate for the eastern Chukchi stock is 3,710 ($1,200 \times 2.62 \times 1.18$) whales.

During 25 June to 6 July 1998, aerial surveys were conducted in the eastern Chukchi Sea (DeMaster et al. 1998). The maximum single day count (1,172 whales) was derived from a photographic count of a large aggregation near Icy Cape (1,018), plus animals (154) counted along an ice edge transect. This count is an underestimate because it was clear to the observers that many more whales were present along and in the ice than they were able to count and only a small portion of the ice edge habitat was surveyed. Furthermore, only one of five belugas equipped with satellite tags a few days earlier remained within the survey area on the day the peak count occurred (DeMaster et al. 1998).

In July 2002, aerial surveys were conducted again in the eastern Chukchi Sea (Lowry and Frost 2002). Those surveys resulted in a peak count of 582 whales. A correction factor for animals that were not available for the count is not available. Offshore sightings during this survey combined with satellite tag data collected in 2001 (Lowry and Frost 2001, Lowry and Frost 2002) indicate that nearshore surveys for belugas will only result in partial counts of this stock.

It is not possible to estimate the abundance for this stock from the 1998 survey. Not only were a large number of whales unavailable for counting, but the large Icy Cape aggregation was in shallow, clear water (DeMaster et al. 1998). Currently, a correction factor (to account for missed whales) does not exist for belugas encountered in such conditions. As a result, the abundance estimate from the 1989-91 surveys (3,710 whales) is still considered to be the most reliable for the eastern Chukchi Sea beluga whale stock.

Aerial surveys were conducted in the summer of 2012 in the northeastern Chukchi and Alaskan Beaufort seas in late June through August (Clarke et al. 2013). Those data are currently being analyzed by the Alaska Beluga Whale Committee and an updated estimate should be available by 2015.

Minimum Population Estimate

The survey technique used for estimating beluga whale abundance is a direct count that incorporates correction factors. Although coefficients of variation (CVs) of the correction factors are not available, the Alaska Scientific Review Group concluded that the population estimate of 3,710 belugas can serve as the estimated minimum population size because the survey did not include all areas where beluga are known to occur (Small and DeMaster 1995). That is, if the beluga distribution in the eastern Chukchi Sea is similar to beluga distribution in the Beaufort Sea, which is likely based on satellite tag results (Suydam et al. 2001, Lowry and Frost 2002), then a substantial fraction of the population was likely to have been in offshore waters during the survey period (DeMaster 1997). However, because the survey data are more than 8 years old, it is not considered a reliable minimum population estimate for calculating a PBR, and N_{MIN} is considered unknown.

Current Population Trend

The current population trend for the eastern Chukchi Sea beluga stock is unknown.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for this beluga whale stock. Hence, until additional data become available, it is recommended that the default maximum theoretical net productivity rate (R_{MAX}) for cetaceans of 4% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. This stock is considered relatively stable and not declining in the presence of known take, thus the recovery factor (F_R) for this stock is 1.0 (DeMaster 1995, Wade and Angliss 1997). However, the 2005 revisions to the SAR guidelines (Wade and Angliss 1997) state that abundance estimates older than 8 years should not be used to calculate PBR due to a decline in confidence in the reliability of an aged abundance estimate. Therefore, the PBR for this stock is considered undetermined (NMFS 2005).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality.*" Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fisheries Information

Three different commercial fisheries that could have interacted with beluga whales from this stock were monitored for incidental take by fishery observers during 1990-1997: Bering Sea (and Aleutian Islands) groundfish trawl, longline, and pot fisheries. Observers did not report any mortality or serious injury to beluga whales incidental to these groundfish fisheries. In the nearshore waters of the southeastern Chukchi Sea, substantial efforts occur in gillnet (mostly set nets) and personal-use fisheries. Although a potential source of mortality, there have been no reported beluga whale takes as a result of these fisheries.

Based on a lack of reported mortalities, the inferred minimum mortality rate incidental to commercial fisheries is zero belugas per year from this stock.

Subsistence/Native Harvest Information

The subsistence take of beluga whales from the eastern Chukchi Sea stock is provided by the Alaska Beluga Whale Committee (ABWC). The most recent subsistence harvest estimates for the stock are provided in Table 1. Given these data, the annual subsistence take by Alaska Native hunters averaged 57.4 belugas landed during the 5-year period 2008-2012 based on reports from ABWC representatives and on-site harvest monitoring.

Table 1. Summary of the number of beluga whales landed by the Alaska Native subsistence harvest of eastern Chukchi Sea beluga whales, 2008-2012. It should be noted that the 2010 and 2011 statistics include takes at Kivalina (2 in 2010 and 2 in 2011) and Kotzebue/Noatak (0 in 2010 and 30 in 2011) which may be from a population that is genetically distinct from the main population comprising the eastern Chukchi Sea beluga whale stock. Totals include landed and struck and lost.

Year	**Reported total number landed**
2008	74
2009	53
2010	36
2011	66
2012	58
Mean annual number of animals landed (2008-2012)	57.4

STATUS OF STOCK

Eastern Chukchi Sea beluga whales are not designated as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act. Therefore, the eastern Chukchi Sea stock of beluga whales is not classified as a strategic stock. The population trend is unknown; however, at this time it is not possible to assess the status of this stock relative to its Optimum Sustainable Population size.

HABITAT CONCERNS

Evidence indicates that the Arctic climate is changing rapidly and significantly, and one result of this change is a reduction in the extent of sea ice in at least some regions (ACIA 2004, Johannessen et al. 2004). These changes are likely to affect marine mammal species in the Arctic. Ice-associated animals, such as the beluga whale, may be sensitive to changes in Arctic weather, sea-surface temperatures, or ice extent, and the concomitant effect on prey availability. Currently, there are insufficient data to make reliable predictions of the effects from Arctic climate change on beluga whales, but Laidre et al. (2008) and Heide-Jørgensen (2010) concluded that on a worldwide basis belugas were likely to be less sensitive to climate change than other Arctic cetaceans because of their wide distribution and flexible behavior. Increased human activity in the Arctic, including increasing oil and gas exploration and development, and increased nearshore development, have the potential to impact beluga whale habitat (Moore et al. 2000, Lowry et al. 2006). However, predicting the type and magnitude of the impacts is difficult at this time.

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BELUGA WHALE (*Delphinapterus leucas*): Eastern Bering Sea Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Beluga whales are distributed throughout seasonally ice-covered arctic and subarctic waters of the Northern Hemisphere (Gurevich 1980), and are closely associated with open leads and polynyas in ice-covered regions (Hazard 1988). Depending on season and region, beluga whales may occur in both offshore and coastal waters, with summer concentrations in upper Cook Inlet, Bristol Bay, the eastern Bering Sea (i.e., Yukon Delta, Norton Sound), eastern Chukchi Sea, and the Mackenzie Delta (Hazard 1988). Satellite transmitters attached to whales from the Beaufort Sea, Chukchi Sea and eastern Bering Sea stocks have provided detailed information on distribution and movements. The few transmitters that lasted through the winter showed that beluga whales from these summering areas overwinter in the Bering Sea and the stocks may use separate wintering locations (Suydam 2009; Alaska Beluga Whale Committee, unpublished data). Belugas found in Bristol Bay and the northern Gulf of Alaska/Cook Inlet remain in those areas throughout the year, showing only small seasonal shifts in distribution (Shelden 1994; Quakenbush 2003; NMFS and ADF&G, unpublished data). Seasonal distribution is affected by ice cover, tidal conditions, access to prey, temperature, and human activities (Lowry 1985).

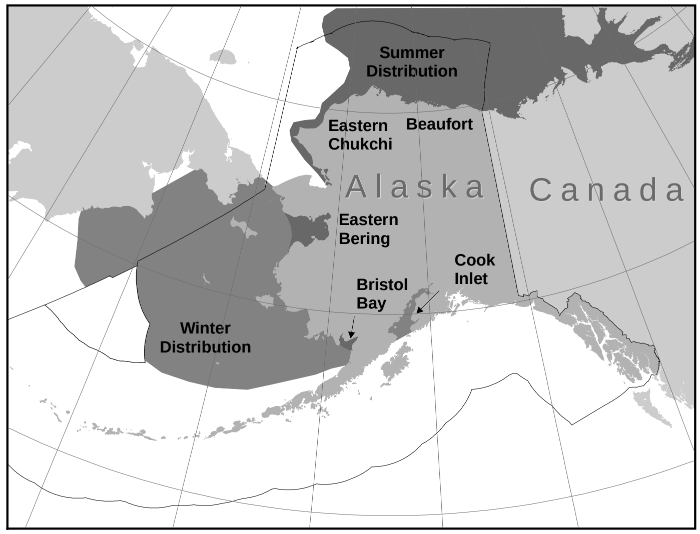

Figure 1. Approximate distribution of beluga whales in Alaska waters. The dark shading displays the summer distribution of the five stocks. Winter distributions are depicted with lighter shading.

The general distribution pattern for beluga whales shows major seasonal changes. During the winter, they occur in offshore waters associated with pack ice. In the spring, they migrate to warmer coastal estuaries, bays, and rivers where they may molt (Finley 1982, Suydam 2009) and give birth to and care for their calves (Sergeant and Brodie 1969). Annual migrations may cover thousands of kilometers (Richard et al. 2001).

Two belugas from the eastern Bering Sea stock were tagged with satellite transmitters in 2012. The belugas were tagged near Nome and moved south from there in ice covered shelf waters during the winter, as far as the vicinity of Hagemeister Island and the Walrus Islands in Bristol Bay, before returning north to Norton Sound in the spring (Alaska Beluga Whale Committee, unpublished data).

The following information was considered in classifying beluga whale stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution discontinuous in summer (Frost and Lowry 1990); 2) Population response data: distinct population trends between regions occupied in summer; 3) Phenotypic data: unknown; and 4) Genotypic data: mitochondrial DNA analyses indicate distinct differences among the five summering areas (O'Corry-Crowe et al. 1997). Based on this information, five beluga whale stocks are recognized within U.S. waters: 1) Cook Inlet, 2) Bristol Bay, 3) eastern Bering Sea, 4) eastern Chukchi Sea, and 5) Beaufort Sea (Fig. 1).

POPULATION SIZE

The Alaska Beluga Whale Committee has been working to develop a population estimate for the eastern Bering Sea stock beginning with the first systematic aerial surveys of beluga whales in the Norton Sound/Yukon Delta region flown during May, June, and September 1992, and June 1993-1995 (Lowry et al. 1999). Beluga density estimates were calculated for June 1992 surveys using strip transect methods, and for June 1993-1995 using line transect methods. Correction factors were applied to account for animals that were missed during the surveys (those below the surface and not visible, and dark colored neonates). Lowry et al. (1999) concluded that the best estimate of abundance for the eastern Bering Sea beluga stock was 17,675 (95% confidence interval 9,056-34,515 not accounting for variance in correction factors) based on counts made in early June 1995. Additional aerial surveys of the Norton Sound/Yukon Delta region were conducted in June 1999 and 2000 (L. Lowry, pers. comm., 29 January 2011). Unlike previous survey years, in 1999 sea ice persisted in western Norton Sound resulting in a much different distribution of belugas, and the data were not used for population estimation. In 2000, systematic transect lines were flown covering the entire study region, and the data were analyzed using a covariate line transect model. Preliminary results indicate 9,593 belugas (CV = 0.32) seen at the surface in the study area (R. Hobbs, AFSC-NMML, pers. comm., 05 March 2014). If this estimate were doubled to correct for the proportion of animals that were diving and thus not visible at the surface, the total abundance for the eastern Bering Sea stock would be 19,186 whales. However, while these results confirm that the eastern Bering Sea beluga stock is quite large they are preliminary and are not ready to use for calculation of N_{MIN} or PBR at this time.

Minimum Population Estimate

For the eastern Bering Sea stock of beluga whales, the minimum population estimate (N_{MIN}) is calculated according to Equation 1 from the PBR Guidelines (Wade and Angliss 1997). Therefore, $N_{MIN} = N/\exp(0.842 \times [\ln(1+[CV(N)]^2)]^{½})$. Using the population estimate (N) of 19,186 and an associated CV(N) of 0.32, N_{MIN} for this stock is 14,751 beluga whales. However, because the survey data are more than 8 years old, it is not considered a reliable minimum population estimate for calculating a PBR, and N_{MIN} is considered unknown. More recent data are considered preliminary and are not ready to be used for calculation of $N_{MIN,}$ but will be available soon (R. Hobbs, AFSC-NMML, pers. comm., 05 March 2014).

Current Population Trend

Surveys to estimate population abundance in Norton Sound were not conducted prior to 1992. Annual estimates of population size from surveys flown in 1992-1995 and 1999-2000 have varied widely, due partly to differences in survey coverage and conditions between years. Data currently available do not allow an evaluation of population trend for the eastern Bering Sea stock.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for the eastern Bering Sea stock of beluga whales. Lowry et al. (2008) estimated the rate of increase of the Bristol Bay beluga stock was 4.8% per year (95% CI = 2.1%-7.5%) over a 12-year period. However, until additional data become available specific to the eastern Bering Sea stock, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 1.0, the value for cetacean stocks that are thought to be stable in the presence of a subsistence harvest (Wade and Angliss 1997). However, the 2005 revisions to the SAR guidelines state that abundance estimates older than 8 years should not be used to calculate PBR due to a decline in confidence in the reliability of an aged abundance estimate. Therefore, the PBR for the eastern Bering Sea stock of beluga whales is considered undetermined (NMFS 2005).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality.*" Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fisheries Information

In previous assessments, there were three different federally observed commercial fisheries in Alaska that could have had incidental serious injuries or mortalities of eastern Bering Sea beluga whales. In 2004, the definitions of these commercial fisheries were changed to reflect target species; this new definition has resulted in the identification of several observed fisheries in the Bering Sea that use trawl, longline, or pot gear. There have been no observed serious injuries or mortalities in any of these commercial fisheries.

In the nearshore waters of the eastern Bering Sea, substantial effort occurs in commercial and subsistence fisheries, mostly for salmon and herring. The salmon fishery uses gillnet gear similar to that used in Bristol Bay where it is known that belugas have been incidentally taken (Frost et al. 1984). However there are no useful data on beluga incidental takes from this stock because there have never been observer programs in the commercial fisheries and there is no reporting requirement for takes in personal use fisheries. In 2010, one beluga was reported entangled in a subsistence salmon gillnet in the eastern Bering Sea (Table 1). NMFS assumes that all beluga whales killed are used for subsistence, regardless of the method of harvest, are reported to the ABWC, and included in the following section on Subsistence/Native Harvest Information.

A reliable estimate of the mortality rate incidental to commercial fisheries is currently unavailable.

Table 1. Summary of eastern Bering Sea stock of beluga whale mortalities and serious injuries by year and type reported to the Alaska Regional Office, marine mammal stranding database, for the 2008-2012 period (Allen et al. 2014, Helker et al. 2015). Only cases of serious injury were recorded in this table; animals with non-serious injuries have been excluded.

Cause of Injury	2008	2009	2010	2011	2012	Mean Annual Mortality
Entangled in subsistence salmon gillnet	0	0	1	0	0	0.2
Minimum total annual mortality						0.20

Because there has never been an observer program for nearshore commercial fisheries in the eastern Bering Sea region, a reliable estimate of the number of deaths incidental to commercial fisheries is currently unavailable.

Subsistence/Native Harvest Information

The subsistence take of beluga whales from the eastern Bering Sea stock is provided by the ABWC. The most recent subsistence harvest estimates for the stock are provided in Table 2 (Alaska Beluga Whale Committee, pers. comm., 13 June 2013). Belugas harvested in Kuskokwim villages are included in the total harvest for the eastern Bering Sea beluga stock. The annual subsistence take by Alaska Natives averaged 181 belugas landed from the eastern Bering Sea stock during the 5-year period 2008-2012.

Table 2. Summary of the number of belugas landed by the Alaska Native subsistence harvest from the eastern Bering Sea stock of beluga whales, 2008-2012.

Year	Reported total number landed
2008	119
2009	181
2010	194
2011	224
2012	186
Mean annual number of animals landed (2008-2012):	180.8

STATUS OF STOCK

The estimated minimum annual mortality incidental to U.S. commercial fisheries is 0. Because the PBR is undetermined, the level of annual U.S. commercial fishery-related mortality that can be considered insignificant and approaching zero mortality and serious injury rate is unknown. The total estimated annual human-caused mortality rate is 181 based on subsistence harvest (180.8) and entanglement in a subsistence salmon gillnet (0.2). Eastern Bering Sea beluga whales are not designated as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act. The level of incidental mortality in commercial fisheries is unknown, although it is considered to be insignificant. Therefore the eastern Bering Sea stock of beluga whales is classified as a non-strategic stock.

HABITAT CONCERNS

Evidence indicates that the Arctic climate is changing significantly and that one result of the change is a reduction in the extent of sea ice in most regions of the Arctic (ACIA 2004, Johannessen et al. 2004). These changes are likely to affect marine mammal species in the Arctic. Ice-associated animals, such as the beluga whale, may be sensitive to changes in Arctic weather, sea-surface temperatures, or ice extent, and the concomitant effect on prey availability. Currently, there are insufficient data to make reliable predictions of the effects of Arctic climate change on beluga whales, but Laidre et al. (2008) and Heide-Jørgensen (2010) concluded that on a worldwide basis belugas were likely to be less sensitive to climate change than other arctic cetaceans because of their wide distribution and flexible behavior. Increased human activity in the Arctic, including increasing oil and gas exploration and development, and increased nearshore development, have the potential to impact habitat for beluga whales (Moore et al. 2000, Lowry et al. 2006), but predicting the type and magnitude of the impacts is difficult at this time.

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BELUGA WHALE (*Delphinapterus leucas*): Bristol Bay Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Beluga whales are distributed throughout seasonally ice-covered arctic and subarctic waters of the Northern Hemisphere (Gurevich 1980), and are closely associated with open leads and polynyas in ice-covered regions (Hazard 1988). Depending on season and region, beluga whales may occur in both offshore and coastal waters, with summer concentrations in upper Cook Inlet, Bristol Bay, the eastern Bering Sea (i.e., Yukon Delta, Norton Sound), eastern Chukchi Sea, and the Mackenzie Delta (Hazard 1988). Satellite transmitters attached to whales from the Beaufort Sea, Chukchi Sea and eastern Bering Sea stocks have provided detailed information on distribution and movements. The few transmitters that lasted through the winter showed that beluga whales from these summering areas overwinter in the Bering Sea and the stocks may use separate wintering locations (Suydam 2009; Alaska Beluga Whale Committee, unpubl. data). Belugas found in Bristol Bay and the northern Gulf of Alaska/Cook Inlet remain in those areas throughout the year, showing only small seasonal shifts in distribution (Shelden 1994; Quakenbush 2003; NMFS and ADF&G, unpubl. data). Seasonal distribution is affected by ice cover, tidal conditions, access to prey, temperature, and human activities (Lowry 1985).

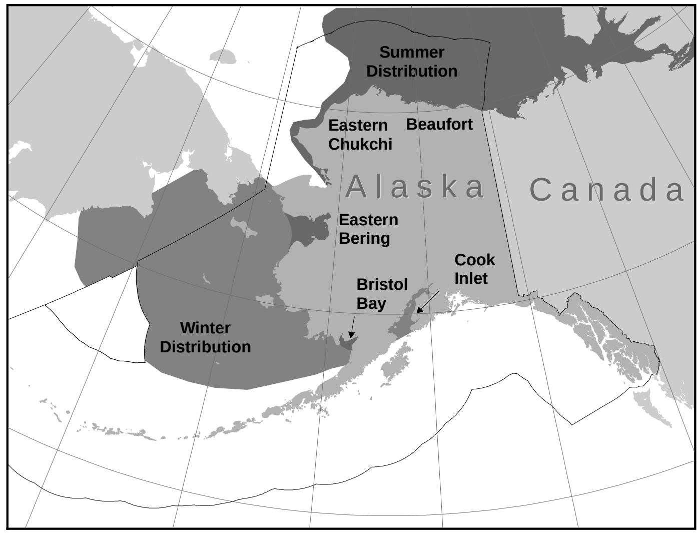

Figure 1. Approximate distribution of beluga whales in Alaska waters. The dark shading displays the summer distribution of the five stocks. Winter distributions are depicted with lighter shading.

The general distribution pattern for beluga whales shows major seasonal changes. During the winter, they occur in offshore waters associated with pack ice. In the spring, they migrate to warmer coastal estuaries, bays, and rivers where they may molt (Finley 1982, Suydam 2009) and give birth to and care for their calves (Sergeant and Brodie 1969). Annual migrations may cover thousands of kilometers (Richard et al. 2001).

Summer movement patterns of Bristol Bay belugas were determined from satellite-linked tags deployed on 10 animals in the Kvichak River during 2002 and 2003, and 5 in the Nushagak River in 2006, 10 in 2008, 5 in 2010, 10 in 2012, and 12 in 2013 (NMFS, BBMMC, ADF&G, unpubl. data). Those whales used the shallow upper portions of Kvichak and Nushagak bays between May and August (Quakenbush, 2003) and remained in the nearshore waters of Bristol Bay through the months of September and October (Quakenbush and Citta 2006). Data from two belugas whose tags lasted into December and January showed that they were in Nushagak and Kvichak bays, suggesting that some belugas do not leave the nearshore waters of Bristol Bay during the winter (L. Quakenbush, Alaska Department of Fish and Game, Fairbanks, AK, pers. comm., 31 March 2008). Tags attached to whales in 2012 and 2013 have confirmed these observations (NMFS, unpubl. data).

The following information was considered in classifying beluga whale stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution discontinuous in summer (Frost and Lowry 1990); 2) Population response data: distinct population trends between regions occupied in summer; 3) Phenotypic data: unknown; and 4) Genotypic data: mitochondrial DNA analyses indicate distinct differences among the five summering areas (O'Corry-Crowe et al. 1997). Based on this information, five beluga whale stocks are recognized within U.S. waters: 1) Cook Inlet, 2) Bristol Bay, 3) eastern Bering Sea, 4) eastern Chukchi Sea, and 5) Beaufort Sea (Fig. 1).

POPULATION SIZE

The sources of information to estimate abundance for belugas in the waters of western and northern Alaska have included both opportunistic and systematic observations. Frost and Lowry (1990) compiled data collected from aerial surveys conducted between 1978 and 1987 that were specifically designed to estimate the number of beluga whales. Surveys did not cover the entire habitat of belugas, but were directed to specific areas at the times of year when belugas are known to concentrate during summer. Frost and Lowry (1990) reported an estimate of 1,000-1,500 whales for Bristol Bay, similar to that reported by Seaman et al. (1985). In 1994, the number was estimated at 1,555 belugas (Lowry and Frost 1998). That estimate was based on a maximum count of 503 animals, which was corrected using radio-telemetry data for the proportion of animals that were diving and thus not visible at the surface (2.62; Frost and Lowry 1995), and for the proportion of newborns and yearlings not observed due to their small size and dark coloration (1.18; Brodie 1971). The Alaska Department of Fish and Game and the Alaska Beluga Whale Committee conducted beluga surveys in Bristol Bay in 1999, 2000, 2004 and 2005, with maximum counts of 690, 531, 794, and 1,067 whales (Lowry et al. 2008). Using the correction factors described above and the maximum counts for 2004 and 2005 gives population estimates of 2,455 and 3,299 whales, with an average annual estimate of 2,877 (L. Lowry, University of Alaska Fairbanks, pers. comm., March 2011).

Minimum Population Estimate

The survey technique used for estimating the abundance of beluga whales in this stock is a direct count which incorporates correction factors. Given this survey method, estimates of the variance of abundance are unavailable. The abundance estimate is thought to be conservative because no correction has been made for whales that were at the surface but were missed by the observers, and the dive correction factor is probably negatively biased (Lowry and Frost 1998). Consistent with the recommendations of the Alaska Scientific Review Group (DeMaster 1997), a default CV(N) of 0.2 was used in the calculation of the minimum population estimate (N_{MIN}). N_{MIN} for this beluga whale stock is calculated using Equation 1 from the PBR Guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the average estimate for 2004 and 2005 (N) of 2,877 and the default CV (0.2), N_{MIN} for the Bristol Bay stock of beluga whales is 2,435.

Current Population Trend

A survey program involving replicate aerial counts using standardized methods was conducted during 1993-2005. Data from 28 complete counts of Kvichak and Nushagak bays made in good or excellent survey conditions were analyzed, and results showed that the population had increased by 65% over the 12-year period (Lowry et al. 2008).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

The estimated rate of increase in abundance of belugas in Bristol Bay during 1993-2005 was 4.8% per year (95% CI = 2.1%-7.5%; Lowry et al. 2008). This estimate exceeds the default cetacean maximum net productivity rate (R_{MAX}) of 4% (Wade and Angliss 1997). It is currently not clear why this stock should be increasing at such a high rate, but possibilities include recovery from research kills in the 1960s, a reduction in subsistence harvests, and a delayed response to increases in salmon stocks (Lowry et al. 2008).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. As this stock is known to be increasing (Lowry et al. 2008), the recovery factor (F_R) is 1.0 (Wade and Angliss 1997, DeMaster 1997; see discussion under PBR for the eastern Bering Sea stock). Thus, for the Bristol Bay stock of beluga whales, PBR = 58 animals (2,435 × 0.024 × 1.0).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality.*" Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fisheries Information

Three different commercial fisheries that could have interacted with beluga whales in Bristol Bay were monitored for incidental take by fishery observers during 1990-1997: Bering Sea (and Aleutian Islands) groundfish trawl, longline, and pot fisheries. Observers did not report any mortality or serious injury of beluga whales incidental to these groundfish fisheries.

Observers have never monitored the Bristol Bay commercial salmon set gillnet and drift gillnet fisheries which combined had 2,845 active permits in 2010. These fisheries are known to have caused mortality of beluga whales from this stock in the past (Frost et al. 1984). However, they have never been monitored by an observer program so there is no reliable information on the number of animals that have been or are being taken.

There is substantial effort in a subsistence gillnet fishery for salmon in Bristol Bay. Belugas are occasionally entangled and killed in this fishery, but there is no established protocol for non-commercial takes to be reported to NMFS. During 2008-2012, one mortality of a beluga in a subsistence salmon net was reported to the stranding network (Table 1). Based on this stranding report, the minimum annual mortality estimate due to fishery interactions over the 5-year period from 2008 to 2012 was 0.2 per year. However, this figure is clearly an underestimate because subsistence fishers are not required to report marine mammal takes, and the commercial fishery has not been observed. Also, it should be noted that in this region of western Alaska, belugas taken incidental to the personal-use or commercial salmon fisheries may be used by Alaska Natives for subsistence and may be included in the subsistence harvest data reported below.

A reliable estimate of the mortality rate incidental to commercial fisheries is currently unavailable.

Table 1. Summary of the Bristol Bay stock of beluga whale mortalities and serious injuries by year and type reported to the Alaska Regional Office, marine mammal stranding database, for the 2008-2012 period (Allen et al. 2014, Helker et al. 2015). Only cases of serious injury were recorded in this table; animals with non-serious injuries have been excluded.

Cause of Injury	2008	2009	2010	2011	2012	Mean Annual Mortality
Entangled in Bristol Bay subsistence king salmon set gillnet	0	1	0	0	0	0.2
Minimum total annual mortality						0.20

Subsistence/Native Harvest Information

Data on the subsistence take of beluga whales from the Bristol Bay stock is provided by the ABWC. The most recent subsistence harvest estimates for the stock are provided in Table 2 (Alaska Beluga Whale Committee, 18 February 2010). These data show that the annual subsistence take by Alaska Natives averaged 24 belugas from the Bristol Bay stock during the 5-year period 2008-2012.

Table 2. Summary of the Alaska Native subsistence harvest from the Bristol Bay stock of beluga whales, 2008-2012. N/A indicates the data are not available.

Year	Reported total number landed
2008	19
2009	20
2010	27
2011	22
2012	32
Mean annual number of animals landed (2008-2012)	24.0

STATUS OF STOCK

It is unknown whether the U.S. commercial fishery-related mortality level is insignificant and approaching zero mortality and serious injury rate (i.e., 10% of PBR; less than 5.8 per year) because a reliable estimate of the mortality rate incidental to commercial fisheries is currently unavailable. Bristol Bay beluga whales are not designated as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act. Based on currently available data, the estimated annual rate of human-caused mortality and serious injury (24 + 0.2 = 24.2) is not known to exceed the PBR (58). Because the population size has been increasing at a rate near R_{MAX}, the sum of human impacts on the population are not a problem at this point (Lowry et al. 2008). Therefore, the Bristol Bay stock of beluga whales is not classified as a strategic stock. However, as noted previously, the estimate of fisheries-related mortality is unreliable and likely to be underestimated.

HABITAT CONCERNS

Evidence indicates that the Arctic climate is changing significantly and that one result of the change is a reduction in the extent of sea ice in most regions of the Arctic (ACIA 2004, Johannessen et al. 2004). These changes are likely to affect marine mammal species in the Arctic. Ice-associated animals, such as the beluga whale, may be sensitive to changes in arctic weather, sea-surface temperatures, or ice extent, and the concomitant effect on prey availability. Currently, there are insufficient data to make reliable predictions of the effects of arctic climate change on beluga whales, but Laidre et al. (2008) and Heide-Jørgensen (2010) concluded that on a worldwide basis belugas were likely to be less sensitive to climate change than other arctic cetaceans because of their wide distribution and flexible behavior. Increased human activity in the Arctic, including increasing oil and gas exploration and development, and increased nearshore development, have the potential to impact habitat for beluga whales (Moore et al. 2000, Lowry et al. 2006), but predicting the type and magnitude of the impacts is difficult at this time. Because the population size has been increasing (Lowry et al. 2008), habitat impacts most likely have been minimal during recent years.

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BELUGA WHALE (*Delphinapterus leucas*): Cook Inlet Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Beluga whales are distributed throughout seasonally ice-covered arctic and subarctic waters of the Northern Hemisphere (Gurevich 1980) and are closely associated with open leads and polynyas in ice-covered regions (Hazard 1988). In Alaska, depending on season and region, beluga whales may occur in both offshore and coastal waters, with summer concentrations in upper Cook Inlet (north of the East and West Forelands), Bristol Bay, the eastern Bering Sea (i.e., Yukon Delta and Norton Sound), eastern Chukchi Sea (including Kotzebue Sound), and Beaufort Sea (Mackenzie River Delta) (Hazard 1988). Seasonal distribution is affected by ice cover, tidal conditions, access to prey, temperature, and human interaction (Lowry 1985). Satellite transmitters on whales from the Beaufort Sea, Eastern Chukchi Sea, and Eastern Bering Sea stocks show monthly home ranges that are relatively distinct among these populations' summering areas and autumn migratory routes (e.g., Hauser et al. 2014). Beluga whales satellite-tagged in Bristol Bay (Quakenbush 2003) and Cook Inlet (Hobbs et al. 2005, Goetz et al. 2012a, Shelden et al. 2015a) remained in those respective areas throughout the year, i.e., they are non-migratory.

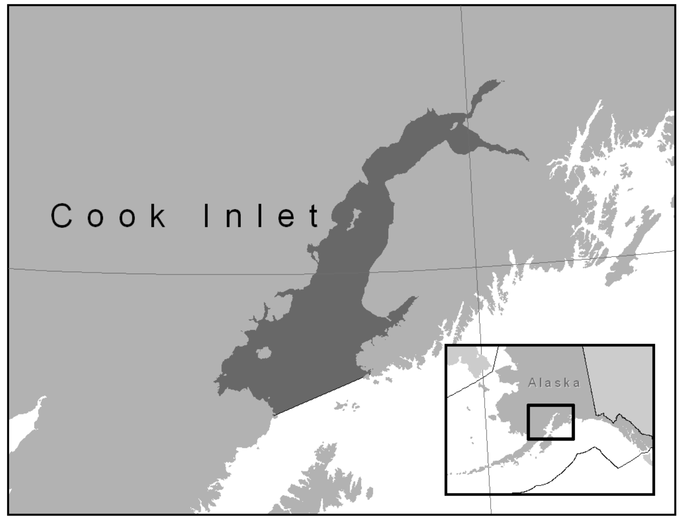

Figure 1. Approximate distribution of beluga whales in Cook Inlet.

Beluga whale stock structure was based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution discontinuous (Frost and Lowry 1990); 2) Population response data: possible extirpation of local populations, distinct population trends among regions occupied in summer; 3) Phenotypic data: unknown; and 4) Genotypic data: mitochondrial DNA analyses indicate distinct differences among populations in summering areas (O'Corry-Crowe et al. 2002). Based on this information, five beluga whale stocks are recognized within U.S. waters: 1) Cook Inlet (Fig. 1), 2) Bristol Bay, 3) Eastern Bering Sea, 4) Eastern Chukchi Sea, and 5) Beaufort Sea.

During ice-free months, Cook Inlet beluga whales are typically concentrated near river mouths (Rugh et al. 2010). The fall-winter-spring distribution of this stock is not fully determined; however, there is evidence that most whales in this population inhabit upper Cook Inlet year-round (Hansen and Hubbard 1999, Rugh et al. 2004, Lammers et al. 2013, Shelden et al. 2015a, Castellote et al. 2015). During summers from 1999 to 2002, satellite tags were attached to a total of 18 beluga whales to determine their distribution through the fall and winter months (Hobbs et al. 2005, Goetz et al. 2012a, Shelden et al. 2015a). Tags on four of these whales transmitted for only a few days and transmissions stopped in September for another whale (Shelden et al. 2015a). Ten tags transmitted whale locations from September through November and, of those, three transmitted into January, three into March, and one into late May (Hobbs et al. 2005, Goetz et al. 2012a, Shelden et al. 2015a). All tagged beluga whales remained in Cook Inlet, primarily in upper inlet waters (Shelden et al. 2015a).

A review of all marine mammal surveys and anecdotal sightings in the northern Gulf of Alaska between 1936 and 2000 found only 28 beluga whale sightings, indicating that very few beluga whales occurred in the Gulf of Alaska outside Cook Inlet (Laidre et al. 2000). A small number of beluga whales (fewer than 20 animals: Laidre et al. 2000, Lucey et al. 2015, O'Corry-Crowe et al. 2015) are regularly observed in Yakutat Bay. Based on genetic analyses, traditional ecological knowledge (TEK), and observations by fishers and others reported year-round, the Yakutat beluga whales likely represent a small, resident group that is reproductively separated from Cook Inlet (Lucey et al. 2015, O'Corry-Crowe et al. 2015). Furthermore, this group in Yakutat appears to be showing signs of inbreeding and low diversity due to their isolation and small numbers (O'Corry-Crowe et al. 2015). Although the beluga whales in Yakutat Bay are not included in the Cook Inlet Distinct Population Segment (DPS) of beluga whales under the Endangered Species Act (ESA), they are considered part of the depleted Cook Inlet stock under the Marine Mammal Protection Act (MMPA) (50 CFR 216.15; 75 FR 12498, 16 March 2010). Notice-and-comment rulemaking procedures would be required to change the NMFS regulatory definition under the MMPA. Thus, Yakutat Bay beluga whales remain designated as depleted and part of the Cook Inlet stock.

POPULATION SIZE

Aerial surveys during June documenting the early summer distribution and abundance of beluga whales in Cook Inlet were conducted by NMFS each year from 1993 to 2012 (Rugh et al. 2000, 2005; Shelden et al. 2013), after which NMFS began biennial surveys in 2014 (Shelden et al. 2015b) (Fig. 2). NMFS changed to a biennial survey schedule after detailed analysis showed that there would be little reduction in assessment quality (Hobbs 2013).

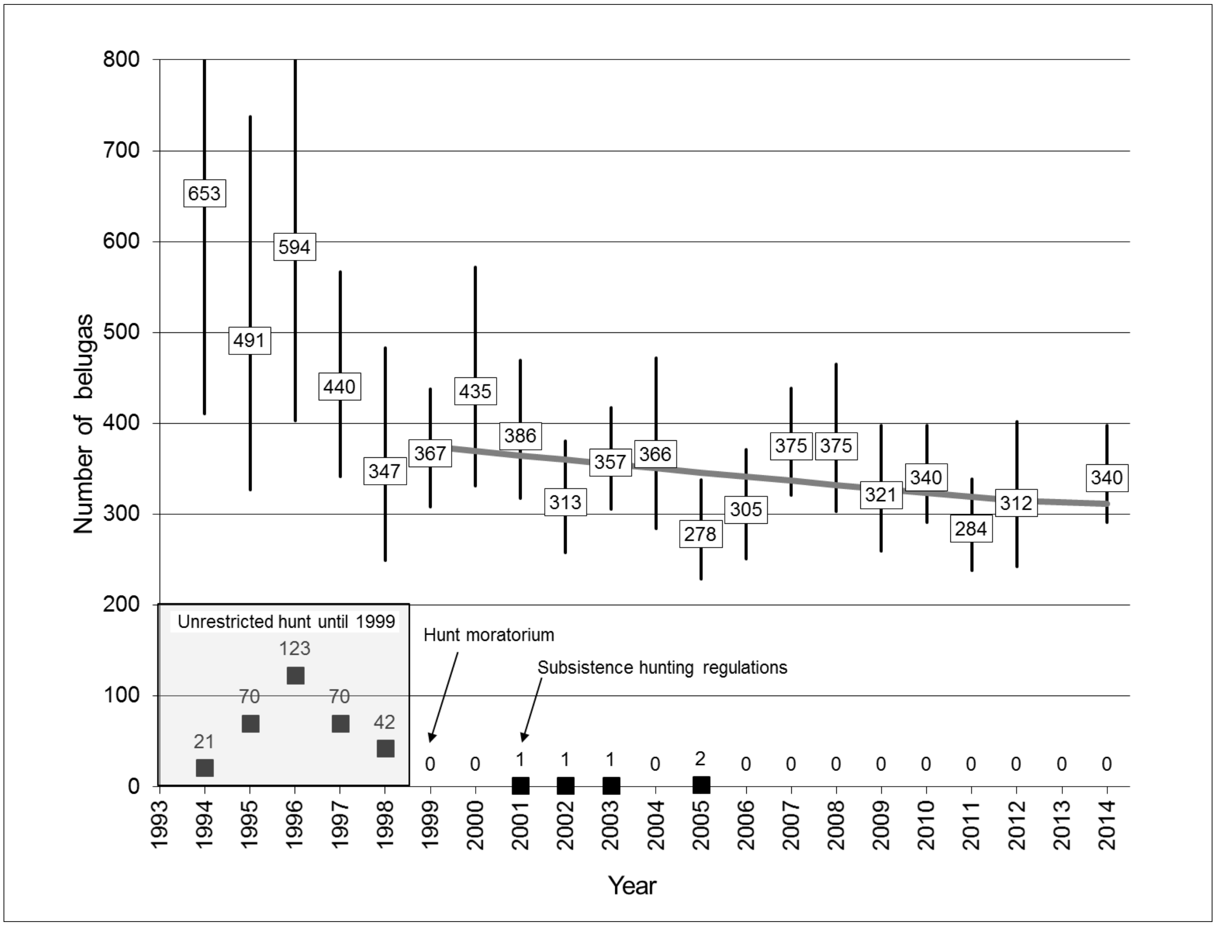

Figure 2. Annual abundance estimates of beluga whales in Cook Inlet, Alaska, 1994-2014 (Hobbs et al. 2015a, Shelden et al. 2015b). Black squares show reported removals (landed plus struck and lost) during the Alaska Native subsistence hunt. A struck and lost average was calculated by the Cook Inlet Marine Mammal Council (CIMMC) and hunters for 1996, 1997, and 1998. Black vertical bars depict plus and minus one standard error for each abundance estimate (box label). From 1999 to 2014, the rate of decline (gray trend line) is 1.3% per year (with a 97% probability that the growth rate is declining), while the 10-year trend (2004-2014) is -0.4% per year (with a 76% probability of declining).

The abundance estimate for beluga whales in Cook Inlet is based on counts by aerial observers and video analysis of whale groups. Paired, independent observers count each whale group while video is collected during each counting pass. Each count is corrected for subsurface animals (availability correction) and animals at the surface that were missed (sightability correction) based on an analysis of the video tapes (Hobbs et al. 2000). When video counts are not available, observers' counts are corrected for availability and sightability using a regression of counts and an interaction term with an encounter rate against the video count estimates (Hobbs et al. 2000). The estimate of the abundance equation variance was revised using the squared standard error of the average for the abundance estimates in place of the abundance estimate variance and the measurement error (Hobbs et al. 2015a). This reduced the coefficients of variation (CVs) by almost half. The June 2014 survey resulted in an estimate of 340 whales (CV = 0.08) (Shelden et al. 2015b). This estimate is more than the estimate of 312 beluga whales for 2012; however, it falls within the statistical variation around the recent trend line and probably represents variability of the estimation process rather than an increase in the population from 2012 to 2014. Annual abundance estimates based on aerial surveys of Cook Inlet beluga whales during the most recent 3-survey period were 284 (2011), 312 (2012), and 340 (2014), resulting in an average abundance estimate for this stock of 312 (CV = 0.10) beluga whales. Data from an abundance estimate survey in June 2016 will be included in a future Stock Assessment Report.

Minimum Population Estimate

The minimum population estimate (N_{MIN}) is calculated according to Equation 1 from the potential biological removal (PBR) guidelines (Wade and Angliss 1997). Thus, $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the 3-survey average population estimate (N) of 312 whales and an associated CV(N) of 0.10, N_{MIN} for the Cook Inlet beluga whale stock is 287 beluga whales.

Current Population Trend

The corrected annual abundance estimates for the period 1994-2014 are shown in Figure 2. From 1999 to 2014, the rate of decline was 1.3% (SE = 0.7%) per year, with a 97% probability that the growth rate is declining (i.e., less than zero), while the 10-year trend (2004-2014) is -0.4% per year (with a 76% probability of declining) (Shelden et al. 2015b).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently not available for the Cook Inlet beluga whale stock. Hence, until additional data become available, the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% is recommended to be employed for this stock (Wade and Angliss 1997). This figure is similar to the 4.8% annual increase that has been documented for the Bristol Bay beluga whale stock (Lowry et al. 2008).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized MMPA, the PBR was defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. In past Stock Assessment Reports for this stock, from 1998 through 2005, NMFS calculated a value for PBR. Given the low abundance relative to historical estimates and low known levels of human-caused mortality since 1999, this stock should have begun to grow at or near its maximum productivity rate (2-6%), but for unknown reasons the Cook Inlet beluga whale stock is not increasing. Because this stock does not meet the assumptions inherent to the use of the PBR, NMFS has decided it would not be appropriate to calculate a maximum number that may be removed while allowing the population to achieve its Optimum Sustainable Population. Thus, the PBR for this stock is undetermined.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

The estimated minimum average annual mortality and serious injury rate incidental to U.S. commercial fisheries is unknown, although probably low, because only one known beluga whale mortality due to fishery interaction has been reported in the past 10 years.

One entanglement in a subsistence fishery was reported to the NMFS Alaska Region on 7 May 2012 by a fisherman who reported a juvenile beluga whale entangled in his salmon fishing net near Kenai, Alaska. The beluga whale was dead and necropsy findings indicated that it was in poor health prior to entanglement and the cause of death was drowning. However, it was not determined whether the beluga whale died before or after the net entanglement.

Alaska Native Subsistence/Harvest Information

Subsistence harvest of beluga whales in Cook Inlet is important to one local village (Tyonek) and the Alaska Native subsistence hunter community in Anchorage. Between 1993 and 1998, the annual subsistence take ranged from 17 to more than 123 animals (Fig. 2), including beluga whales struck and lost (NMFS 2015).

Following a significant decline in Cook Inlet beluga whale abundance estimates between 1994 and 1998, the Federal government took actions to conserve, protect, and prevent further declines in the abundance of these whales. In 1999 and 2000, Public Laws 106-31 and 106-553 established a moratorium on Cook Inlet beluga whale harvests except for subsistence hunts conducted under cooperative agreements between NMFS and affected Alaska Native organizations. A cooperative agreement, also referred to as a co-management agreement, was not signed in 1999, so harvest was not authorized in 1999 and 2000. Harvests from 2001 through 2004 were conducted under harvest regulations (69 FR 17973, 6 April 2004) following an interim harvest management plan developed through an administrative hearing. Three beluga whales were harvested in Cook Inlet under this interim harvest plan. In August 2004, an administrative hearing was held to create a long-term harvest plan. An interim plan would have allowed up to eight whales to be harvested between 2005 and 2009 (https://alaskafisheries.noaa.gov/pr/interim-harvest-plan, accessed December 2016). Two whales were taken in 2005 and no takes were authorized in 2006 and later under this agreement. A long-term harvest plan (https://alaskafisheries.noaa.gov/pr/cib-long-term-harvest-management, accessed December 2016) established allowable harvest levels for a 5-year period, based on the average abundance in the previous 5-year period and the growth rate during the previous 10-year period. A harvest is not allowed if the previous 5-year average abundance is less than 350 beluga whales. Under the long-term harvest plan, the 5-year average abundance during the first review period 2003-2007 was 336 whales and a harvest would not have been allowed during the subsequent 5-year period 2008-2012 (73 FR 60976, 15 October 2008), so the cooperative agreement was not signed and no hunt occurred. The average abundance of Cook Inlet beluga whales remained below 350 whales during the second review period 2008-2012; therefore, a harvest is not allowed for the current 5-year period 2013-2017.

Other Mortality

Mortality related to live stranding events, where a group of beluga whales becomes stranded as the tide recedes has been reported in Cook Inlet (Table 1). Improved record-keeping was initiated in 1994, and reports have since included the number of beachcast carcasses and live stranded beluga whales (NMFS 2015). Most whales involved in a live stranding event survive, although some deaths may be missed by observers if whales die later from live stranding-related injuries (Vos and Shelden 2005, Burek-Huntington et al. 2015). Between 2009 and 2014, there were approximately 145-150 whales involved in nine known live stranding events, with two deaths reported (Table 1). In 2014, necropsy results from two dead whales found in Turnagain Arm suggested the whales had recently live stranded and that the live stranding may have contributed to their deaths. No live stranding events were reported to NMFS in the period prior to the discovery of these whales, suggesting that not all strandings are observed (Table 1). Most live strandings occur in Knik Arm or Turnagain Arm, both of which are shallow and dangerous waterways. Turnagain Arm has the largest tidal range in the U.S., with a mean of 9.2 m (30 ft).

Table 1. Cook Inlet beluga whale strandings investigated by NMFS during 2009-2014 (NMFS 2015).

Year	Beachcast carcasses	Number of beluga whales per live stranding event (number of associated known or suspected resulting deaths)
2009	4	16-21 (0)
2010	5	11(0), 2(0)
2011	3	2(0)
2012	3	12(0), 23(0), 3(0)
2013	5	0
2014	10	76+ (0), unknown (2)
Total	30	145-150 (2)

Another source of beluga whale mortality in Cook Inlet is predation by mammal-eating killer whales. Killer whale sightings were not well documented and were likely rare in the upper inlet prior to the mid-1980s. From 1982 through 2014, 29 killer whale sightings in upper Cook Inlet (north of the East and West Forelands) were reported to NMFS. It is not known which of these were mammal-eating killer whales (i.e., transient killer whales) that might prey on beluga whales and which were fish-eating killer whales (i.e., resident killer whales) that would not prey on beluga whales. Between 9 and 12 beluga whale deaths during this time were suspected to be a direct result of killer whale predation (NMFS 2015). The last confirmed killer whale predation of a beluga whale in Cook Inlet occurred in 2008 in Turnagain Arm. In June 2010, a beluga whale carcass found near Point Possession was speculated to have injuries associated with killer whale predation; however, the poor condition of the beluga whale carcass prevented a positive determination of cause of death. From 2011 through 2014, NMFS received no reports of killer whale sightings in upper Cook Inlet or possible predation attempts.

A photo-identification study (Kaplan et al. 2009) did not find any instances where Cook Inlet beluga whales appeared to have been entangled in, or to have otherwise interacted with, fishing gear. However, in 2010, a beluga whale with a rope entangled around its girth was observed and photo-documented during May through August. The same whale was photographed in July and August 2011, August 2012, and July 2013, still entangled in the rope line (McGuire et al. 2014). This whale is currently considered to have a non-serious injury (Helker et al. 2016).

Between 1998 and 2013, 38 necropsies were performed on beluga whale carcasses (23% of the known stranded carcasses during this time period) (Burek-Huntington et al. 2015). The sample included adults (n = 25), juveniles (n = 6), calves (n = 3), and aborted fetuses (n = 4). When possible, a primary cause of death was noted along with contributing factors. Cause of death was unknown for 29% of the necropsied carcasses. Cause of death in the others was attributed to various types of trauma (18%), perinatal mortality (13%), mass stranding (13%), single stranding (11%), malnutrition (8%), or disease (8%). Several animals had mild to moderate pneumonia, kidney disease, and/or stomach ulcers that likely contributed to their cause of death.

STATUS OF STOCK

The Cook Inlet beluga whale stock was designated as depleted under the MMPA (65 FR 34590, 21 May 2000), and on 22 October 2008, NMFS listed Cook Inlet beluga whales as endangered under the ESA (73 FR 62919, 22 October 2008). Therefore, the Cook Inlet beluga whale stock is considered a strategic stock. There are no observers on fisheries in Cook Inlet and there have been no voluntary reports of beluga whale mortality or serious injury in U.S. commercial fisheries. The mean annual mortality and serious injury rate for commercial fisheries is likely low, although the incompleteness of the data for commercial fisheries operating within the range of Cook Inlet beluga whales is a concern for this small population. NMFS convened a Recovery Team to aid in the development of a Recovery Plan for Cook Inlet beluga whales; the Recovery Team's plan was finalized in December 2016 (NMFS 2016).

HABITAT CONCERNS

Beluga whale critical habitat includes two geographic areas of marine habitat in Cook Inlet that comprise 7,800 km^2 (3,013 mi^2), excluding waters by the Port of Anchorage (76 FR 20180, 11 April 2011). Based on available information from aerial surveys, tagged whales, and opportunistic sightings, beluga whales remain within the inlet year-round. Since 2000, most whales have been found in the upper inlet north of the East and West Forelands during the summer months (Rugh et al. 2010) and in the fall as well (Rugh et al. 2004), with tagged whales travelling between the lower and upper inlet and offshore waters >10 m deep during the winter (Hobbs et al. 2005, Goetz et al. 2012a, Shelden et al. 2015a, Castellote et al. 2015). Whether this contracted distribution is a result of changing habitat (Moore et al. 2000), prey concentration, or predator avoidance (Shelden et al. 2003) or can simply be explained as the contraction of a reduced population into a small number of preferred habitat areas (Goetz et al. 2007, 2012b) is unknown. With the limited range of this stock, Cook Inlet beluga whales are vulnerable to human-induced or natural perturbations within their preferred habitat. Goetz et al. (2012b) modeled habitat preferences using NMFS' 1994-2008 abundance survey data. In large areas, such as the Susitna Delta and Knik Arm, they found a high probability of beluga whale presence in larger group sizes. Beluga whale presence also increased closer to rivers with Chinook salmon (*Oncorhynchus tshawytscha*) runs, such as the Susitna River. The Susitna Delta also supports two major spawning migrations of a small, schooling smelt (eulachon, *Thaleichthys pacificus*) in May and July. Threats that have the potential to impact this stock and its habitat include the following: changes in prey availability due to natural environmental variability, ocean acidification, and commercial fisheries; climatic changes affecting habitat; predation by killer whales; contaminants; noise; ship strikes; waste management; urban runoff; construction projects; and physical habitat modifications that may occur as Cook Inlet becomes increasingly urbanized (Moore et al. 2000, Lowry et al. 2006, Hobbs et al. 2015b). Planned projects that may alter the physical habitat of Cook Inlet include highway improvements; mine construction and operation; oil and gas exploration and development; and expansion and improvements to ports.

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NARWHAL (*Monodon monoceros*): Unidentified Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Narwhals are found year-round north of 60°N, primarily in the waters of the Canadian Arctic, Hudson Bay, Baffin Bay, Davis Strait, West Greenland, East Greenland, and the waters around Svalbard, Franz Josef Land, and Novaya Zemyla (Gjertz 1991, Jefferson et al. 2012, Higdon and Ferguson 2014) While large aggregations are found in eastern Arctic waters, they rarely occur in the western Arctic, namely the East Siberian, Bering, Chukchi, and Beaufort seas (COSEWIC 2004) (Fig. 1). The three recognized narwhal populations are based on geographic separation: Baffin Bay, Hudson Bay, and East Greenland (DFO 1998a, 1998b; COSEWIC 2004). The Baffin Bay population summers in the waters along West Greenland and the Canadian High Arctic and overwinters in Baffin Bay and Davis Strait (Koski and Davis 1994, Dietz et al. 2001, Heide-Jørgensen et al. 2003). Narwhals from the northwest Hudson Bay population are thought to overwinter in eastern Hudson Strait (Richard 1991). The East Greenland population is believed to winter in the pack ice between eastern Greenland and Svalbard (Dietz et al. 1994). A poorly described population inhabits the waters around Svalbard, Franz Josef Land, and Novaya Zemyla (Gjertz 1991, Lydersen et al. 2007). The amount of interchange between these populations is unknown. Populations are defined for management purposes, and these designated populations may actually consist of several populations (COSEWIC 2004). Population definition based on molecular genetic studies of narwhals remains unresolved at this time due to extremely low genetic variability within and among management stocks (Palsbøll et al. 1997; de March et al. 2001, 2003).

Figure 1. Potential distribution of narwhals in arctic waters based on extralimital sightings and strandings (George and Suydam, unpubl. ms.; Reeves and Tracey 1980; COSEWIC 2004).

Local observations and traditional ecological knowledge are the primary source for any data on narwhals in Alaska waters, dating back to the 1800s (Bee and Hall 1956; Geist et al. 1960; Noongwook et al. 2007; George and Suydam, unpubl. ms.). The earliest record dates back to 1874, with most occasional sightings occurring around the area east of Point Barrow (Scammon 1874, Ray and Murdoch 1885, Turner 1886, Nelson and True 1887, Murdoch 1898, MacFarlane 1905, Dufresne 1946, Anderson 1947, Bee and Hall 1956, Geist et al. 1960). Narwhal occurrences are reported in Bee and Hall (1956) from Point Barrow to the Colville River Delta. Ljungblad et al. (1983) reported a sighting of two male narwhals northwest of King Island in the Bering Sea, during a systematic scientific survey. Sightings have occurred in Russian waters of the northern Chukchi Sea (Yablokov and Bel'kovich 1968, Reeves and Tracey 1980). George and Suydam (unpubl. ms.) summarized observations from Alaska Native hunters during eight sightings of narwhals in the Chukchi and Beaufort seas between 1989 and 2008. Of these records, seven sightings were live animals totaling 11-12 individuals; one record was of a beachcast narwhal tusk at Cape Sabine. Four of the seven live narwhal sightings consisted of mixed groups of belugas and narwhals (George and Suydam, unpubl. ms.).

Several narwhal specimens collected in Alaska have been documented. Murie (1936) reported a single tusk that was found on a sandbar at Cape Chibukak, St. Lawrence Island. Huey (1952) reported on a specimen collected near Cape Halkett, Harrison Bay, at the mouth of the Colville River, in the Beaufort Sea. Three additional specimen records from various locations were documented in Geist et al. (1960): one specimen was found on the beach of Kiwalik Bay (Kotzebue Sound), another was initially sighted alive at the mouth of the Caribou River in Nelson Lagoon (Alaska Peninsula) but later died, and a third specimen was a tusk found on a beach near Wainwright, on the Chukchi Sea.

It is believed that these incidental narwhal records that occurred in the Beaufort, Chukchi, and Bering seas and Bristol Bay are whales from the Baffin Bay population, which are known to move into the Canadian Arctic Archipelago and as far north and west as ice conditions will permit (COSEWIC 2004). However, there is no evidence or method to confirm this. There are insufficient data to apply the phylogeographic approach to stock structure (Dizon et al. 1992) for narwhals.

POPULATION SIZE

Reliable estimates of abundance for narwhals in Alaska are currently unavailable.

Minimum Population Estimate

At this time, it is not possible to produce a reliable minimum population estimate (N_{MIN}) for this stock, as current estimates of abundance are unavailable.

Current Population Trend

At present, reliable data on trends in population abundance are unavailable.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for narwhals in Alaska. Hence, until additional data become available, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% be employed (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for these stocks is 0.5, the value for cetacean stocks with unknown population status (Wade and Angliss 1997). However, in the absence of a reliable estimate of a minimum abundance, the PBR for this stock is unknown.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

There are no U.S. commercial fisheries operating within the normal range of narwhals in Alaska. There are no observer program records of narwhal mortality or serious injury incidental to commercial fisheries in Alaska. The estimated mean annual mortality and serious injury rate incidental to U.S. commercial fisheries is zero.

Subsistence/Native Harvest Information

There is no known subsistence harvest of narwhals by Alaska Natives.

STATUS OF STOCK

Narwhals are not designated as depleted under the MMPA or listed as threatened or endangered under the Endangered Species Act. Reliable estimates of the minimum population, population trend, PBR, and status of the stock relative to its Optimum Sustainable Population are currently not available. There are no federal or state commercial fisheries operating in the marine waters of the Arctic, and there are no reports of mortality or serious injury of narwhals in Alaska, therefore, the mean annual mortality and serious injury rate is considered insignificant and approaching zero. The estimated annual rate of human-caused mortality and serious injury is believed to be zero for this stock. Thus, the Unidentified stock of narwhals in Alaska is not classified as strategic.

HABITAT CONCERNS

Narwhals tend to prefer heavy ice cover in the winter and animals studied in Baffin Bay chose areas associated with high concentrations of Greenland halibut, which correspond to the coldest bottom temperatures (Laidre et al. 2004b; Laidre and Heide-Jørgensen 2005b, 2011). Narwhals wintering in Hudson Strait are also found in ice-covered areas of deep water, but the maximum depths are much shallower than the areas used by narwhals in Baffin Bay (Laidre et al. 2003, 2004a). As the Arctic warms through climate change, ice cover will be thinner, form later, melt earlier, and be less predictable. A warming Arctic will also see changes in ocean currents which create conditions that support concentrations of winter narwhal prey species, such as Greenland halibut. This may result in a shift in distribution of narwhals and their prey, requiring changes in migration timing, as well as destinations

(Kovaks and Lydersen 2008; Laidre et al. 2008, 2010, 2015). An increased risk of ice entrapment is associated with the changes in sea-ice formation, because seasonal cues for the timing of freeze up have changed and because later freezing may result in large expanses of open water freezing at one time (Heide-Jørgensen et al. 2002, Heide-Jørgensen and Laidre 2004, Laidre and Heide-Jørgensen 2005a, Laidre et al. 2012).

In addition to changing sea ice, narwhals are threatened by a number of changes associated with warming of the Arctic, including increased shipping and development, which adds noise; risk of pollution and ship strikes; risk of predation by killer whales (*Orcinus orca*) (Laidre et al. 2006); shifts in prey abundance and distribution; and exposure to novel diseases (Laidre et al. 2015).

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KILLER WHALE (*Orcinus orca*): Eastern North Pacific Alaska Resident Stock

NOTE – NMFS has preliminary genetic information on killer whales in Alaska which indicates that the current stock structure of killer whales in Alaska needs to be reassessed. NMFS is evaluating the new genetic information. In the interim, new information on killer whale mortality levels is provided within this report. A complete revision of the killer whale stock assessments will be postponed until the stock structure evaluation is completed and any new stocks are identified.

STOCK DEFINITION AND GEOGRAPHIC RANGE

Killer whales have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Although reported from tropical and offshore waters, killer whales occur at higher densities in colder and more productive waters of both hemispheres, with the greatest densities found at high latitudes (Mitchell 1975, Leatherwood and Dahlheim 1978, Forney and Wade, 2006). Killer whales are found throughout the North Pacific. Along the west coast of North America, killer whales occur along the entire Alaska coast (Braham and Dahlheim 1982), in British Columbia and Washington inland waterways (Bigg et al. 1990), and along the outer coasts of Washington, Oregon, and California (Green et al. 1992; Barlow 1995, 1997; Forney et al. 1995). Seasonal and year-round occurrence has been noted for killer whales throughout Alaska (Braham and Dahlheim 1982) and in the intracoastal waterways of British Columbia and Washington State, where whales have been labeled as "resident," "transient," and "offshore" type killer whales (Bigg et al. 1990, Ford et al. 2000, Dahlheim et al. 2008) based on aspects of morphology, ecology, genetics, and behavior (Ford and Fisher 1982; Baird and Stacey 1988; Baird et al. 1992; Hoelzel et al. 1998, 2002; Barrett-Lennard 2000; Dahlheim et al. 2008). Through examination of photographs of recognizable individuals and pods, movements of whales between geographical areas have been documented. For example, whales identified in Prince William Sound have been observed near Kodiak Island (Matkin et al. 1999) and whales identified in Southeast Alaska have been observed in Prince William Sound, British Columbia, and Puget Sound (Leatherwood et al. 1990, Dahlheim et al. 1997). Movements of killer whales between the waters of Southeast Alaska and central California have also been documented (Goley and Straley 1994, Black et al. 1997, Dahlheim and White 2010).

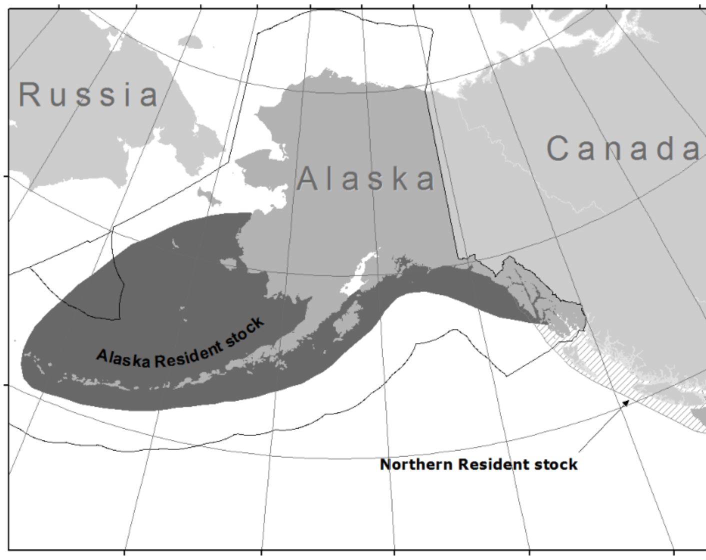

Figure 1. Approximate distribution of resident killer whales in the eastern North Pacific (shaded areas). The distribution of resident and transient killer whale stocks in the eastern North Pacific largely overlap (see text).

Several studies provide evidence that the resident, offshore, and transient ecotypes are genetically distinct in both mtDNA and nuclear DNA (Hoelzel and Dover 1991; Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). A recent global genetic study of killer whales using the entire mitochondrial genome found that some killer whale ecotypes represent deeply divergent evolutionary lineages and warrant elevation to species or subspecies status (Morin et al. 2010). In particular, estimates from mitogenome sequence data indicate that transient killer whales diverged from all other killer whale lineages ~700,000 years ago. In light of these differences, the Society for Marine Mammalogy's Committee on Taxonomy currently recognizes the resident and transient North Pacific ecotypes as un-named *Orcinus orca* subspecies (Committee on Taxonomy 2012). In recognition of its status as an un-named subspecies or species, some researchers now refer to transient-type killer whales as Bigg's killer whales (e.g., Ford 2011, Riesch et al. 2012), in tribute to the late Dr. Michael Bigg.

Genetic differences have also been found between populations within the transient and resident ecotypes (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). Within the resident ecotype, association data were used to describe three separate populations in the North Pacific: Southern Residents, Northern Residents, and Alaska Residents (Bigg et al. 1990; Ford et al. 1994, 2000; Dahlheim et al. 1997; Matkin et al. 1999). In previous stock assessment reports, the Alaska and Northern Resident populations were considered one stock. Acoustic data (Ford 1989, 1991; Yurk et al. 2002) and genetic data (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000) have now confirmed that these three units represent discrete populations. The Southern Resident population is found in summer primarily in waters of Washington state and southern British Columbia and has never been seen to associate with other resident stocks. The Northern Resident population is found in summer primarily in central and northern British Columbia. Members of the Northern Resident population have been documented in southeastern Alaska; however, they have not been seen to intermix with Alaska Residents (Fig. 1). Alaska Resident whales are found from southeastern Alaska to the Aleutian Islands and Bering Sea. Intermixing of Alaska Residents have been documented among the three areas, at least as far west as the eastern Aleutian Islands.

Based on data regarding association patterns, acoustics, movements, and genetic differences, eight killer whale stocks are now recognized within the Pacific U.S. EEZ: 1) the Alaska Resident stock - occurring from southeastern Alaska to the Aleutian Islands and Bering Sea, 2) the Northern Resident stock - occurring from Washington State through part of southeastern Alaska, 3) the Southern Resident stock - occurring mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from southeastern Alaska through California, 4) the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock - occurring mainly from Prince William Sound through the Aleutian Islands and Bering Sea, 5) the AT1 Transient stock - occurring in Alaska from Prince William Sound through the Kenai Fjords, 6) the West Coast transient stock - occurring from California through southeastern Alaska, 7) the Offshore stock - occurring from California through Alaska, and 8) the Hawaiian stock. Transient whales in Canadian waters are considered part of the West Coast Transient stock. The Stock Assessment Reports for the Alaska Region contain information concerning all the killer whale stocks except the Hawaiian and Offshore stocks.

Resident killer whales ranging from Southeastern Alaska to Kodiak Island have been observed in regular association during multipod encounters since 1984 (Matkin et al. 2010). Tagging data also indicates the range of killer whales seen in these aggregations extends from Southeastern Alaska to south of Kodiak Island (Matkin et al. 2010). Although recent studies have documented movements of Alaska Resident killer whales from the Bering Sea into the Gulf of Alaska as far north as southern Kodiak Island, none of these whales have been photographed further north and east in the Gulf of Alaska where regular photoidentification studies have been conducted since 1984 (P. Wade, pers. comm., MML-AFSC, Seattle, WA, 10 December 2012; unpublished data; Matkin et al. 2010). The resident-type killer whales encountered in western Alaska possibly belong to groups that are distinct from the groups of resident killer whales in the Gulf of Alaska because no call syllables or call patterns (sequence of syllables) between groups were found to match (Matkin et al. 2007).

POPULATION SIZE

The Alaska Resident stock includes killer whales from southeastern Alaska to the Aleutian Islands and Bering Sea. Preliminary analysis of photographic data resulted in the following minimum counts for resident killer whales belonging to the Alaska Resident stock (Note: individual whales have been matched between geographical regions and missing animals likely to be dead have been subtracted). In southeastern Alaska, 109 resident whales have been identified as of 2009 (MML and North Gulf Oceanic Society (NGOS), 3430 Main Street, Suite B1, Homer, Alaska; unpublished data). In Prince William Sound and Kenai Fjords, another 675 resident whales have been identified as of 2009 (Matkin et al. 2003; C. Matkin, North Gulf Oceanic Society, pers. comm.).

Beginning in 2001, dedicated killer whale studies were initiated by the NMFS Marine Mammal Laboratory (MML) in Alaska waters west of Kodiak Island, including the Aleutian Islands and Bering Sea. Between 2001 and 2009, using field assessments based on morphology, association data, and genetic analyses, additional resident whales were added to the Alaska Resident stock. Internal matches within the MML data set have been subtracted, resulting in a final count of western Alaska residents for 2001-2012 as 1,475 whales. Studies conducted in western Alaska by the NGOS have resulted in the collection of photographs of approximately 600 resident killer whales; however, the NGOS and MML data sets have not yet been matched so it is unknown how many of these 600 animals are included in the MML collection. Another 41 whales were identified off Kodiak between 2000 and 2003 by the NGOS. These whales are added to the total of western Alaska residents although they have not been matched to MML photographs.

MML conducted killer whale line-transect surveys for 3 years in July and August in 2001-2003. These surveys covered an area from approximately Resurrection Bay in the Kenai Fjords to the central Aleutians. The surveys covered an area from shore to 30-45 nautical miles offshore, with randomly located transects in a zigzag pattern. A total of 9,053 km of tracklines were surveyed between the Kenai Peninsula (~150°W) and Amchitka Pass

(~179ºW). A total of 41 on-effort sightings of killer whales were recorded, with an additional 16 sightings off-effort. Estimated abundance of resident killer whale from these surveys was 991 (CV = 0.52), with a 95% confidence interval of 380-2,585 (Zerbini et al. 2007).

The line transect surveys provide an "instantaneous" (across ~40 days) estimate of the number of resident killer whales in the survey area. It should be noted that the photographic catalogue encompasses a larger area, including some data from areas such as Prince William Sound and the Bering Sea that were outside the line-transect survey area. Additionally, the number of whales in the photographic catalogue is a documentation of all whales seen in the area over the time period of the catalogue; movements of some individual whales have been documented between the line-transect survey area and locations outside the survey area. Accordingly, a larger number of resident killer whales may use the line-transect survey area at some point over the 3 years than would necessarily be found at one time in the survey area in July and August in a particular year.

Combining the counts of known resident whales gives a minimum number of 2,347 (Southeast Alaska + Prince William Sound + Western Alaska; 121 + 751 + 1,475) killer whales belonging to the Alaska Resident stock (Table 1).

Table 1. Numbers of animals in each pod of killer whales belonging to the Alaska Resident stock of killer whales. A number followed by a "+" indicates a minimum count for that pod.

Pod ID	1999/2000 estimate (and source)	2001/2004 estimate (and source)	2005-2012 estimate (and source)
Southeast Alaska			33 (Matkin et al. in prep.)
AF22			
AF5	49 (Dahlheim et al. 1997, Matkin et al. 1999)	61 (C. Matkin, NGOS, pers. comm.)	46 (Matkin et al. in prep.)
AG	27 (Dahlheim et al. 1997, Matkin et al. 1999)	33 (C. Matkin, NGOS, pers. comm.)	42 (Matkin et al. in prep.)
AZ	23+ (Dahlheim, AFSC-MML, pers. comm.)	23+ (Dahlheim et al. 1997)	Not seen since prior to 1997
Total, Southeast Alaska	**99+**	**117+**	**121 (excluding AZ)**
Prince William Sound	**Matkin et al. 1999**	**Matkin et al. 2003 and C. Matkin, NGOS, pers. comm.**	**Matkin et al. in prep.**
AA1	---	8	8
AA30	---	---	24
AB	25	19	20
AB25	---	10	19
AD05	---	16	22
AD16	7	4	9
AE	16	19	17
AH01		9	9
AH20		12	12
AI	7	7	8
AJ	38	42	57
AK	12	13	19
AL	---	---	23
AN10	20	27	36
AN20	assume 9	33	30
AS2	assume 20	21	31
AS30		14	19
AW		24	27
AX01	21	20	33
AX27		24	26
AX32		15	18
AX40		14	16
AX48		20	23
AY	assume 11	18	21
Unassigned to pods	138 (C. Matkin, NGOS, pers. comm.)	112	220

Pod ID	1999/2000 estimate (and source)	2001/2004 estimate (and source)	2005-2012 estimate (and source)
Total, Prince William Sound/ Kenai Fjord/ Kodiak	**341**	**501**	**751**
Western Alaska	**Dahlheim et al. 1997 and MML unpublished data[2]**	**2001/2003 MML unpublished data[2]**	**2001-2012 MML/NGOS unpublished catalog[2]**
Unassigned to pods (MML)	68+	464	1,475 (H. Fearnbach, NOAA-SWFSC, pers. comm., April 2013)
Total, Western Alaska	**68+**	**505**	**1,475**
Total, all areas	**507**	**1,123**	**2,347[1]**

[1]Although there is strong evidence (Matkin et al. 2003, 2010) the resident killer whale numbers have been increasing in the Gulf of Alaska, the bulk of the increase from the 2001-2004 counts to the 2005-2009 counts is believed to be due to the discovery of new animals, not recruitment. Animals reported here have been photographed in the 2001-2012 period. [2]Available from M. Dahlheim, Marine Mammal Laboratory, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115.

Minimum Population Estimate

The survey technique utilized for obtaining the abundance estimate of killer whales is a direct count of individually identifiable animals. Thus the minimum population estimate (N_{MIN}) for the Alaska Resident stock of killer whales based on photo-identification studies conducted between 2005-2009 is 2,084 animals (Table 1). Other estimates of the overall population size (i.e., N_{BEST}) and associated CV(N) are not currently available. Given that researchers continue to identify new whales, the estimate of abundance based on the number of uniquely identified individuals known to be alive is likely conservative. However, the rate of discovering new resident whales within southeastern Alaska and Prince William Sound is relatively low (MML, unpublished data). Conversely, the rate of discovery of new whales in western Alaska was initially high (i.e., 2001 and 2002 field seasons). However, recent photographic data collected during 2003 and 2004 indicates that the rate of discovering new individual whales has decreased.

Using the line-transect estimate of 991 (CV = 0.52) results in an estimate of N_{MIN} (20th percentile) of 656. This is lower than the minimum number of individuals identified from photographs in recent years, so the photographic catalogue number is used for PBR calculations.

Some overlap of Northern Resident whales occur with the Alaska Resident stock in southeastern Alaska. However, information on the percentage of time that the Northern Resident stock spends in Alaska waters is unknown. However, as noted above, this minimum population estimate is considered conservative. This approach is consistent with the recommendations of the Alaska Scientific Review Group (DeMaster 1996).

Current Population Trend

Data from Matkin et al. (2003) indicate that the component of the Alaska Resident stock that summers in the Prince William Sound and Kenai Fjords area is increasing. With the exception of AB pod, which declined drastically after the *Exxon Valdez* oil spill and has not yet recovered, the component of the Alaska Resident stock in the Prince William Sound and Kenai Fjords area increased 3.2% (95% CI = 1.94 to 4.36%) per year from 1990 to 2005 (Matkin et al. 2008). Although the current minimum population count of 2,084 is higher than the last population count of 1,123, examination of only count data does not provide a direct indication of the net recruitment into the population. At present, reliable data on trends in population abundance for the entire Alaska Resident stock of killer whales are unavailable.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for this stock of killer whales. Studies of resident killer whale pods in the Pacific Northwest resulted in estimated population growth rates of 2.92% and 2.54% over the period from 1973 to 1987 (Olesiuk et al. 1990, Brault and Caswell 1993), and 3.3% over the period 1984-2002 (Matkin et al. 2003). Until additional stock-specific data become available, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for cetacean stocks with unknown population status (Wade and Angliss 1997). Thus, for the Eastern North Pacific Alaska Resident killer whale stock, PBR = 24 animals (2,347 × 0.02 × 0.5).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information on U.S. commercial fisheries in Alaska waters (including observer programs, observer coverage, and observed incidental takes of marine mammals) is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

Three of the federally-regulated U.S. commercial fisheries, monitored for incidental mortality and serious injury of marine mammals by fishery observers, incurred mortality and serious injury of killer whales (unknown stock) between 2010 and 2014: the Bering Sea/Aleutian Islands flatfish trawl, Bering Sea/Aleutian Islands rockfish trawl, and Bering Sea/Aleutian Islands Pacific cod longline fisheries (Table 1; Breiwick 2013; MML, unpubl. data).

Fishery observers have collected tissue samples from many of the killer whales that were killed incidental to U.S. commercial fisheries. Genetic analyses of samples from seven killer whales collected between 1999 and 2004 have confirmed that Alaska Resident killer whale mortality occurred incidental to the Bering Sea/Aleutian Islands flatfish trawl (n = 3) and Bering Sea/Aleutian Islands Pacific cod longline fisheries (n = 1) and that Gulf of Alaska, Aleutian Islands, and Bering Sea Transient killer whale mortality occurred incidental to the Bering Sea/Aleutian Islands pollock trawl fishery (n = 3) (M. Dahlheim, NMFS-AFSC-MML, pers. comm., 20 February 2013). Given the overlap in the range of transient and resident stocks in Alaska waters, unless genetic samples can be collected from animals injured or killed by gear or the ship's propeller, these events are assigned to both the transient and resident stock occurring in that area. Thus, the estimated mean annual mortality and serious injury rate of one killer whale in 2010-2014 will be assigned to both the Alaska Resident and Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stocks of killer whales (Table 2; Breiwick 2013; MML, unpubl. data).

Typically, if mortality or serious injury occurs incidental to U.S. commercial fishing, it is due to interactions with the fishing gear. However, reports indicate that observed killer whale mortality incidental to the Bering Sea/Aleutian Islands trawl fisheries often occurs due to contact with the ship's propeller (e.g., the 2010 mortality in the Bering Sea/Aleutian Islands rockfish trawl fishery).

Table 2. Summary of incidental mortality and serious injury of Alaska Resident killer whales due to U.S. commercial fisheries in 2010-2014 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports. N/A indicates that data are not available.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Is. flatfish trawl	2010 2011 2012 2013 2014	obs data	99 100 99 99 99	0 0 0 (+1)[a] 2 0	0 0 0 (+1)[b] 2 0	0.4 (+0.2)[c] (CV = 0)
Bering Sea/Aleutian Is. rockfish trawl	2010 2011 2012 2013 2014	obs data	99 99 100 99 99	1 0 0 0 0	1 0 0 0 0	0.2 (CV = 0)

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Is. Pacific cod longline	2010 2011 2012 2013 2014	obs data	64 57 51 66 64	0 0 0 (+1)[d] 0 0	0 0 0 (+1)[e] 0 0	0 (+0.2)[f] (CV = N/A)
Minimum total estimated annual mortality						1 (CV = 0)

[a]Total mortality and serious injury observed in 2012: 0 whales in sampled hauls + 1 whale in an unsampled haul.
[b]Total estimate of mortality and serious injury in 2012: 0 whales (extrapolated estimate from 0 whales observed in sampled hauls) + 1 whale (1 whale observed in an unsampled haul).
[c]Mean annual mortality and serious injury for fishery: 0.4 whales (mean of extrapolated estimates from sampled hauls) + 0.2 whales (mean of number observed in unsampled hauls).
[d]Total mortality and serious injury observed in 2012: 0 whales in sampled hauls + 1 whale in an unsampled haul.
[e]Total estimate of mortality and serious injury in 2012: 0 whales (extrapolated estimate from 0 whales observed in sampled hauls) + 1 whale (1 whale observed in an unsampled haul).
[f]Mean annual mortality and serious injury for fishery: 0 whales (mean of extrapolated estimates from sampled hauls) + 0.2 whales (mean of number observed in unsampled hauls).

A minimum estimate of the mean annual mortality and serious injury rate incidental to U.S. commercial fisheries in 2010-2014 is one Alaska Resident killer whale, based on observer data (Table 2).

Subsistence/Native Harvest Information

There are no reports of a subsistence harvest of killer whales in Alaska.

Other Mortality

During the 1992 killer whale surveys conducted in the Bering Sea and western Gulf of Alaska, 9 of 182 (4.9%) individual whales in 7 of the 12 (58%) pods encountered had evidence of bullet wounds (Dahlheim and Waite 1993). The relationship between wounding due to shooting and survival is unknown. In Prince William Sound, the pod responsible for most of the fishery interactions experienced a high level of mortality: between 1986 and 1991, 22 whales out of a pod of 37 (59%) disappeared (Matkin et al. 1994). The cause of death for these whales is unknown, but it may be related to gunshot wounds or effects of the *Exxon Valdez* oil spill (Dahlheim and Matkin 1994). It is unknown who was responsible for shooting at killer whales.

There have been no obvious bullet wounds observed on killer whales during surveys in the Bering Sea and western Gulf of Alaska (J. Durban, NMFS-SWFSC, pers. comm.). However, researchers have reported that killer whale pods in certain areas exhibit vessel avoidance behavior, which may indicate that shootings occur in some places.

Other Issues

Killer whales are known to depredate longline catches in the Bering Sea (Dahlheim 1988; Yano and Dahlheim 1995; Perez 2003, 2006; Sigler et al. 2003) and in the Gulf of Alaska (Sigler et al. 2003, Perez 2006). In addition, there have been many reports of killer whales consuming the processing waste of Bering Sea groundfish trawl fishing vessels (Perez 2006). Resident killer whales are most likely to be involved in such fishery interactions since these whales are known to be fish eaters.

Fisheries observers report that large groups of killer whales in the Bering Sea follow vessels for days at a time, actively consuming the processing waste (NMFS-AFSC, Fishery Observer Program, unpubl. data). On some vessels, the waste is discharged in the vicinity of the vessel's propeller (NMFS, unpubl. data); consumption of the processing waste in the vicinity of the propeller may be the cause of the propeller-caused mortalities of killer whales in the trawl fisheries.

STATUS OF STOCK

The Eastern North Pacific Alaska Resident stock of killer whales is not designated as depleted under the MMPA or listed as threatened or endangered under the Endangered Species Act. The minimum abundance estimate for the Alaska Resident stock is likely underestimated because researchers continue to encounter new whales in the

Gulf of Alaska and western Alaska waters. Because the population estimate is likely to be conservative, the PBR is also conservative.

Based on currently available data, a minimum estimate of the mean annual mortality and serious injury rate due to U.S. commercial fisheries (1 whale) is less than 10% of the PBR (10% of PBR = 2.4) and, therefore, is considered to be insignificant and approaching zero mortality and serious injury rate. A minimum estimate of the total annual level of human-caused mortality and serious injury (1 whale) is not known to exceed the PBR (24). Therefore, the Eastern North Pacific Alaska Resident stock of killer whales is not classified as a strategic stock. Population trends and status of this stock relative to its Optimum Sustainable Population are currently unknown.

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KILLER WHALE (*Orcinus orca*): Eastern North Pacific Northern Resident Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Killer whales have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Although reported from tropical and offshore waters, killer whales occur at higher densities in colder and more productive waters of both hemispheres, with the greatest densities found at high latitudes (Mitchell 1975, Leatherwood and Dahlheim 1978, Forney and Wade, 2006). Killer whales are found throughout the North Pacific. Along the west coast of North America, killer whales occur along the entire Alaskan coast (Braham and Dahlheim 1982), in British Columbia and Washington inland waterways (Bigg et al. 1990), and along the outer coasts of Washington, Oregon, and California (Green et al. 1992; Barlow 1995, 1997; Forney et al. 1995). Seasonal and year-round occurrence has been noted for killer whales throughout Alaska (Braham and Dahlheim 1982) and in the intracoastal waterways of British Columbia and Washington State, where whales have been labeled as 'resident,' 'transient,' and 'offshore' type killer whales (Bigg et al. 1990, Ford et al. 2000; Dahlheim et al. 2008) based on aspects of morphology, ecology, genetics, and behavior (Ford and Fisher 1982; Baird and Stacey 1988; Baird et al. 1992; Hoelzel et al. 1998, 2002; Barrett-Lennard 2000; Dahlheim et al. 2008). Through examination of photographs of recognizable individuals and pods, movements of whales between geographical areas have been documented. For example, resident type whales identified in Prince William Sound have been observed in southeastern Alaska and lower Cook Inlet. (Matkin et al. 2010) Movements of transient type killer whales between the waters of Southeast Alaska and central California have also been documented (Goley and Straley 1994; Black et al. 1997; Dahlheim and White 2010).

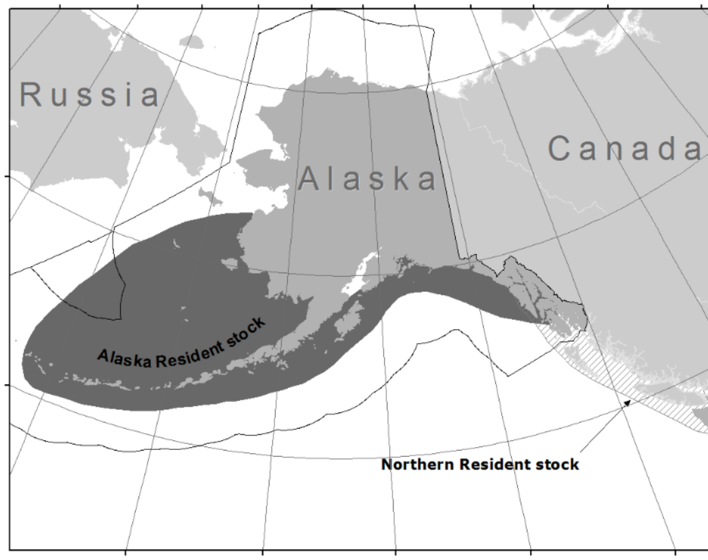

Figure 1. Approximate distribution of killer whales in the eastern North Pacific (shaded area). The distribution of the eastern North Pacific Resident and Transient stocks are largely overlapping (see text).

Several studies provide evidence that the 'resident', 'offshore', and 'transient' ecotypes are genetically distinct in both mtDNA and nuclear DNA (Hoelzel and Dover 1991; Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). A recent global genetic study of killer whales using the entire mitochondrial genome found that some killer whale ecotypes represent deeply divergent evolutionary lineages and warrant elevation to species or subspecies status (Morin et al. 2010). In particular, estimates from mitogenome sequence data indicate that transient killer whales diverged from all other killer whale lineages ~700,000 years ago. In light of these differences, the Society for Marine Mammalogy's Committee on Taxonomy currently recognizes the resident and transient North Pacific ecotypes as un-named *Orcinus orca* subspecies (Committee on Taxonomy 2012). In recognition of its status as an un-named subspecies or species, some researchers now refer to transient-type killer whales as Bigg's killer whales (e.g., Ford 2011; Riesch et al. 2012), in tribute to the late Dr. Michael Bigg.

Genetic differences have also been found between populations within the 'transient' and 'resident' ecotypes (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). Within the resident ecotype, association data were initially used to describe three separate communities in the North Pacific (Bigg et al. 1990; Ford et al. 1994, 2000; Matkin et al. 1999). The Southern Resident population is found in summer primarily in waters of Washington state and southern British Columbia. The Northern Resident population is found in summer primarily in central and northern British Columbia. Alaska resident whales are found in marine waters of southern and southwestern Alaska. Acoustic data (Ford 1989, 1991; Yurk et al. 2002) and genetic data (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000) have confirmed that these three units represent discrete populations.

Based on data regarding association patterns, acoustics, movements, and genetic differences, eight killer whale stocks are now recognized within the Pacific U.S. EEZ: 1) the Alaska Resident stock - occurring from southeastern Alaska to the Aleutian Islands and Bering Sea, 2) the Northern Resident stock - occurring from Washington State through part of southeastern Alaska, 3) the Southern Resident stock - occurring mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from southeastern Alaska through California, 4) the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock - occurring mainly from Prince William Sound through the Aleutian Islands and Bering Sea, 5) the AT1 transient stock - occurring in Alaska from Prince William Sound through the Kenai Fjords, 6) the West Coast transient stock - occurring from California through southeastern Alaska, 7) the Offshore stock - occurring from California through Alaska, and 8) the Hawaiian stock. 'Transient' whales in Canadian waters are considered part of the West Coast Transient stock. The Stock Assessment Reports for the Alaska Region contain information concerning all the killer whale stocks except the Hawaiian and Offshore stocks.

The Eastern North Pacific Northern Resident stock is a transboundary stock, and includes killer whales that frequent British Columbia, Canada and southeastern Alaska (Dahlheim et al. 1997; Ford et al. 2000). They have been seen infrequently in Washington state waters.

POPULATION SIZE

Photo-identification studies since 1970 (Ford et al. 2000) have catalogued every individual belonging to the Eastern North Pacific Northern Resident stock (note that individual whales that have been matched between geographical regions and missing animals likely to be dead have been subtracted). In 1998, the photo catalog included 216 whales (Ford et al. 2000). The photo-identification catalogue was updated in 2011 summarizing individual identifications made between 1974 and 2010. At the conclusion of the 2010 field season, the population was composed of three clans representing a total of 261 whales (plus four missing and possibly dead). The population is twice the size it was in 1974, representing an average annual increase of 2.1% (Ellis et al. 2011).

Table 1. Numbers of animals in each pod of killer whales belonging to the Eastern North Pacific Northern Resident stock of killer whales.

British Columbia	Ford et al. 1994	Ford et al. 2000	Ellis et al. 2011
A1	15	16	22
A4	11	11	16
A5	12	13	13
B1	9	7	6*
C1	13	14	17*
D1	7	12	12
H1	8	9	5
I1	10	8	18*
I2	7	2	3
I18	19	16	24
G1	28	29	34*
G12	11	13	16
I11	18	22	26
I31	10	12	10
R1	23	29	38
W1	3	3	1
Total	**204**	**216**	**261**

Note: * indicates that one whale may be missing/ dead

Minimum Population Estimate

The technique used for estimating abundance of killer whales is a direct count of individually identifiable animals. Other estimates of the overall population size (i.e., N_{BEST}) and associated CV(N) are not currently available. Because this population has been studied for such a long time, each individual is well documented, and except for births, no new individuals are expected to be discovered. Therefore, the estimated population size of 261 animals can also serve as a minimum count of the population.

Thus, the minimum population estimate (N_{MIN}) for the Northern Resident stock of killer whales is 261 animals, which includes animals found in Canadian waters (see PBR Guidelines (Wade and Angliss 1997) regarding the status of migratory transboundary stocks). This approach is consistent with the recommendations of the Alaska Scientific Review Group (DeMaster 1996). Information on the percentage of time animals typically encountered in Canadian waters spend in U. S. waters is unknown.

Current Population Trend

From the mid 1970s to the mid 1990s, the northern resident killer whale population grew steadily at an annual rate of 2.6% (i.e., from 122 whales in 1974 to 218 in 1997). A decline was reported during the 1998 -2001 period at a rate of 7%. That period coincided with a significant reduction in Chinook salmon (Ford et al. 2010). Then after 2001, the growth was positive with the population increasing at an average rate of 3.1% per year (2001 – 2010). At the end of the 2010 field season, 261 whales were catalogued. This represents an average annual increase of 2.1% over the 36-year time series (Ellis et al. 2011).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Studies of northern 'resident' killer whale pods in British Columbia and Washington waters resulted in estimated population growth rates of 2.92% and 2.54% over the period from 1973 to 1987 (Olesiuk et al. 1990, Brault and Caswell 1993). Analyses of photographic data collected from 1974 through 2010 indicated a population growth from 122 individuals to 261 whales. This represents an average annual increase of 2.1% over the 36-year period (Ellis et al. 2011). The period from 2001 to 2010 was a period of maximum growth for this population when it grew at an average rate of 3.1% per year. Therefore, the maximum net productivity rate (R_{MAX}) is estimated to be 3.1% (Ellis et al. 2011, Olesiuk et al. 2005).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for cetacean stocks with unknown population status (Wade and Angliss 1997). Thus, for the Eastern North Pacific Northern Resident killer whale stock, PBR = 1.96 animals ($261 \times 0.015 \times 0.5$).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*." Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fisheries Information

All Canadian trawl and longline fisheries are monitored by observers or video; salmon net fisheries are not observed (J. Ford, pers. comm., Department of Fisheries and Oceans, British Columbia, Canada, 30 January 2013). The interaction of resident killer whales with the sablefish longline fishery accounts for a large proportion of the commercial fishing/killer whale interactions in Alaska waters. Such interactions have not been reported in Canadian waters where sablefish are taken via a pot fishery. Interactions have been reported between northern resident killer whales in the British Columbia halibut longline and salmon troll fisheries (J. Ford, pers. comm., Department of Fisheries and Oceans, British Columbia, Canada, 30 January 2013). Since 1990, there have been no reported fishery-related strandings or bycatch of killer whales in Canadian waters. However, in 1994, one killer whale was reported to have contacted a salmon gillnet but did not entangle (Guenther et al. 1995).

Subsistence/Native Harvest Information

Killer whales are not harvested for subsistence in Alaska or Canada.

Other Mortality

Collisions of killer whales with vessels occur occasionally. One mortality of a northern resident killer whale (C21) in Prince Rupert, BC was reported in 2006 (Williams and O'Hara 2010). The shooting of killer whales in Canadian waters has been a concern in the past. However, in recent years the Canadian portion of the stock has been researched so extensively that evidence of bullet wounds would have been noticed if shooting was prevalent (G. Ellis, Pacific Biological Station, Canada, pers. comm.).

Other Issues

In U.S. waters, there is considerable interaction between killer whales and fisheries aside from incidental take. Interactions between killer whales and longline vessels, specifically predation by killer whales on sablefish catch, have been well documented (Dahlheim 1988, Yano and Dahlheim 1995, Sigler et al. 2002). In Canada, northern resident killer whales have been reported to depredate fish from both commercial salmon trollers and recreational sportfishers, as well as halibut longliners. Most reports occur in the northern half of the coast, especially Dixon Entrance, and early in the season (April to June), although some are scattered throughout the summer (J. Ford, pers. comm., Department of Fisheries and Oceans, British Columbia, Canada, 3 December 2012).

STATUS OF STOCK

The Northern Resident killer whale stock is not designated as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act. In 2001, the Committee on the Status of Endangered Wildlife in Canada designated northern resident killer whales in British Columbia as "threatened" and listed in Schedule 1 of the Species at Risk Act (SARA) for Canada. Resident killer whales in British Columbia are considered to be at risk based on their small population size, low reproductive rate, and the existence of a variety of anthropogenic threats that have the potential to prevent recovery or to cause further declines (DFO, 2008). Monitoring of fisheries in BC over the past decade has been quite extensive and likely at the same level as in U.S. waters. No incidental killer whale mortalities from fishery interactions have been reported or observed (J. Ford, pers. comm., Department of Fisheries and Oceans, British Columbia, Canada, 30 January 2013).

Based on currently available data, the estimated annual U. S. commercial fishery-related mortality level is zero, which does not exceed 10% of the PBR (0.20) and therefore is considered to be insignificant and approaching zero mortality and serious injury rate. The estimated annual level of human-caused mortality and serious injury (0) is not known to exceed the PBR (2.0). Therefore, the eastern North Pacific Northern Resident stock of killer whales is not classified as a strategic stock. Population trends and status of this stock relative to its Optimum Sustainable Population size are currently unknown.

HABITAT CONCERNS

Ford et al. (2005) showed that a sharp drop in coast-wide Chinook salmon abundance during the late 1990s was correlated with a significant decline in resident whale survival. They noted that the whales' preference for chinook salmon is likely due to this species' relatively large size, high lipid content and, unlike other salmonids, its year-round presence in the whales' range. They further note that resident killer whales may be especially dependent on chinook during winter, when this species is the primary salmonid available in coastal waters, and the whales may be subject to nutritional stress leading to increased mortality if the quantity and/or quality of this prey resource declines.

Vessel traffic, particularly increased whale-watching activity, is another potential concern for this stock.

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Revised 12/30/2016

KILLER WHALE (*Orcinus orca*): Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient Stock

NOTE – NMFS has preliminary genetic information on killer whales in Alaska which indicates that the current stock structure of killer whales in Alaska needs to be reassessed. NMFS is evaluating the new genetic information. In the interim, new information on killer whale mortality levels is provided within this report. A complete revision of the killer whale stock assessments will be postponed until the stock structure evaluation is completed and any new stocks are identified.

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Killer whales have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Although reported from tropical and offshore waters, killer whales occur at higher densities in colder and more productive waters of both hemispheres, with the greatest densities found at high latitudes (Mitchell 1975, Leatherwood and Dahlheim 1978, Forney and Wade 2006). Killer whales are found throughout the North Pacific. Along the west coast of North America, killer whales occur along the entire Alaska coast (Braham and Dahlheim 1982), in British Columbia and Washington inland waterways (Bigg et al. 1990), and along the outer coasts of Washington, Oregon, and California (Green et al. 1992; Barlow 1995, 1997; Forney et al. 1995). Seasonal and year-round occurrence has been noted for killer whales throughout Alaska (Braham and Dahlheim 1982) and in the intracoastal waterways of British Columbia and Washington State, where whales have been labeled as "resident," "transient," and "offshore" type killer whales (Bigg et al. 1990, Ford et al. 2000, Dahlheim et al. 2008) based on aspects of morphology, ecology, genetics, and behavior (Ford and Fisher 1982; Baird and Stacey 1988; Baird et al. 1992; Hoelzel et al. 1998, 2002; Barrett-Lennard 2000; Dahlheim et al. 2008). Through examination of photographs of recognizable individuals, movements of whales between geographical areas have been documented. For example, whales identified in Prince William Sound have been observed near Kodiak Island (Matkin et al. 1999) and whales identified in Southeast Alaska have been observed in Prince William Sound, British Columbia, and Puget Sound (Leatherwood et al. 1990, Dahlheim et al. 1997). Movements of killer whales between the waters of Southeast Alaska and central California have also been documented (Goley and Straley 1994, Black et al. 1997, Dahlheim and White 2010).

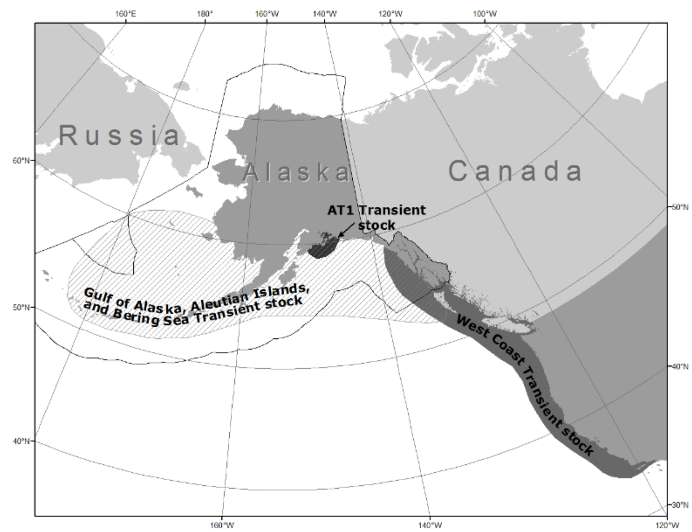

Figure 1. Approximate distribution of transient killer whales in the eastern North Pacific (shaded areas). The distribution of resident and transient killer whale stocks in the eastern North Pacific largely overlap (see text).

Several studies provide evidence that the resident, offshore, and transient ecotypes are genetically distinct in both mtDNA and nuclear DNA (Hoelzel and Dover 1991; Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). Genetic differences have also been found between populations within the transient and resident ecotypes (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). A recent global genetic study of killer whales using the entire mitochondrial genome found that some killer whale ecotypes represent deeply divergent evolutionary lineages and warrant elevation to species or subspecies status (Morin et al. 2010). In particular, estimates from mitogenome sequence data indicate that transient killer whales diverged from all other killer whale lineages ~700,000 years ago. In light of these differences, the Society for Marine Mammalogy's Committee on Taxonomy currently recognizes the resident and transient North Pacific ecotypes as un-named *Orcinus orca* subspecies (Committee on Taxonomy 2012). In recognition of its status as an un-named subspecies or species, some researchers now refer to transient-type killer whales as Bigg's killer whales (e.g., Ford 2011, Riesch et al. 2012), in tribute to the late Dr. Michael Bigg.

Until recently, transient killer whales in Alaska had only been studied intensively in Southeast Alaska and in the Gulf of Alaska (from Prince William Sound, through the Kenai Fjords, and around Kodiak Island). In the Gulf of Alaska, Matkin et al. (1999) described two populations of transients which were never found in association with one another, the so-called "Gulf of Alaska" transients and "AT1" transients. Gulf of Alaska transients are documented throughout the Gulf of Alaska, including occasional sightings in Prince William Sound. AT1 transients are primarily seen in Prince William Sound and in the Kenai Fjords region, and are therefore partially sympatric with Gulf of Alaska transients. Recently, on one occasion, members of the Gulf of Alaska transient population were seen in association with the transient killer whales that range from California to southeastern Alaska, the West Coast Transients, which are identified by a unique mtDNA haplotype (Matkin et al. 2012). Photographs have identified 14 out of 217 whales considered "outer coast" transients in British Columbia that were also photographed in Alaska waters and considered Gulf of Alaska transients (Matkin et al. 2012, Ford et al. 2013). Transients that are within the Gulf of Alaska population have been found to have two mtDNA haplotypes, neither of which is found in the West Coast or AT1 populations. Members of the AT1 population share a single mtDNA haplotype. Transient killer whales from the West Coast stock have been found to share a single mtDNA haplotype that is not found in the other stocks. Additionally, all three populations have been found to have significant differences in nuclear (microsatellite) DNA (Barrett-Lennard 2000). Acoustic differences have been found between these stocks by Saulitis (1993) and Saulitis et al. (2005). For these reasons, the Gulf of Alaska transients are considered part of a population that is discrete from the AT1 population, and both of these communities are considered discrete from the West Coast Transients.

Biopsy samples from the eastern Aleutians and south side of the end of the Alaska Peninsula have produced the same haplotypes as killer whales in the northern Gulf of Alaska; however, nuclear DNA analysis strongly suggest they belong to a separate population (Parsons et al. 2013). Samples from the central Aleutian Islands and Bering Sea have identified mtDNA haplotypes not found in Gulf of Alaska transients, suggesting additional population structure in western Alaska. At this time transient-type killer whales from the Aleutian Islands and Bering Sea are considered to be part of a single population that includes Gulf of Alaska transients. Killer whales are observed in the northern Bering Sea and Beaufort Sea that have the physical characteristics of transient type whales, but little is known about these whales.

In summary, within the transient ecotype, association data (Ford et al. 1994, Ford and Ellis 1999, Matkin et al. 1999), acoustic data (Saulitis 1993, Ford and Ellis 1999) and genetic data (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000) confirm that at least three communities of transient whales exist and represent three discrete populations: 1) Gulf of Alaska, Aleutian Islands, and Bering Sea Transients, 2) AT1 Transients, and 3) West Coast Transients (Fig. 1).

Based on data regarding association patterns, acoustics, movements, and genetic differences, eight killer whale stocks are now recognized within the Pacific U.S. EEZ: 1) the Alaska Resident stock - occurring from southeastern Alaska to the Aleutian Islands and Bering Sea, 2) the Northern Resident stock - occurring from Washington State through part of southeastern Alaska, 3) the Southern Resident stock - occurring mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from southeastern Alaska through California, 4) the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock - occurring mainly from Prince William Sound through the Aleutian Islands and Bering Sea, 5) the AT1 Transient stock - occurring in Alaska from Prince William Sound through the Kenai Fjords, 6) the West Coast Transient stock - occurring from California through southeastern Alaska, 7) the Offshore stock - occurring from California through Alaska, and 8) the Hawaiian stock. Transient whales in Canadian waters are considered part of the West Coast Transient stock. The Stock Assessment Reports for the Alaska Region contain information concerning all the killer whale stocks except the Hawaiian and Offshore stocks.

In recent years, a small number of the Gulf of Alaska transients (identified by genetics and association) have been seen in southeastern Alaska; previously only West Coast Transients had been seen in southeastern Alaska. Therefore, the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock occupies a range that includes all of the U.S. EEZ in Alaska, though few individuals from this population have been seen in southeastern Alaska.

POPULATION SIZE

In January 2004 the North Gulf Oceanic Society (NGOS) and the Marine Mammal Laboratory (MML) held a joint workshop to match identification photographs of transient killer whales from this population. That analysis of photographic data resulted in the following minimum counts for transient killer whales belonging to the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock. In the Gulf of Alaska (east of the Shumagin Islands), 82 whales were identified by NGOS, including whales from Matkin et al. (1999) as well as whales identified in subsequent years (but not including whales identified as part of the AT1 population). MML identified 43 whales and 11 matches were found between the NGOS and MML catalogues. Since that time an additional 22 whales have been added to the NGOS catalogue (Matkin et al. in prep.). Therefore, a total of 136 transients (104 + 43 - 11) have been identified in the Gulf of Alaska. In the Aleutian Islands (west of and including the Shumagin Islands) and Bering Sea, the combined NGOS/MML catalogue (NGOS/MML 2012) now contains 451 individually identifiable whales (not counting unmarked calves and not counting two Gulf of Alaska transient whales that have been photographed in that region). All have been photographed in the past ten years. Combining the Aleutian Islands and Bering Sea count (451) with the Gulf of Alaska count (136), a total count of 587 individual whales have been identified in catalogues of this stock.

MML conducted killer whale line-transect surveys for 3 years in July and August in 2001-2003. These surveys covered an area from approximately Resurrection Bay in the Kenai Fjords to the central Aleutians. The surveys covered an area from shore to 30-45 nautical miles offshore, with randomly located transects in a zigzag pattern. Estimated transient killer whale abundance from these surveys, using post-encounter estimates of group size, was 249 (CV = 0.50), with a 95% confidence interval of 99-628 (Zerbini et al. 2007).

Mark-recapture methods were used to estimate the number of mammal-eating transient killer whales using the coastal waters from the central Gulf of Alaska to the central Aleutian Islands, using photographs collected during the three line-transect surveys (Zerbini et al. 2007), along with photographs collected from a variety of additional surveys during the same time period (Durban et al. 2010). A total of 154 individuals were identified from 6,489 photographs collected between July 2001 and August 2003. A Bayesian mixture model estimated seven distinct clusters (95% Probability Interval = 7-10) of individuals that were differentially covered by 14 boat-based surveys exhibiting varying degrees of association in space and time, leading to a total estimate of 345 whales (95% Probability Interval = 255-487). This estimate is higher than the line-transect estimate for at least two reasons. First, the line-transect estimate provides an "instantaneous" (across ~40 days) estimate of the average number of transient killer whales in the survey area, whereas the mark-recapture methods provide an estimate of the total number of whales to use the survey area over the three years, which is known to be greater due to the long distance movements documented by satellite tags (J. Durban, Southwest Fisheries Science Center, pers. comm.). Second, the mark-recapture estimate included photographic data from a broader seasonal time period, and therefore includes transient killer whales documented in the False Pass/Unimak Island area in spring where they aggregate to prey on gray whales on migration (Matkin et al. 2007). Many of these whales have not been seen in that region in the summer. However, mark recapture estimates do not include most of the Bering Sea and Pribilof Islands.

It should be noted that the photographic catalogue encompasses a larger area, including some data from areas such as the Bering Sea and Pribilof Islands that were outside the line-transect survey area. The photo catalogue also encompasses a much longer time period (through 2012). Additionally, the number of whales in the photographic catalogue is a documentation of all whales seen in the area over the time period of the catalogue; movements of some individual whales have been documented between the line-transect survey area and locations outside the survey area. Accordingly, a larger number of transient killer whales may use the line-transect survey area at some point over the 3 years than would necessarily be found at one time in the survey area in July and August in a particular year.

Minimum Population Estimate

The 20^{th} percentile of the line transect survey estimate is 167. The 20^{th} percentile of the mark-recapture estimates of 345 is ~303. A total count of 587 individual whales have been identified in the photograph catalogues from the Gulf of Alaska (Matkin et al. in prep.) and from western Alaska (NGOS/MML 2012). The photograph catalogue estimate of transient killer whales is a direct count of individually identifiable animals. However, the number of catalogued whales does not necessarily represent the number of live animals. Some animals may have died, but whales cannot be presumed dead if not resighted because long periods of time between sightings are common for some transient animals. The catalogue for the western area used data only from 2001-2012, decreasing the potential bias from using whales that may have died prior to the end of the time period. However, given that researchers continue to identify new whales and the entire range has not been surveyed, the estimate of abundance based on the number of uniquely identified individuals catalogued is likely conservative. The catalogue count is slightly higher than the 20^{th} percentile of the mark-recapture estimates, in part because it included data from areas such as Prince William Sound and the Bering Sea that were outside the survey area.

Thus, the minimum population estimate (N_{MIN}) for the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock of killer whales is 587 animals based on the count of individuals using photo-identification.

Current Population Trend

Recently Matkin et al. (2012) analyzed photographic data collected since 1984 and determined Gulf of Alaska transients in the northern Gulf of Alaska have had stable numbers. At present, reliable data on trends in population abundance for the Aleutian Islands and Bering Sea portion of this stock of killer whales are unavailable.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for this stock of killer whales. Studies of resident killer whale pods in the Pacific Northwest resulted in estimated population growth rates of 2.92% and 2.54% over the period from 1973 to 1987 (Olesiuk et al. 1990, Brault and Caswell 1993). Until stock-specific data become available, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{Max} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for cetacean stocks with unknown population status with a mortality rate CV ≥ 0.80 (Wade and Angliss 1997). Thus, for the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient killer whale stock, PBR = 5.87 animals (587 × 0.02 × 0.5). Although only a few individuals have been observed in Canadian waters, the proportion of time that this trans-boundary stock spends in Canadian waters cannot be determined (G. Ellis, Pacific Biological Station, Canada, pers. comm.).

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information on U.S. commercial fisheries in Alaska waters (including observer programs, observer coverage, and observed incidental takes of marine mammals) is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

Three of the federally-regulated U.S. commercial fisheries, monitored for incidental mortality and serious injury of marine mammals by fishery observers, incurred serious injury and mortality of killer whales (unknown stock) in 2010-2014: the Bering Sea/Aleutian Islands flatfish trawl, Bering Sea/Aleutian Islands rockfish trawl, and Bering Sea/Aleutian Islands Pacific cod longline fisheries (Table 1; Breiwick 2013; MML, unpubl. data).

Fishery observers have collected tissue samples from many of the killer whales that were killed incidental to U.S. commercial fisheries. Genetic analyses of samples from seven killer whales collected between 1999 and 2004 have confirmed that Alaska Resident killer whale mortality occurred incidental to the Bering Sea/Aleutian Islands flatfish trawl (n = 3) and Bering Sea/Aleutian Islands Pacific cod longline fisheries (n = 1) and that Gulf of Alaska, Aleutian Islands, and Bering Sea Transient killer whale mortality occurred incidental to the Bering Sea/Aleutian Islands pollock trawl fishery (n = 3) (M. Dahlheim, NMFS-AFSC-MML, pers. comm., 20 February 2013). Given the overlap in the range of transient and resident stocks in Alaska waters, unless genetic samples can be collected from animals injured or killed by gear or the ship's propeller, these events are assigned to both the transient and resident stock occurring in that area. Thus, the estimated mean annual mortality and serious injury rate of one killer whale in 2010-2014 will be assigned to both the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient and the Alaska Resident stocks of killer whales (Table 1).

Typically, if mortality or serious injury occurs incidental to U.S. commercial fishing, it is due to interactions with the fishing gear. However, reports indicate that observed killer whale mortality incidental to Bering Sea/Aleutian Islands trawl fisheries often occurs due to contact with the ship's propeller (e.g., the 2010 mortality in the Bering Sea/Aleutian Islands rockfish trawl fishery).

Table 1. Summary of incidental mortality and serious injury of Gulf of Alaska, Aleutian Islands, and Bering Sea Transient killer whales due to U.S. commercial fisheries in 2010-2014 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports. N/A indicates that data are not available.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Is. flatfish trawl	2010 2011 2012 2013 2014	obs data	99 100 99 99 99	0 0 0 (+1)[a] 2 0	0 0 0 (+1)[b] 2 0	0.4 (+0.2)[c] (CV = 0)
Bering Sea/Aleutian Is. rockfish trawl	2010 2011 2012 2013 2014	obs data	99 99 100 99 99	1 0 0 0 0	1 0 0 0 0	0.2 (CV = 0)
Bering Sea/Aleutian Is. Pacific cod longline	2010 2011 2012 2013 2014	obs data	64 57 51 66 64	0 0 0 (+1)[d] 0 0	0 0 0 (+1)[e] 0 0	0 (+0.2)[f] (CV = N/A)
Minimum total estimated annual mortality						1 (CV = 0)

[a]Total mortality and serious injury observed in 2012: 0 whales in sampled hauls + 1 whale in an unsampled haul.
[b]Total estimate of mortality and serious injury in 2012: 0 whales (extrapolated estimate from 0 whales observed in sampled hauls) + 1 whale (1 whale observed in an unsampled haul).
[c]Mean annual mortality and serious injury for fishery: 0.4 whales (mean of extrapolated estimates from sampled hauls) + 0.2 whales (mean of number observed in unsampled hauls).
[d]Total mortality and serious injury observed in 2012: 0 whales in sampled hauls + 1 whale in an unsampled haul.
[e]Total estimate of mortality and serious injury in 2012: 0 whales (extrapolated estimate from 0 whales observed in sampled hauls) + 1 whale (1 whale observed in an unsampled haul).
[f]Mean annual mortality and serious injury for fishery: 0 whales (mean of extrapolated estimates from sampled hauls) + 0.2 whales (mean of number observed in unsampled hauls).

A minimum estimate of the mean annual mortality and serious injury rate incidental to U.S. commercial fisheries in 2010-2014 is one Gulf of Alaska, Aleutian Islands, and Bering Sea Transient killer whale, based on observer data (Table 1).

Subsistence/Native Harvest Information

There are no reports of a subsistence harvest of killer whales in Alaska or Canada.

Other Mortality

Collisions with boats may be an occasional source of mortality or serious injury of killer whales. For example, a killer whale struck the propeller of a vessel in the Bering Sea/Aleutian Islands rockfish trawl fishery in 2010 (Table 1).

Other Issues

Killer whales are known to depredate longline catches in the Bering Sea (Dahlheim 1988; Yano and Dahlheim 1995; Perez 2003, 2006; Sigler et al. 2003) and in the Gulf of Alaska (Sigler et al. 2003, Perez 2006). In addition, there have been many reports of killer whales consuming the processing waste of Bering Sea groundfish trawl fishing vessels (Perez 2006). However, resident killer whales are most likely to be involved in such fishery interactions since these whales are known to be fish eaters.

STATUS OF STOCK

The Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock of killer whales is not designated as depleted under the MMPA or listed as threatened or endangered under the Endangered Species Act. Based on currently available data, a minimum estimate of the mean annual mortality and serious injury rate due to U.S. commercial fisheries (1 whale) is greater than 10% of the PBR (10% of PBR = 0.6) and, therefore, cannot be considered to be insignificant and approaching zero mortality and serious injury rate. A minimum estimate of the total annual level of human-caused mortality and serious injury (1 whale) is less than the PBR (5.9). Therefore, the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock of killer whales is not classified as a strategic stock. Population trends and status of this stock relative to its Optimum Sustainable Population are currently unknown.

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KILLER WHALE (*Orcinus orca*): AT1 Transient Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Killer whales have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Although reported from tropical and offshore waters, killer whales occur at higher densities in colder and more productive waters of both hemispheres, with the greatest densities found at high latitudes (Mitchell 1975, Leatherwood and Dahlheim 1978, Forney and Wade 2006). Killer whales are found throughout the North Pacific. Along the west coast of North America, seasonal and year-round occurrence of killer whales has been noted along the entire Alaska coast (Braham and Dahlheim 1982), in British Columbia and Washington inland waterways (Bigg et al. 1990), and along the outer coasts of Washington, Oregon, and California (Green et al. 1992; Barlow 1995, 1997; Forney et al. 1995). Killer whales from these areas have been labeled as "resident," "transient," and "offshore" type killer whales (Bigg et al. 1990, Ford et al. 2000, Dahlheim et al. 2008) based on aspects of morphology, ecology, genetics, and behavior (Ford and Fisher 1982; Baird and Stacey 1988; Baird et al. 1992; Hoelzel et al. 1998, 2002; Barrett-Lennard 2000; Dahlheim et al. 2008). Through examination of photographs of recognizable individuals and pods, movements of whales between geographical areas have been documented. For example, whales identified in Prince William Sound have been observed near Kodiak Island (Matkin et al. 1999) and whales identified in Southeast Alaska have been observed in Prince William Sound, British Columbia, and Puget Sound (Leatherwood et al. 1990, Dahlheim et al. 1997). Movements of killer whales between the waters of Southeast Alaska and central California have also been documented (Goley and Straley 1994, Black et al. 1997, Dahlheim and White 2010).

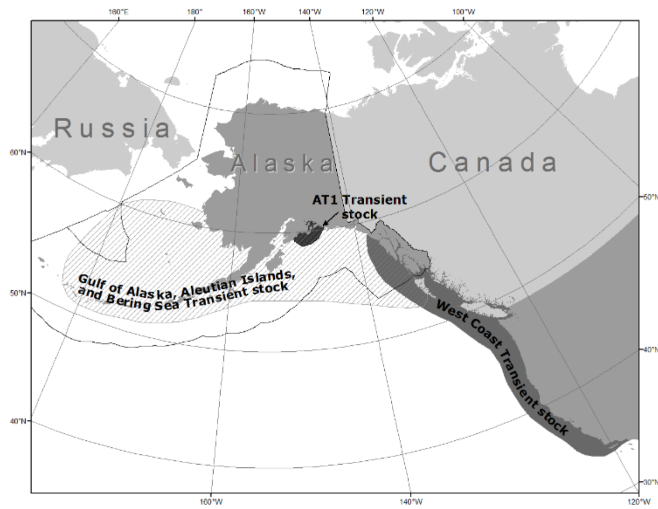

Figure 1. Approximate distribution of transient killer whales in the eastern North Pacific (shaded areas). The distribution of resident and transient killer whale stocks in the eastern North Pacific largely overlap (see text).

Several studies provide evidence that the resident, offshore, and transient ecotypes are genetically distinct in both mtDNA and nuclear DNA (Hoelzel and Dover 1991; Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). Genetic differences have also been found between populations within the transient and resident ecotypes (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). A recent global genetic study of killer whales using the entire mitochondrial genome found that some killer whale ecotypes represent deeply divergent evolutionary lineages and warrant elevation to species or subspecies status (Morin et al. 2010). In particular, estimates from mitogenome sequence data indicate that transient killer whales diverged from all other killer whale lineages ~700,000 years ago. In light of these differences, the Society for Marine Mammalogy's Committee on Taxonomy currently recognizes the resident and transient North Pacific ecotypes as un-named *Orcinus orca* subspecies (Committee on Taxonomy 2016). In recognition of its status as an un-named subspecies or species, some researchers now refer to transient-type killer whales as Bigg's killer whales (e.g., Ford 2011, Riesch et al. 2012), in tribute to the late Dr. Michael Bigg.

The first studies of transient killer whales in Alaska were conducted in Southeast Alaska and in the Gulf of Alaska (from Prince William Sound, through the Kenai Fjords, and around Kodiak Island). In the Gulf of Alaska, Matkin et al. (1999) described two genetically distinct populations of transients which were never found in association with one another, the so-called "Gulf of Alaska" transients and "AT1" transients. In the past, neither of these populations were known to associate with the population of transient killer whales that ranged from California to Southeast Alaska, which are described as the West Coast Transient stock. Gulf of Alaska transients are documented throughout the Gulf of Alaska, including occasional sightings in Prince William Sound. AT1 transients have been seen only in Prince William Sound and in the Kenai Fjords region, and are therefore partially sympatric with Gulf of Alaska transients. In addition, recent data have identified 14 out of 217 transients on the outer coast of Southeast Alaska and British Columbia as Gulf of Alaska transients and in one encounter they were observed mixing with West Coast Transients (Matkin et al. 2012, Ford et al. 2013). Transients within the Gulf of Alaska population have been found to have two mtDNA haplotypes, neither of which is found in the West Coast or AT1 populations. Members of the AT1 population share a single mtDNA haplotype. Transient killer whales from the West Coast population have been found to share a single mtDNA haplotype that is not found in the other populations. Additionally, all three populations have been found to have significant differences in nuclear (microsatellite) DNA (Barrett-Lennard 2000). Acoustic differences have been found as well; Saulitis et al. (2005) described acoustic differences between Gulf of Alaska transients and AT1 transients. For these reasons, the Gulf of Alaska transients are considered part of a population that is discrete from the AT1 population, and both of these populations are considered discrete from the West Coast Transients.

Biopsy samples from the eastern Aleutians and the south side of the west end of the Alaska Peninsula have produced the same haplotypes as killer whales in the northern Gulf of Alaska, however, nuclear DNA analysis strongly suggests they belong to a separate population (Parsons et al. 2013). The geographic distribution of mtDNA haplotypes revealed samples from the central Aleutian Islands and Bering Sea with haplotypes not found in Gulf of Alaska transients, suggesting additional population structure in western Alaska. At this time, transient-type killer whales from the Aleutian Islands and Bering Sea are considered to be part of a single population that includes Gulf of Alaska transients. Killer whales observed in the northern Bering Sea and Beaufort Sea have physical characteristics of transient-type whales, but little is known about these whales. AT1 haplotype whales are also present west of the Aleutian Islands and into the Bering Sea; however, nuclear DNA analysis indicates these animals are not part of the AT1 transient population in the Gulf of Alaska (L. Barrett-Lennard, Vancouver Aquarium, pers. comm., 21 March 2014).

In summary, within the transient ecotype, association data (Ford et al. 1994, Ford and Ellis 1999, Matkin et al. 1999), acoustic data (Ford and Ellis 1999, Saulitis et al. 2005), and genetic data (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000) confirm that at least three communities of transient whales exist and represent three discrete populations: 1) Gulf of Alaska, Aleutian Islands, and Bering Sea transients, 2) AT1 transients, and 3) West Coast transients.

Based on data regarding association patterns, acoustics, movements, and genetic differences, eight killer whale stocks are now recognized within the Pacific U.S. Exclusive Economic Zone: 1) the Alaska Resident stock - occurring from Southeast Alaska to the Aleutian Islands and Bering Sea, 2) the Northern Resident stock - occurring from Washington State through part of Southeast Alaska, 3) the Southern Resident stock - occurring mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from Southeast Alaska through California, 4) the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock - occurring mainly from Prince William Sound through the Aleutian Islands and Bering Sea, 5) the AT1 Transient stock - occurring in Alaska from Prince William Sound through the Kenai Fjords (Fig. 1), 6) the West Coast Transient stock - occurring from California through Southeast Alaska, 7) the Offshore stock - occurring from California through Alaska, and 8) the Hawaiian stock. Transient whales in Canadian waters are considered part of the West Coast Transient stock. The Hawaiian and Offshore stocks are reported separately in the Stock Assessment Reports for the U.S. Pacific Region.

AT1 killer whales were first identified as a separate, cohesive group in 1984, when 22 transient-type whales were documented in Prince William Sound (Leatherwood et al. 1984, Heise et al. 1991), though individual whales from the group had been photographed as early as 1978 (von Ziegesar et al. 1986). Once the North Gulf Oceanic Society began consistent annual research effort in Prince William Sound, AT1 killer whales were resighted frequently. In fact, AT1 killer whales were found to be some of the most frequently sighted killer whales in Prince William Sound (Matkin et al. 1993, 1994, 1999). Gulf of Alaska transients are seen less frequently in Prince William Sound, with periods of several years or more between resightings.

AT1 killer whales have never been seen in association with sympatric resident killer whale pods or with Gulf of Alaska transients (Matkin et al. 1999, 2012), are genetically and acoustically distinct from other transient killer whales in the North Pacific (Barrett-Lennard 2000, Saulitis et al. 2005), and appear to have a more limited range than other transients. Their approximately 200-mile known range includes only Prince William Sound and Kenai Fjords and adjacent offshore waters (Matkin et al. 1999, 2012).

POPULATION SIZE

Using photographic-identification methods, all 22 individuals in the AT1 Transient population were censused for the first time in 1984 (Leatherwood et al. 1984). All 22 AT1s were seen annually or biannually from 1984 to 1988 (Matkin et al. 1999, 2003). The *Exxon Valdez* oil spill occurred in spring of 1989. Nine individuals from the AT1 group have been missing since 1990 (last seen in 1989), and two have been missing since 1992 (last seen in 1990 and 1991). Three of the missing AT1s (AT5, AT7, and AT8) were seen near the leaking *Exxon Valdez* shortly after the spill (Matkin et al. 1993, 1994, 2008). Two whales were found dead, stranded in 1989-1990, both genetically assigned to the AT1 population and one visually recognized as AT19, one of the missing nine (Matkin et al. 1994, 2008; Heise et al. 2003). The second unidentified whale was most likely one of the other missing AT1 whales. Additional mortalities of four older males include whales AT1 found stranded in 2000, AT13 and AT17 missing in 2002 (one of which was thought to be the carcass from the AT1 population that was found in 2002), and AT14 missing in 2003. A genetically assigned AT1 stranded whale found in 2003 was probably AT14 but could also have been AT13 (Matkin et al. 2008). No births have occurred in this population since 1984 and none of the missing whales have been seen since 2003 and are presumed dead. There is an extremely small probability (0.4%) that AT1 killer whales that are missing for 3 years or more are still alive (Matkin et al. 2008). No AT1 whale missing for at least 4 years has ever been resighted and all 15 missing whales are presumed dead (Matkin et al. 2008). In 2015, all seven whales (AT2, AT3, AT4, AT6, AT9, AT10, and AT18) were observed by researchers from the North Gulf Oceanic Society. Therefore, the population estimate as of the summer of 2015 remains at seven whales (C. Matkin, North Gulf Oceanic Society, pers. comm., 20 October 2015). There has been no recruitment in this population since 1984 (Matkin et al. 2012).

Minimum Population Estimate

The abundance estimate of killer whales is a direct count of individually identifiable animals. Only 11 whales were seen between 1990 and 1999. Since then, four of those whales have not been seen for four or more consecutive years, so the minimum population estimate is seven whales (Matkin et al. 2008). Fourteen years of annual effort have failed to discover any whales that had not been seen previously, so there is no reason to believe there are additional whales in the population. Therefore, this minimum population estimate is the total population size.

Current Population Trend

The population counts have declined from a level of 22 whales in 1989 to 7 whales in 2015, a decline of 68%. Most of the mortality apparently occurred in 1989-1990.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for this stock of killer whales. Studies of resident killer whale pods in the Pacific Northwest resulted in estimated population growth rates of 2.9% and 2.5% over the period from 1973 to 1987 (Olesiuk et al. 1990, Brault and Caswell 1993). Until additional stock-specific data become available, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.1, as the stock is considered depleted under the MMPA and there has been no recruitment into the stock since 1984. Thus, for the AT1 killer whale stock, PBR = 0 whales ($7 \times 0.02 \times 0.1$).

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information on U.S. commercial fisheries in Alaska waters (including observer programs, observer coverage, and observed incidental takes of marine mammals) is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

The known range of the AT1 stock is limited to waters of Prince William Sound and Kenai Fjords. There are no federally-managed commercial fisheries in this area. State-managed commercial fisheries prosecuted within the range of this stock, such as the Prince William Sound salmon set and drift gillnet fisheries, and various herring fisheries, are not known to incur incidental mortality or serious injury of AT1 killer whales. Several subsistence fisheries (salmon, halibut, non-salmon finfish, and shellfish) also occur within this area, and no incidental mortality or serious injury has been reported for these fisheries.

Alaska Native Subsistence/Harvest Information

There are no reports of a subsistence harvest of killer whales in Alaska or Canada.

Other Mortality

Collisions with boats may be an occasional source of mortality or serious injury of killer whales. For example, a killer whale struck the propeller of a vessel in the Bering Sea/Aleutian Islands rockfish trawl fishery in 2010; however, this mortality did not involve a whale from the AT1 stock. There has been no known mortality or serious injury of AT1 killer whales due to ship strikes. Most of the mortality occurred from 1989 to 1990 following the *Exxon Valdez* oil spill.

STATUS OF STOCK

The AT1 Transient stock of killer whales is below its Optimum Sustainable Population and designated as depleted under the MMPA; therefore, it is classified as a strategic stock. The AT1 Transient stock is not listed as threatened or endangered under the Endangered Species Act. Based on currently available data, the estimated mean annual mortality and serious injury rate due to U.S. commercial fisheries (0) does not exceed 10% of the PBR (0) and, therefore, can be considered insignificant and approaching zero mortality and serious injury rate. At least 11 animals were alive in 1998, but it appears that only 7 individuals remain alive. The AT1 group has been reduced to 32% (7/22) of its 1984 level. Since no births have occurred in the past 30 years, it is unlikely that this stock will recover.

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KILLER WHALE (*Orcinus orca*):
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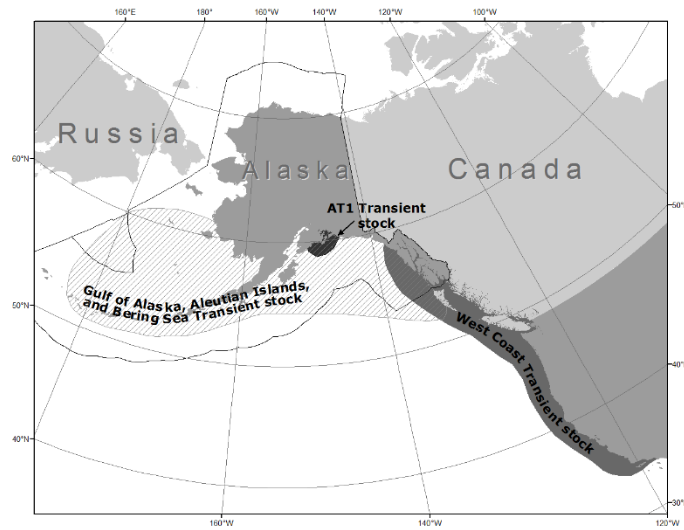

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Several studies provide evidence that the 'resident', 'offshore', and 'transient' ecotypes are genetically distinct in both mtDNA and nuclear DNA (Hoelzel and Dover 1991; Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). Genetic differences have also been found between populations within the 'transient' and 'resident' ecotypes (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). A recent global genetic study of killer whales using the entire mitochondrial genome found that some killer whale ecotypes represent deeply divergent evolutionary lineages and warrant elevation to species or subspecies status (Morin et al. 2010). In particular, estimates from mitogenome sequence data indicate that transient killer whales diverged from all other killer whale lineages ~700,000 years ago. In light of these differences, the Society for Marine Mammalogy's Committee on Taxonomy currently recognizes the resident and transient North Pacific ecotypes as un-named *Orcinus orca* subspecies (Committee on Taxonomy 2012). In recognition of its status as an un-named subspecies or species, some researchers now refer to transient-type killer whales as Bigg's killer whales (e.g., Ford 2011, Riesch et al. 2012), in tribute to the late Dr. Michael Bigg.

Based on data regarding association patterns, acoustics, movements, and genetic differences, eight killer whale stocks are now recognized within the Pacific U.S. EEZ: 1) the Alaska Resident stock - occurring from southeastern Alaska to the Aleutian Islands and Bering Sea, 2) the Northern Resident stock - occurring from Washington State through part of southeastern Alaska, 3) the Southern Resident stock - occurring mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from southeastern Alaska through California, 4) the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock - occurring mainly from Prince William Sound through the Aleutian Islands and Bering Sea, 5) the AT1 transient stock - occurring in Alaska from Prince William Sound through the Kenai Fjords, 6) the West Coast transient stock - occurring from California through southeastern Alaska, 7) the Offshore stock - occurring from California through Alaska, and 8) the Hawaiian stock. 'Transient' whales in Canadian waters are considered part of the West Coast Transient stock. The Stock Assessment Reports for the Alaska Region contain information concerning all the killer whale stocks except the Hawaiian and Offshore stocks.

Until recently, transient killer whales in Alaska had only been studied intensively in Southeast Alaska and in the Gulf of Alaska (from Prince William Sound, through the Kenai Fjords, and around Kodiak Island). In the Gulf of Alaska, Matkin et al. (1999) described two populations of transients which were never found in association with one another, the so-called 'Gulf of Alaska' transients and 'AT1' transients. Gulf of Alaska' transients are documented throughout the Gulf of Alaska, including occasional sightings in Prince William Sound. AT1 transients are primarily seen in Prince William Sound and in the Kenai Fjords region, and are therefore partially sympatric with 'Gulf of Alaska' transients. Recently members of the Gulf of Alaska transient population have been seen in association with the transient killer whales that range from California to southeastern Alaska, the west coast transients, which are identified by a unique mtDNA haplotype. Recent data have identified 14 out of 217 whales considered "outer coast" transients in British Columbia as photographed in Alaskan waters and considered Gulf of Alaska transients (Ford et al. 2013). Transients within the 'Gulf of Alaska' population have been found to have two mtDNA haplotypes, neither of which is found in the west coast or AT1 populations. Members of the AT1 population share a single mtDNA haplotype. Transient killer whales from the 'west coast' stock have been found to share a single mtDNA haplotype that is not found in the other communities. Additionally, all three populations have been found to have significant differences in nuclear (microsatellite) DNA (Barrett-Lennard 2000). Acoustic differences have been found, as well, as Saulitis (1993) and Saulitis et al. 2005 described acoustic differences between 'Gulf of Alaska' transients and AT1 transients. For these reasons, the 'Gulf of Alaska' transients are considered part of a population that is discrete from the AT1 population, and both of these communities are considered discrete from the 'west coast' transients.

Biopsy samples from the eastern Aleutians and south side of the end of the Alaska Peninsula have produced the same haplotypes as killer whales in the northern Gulf of Alaska, however nuclear DNA analysis strongly suggest they belong to a separate population (Parsons et al. 2013). Samples from the central Aleutian Islands and Bering Sea have identified mtDNA haplotypes not found in Gulf of Alaska transients, suggesting additional population structure in western Alaska. At this time, transient-type killer whales from the Aleutian Islands and Bering Sea are considered to be part of a single population that includes 'Gulf of Alaska' transients. Killer whales are observed in the northern Bering Sea and Beaufort Sea that have the physical characteristics of transient type whales, but little is known about these whales.

In summary, within the transient ecotype, association data (Ford et al. 1994, Ford and Ellis 1999, Matkin et al. 1999), acoustic data (Saulitis 1993, Ford and Ellis 1999) and genetic data (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000, Parsons et al. 2013) confirm that at least three communities of transient whales exist and represent three discrete populations: 1) Gulf of Alaska, Aleutian Islands, and Bering Sea transients, 2) AT1 transients, and 3) West Coast transients.

Most of the transient whales photographed in the inland waters of Southeast Alaska share the west coast transient haplotype and have been seen in association with British Columbia/Washington State transients. Transients most often seen off California have also share the West Coast Transient (WCT) haplotype and have been observed in association with transients in Washington and British Columbia. The West Coast Transient Stock is therefore considered to include transient killer whales from California through southeastern Alaska. However, it should be noted that Fisheries and Oceans Canada recently decided to exclude whales from California from their assessment of the "West Coast Transient (WCT) Population" (DFO 2007). They noted that 100 or so transient killer whales identified off the central coast of California (Black et al. 1997) were in the past considered to be an extension of this population because of acoustical similarities and occasional mixing with WCT individuals in BC waters (Ford and Ellis 1999), but that a recent reassessment indicated that the available evidence was insufficient to warrant inclusion of those whales in the WCT population (DFO 2010). Canadian researchers have now identified 46 individual whales in British Columbia that are known from California (J. Ford, pers. comm., Department of Fisheries and Oceans, British Columbia, Canada, 30 January 2013). They also noted that the Gulf of Alaska transients are seen occasionally within the range of WCTs (in southeastern Alaska and off British Columbia) but have only been observed to travel in association with WCTs on one occasion (DFO 2007, Matkin et al. 2012). For the purposes of this stock assessment report, the West Coast Transient Stock continues to include animals that occur in California, Oregon, Washington, British Columbia and southeastern Alaska.

POPULATION SIZE

The west coast transient stock is a trans-boundary stock, including killer whales from British Columbia. Preliminary analysis of photographic data resulted in the following minimum counts for 'transient' killer whales belonging to the west coast transient stock. Over the time series from 1975 to 2012, 521 individual transient killer whales have been identified. Of these, 217 are considered part of the poorly known "outer coast" subpopulation and 304 belong to the well-known "inner coast" population. However of the 304, the number of whales currently alive is not certain (see Ford et al. 2013). A recent mark-recapture estimate that does not include the "outer coast" subpopulation or whales from California for the west coast transient population resulted in an estimate of 243 (95% probability interval = 180-339) in 2006 (DFO 2009). This estimate applies to the population of west coast transient whales that occur in the inside waters of southeastern Alaska, British Columbia, and northern Washington. Given that the California transient numbers have not been updated since the publication of the catalogue in 1997 (Black et al. 1997), the total number of transient killer whales reported above should be considered as a minimum count for the west coast transient stock.

Minimum Population Estimate

The abundance estimate of killer whales is a direct count of individually identifiable animals. However, the number of cataloged whales does not necessarily represent the number of live animals. Some animals may have died, but whales can not be presumed dead if not resighted because long periods of time between sightings are common for some 'transient' animals. The connection of the outer coast whales with the west coast transient population of inshore waters is not well established, and the photographic catalogue from California has not been updated in 15 years. Estimates of the overall population size (i.e., N_{BEST}) and associated CV(N) that include the "outer coast" whales are not currently available. Thus, the minimum population estimate (N_{MIN}) for the West Coast Transient stock of killer whales is derived from the recent mark-recapture analysis for West Coast transient population whales from the inside waters of Alaska and British Columbia of 243 whales (95% probability interval = 180-339) in 2006 (DFO 2009), which includes animals found in Canadian waters (see PBR Guidelines regarding the status of migratory trans-boundary stocks, Wade and Angliss 1997). Information on the percentage of time animals typically encountered in Canadian waters spend in U.S. waters is unknown. However, as noted above, this minimum population estimate is considered conservative. This approach is consistent with previous recommendations of the Alaska Scientific Review Group (DeMaster 1996).

Current Population Trend

Recent analyses of the inshore west coast transient population indicate that this segment grew rapidly from the mid-1970s to mid-1990s as a result of a combination of high birth rate, survival, as well as greater immigration of animals into the nearshore study area (DFO 2009). The rapid growth of the west coast transient population in the mid-1970s to mid-1990s coincided with a dramatic increase in the abundance of the whales' primary prey, harbor seals, in nearshore waters. Population growth began slowing in the mid-1990s and has continued to slow in recent years (DFO 2009). Given population estimates are based on photo identification of individuals and considered minimum estimates, no reliable estimate of trend is available.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for this stock of killer whales. Analyses in DFO (2009) estimated a rate of increase of about 6% per year in this population from 1975 to 2006, but this included recruitment of non-calf whales into the population, at least in the first half of the time period, interpreted as either a movement of some whales into nearshore waters from elsewhere, or from better spatial sampling coverage. The population increased at a rate of approximately 2% for the second half of the time period, when recruitment of new individuals was nearly exclusively from new-born individuals (DFO 2009). Studies of 'resident' killer whale pods in the Pacific Northwest resulted in estimated population growth rates of 2.92% and 2.54% over the period from 1973 to 1987 (Olesiuk et al. 1990, Brault and Caswell 1993) and an observed growth rate of 3.1% was observed in northern resident killer whales and used in calculations of R_{MAX} for that stock. However, until additional data become available for this stock of transient type killer whales, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for cetacean stocks with unknown population status with a mortality rate CV = 0.80 (Wade and Angliss 1997). Thus, for the West Coast Transient killer whale stock, PBR = 2.4 animals (243 × 0.02 × 0.5). The proportion of time that this trans-boundary stock spends in Canadian waters cannot be determined (G. Ellis, Pacific Biological Station, Canada, pers. comm.)

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*." Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fisheries Information

NMFS observers monitored the California/Oregon thresher shark/swordfish drift gillnet fishery from 1994 to 2003 (Julian 1997, Julian and Beeson 1998, Cameron and Forney 1999, Carretta 2002, Carretta and Chivers 2003, Carretta and Chivers 2004). The observed mortality in this fishery, in 1995, was a transient whale as determined by genetic testing (S. Chivers, NMFS-SWFSC, pers. comm.). Overall entanglement rates in the California/Oregon thresher shark/swordfish drift gillnet fishery dropped considerably after the 1997 implementation of a Take Reduction Plan, which included skipper education workshops and required the use of pingers and minimum 6-fathom extenders (Barlow and Cameron 1999). Because the California/Oregon thresher shark/swordfish drift gillnet fishery is observed and has not incurred incidental serious injuries or mortalities of killer whales between 1999-2003, the estimate of fishery-related take for this fishery is zero. Thus, the mean annual mortality rate for this stock is zero. Additional fisheries that could interact with the Eastern North Pacific Transient stock of killer whales are listed in Appendix 3.

The estimated minimum mortality rate incidental to recently monitored U.S. commercial fisheries is zero animals per year.

All Canadian trawl and longline fisheries are monitored by observers or video; salmon net fisheries are not observed (J. Ford, pers. comm., Department of Fisheries and Oceans, British Columbia, Canada, 30 January 2013). The sablefish longline fishery accounts for a large proportion of the commercial fishing/killer whale interactions in Alaska waters. However, transient killer whales typically are not involved in these interactions. Resident killer whales are well documented to interact with the longline fishery. Such interactions have not been reported in Canadian waters where sablefish are taken via a pot fishery. Canada has a Marine Mammal Response Network to track human interaction incidents such as entanglements (J. Ford, pers. comm., Department of Fisheries and Oceans, British Columbia, Canada, 30 January 2013). Since 1990, there have been no reported fishery-related strandings of killer whales in Canadian waters. In 1994, one killer whale was reported to have contacted a salmon gillnet, but it did not entangle (Guenther et al. 1995).

Subsistence/Native Harvest Information

There are no reports of a subsistence harvest of killer whales in Alaska or Canada.

Other Mortality

The shooting of killer whales in Canadian waters has been a concern in the past. However, in recent years there have been no reports of shooting incidents in Canadian waters. In fact, the likelihood of shooting incidents involving 'transient' killer whales is thought to be minimal since commercial fishermen are most likely to observe 'transients' feeding on seals or sea lions instead of interacting with their fishing gear (G. Ellis, Pacific Biological Station, Canada, pers. comm.).

Collisions with boats are another source of mortality. Killer whales interacting with trawl vessels are occasionally struck by the propeller; there were 4 incidents of mortality and serious injury in the Bering Sea/Aleutian Islands flatfish trawl and Bering Sea/ Aleutian Islands rockfish trawl fisheries between 2007-2011. Stock identification for these occurrences is unknown; however, this area is outside of the known range for this stock. There have been no reported mortalities of killer whales from this stock due to vessel collisions.

STATUS OF STOCK

The West Coast transient killer whale stock is not designated as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act. In 2001, the Committee on the Status of Endangered Wildlife in Canada designated west coast transient killer whales in British Columbia as "threatened" under the Species at Risk Act (SARA) for Canada. Human-caused mortality may have been underestimated, primarily due to a lack of information on Canadian fisheries, and that the minimum abundance estimate is considered conservative (because researchers continue to encounter new whales and provisionally classified whales from Southeast Alaska and off the coast of California were not included), resulting in a conservative PBR estimate. Based on currently available data, the estimated annual U. S. commercial fishery-related mortality level (0) does not exceed 10% of the PBR (0.2) and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate. The estimated annual level of human-caused mortality and serious injury (0 animals per year) does not exceed the PBR (2.4). Therefore, the West Coast Transient stock of killer whales is not classified as a strategic stock. Population trends and status of this stock relative to its Optimum Sustainable Population (OSP) level are currently unknown.

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PACIFIC WHITE-SIDED DOLPHIN (*Lagenorhynchus obliquidens*): North Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The Pacific white-sided dolphin is found throughout the temperate North Pacific Ocean, north of the coasts of Japan and Baja California, Mexico. In the eastern North Pacific the species occurs from the southern Gulf of California, north to the Gulf of Alaska, west to Amchitka in the Aleutian Islands, and is rarely encountered in the southern Bering Sea. The species is common both on the high seas and along the continental margins, and animals are known to enter the inshore passes of Alaska, British Columbia, and Washington (Ferrero and Walker 1996).

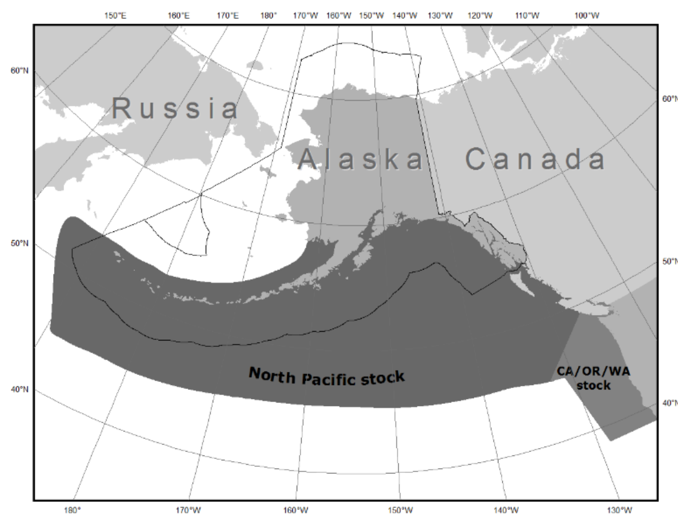

Figure 1. Approximate distribution of Pacific white-sided dolphins in the eastern North Pacific (dark shaded areas).

The following information was considered in classifying Pacific white-sided dolphin stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution is continuous; 2) Population response data: unknown; 3) Phenotypic data: two morphological forms are recognized (Walker et al. 1986, Chivers et al. 1993); and 4) Genotypic data: preliminary genetic analyses on 116 Pacific white-sided dolphins collected in four areas (Baja California, the U.S. west coast, British Columbia/Southeast Alaska, and offshore) do not support phylogeographic partitioning, though they are sufficiently differentiated to be treated as separate management units (Lux et al. 1997). This limited information is not sufficient to define stock structure throughout the North Pacific beyond the generalization that a northern form occurs north of about 33°N from southern California along the coast to Alaska and a southern form ranges from about 36°N southward along the coasts of California and Baja California, while the core of the population ranges across the North Pacific to Japan at latitudes south of 45°N. Data are lacking to determine whether this latter group might include animals from one or both of the coastal forms. Although the genetic data are unclear, management issues support the designation of two stocks; because the California and Oregon thresher shark/swordfish drift gillnet fishery (operating between 33°N and approximately 47°N) and, to a lesser extent, the groundfish and salmon fisheries in Alaska are known to interact with Pacific white-sided dolphins, two management stocks are recognized: 1) the California/Oregon/Washington stock, and 2) the North Pacific stock (Fig. 1). The California/Oregon/Washington stock is reported separately in the Stock Assessment Reports for the U.S. Pacific Region.

POPULATION SIZE

The most complete population abundance estimate for Pacific white-sided dolphins was calculated from line-transect analyses applied to the 1987-1990 central North Pacific marine mammal sighting survey data (Buckland et al. 1993). The Buckland et al. (1993) abundance estimate, 931,000 (CV = 0.90) animals, more closely reflects a range-wide estimate rather than one that can be applied to either of the two management stocks off the west coast of North America. Furthermore, Buckland et al. (1993) suggested that Pacific white-sided dolphins show strong vessel attraction but that a correction factor was not available to apply to the estimate. While the Buckland et al. (1993) abundance estimate is not considered appropriate to apply to the management stock in Alaskan waters, the portion of the estimate derived from sightings north of 45°N in the Gulf of Alaska can be used as the population estimate for this area (26,880). For comparison, Hobbs and Lerczak (1993) estimated 15,200 (95% CI: 868-265,000) Pacific white-sided dolphins in the Gulf of Alaska based on a single sighting of 20 animals. Small cetacean aerial surveys in the Gulf of Alaska during 1997 sighted one group of 164 Pacific white-sided dolphins off Dixon entrance, while similar surveys in Bristol Bay in 1999 made 18 sightings of a school, or parts thereof, off Port Moller (R. Hobbs, NMFS-AFSC-NMML, pers. comm.).

Minimum Population Estimate

Historically, the minimum population estimate (N_{MIN}) for this stock was 26,880, based on the sum of abundance estimates for four separate 5° × 5° blocks north of 45°N (1,970 + 6,427 + 6,101 + 12,382 = 26,880) from surveys conducted during 1987-1990, reported in Buckland et al. (1993). This was considered a minimum estimate because the abundance of animals in a fifth 5° × 5° block (53,885), which straddled the boundary of the two coastal management stocks, was not included in the estimate for the North Pacific stock and because much of the potential habitat for this stock was not surveyed between 1987 and 1990. However, because the abundance estimate is more than 8 years old, the current minimum population estimate for this stock is unknown.

Current Population Trend

At present, there is no reliable information on trends in abundance for this stock of Pacific white-sided dolphins.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is not currently available for the North Pacific stock of Pacific white-sided dolphins. Life-history analyses by Ferrero and Walker (1996) suggest a reproductive strategy consistent with the delphinid pattern on which the 4% cetacean maximum net productivity rate (R_{MAX}) was based. Thus, it is recommended that the cetacean maximum net productivity rate (R_{MAX}) of 4% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for cetacean stocks of unknown status (Wade and Angliss 1997). The estimate of abundance for Pacific white-sided dolphins is more than 8 years old; Wade and Angliss (1997) recommend that abundance estimates older than 8 years no longer be used to calculate a PBR level. In addition, there is no corroborating evidence from recent surveys in Alaska that provide abundance estimates for a portion of the stock's range or any indication of the current status of this stock. Thus, the PBR for this stock is undetermined (NMFS 2005).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*." Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fisheries Information

Between 1978 and 1991, mortality and serious injury of thousands of Pacific white-sided dolphins occurred annually incidental to high-seas fisheries for salmon and squid. However, these fisheries were closed in 1991 and no other large-scale fisheries have operated in the central North Pacific since 1991.

Detailed information (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

Until 2003, there were six different federally-regulated commercial fisheries in Alaska that could have interacted with Pacific white-sided dolphins. These fisheries were monitored for incidental mortality and serious injury by fishery observers. As of 2003, changes in fishery definitions in the MMPA List of Fisheries have resulted in separating these 6 fisheries into 22 fisheries (69 FR 70094, 2 December 2004). This change does not represent a change in fishing effort but provides managers with better information on the component of each fishery that is responsible for the incidental mortality or serious injury of marine mammal stocks in Alaska. No mortality or serious injury of Pacific white-sided dolphins incidental to observed U.S. commercial fisheries was reported between 2009 and 2013 (Breiwick 2013; NMML, unpubl. data).

Note that no observers have been assigned to several of the gillnet fisheries that are known to interact with this stock, making the estimated mortality and serious injury rate unreliable. However, because the stock size is large, it is unlikely that unreported mortality and serious injury from those fisheries would be significant.

Alaska Native Subsistence/Harvest Information

There are no reports of subsistence takes of Pacific white-sided dolphins in Alaska.

Other Mortality

From 2009 to 2013, no human-caused mortality or serious injury of Pacific white-sided dolphins was reported to the NMFS Alaska Region stranding database (Helker et al. 2015).

STATUS OF STOCK

Pacific white-sided dolphins are not designated as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act. The North Pacific stock of Pacific white-sided dolphins is not classified as a strategic stock. Because the PBR for Pacific white-sided dolphins is undetermined, the level of human-caused mortality and serious injury relative to PBR is unknown and the level of annual U.S. commercial fishery-related mortality and serious injury that can be considered insignificant and approaching zero mortality and serious injury rate is unknown. Population trends and status of this stock relative to its Optimum Sustainable Population are currently unknown.

HABITAT CONCERNS

While the majority of Pacific white-sided dolphins are found throughout the North Pacific, there are also significant numbers found in shelf break and deeper nearshore areas. Thus, they are subject to a variety of habitat impacts. Of particular concern are nearshore areas, bays, channels, and inlets where some Pacific white-sided dolphins are vulnerable to physical modifications of nearshore habitats, resulting from urban and industrial development (including waste management and nonpoint source runoff), and noise (Linnenschmidt et al. 2013).

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HARBOR PORPOISE (*Phocoena phocoena*): Southeast Alaska Stock

NOTE – December 2015: In areas outside of Alaska, studies of harbor porpoise distribution have indicated that stock structure is likely more fine-scaled than is reflected in the Alaska Stock Assessment Reports. At this time, no data are available to define stock structure for harbor porpoise on a finer scale in Alaska. However, based on comparisons with other regions, it is likely that several regional and sub-regional populations exist. Should new information on harbor porpoise stocks become available, the harbor porpoise Stock Assessment Reports will be updated.

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the eastern North Pacific Ocean, harbor porpoise range from Point Barrow and offshore areas of the Chukchi Sea, along the Alaska coast, and down the west coast of North America to Point Conception, California (Gaskin 1984, Christman and Aerts 2015). Harbor porpoise primarily frequent the coastal waters of the Gulf of Alaska and Southeast Alaska (Dahlheim et al. 2000, 2009), typically occurring in waters less than 100 m deep (Hobbs and Waite 2010). Within the inland waters of Southeast Alaska, harbor porpoise distribution is clumped with greatest densities observed in the Glacier Bay/Icy Strait region and near Zarembo and Wrangell Islands and the adjacent waters of Sumner Strait (Dahlheim et al. 2009). The average density of harbor porpoise in Alaska appears to be less than that reported off the west coast of the continental U.S., although areas of high densities do occur in Glacier Bay and the adjacent waters of Icy Strait, Yakutat Bay, the Copper River Delta, Sitkalidak Strait (Dahlheim et al. 2000, 2009, 2015; Hobbs and Waite 2010), and lower Cook Inlet (Shelden et al. 2014).

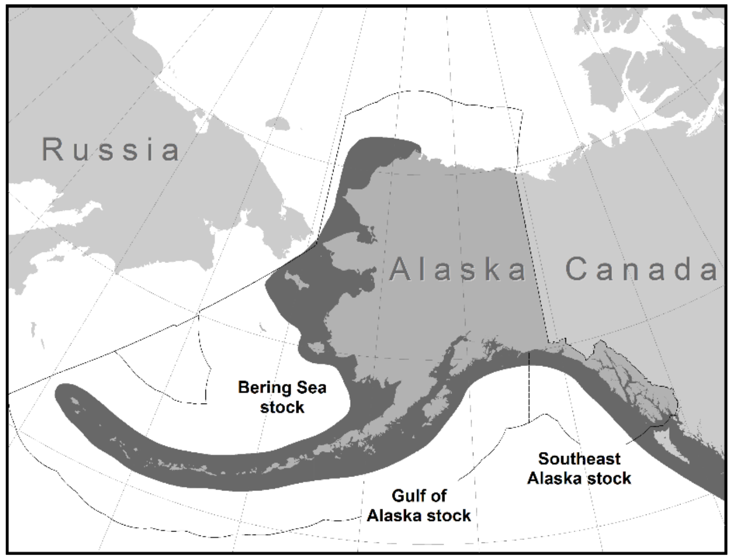

Figure 1. Approximate distribution of harbor porpoise in Alaska waters (dark shaded area).

Stock discreteness in the eastern North Pacific was analyzed using mitochondrial DNA from samples collected along the west coast (Rosel 1992), including one sample from Alaska. Two distinct mitochondrial DNA groupings or clades were found. One clade is present in California, Washington, British Columbia, and the single sample from Alaska (no samples were available from Oregon), while the other is found only in California and Washington. Although these two clades are not geographically distinct by latitude, the results may indicate a low mixing rate for harbor porpoise along the west coast of North America. Investigation of pollutant loads in harbor porpoise ranging from California to the Canadian border also suggests restricted harbor porpoise movements (Calambokidis and Barlow 1991); these results are reinforced by a similar study in the northwest Atlantic (Westgate and Tolley 1999). Further genetic testing of the same samples mentioned above, along with a few additional samples including eight more from Alaska, found differences between some of the four areas investigated, California, Washington, British Columbia, and Alaska, but inference was limited by small sample size (Rosel et al. 1995). Those results demonstrate that harbor porpoise along the west coast of North America are not panmictic and that movement is sufficiently restricted to result in genetic differences. This is consistent with low movement suggested by genetic analysis of harbor porpoise specimens from the North Atlantic (Rosel et al. 1999). Numerous stocks have been delineated with clinal differences over areas as small as the waters surrounding the British Isles (Walton 1997). In a molecular genetic analysis of small-scale population structure of eastern North Pacific harbor porpoise, Chivers et al. (2002) included 30 samples from Alaska, 16 of which were from the Copper River Delta, 5 from Barrow, 5 from Southeast Alaska, and 1 sample each from St. Paul, Adak, Kodiak, and Kenai. Unfortunately, no conclusions could be drawn about the genetic structure of harbor porpoise within Alaska because of the insufficient number of samples from each region. Accordingly, harbor porpoise stock structure in Alaska is defined by geographic areas at this time.

Although it is difficult to determine the true stock structure of harbor porpoise populations in the northeast Pacific, from a management standpoint it would be prudent to assume that regional populations exist and that they should be managed independently (Rosel et al. 1995, Taylor et al. 1996). For example, the porpoise concentrations found in Glacier Bay/Icy Strait and around Zarembo/Wrangell Islands may represent different subpopulations (Dahlheim et al. 2015) based on analogy with other west coast harbor porpoise populations, differences in trends in abundance of the two concentrations, and a hiatus in distribution between the northern and southern harbor porpoise concentrations. NMFS will consider whether these concentrations should be considered "prospective stocks" in a future Stock Assessment Report. Incidental takes from commercial fisheries within a small region (e.g., Wrangell and Zarembo Islands area) are of concern because of the potential impact on undefined localized stocks of harbor porpoise.

Accordingly, from the above information, three harbor porpoise stocks in Alaska were specified, recognizing that the boundaries of these three stocks were identified primarily based upon geography or perceived areas of porpoise low density: 1) the Southeast Alaska stock - occurring from Dixon Entrance to Cape Suckling, Alaska, 2) the Gulf of Alaska stock - occurring from Cape Suckling to Unimak Pass, and 3) the Bering Sea stock - occurring throughout the Aleutian Islands and all waters north of Unimak Pass (Fig. 1). To date, there have been no analyses to assess the validity of these stock designations or to assess possible substructure within these stocks.

POPULATION SIZE

Information on harbor porpoise abundance and relative abundance has been collected for coastal and inside waters of Southeast Alaska by the Alaska Fisheries Science Center's Marine Mammal Laboratory (MML) using both aerial and shipboard surveys. Aerial surveys of this stock were conducted in June and July 1997 and resulted in an observed abundance estimate of 3,766 (CV = 0.162) porpoise (Hobbs and Waite 2010); the surveys included a subset of smaller bays and inlets. Correction factors for observer perception bias and porpoise availability at the surface were used to develop an estimated corrected abundance of 11,146 (3,766 × 2.96; CV = 0.242) harbor porpoise in the coastal and inside waters of Southeast Alaska (Hobbs and Waite 2010).

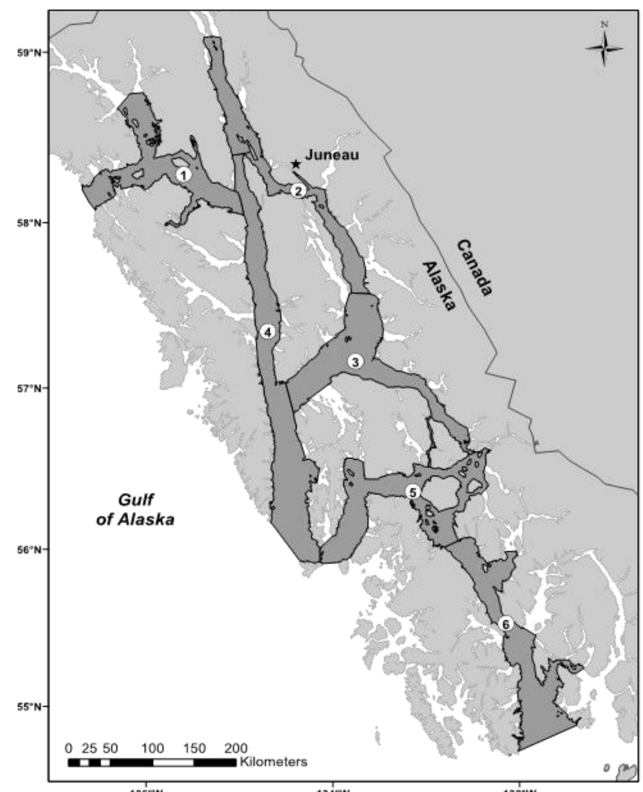

Figure 2. Survey strata defined for line-transect survey effort allocation in Southeast Alaska (as illustrated in Fig. 1 of Dahlheim et al. 2015).

In 1991, researchers initiated harbor porpoise studies aboard the NOAA ship *John N. Cobb* with broad survey coverage through the inland waters of Southeast Alaska. Between 1991 and 1993, line-transect methodology was used to 1) obtain population estimates of harbor porpoise, 2) establish a baseline for detecting trends in abundance, and 3) define overall distributional patterns and seasonality of harbor porpoise. The 1991-1993 vessel surveys were carried out each year in the spring, summer, and fall. Annual surveys were continued between 1994 and 2005; however, only two trips per year were conducted, one either in spring or summer and the other in fall. These surveys were not designed to survey harbor porpoise habitat and standard line-transect methodology was not used; however, all cetaceans observed were recorded. During this 12-year period, observers reported fewer overall encounters with harbor porpoise. To fully assess abundance and population trends for harbor porpoise, line-transect methodology was used during the survey cruises in 2006 and 2007 (Dahlheim et al. 2009) and in 2010-2012. Previous studies reported no evidence of seasonality for harbor porpoise occupying the inland waters of Southeast Alaska. Thus, only data collected during the summer season were analyzed, given the broader spatial coverage and the greater number of surveys (i.e., a total of eight line-transect vessel surveys) completed during this season. Methods applied to the 2006-2012 surveys were comparable to those employed during the early 1990s; however, because these surveys only covered a portion of inland waters and not the entire range of this stock, they are not used to compute a stock-specific estimate of abundance. Each year, greater densities of harbor porpoise were observed in the Glacier Bay/Icy Strait region and near Zarembo and Wrangell Islands and adjacent waters of Sumner Strait. The relative abundance of harbor porpoise in inland waters of Southeast Alaska was found to vary across survey periods spanning the 22-year study (1991-2012). Abundance estimated in 1991-1993 (N = 1,076; 95% CI = 910-1,272) was higher than the estimate obtained for 2006-2007 (N = 604; 95% CI = 468-780) but comparable to the estimate for 2010-2012 (N = 975; 95% CI = 857-1,109; Dahlheim et al. 2015). These estimates assume the probability of detection directly on the trackline to be unity (g(0) = 1) because estimates of g(0) have not been computed for these surveys. Therefore, these estimates may be biased low to an unknown degree. A range of possible g(0) values for harbor porpoise vessel surveys in other regions is 0.5-0.8 (Barlow 1988, Palka 1995), suggesting that as much as 50% of the porpoise can be missed, even by experienced observers.

Using the 2010-2012 survey data for the inland waters of Southeast Alaska, Dahlheim et al. (2015) calculated abundance estimates for the concentrations of harbor porpoise in the northern (Areas 1, 2, and 4) and southern (Areas 3, 5, and 6) regions of the inland waters (Fig. 2). The resulting abundance estimates are 398 (CV = 0.12) harbor porpoise in the northern inland waters (including Cross Sound, Icy Strait, Glacier Bay, Lynn Canal, Stephens Passage, and Chatham Strait) and 577 (CV = 0.14) harbor porpoise in the southern inland waters (including Frederick Sound, Sumner Strait, Wrangell and Zarembo Islands, and Clarence Strait as far south as Ketchikan). Because these abundance estimates have not been corrected for g(0), these estimates are likely conservative.

Minimum Population Estimate

For the Southeast Alaska stock of harbor porpoise, the minimum population estimate (N_{MIN}) for the 1997 aerial surveys is 1,996 calculated using Equation 1 from the potential biological removal (PBR) guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842 \times [\ln(1+[CV(N)]^2)]^{½})$. However, these survey data are now more than 8 years old. Using the 2010-2012 abundance estimate for harbor porpoise occupying the inland waters of Southeast Alaska of 975 (CV = 0.10), N_{MIN} is 896 harbor porpoise. Since the abundance estimate represents some portion of the total number of animals in the stock, using this estimate to calculate N_{MIN} results in a negatively-biased N_{MIN} for the stock. Although harbor porpoise in the northern and southern regions of the inland waters of Southeast Alaska have not been determined to be subpopulations or stocks, PBR calculations for these areas may provide a frame of reference for comparison to harbor porpoise takes in the portion of the Southeast Alaska salmon drift gillnet fishery that was monitored in 2012-2013. We used pooled 2010-2012 abundance estimates of 398 (CV = 0.12; assumes g(0) = 1) for the northern region and 577 (CV = 0.14; assumes g(0) = 1) for the southern region (Dahlheim et al. 2015) to calculate N_{MINs} of 359 and 513, respectively, for the concentrations of harbor porpoise in the northern and southern regions of the inland waters of Southeast Alaska. ADF&G Districts 6, 7, and 8, where the Southeast Alaska salmon drift gillnet fishery was observed in 2012-2013 (Manly 2015), partially overlap porpoise survey areas (Areas 5 and 6: Dahlheim et al. 2015) in the southern region of the inland waters.

Current Population Trend

The abundance of harbor porpoise in the Southeast Alaska stock was estimated in 1993 and 1997. In 1993, abundance estimates were determined from a coastal aerial survey from Prince William Sound to Dixon Entrance and a vessel survey in the inside waters of Southeast Alaska (Dahlheim et al. 2000). These surveys produced abundance estimates of 3,982 and 1,586 for the two areas, respectively, giving a combined estimate for the range of the Southeast Alaska harbor porpoise stock of 5,568. The 1997 abundance estimate was determined with an aerial survey for both the coastal region from Prince William Sound to Dixon Entrance and the inside waters of Southeast Alaska (Hobbs and Waite 2010). The 1997 estimate of 11,146 is double the 1993 estimate; however these estimates are not directly comparable because of differences in survey methods. The total area surveyed in 1997 was greater than in 1993 and included a correction of perception bias. For this reason, these estimates from aerial surveys are not appropriate to estimate trends.

An analysis of the line-transect vessel survey data collected throughout the inland waters of Southeast Alaska between 1991 and 2010 suggested high probabilities of a population decline ranging from 2 to 4% per year for the whole study area and highlighted a potentially important conservation issue (Zerbini et al. 2011). However, when data from 2011 and 2012 were added to this analysis, the population decline was no longer significant (Dahlheim et al. 2015). It is unclear why a negative trend in harbor porpoise numbers was detected in inland waters of Southeast Alaska in 1991-2010 and reversed thereafter (Dahlheim et al. 2015). Regionally, abundance was relatively constant in the northern region of the inland waters of Southeast Alaska throughout the survey period, while declines were documented in the southern region (Dahlheim et al. 2015).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not currently available for the Southeast Alaska stock of harbor porpoise. Hence, until additional data become available, it is recommended that the cetacean maximum theoretical net productivity rate of 4% be employed (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for cetacean stocks with unknown population status (Wade and Angliss 1997). Using the N_{MIN} of 896 (based on the 2010-2012 abundance estimate for harbor porpoise in the inland waters of Southeast Alaska), PBR is 8.9 (896 × 0.02 × 0.5). However, based on text above related to prospective stocks, we have also calculated N_{MINs} and PBRs for harbor porpoise in the northern and southern regions of the inland waters of Southeast Alaska. These PBR calculations may provide a frame of reference for the observed takes of harbor porpoise in the portion of the Southeast Alaska salmon drift gillnet fishery that was monitored in 2012-2013. Based on the pooled 2010-2012 abundance estimates and corresponding N_{MINs}, the PBR calculations for the northern and southern regions of the inland waters of Southeast Alaska are 3.6 (N = 398; CV = 0.12; N_{MIN} = 359) and 5.1 (N = 577; CV = 0.14; N_{MIN} = 513) harbor porpoise, respectively.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information on U.S. commercial fisheries in Alaska waters (including observer programs, observer coverage, and observed incidental takes of marine mammals) is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

No mortality or serious injury of harbor porpoise from the Southeast Alaska stock has been observed incidental to U.S. federal commercial fisheries in Alaska in 2010-2014 (Breiwick 2013; MML, unpubl. data).

In 2007 and 2008, the Alaska Marine Mammal Observer Program (AMMOP) placed observers in four regions where the state-managed Yakutat salmon set gillnet fishery operates (Manly 2009). These regions included the Alsek River area, the Situk area, the Yakutat Bay area, and the Kaliakh River and Tsiu River areas. Based on four mortalities and serious injuries observed during these 2 years, the estimated mean annual mortality and serious injury rate in the Yakutat salmon set gillnet fishery was 22 harbor porpoise (Table 1).

In 2012 and 2013, the AMMOP placed observers on independent vessels in the state-managed Southeast Alaska salmon drift gillnet fishery in ADF&G Management Districts 6, 7, and 8 to assess mortality and serious injury of marine mammals (Manly 2015). These Management Districts cover areas of Frederick Sound, Sumner Strait, Clarence Strait, and Anita Bay which include, but are not limited to, areas around and adjacent to Petersburg and Wrangell and Zarembo Islands. In 2013, four harbor porpoise were observed entangled and released: two were determined to be seriously injured and two were determined to be not seriously injured. Based on the two observed serious injuries, 23 serious injuries were estimated for Districts 6, 7, and 8 in 2013, resulting in an estimated mean annual mortality and serious injury rate of 12 harbor porpoise in 2012-2013 (Table 1). Since these three districts represent only a portion of the overall fishing effort in this fishery, this is a minimum estimate of mortality for the fishery.

Table 1. Summary of incidental mortality and serious injury of harbor porpoise from the Southeast Alaska stock due to U.S. commercial fisheries in 2010-2014 (or the most recent data available) and calculation of the mean annual mortality and serious injury rate (Manly 2009, 2015). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Yakutat salmon set gillnet	2007 2008	obs data	5.3 7.6	1 3	16.1 27.5	22 (CV = 0.54)
SE Alaska salmon drift gillnet (Districts 6, 7, and 8)	2012 2013	obs data	6.4 6.6	0 2	0 23	12 (CV = 1.0)
Minimum total estimated annual mortality						34 (CV = 0.77)

One harbor porpoise mortality due to entanglement in a Yakutat salmon set gillnet, was reported to the NMFS Alaska Region in 2010 (Helker et al. 2016); however, the AMMOP mean estimated annual mortality for the fishery accounts for this mortality (Table 1).

A complete estimate of the total mortality and serious injury incidental to U.S. commercial fisheries is unavailable for this stock because not all salmon and herring fisheries have been observed. However, the minimum mean annual mortality and serious injury rate incidental to U.S. fisheries is estimated as 34 harbor porpoise.

Alaska Native Subsistence/Harvest Information

Subsistence hunters in Alaska have not been reported to take from this stock of harbor porpoise.

STATUS OF STOCK

Harbor porpoise are not designated as depleted under the MMPA or listed as threatened or endangered under the Endangered Species Act. The total estimated annual level of human-caused mortality and serious injury for Southeast Alaska harbor porpoise (34 porpoise) exceeds the calculated PBR (8.9 porpoise), and the mean annual U.S. commercial fishery-related mortality and serious injury rate (34 porpoise) is more than 10% of the calculated PBR (10% of PBR = 0.9 porpoise). However, the calculated PBR is considered unreliable for the entire stock because it is based on estimates from surveys of only a portion (the inside waters of Southeast Alaska) of the range of this stock as currently designated. Because the abundance estimates are more than 8 years old (with the exception of the 2010-2012 abundance estimates provided for the inland waters of Southeast Alaska) and the frequency of incidental mortality and serious injury in U.S. commercial fisheries throughout Southeast Alaska is not known, the Southeast Alaska stock of harbor porpoise is classified as a strategic stock. Population trends and status of this stock relative to its Optimum Sustainable Population are currently unknown.

HABITAT CONCERNS

Harbor porpoise are mostly found in nearshore areas and inland waters, including bays, tidal areas, and river mouths (Dahlheim et al. 2000, 2009, 2015; Hobbs and Waite 2010). As a result, harbor porpoise are vulnerable to physical modifications of nearshore habitats resulting from urban and industrial development (including waste management and nonpoint source runoff) and activities such as construction of docks and other over-water structures, filling of shallow areas, dredging, and noise (Linnenschmidt et al. 2013).

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HARBOR PORPOISE (*Phocoena phocoena*): Gulf of Alaska Stock

NOTE – December 2015: In areas outside of Alaska, studies of harbor porpoise distribution have indicated that stock structure is likely more fine-scaled than is reflected in the Alaska Stock Assessment Reports. At this time, no data are available to define stock structure for harbor porpoise on a finer scale in Alaska. However, based on comparisons with other regions, it is likely that several regional and sub-regional populations exist. Should new information on harbor porpoise stocks become available, the harbor porpoise Stock Assessment Reports will be updated.

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the eastern North Pacific Ocean, the harbor porpoise ranges from Point Barrow and offshore areas of the Chukchi Sea, along the Alaska coast, and down the west coast of North America to Point Conception, California (Gaskin 1984, Christman and Aerts 2015). Harbor porpoise primarily frequent the coastal waters of the Gulf of Alaska and Southeast Alaska (Dahlheim et al. 2000, 2009), typically occurring in waters less than 100 m deep (Hobbs and Waite 2010). The average density of harbor porpoise in Alaska appears to be less than that reported off the west coast of the continental U.S., although areas of high densities do occur in Glacier Bay and the adjacent waters of Icy Strait, Yakutat Bay, the Copper River Delta, Sitkalidak Strait (Dahlheim et al. 2000, 2009, 2015; Hobbs and Waite 2010), and lower Cook Inlet (Shelden et al. 2014).

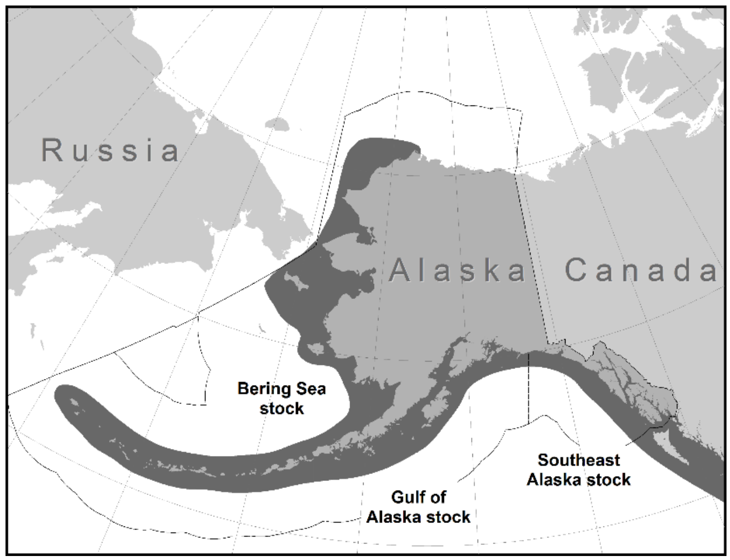

Figure 1. Approximate distribution of harbor porpoise in Alaska waters (dark shaded area).

Stock discreteness in the eastern North Pacific was analyzed using mitochondrial DNA from samples collected along the west coast (Rosel 1992), including one sample from Alaska. Two distinct mitochondrial DNA groupings or clades were found. One clade is present in California, Washington, British Columbia, and the single sample from Alaska (no samples were available from Oregon), while the other is found only in California and Washington. Although these two clades are not geographically distinct by latitude, the results may indicate a low mixing rate for harbor porpoise along the west coast of North America. Investigation of pollutant loads in harbor porpoise ranging from California to the Canadian border also suggests restricted harbor porpoise movements (Calambokidis and Barlow 1991); these results are reinforced by a similar study in the northwest Atlantic (Westgate and Tolley 1999). Further genetic testing of the same samples mentioned above, along with a few additional samples including eight more from Alaska, found differences between some of the four areas investigated, California, Washington, British Columbia, and Alaska, but inference was limited by small sample size (Rosel et al. 1995). Those results demonstrate that harbor porpoise along the west coast of North America are not panmictic and that movement is sufficiently restricted to result in genetic differences. This is consistent with low movement suggested by genetic analysis of harbor porpoise specimens from the North Atlantic (Rosel et al. 1999). Numerous stocks have been delineated with clinal differences over areas as small as the waters surrounding the British Isles (Walton 1997). In a molecular genetic analysis of small-scale population structure of eastern North Pacific harbor porpoise, Chivers et al. (2002) included 30 samples from Alaska, 16 of which were from Copper River Delta, 5 from Barrow, 5 from Southeast Alaska, and 1 sample each from St. Paul, Adak, Kodiak, and Kenai. Unfortunately, no conclusions could be drawn about the genetic structure of harbor porpoise within Alaska because of the insufficient number of samples from each region. Accordingly, harbor porpoise stock structure in Alaska is defined by geographic areas at this time.

Although it is difficult to determine the true stock structure of harbor porpoise populations in the northeast Pacific, from a management standpoint, it would be prudent to assume that regional populations exist and that they should be managed independently (Rosel et al. 1995, Taylor et al. 1996). Accordingly, from the above information, three harbor porpoise stocks in Alaska were specified, recognizing that the boundaries of these three stocks were inferred primarily based upon geography or perceived areas of low porpoise density: 1) the Southeast Alaska stock - occurring from Dixon Entrance to Cape Suckling, Alaska, 2) the Gulf of Alaska stock - occurring from Cape Suckling to Unimak Pass, and 3) the Bering Sea stock - occurring throughout the Aleutian Islands and all waters north of Unimak Pass (Fig. 1). To date, there have been no analyses to assess the validity of these stock designations or to assess possible substructure within these stocks.

POPULATION SIZE

In June and July of 1998 and 1999, an aerial survey covered the waters of the western Gulf of Alaska from Cape Suckling to Unimak Island, offshore to the 1,000 fathom depth contour. Two types of corrections were needed for these aerial surveys: one for observer perception bias and one to correct for porpoise availability/visibility at the surface. The 1998 survey resulted in an abundance estimate for the Gulf of Alaska harbor porpoise stock of 10,489 (CV = 0.115) animals (Hobbs and Waite 2010), which includes a correction factor (1.372; CV = 0.066) for perception bias to correct for animals that were present but not counted because they were not detected by observers. Laake et al. (1997) estimated the availability bias for aerial surveys of harbor porpoise in Puget Sound to be 2.96 (CV = 0.180); the use of this correction factor is preferred to other published correction factors (e.g., Barlow et al. 1988, Calambokidis et al. 1993) because it is an empirical estimate of availability bias. The estimated corrected abundance estimate from the 1998 survey is 31,046 (10,489 × 2.96 = 31,046; CV = 0.214) (Hobbs and Waite 2010).

This latest estimate of abundance (31,046) is considerably higher than the estimate reported in the 1999 stock assessment (8,271; CV = 0.309), which was based on surveys in 1991-1993. This disparity largely stems from changes in the area covered by the two surveys and differences in harbor porpoise density encountered in areas added to, or dropped from, the 1998 survey relative to the 1991-1993 surveys. The survey area in 1998 (119,183 km^2) was greater than the area covered in the combined portions of the 1991, 1992, and 1993 surveys (106,600 km^2). The 1998 survey included selected bays, channels, and inlets in Prince William Sound, the outer Kenai Peninsula, the south side of the Alaska Peninsula, and the Kodiak Archipelago, whereas, the earlier survey included only open water areas. Several of the bays and inlets covered by the 1998 survey had higher harbor porpoise densities than observed in the open waters. In addition, the 1998 estimate provided by Hobbs and Waite (2010) empirically estimates the perception bias and uses this in addition to the correction factor for availability bias. Finally, the 1998 estimate extrapolates available densities to estimate the number of porpoise which would likely be found in unsurveyed inlets within the study area. For these reasons, the 1998 survey result is probably more representative of the size of the Gulf of Alaska harbor porpoise stock.

Minimum Population Estimate

The minimum population estimate (N_{MIN}) for this stock is calculated using Equation 1 from the potential biological removal (PBR) guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the population estimate (N) of 31,046 and its associated coefficient of variation (CV) of 0.214, N_{MIN} for the Gulf of Alaska stock of harbor porpoise is 25,987 (Hobbs and Waite 2010). However, because the survey data are now more than 8 years old, N_{MIN} is considered unknown.

Current Population Trend

At present, there is no reliable information on trends in abundance for the Gulf of Alaska stock of harbor porpoise since survey methods and results are not comparable.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not currently available for the Gulf of Alaska stock of harbor porpoise. Hence, until additional data become available, it is recommended that the cetacean maximum theoretical net productivity rate of 4% be employed (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for cetacean stocks with unknown population status (Wade and Angliss 1997). However, the 2005 revisions to the Stock Assessment Report guidelines (Wade and Angliss 1997) state that abundance estimates older than 8 years should not be used to calculate PBR due to a decline in confidence in the reliability of an aged abundance estimate (NMFS 2005). Therefore, the PBR for this stock is considered undetermined.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information on U.S. commercial fisheries in Alaska waters (including observer programs, observer coverage, and observed incidental takes of marine mammals) is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

No incidental mortality or serious injury of the Gulf of Alaska stock of harbor porpoise was observed in U.S. commercial fisheries in 2010-2014 (Breiwick 2013; MML, unpubl. data). Observers monitoring the State of Alaska-managed Prince William Sound salmon drift gillnet fishery in 1990 and 1991 recorded 1 mortality in 1990 and 3 in 1991, which extrapolated to 8 (95% CI: 1-23) and 32 (95% CI: 3-103) for the entire fishery, resulting in a mean annual mortality and serious injury rate of 20 (CV = 0.60) porpoise when averaged over 1990 and 1991 (Table 1; Wynne et al. 1991, 1992). The Prince William Sound salmon drift gillnet fishery has not been observed since 1991 and no additional data are available for that fishery.

In 1999 and 2000, observers were placed on the state-managed Cook Inlet salmon set and drift gillnet vessels. One harbor porpoise mortality was observed in 2000 in the Cook Inlet salmon drift gillnet fishery (Manly 2006). This single mortality extrapolates to an estimated mortality and serious injury rate of 31 porpoise for that year and an average of 16 porpoise per year when averaged over the 2 years of observer data (Table 1).

In 2002 and 2005, observers were placed on state-managed Kodiak Island set gillnet vessels. Harbor porpoise mortality observed in this fishery (2 each in both 2002 and 2005) (Manly 2007) extrapolates to an estimated mean annual mortality and serious injury rate of 36 harbor porpoise (Table 1).

Table 1. Summary of incidental mortality and serious injury of Gulf of Alaska harbor porpoise due to state-managed fisheries from 1990 through 2005 and calculation of the mean annual mortality and serious injury rate (Wynne et al. 1991, 1992; Manly 2006, 2007). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Prince William Sound salmon drift gillnet	1990 1991	obs data	4 5	1 3	8 32	20 (CV = 0.60)
Cook Inlet salmon drift gillnet	1999 2000	obs data	1.6 3.6	0 1	0 31	16 (CV = 1.0)
Cook Inlet salmon set gillnet	1999 2000	obs data	0.16-1.1 0.34-2.7	0 0	0 0	0
Kodiak Island set gillnet	2002 2005	obs data	6.0 4.9	2 2	32 39	36 (CV = 0.68)
Minimum total estimated annual mortality						72 (CV = 0.44)

Strandings of marine mammals with fishing gear attached or with injuries caused by interactions with fishing gear are another source of mortality data. In 2013, one Gulf of Alaska harbor porpoise mortality, due to entanglement in a commercial salmon drift gillnet near Kenai, Alaska, was reported to the NMFS Alaska Region stranding network (Helker et al. 2016). However, this event is accounted for in the extrapolated estimate (derived from Alaska Marine Mammal Observer Program (AMMOP) observer data) of annual mortality and serious injury occurring in the commercial Cook Inlet salmon drift gillnet fishery (Table 1). An additional harbor porpoise mortality from this stock, due to entanglement in unidentified fishing net near Homer, Alaska, was reported to the NMFS Alaska Region in 2014, resulting in a minimum mean annual mortality and serious injury rate of 0.2 harbor porpoise in unknown (commercial, recreational, or subsistence) fisheries in 2010-2014 (Table 2; Helker et al. 2016).

Table 2. Summary of incidental mortality and serious injury of Gulf of Alaska harbor porpoise, by year and type, reported to the NMFS Alaska Region marine mammal stranding network in 2010-2014 (Helker et al. 2016). Only cases of serious injury were recorded in this table; animals with non-serious injuries have been excluded.

Cause of Injury	2010	2011	2012	2013	2014	Mean annual mortality
Entangled in unidentified net*	0	0	0	0	1	0.2
*Total in unknown (commercial, recreational, or subsistence) fisheries						0.2

A complete estimate of the total mortality and serious injury incidental to U.S. commercial fisheries is unavailable because of the absence of observer placements in all salmon and herring fisheries. However, the minimum estimated mean annual mortality and serious injury rate incidental to all fisheries is 72 harbor porpoise from this stock (72 in U.S. commercial fisheries + 0.2 in unknown fisheries).

Alaska Native Subsistence/Harvest Information

Porpoise in the Gulf of Alaska were hunted by prehistoric societies in Kodiak, Cook Inlet, and Prince William Sound (Shelden et al. 2014). Subsistence hunters have not been reported to harvest from this stock of harbor porpoise since the early 1900s (Shelden et al. 2014).

STATUS OF STOCK

Harbor porpoise are not designated as depleted under the MMPA or listed as threatened or endangered under the Endangered Species Act. Because the PBR is undetermined, it is unknown if the minimum estimate of the mean annual U.S. commercial fishery-related mortality and serious injury rate (72 porpoise) can be considered insignificant and approaching zero mortality and serious injury rate. The total estimated annual level of human-caused mortality and serious injury is 72 harbor porpoise. Because the most recent abundance estimate is more than 8 years old and information on incidental harbor porpoise mortality and serious injury in commercial fisheries is not complete, the Gulf of Alaska stock of harbor porpoise is classified as a strategic stock. Population trends and status of this stock relative to its Optimum Sustainable Population are currently unknown.

HABITAT CONCERNS

Harbor porpoise are mostly found in nearshore areas, bays, tidal areas, and river mouths (Dahlheim et al. 2000, Hobbs and Waite 2010). As a result, harbor porpoise are vulnerable to physical modifications of nearshore habitats resulting from urban and industrial development (including waste management and nonpoint source runoff) and activities such as construction of docks and other over-water structures, filling of shallow areas, dredging, and noise (Linnenschmidt et al. 2013).

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HARBOR PORPOISE (*Phocoena phocoena*): Bering Sea Stock

NOTE – December 2015: In areas outside of Alaska, studies of harbor porpoise distribution have indicated that stock structure is likely more fine-scaled than is reflected in the Alaska Stock Assessment Reports. At this time, no data are available to define stock structure for harbor porpoise on a finer scale in Alaska. However, based on comparisons with other regions, it is likely that several regional and sub-regional populations exist. Should new information on harbor porpoise stocks become available, the harbor porpoise Stock Assessment Reports will be updated.

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the eastern North Pacific Ocean, the harbor porpoise ranges from Point Barrow and offshore areas of the Chukchi Sea, along the Alaska coast, and down the west coast of North America to Point Conception, California (Gaskin 1984, Christman and Aerts 2015). Harbor porpoise primarily frequent the coastal waters of the Gulf of Alaska and Southeast Alaska (Dahlheim et al. 2000, 2009), typically occurring in waters less than 100 m deep (Hobbs and Waite 2010). The average density of harbor porpoise in Alaska appears to be less than that reported off the west coast of the continental U.S., although areas of high densities do occur in Glacier Bay and the adjacent waters of Icy Strait, Yakutat Bay, the Copper River Delta, Sitkalidak Strait (Dahlheim et al. 2000, 2009, 2015; Hobbs and Waite 2010), and lower Cook Inlet (Shelden et al. 2014).

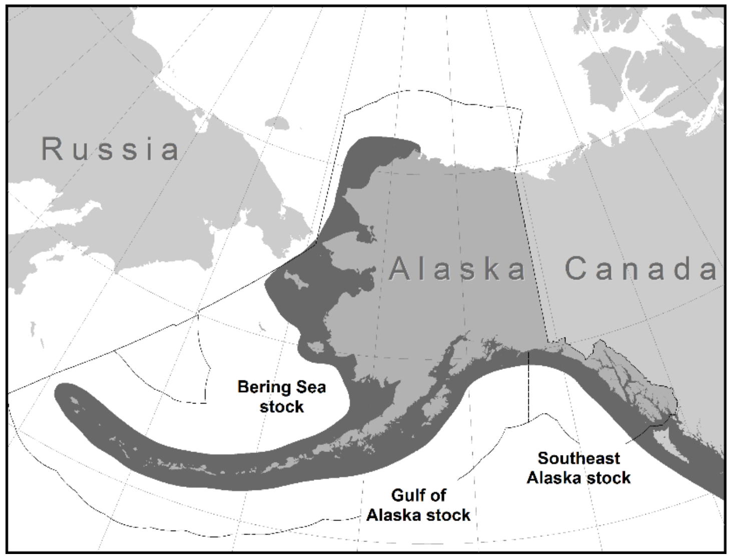

Figure 1. Approximate distribution of harbor porpoise in Alaska waters (dark shaded area).

Stock discreteness in the eastern North Pacific was analyzed using mitochondrial DNA from samples collected along the west coast (Rosel 1992), including one sample from Alaska. Two distinct mitochondrial DNA groupings or clades were found. One clade is present in California, Washington, British Columbia, and the single sample from Alaska (no samples were available from Oregon), while the other is found only in California and Washington. Although these two clades are not geographically distinct by latitude, the results may indicate a low mixing rate for harbor porpoise along the west coast of North America. Investigation of pollutant loads in harbor porpoise ranging from California to the Canadian border also suggests restricted harbor porpoise movements (Calambokidis and Barlow 1991); these results are reinforced by a similar study in the northwest Atlantic (Westgate and Tolley 1999). Further genetic testing of the same samples mentioned above, along with a few additional samples including eight more from Alaska, found differences between some of the four areas investigated, California, Washington, British Columbia, and Alaska, but inference was limited by small sample size (Rosel et al. 1995). Those results demonstrate that harbor porpoise along the west coast of North America are not panmictic and that movement is sufficiently restricted to result in genetic differences. This is consistent with low movement suggested by genetic analysis of harbor porpoise specimens from the North Atlantic (Rosel et al. 1999). Numerous stocks have been delineated with clinal differences over areas as small as the waters surrounding the British Isles (Walton 1997). In a molecular genetic analysis of small-scale population structure of eastern North Pacific harbor porpoise, Chivers et al. (2002) included 30 samples from Alaska, 16 of which were from Copper River Delta, 5 from Barrow, 5 from Southeast Alaska, and 1 sample each from St. Paul, Adak, Kodiak, and Kenai. Unfortunately, no conclusions could be drawn about the genetic structure of harbor porpoise within Alaska because of the insufficient number of samples from each region. Accordingly, harbor porpoise stock structure in Alaska is defined by geographic areas at this time.

Although it is difficult to determine the true stock structure of harbor porpoise populations in the northeast Pacific, from a management standpoint it would be prudent to assume that regional populations exist and that they should be managed independently (Rosel et al. 1995, Taylor et al. 1996). Accordingly, from the above information, three harbor porpoise stocks in Alaska were specified, recognizing that the boundaries of these three stocks were inferred primarily based upon geography or perceived areas of low porpoise density: 1) the Southeast Alaska stock - occurring from Dixon Entrance to Cape Suckling, Alaska, 2) the Gulf of Alaska stock - occurring from Cape Suckling to Unimak Pass, and 3) the Bering Sea stock - occurring throughout the Aleutian Islands and all waters north of Unimak Pass (Fig. 1). To date, there have been no analyses to assess the validity of these stock designations or to assess possible substructure within these stocks.

Harbor porpoise have been sighted during seismic surveys of the Chukchi Sea conducted in the nearshore and offshore waters by the oil and gas industry between July and November from 2006 to 2010 (Funk et al. 2010, 2011; Aerts et al. 2011; Reiser et al. 2011). Harbor porpoise were the third most frequently sighted cetacean species in the Chukchi Sea, after gray and bowhead whales, with most sightings occurring during the September-October monitoring period (Funk et al. 2011, Reiser et al. 2011). Over the 2006-2010 industry-sponsored monitoring period, six sightings of 11 harbor porpoise were reported in the Beaufort Sea, suggesting harbor porpoise regularly occur in both the Chukchi and Beaufort seas (Funk et al. 2011).

POPULATION SIZE

In June and July of 1999, an aerial survey covered the waters of Bristol Bay. Two types of corrections were needed for these aerial surveys: one for observer perception bias to correct for animals not counted because they were not observed and one to correct for porpoise availability/visibility at the surface. The 1999 survey resulted in an observed abundance estimate for the Bering Sea harbor porpoise stock of 16,289 (CV = 0.132; Hobbs and Waite 2010), which includes the perception bias correction factor (1.337; CV = 0.062) obtained during the survey using an independent belly window observer. Laake et al. (1997) estimated the availability bias for aerial surveys of harbor porpoise in Puget Sound to be 2.96 (CV = 0.180); the use of this correction factor is preferred to other published correction factors (e.g., Barlow et al. 1988, Calambokidis et al. 1993) because it is an empirical estimate of availability bias. However the Laake et al. (1997) correction results from a different area and should be replaced with a correction derived from data collected in Alaska. Applying this second correction factor, the corrected abundance estimate is 48,215 (16,289 × 2.96 = 48,215; CV = 0.223). The estimate for 1999 can be considered conservative for that time period, as the surveyed areas did not include known harbor porpoise range along the Aleutian Island chain, near the Pribilof Islands, or in the waters north of Cape Newenham (approximately 59°N).

Shipboard visual line-transect surveys for cetaceans were conducted on the eastern Bering Sea shelf in association with pollock stock assessment surveys in June and July of 1999, 2000, 2002, 2004, 2008, and 2010 (Moore et al. 2002; Friday et al. 2012, 2013). The entire range of the survey was completed in three of those years (2002, 2008, and 2010) and harbor porpoise abundance estimates were calculated for each of these surveys (Friday et al. 2013); however, correction factors were not applied for perception bias, availability bias, or responsive movement to the ship. The abundance estimate was 1,971 (CV = 0.46) for 2002, 4,056 (CV = 0.40) for 2008, and 833 (CV = 0.66) for 2010. Although the 2010 estimate is the lowest of the three years, it is not significantly different from the 2002 and 2008 estimates (Friday et al. 2013). These surveys are useful for showing distribution throughout the southeastern Bering Sea and the relationship to hydrographic domains; however, because the surveys were not designed for harbor porpoise and no correction factors are available, the abundance estimates are not used to calculate a population estimate.

Minimum Population Estimate

The minimum population estimate (N_{MIN}) for this stock is calculated using Equation 1 from the potential biological removal (PBR) guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the 1999 partial population estimate (N) of 48,215 and its associated coefficient of variation (CV) of 0.223, N_{MIN} for the Bering Sea stock of harbor porpoise is 40,039 (Hobbs and Waite 2010). However, because the survey data are more than 8 years old, N_{MIN} is considered unknown.

Current Population Trend

There is no reliable information on current trends in abundance for the Bering Sea stock of harbor porpoise.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not available for this stock of harbor porpoise. Hence, until additional data become available, it is recommended that the cetacean maximum theoretical net productivity rate of 4% be employed (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for cetacean stocks with unknown population status (Wade and Angliss 1997). However, the 2005 revisions to the Stock Assessment Report guidelines (Wade and Angliss 1997) state that abundance estimates older than 8 years should not be used to calculate PBR due to a decline in confidence in the reliability of an aged abundance estimate (NMFS 2005). Therefore, the PBR for this stock is considered undetermined.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information on U.S. commercial fisheries in Alaska waters (including observer programs, observer coverage, and observed incidental takes of marine mammals) is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

No mortality or serious injury of Bering Sea harbor porpoise was observed incidental to U.S. commercial fisheries during 2010-2014 (Breiwick 2013; MML, unpubl. data).

One harbor porpoise mortality due to entanglement in a commercial salmon gillnet in Kotzebue, Alaska, was reported to the NMFS Alaska Region stranding network in 2013 (Table 1; Helker et al. 2016), resulting in a minimum average annual mortality and serious injury rate of 0.2 Bering Sea harbor porpoise in U.S. commercial fisheries in 2010-2014 (Table 1). A complete estimate of the total mortality and serious injury rate incidental to U.S. commercial fisheries is currently unavailable because of the absence of observer placements in all of the salmon and herring fisheries.

In 2012, one harbor porpoise entangled in a subsistence salmon gillnet in Nome, Alaska (Helker et al. 2016), resulting in a minimum average annual mortality and serious injury rate of 0.2 harbor porpoise due to subsistence fishery interactions in 2010-2014 (Table 1).

Table 1. Summary of incidental mortality and serious injury of Bering Sea harbor porpoise, by year and type, reported to the NMFS Alaska Region marine mammal stranding network in 2010-2014 (Helker et al. 2016). Only cases of serious injury were recorded in this table; animals with non-serious injuries have been excluded.

Cause of injury	2010	2011	2012	2013	2014	Mean annual mortality
Entangled in Kotzebue commercial salmon set gillnet	0	0	0	1	0	0.2
Entangled in Nome subsistence salmon gillnet	0	0	1	0	0	0.2
Total in commercial fisheries						0.2
Total in subsistence fisheries						0.2

Alaska Native Subsistence/Harvest Information

Subsistence hunters in Alaska have not been reported to hunt from this stock of harbor porpoise; however, when porpoise are caught incidental to subsistence or commercial fisheries, subsistence hunters may claim the carcass for subsistence use (R. Suydam, North Slope Borough, pers. comm.).

STATUS OF STOCK

Harbor porpoise are not designated as depleted under the MMPA or listed as threatened or endangered under the Endangered Species Act. Because the PBR is undetermined, the mean annual U.S. commercial fishery-related mortality and serious injury rate that can be considered insignificant and approaching zero mortality and serious injury rate is unknown; a minimum estimate of the current rate (from stranding data) is 0.2 harbor porpoise; however, most of the fisheries likely to interact with this stock of harbor porpoise have never been monitored. A minimum estimate of the total annual level of human-caused mortality and serious injury is 0.4 harbor porpoise; however, the estimated annual level of human-caused mortality and serious injury relative to PBR is unknown. Because the abundance estimates are more than 8 years old and information on incidental mortality and serious injury in commercial fisheries is sparse, the Bering Sea stock of harbor porpoise is classified as a strategic stock. Population trends and status of this stock relative to its Optimum Sustainable Population are currently unknown.

HABITAT CONCERNS

Harbor porpoise are found over the shelf waters of the southeastern Bering Sea (Dahlheim et al. 2000, Hobbs and Waite 2010). In the nearshore waters of this region, harbor porpoise are vulnerable to physical modifications of nearshore habitats resulting from urban and industrial development (including waste management and nonpoint source runoff) and activities such as construction of docks and other over-water structures, filling of shallow areas, dredging, and noise (Linnenschmidt et al. 2013). Climate change and changes to sea-ice coverage may be opening up new habitats, or resulting in shifts in habitat, as evident by an increase in the number of reported sightings of harbor porpoise in the Chukchi Sea (Funk et al. 2010, 2011). Shipping and noise from oil and gas activities may also be a habitat concern for harbor porpoise, particularly in the Chukchi Sea.

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DALL'S PORPOISE (*Phocoenoides dalli*): Alaska Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Dall's porpoise are widely distributed across the entire North Pacific Ocean (Fig. 1). They are found over the continental shelf adjacent to the slope and over deep (2,500+ m) oceanic waters (Hall 1979). They have been sighted throughout the North Pacific as far north as 65°N (Buckland et al. 1993) and as far south as 28°N in the eastern North Pacific (Leatherwood and Fielding 1974). The only apparent distribution gaps in Alaska waters are upper Cook Inlet and the shallow eastern flats of the Bering Sea. Throughout most of the eastern North Pacific they are present during all months of the year, although there may be seasonal onshore-offshore movements along the west coast of the continental U.S. (Loeb 1972, Leatherwood and Fielding 1974) and winter movements of populations out of areas with ice such as Prince William Sound (Hall 1979).

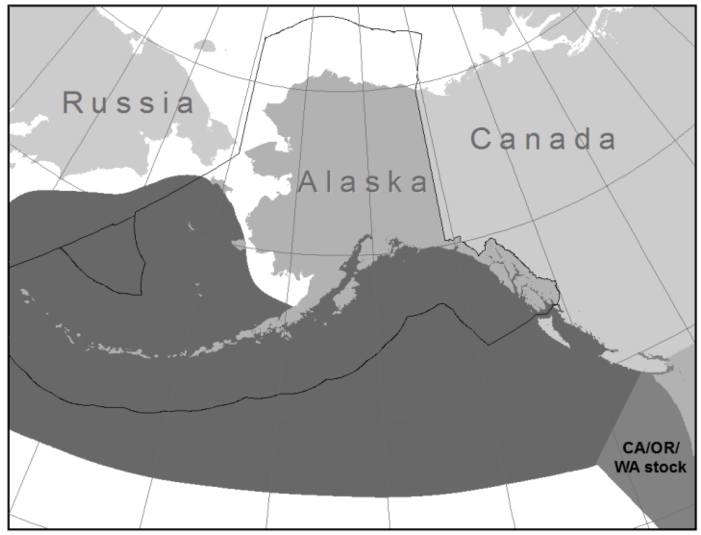

Figure 1. Approximate distribution of Dall's porpoise in Alaska waters (dark shaded area).

Surveys on the eastern Bering Sea shelf and slope to the 1,000 m isobath in 1999, 2000, 2002, 2004, 2008, and 2010 provided information about the distribution and relative abundance of Dall's porpoise in this area (Moore et al. 2002; Friday et al. 2012, 2013). Dall's porpoise were sighted on the shelf and slope in waters deeper than 100 m in 2002, 2008, and 2010 with greater densities at the shelf break than in shallower waters (Friday et al. 2013).

The following information was considered in classifying stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution continuous; 2) Population response data: differential timing of reproduction between the Bering Sea and western North Pacific; 3) Phenotypic data: unknown; and 4) Genotypic data: unknown. The stock structure of eastern North Pacific Dall's porpoise is not adequately understood at this time, but based on patterns of stock differentiation in the western North Pacific, where they have been more intensively studied, it is expected that separate stocks will emerge when data become available (Perrin and Brownell 1994). Based primarily on the population response data (Jones et al. 1986) and preliminary genetics analyses (Winans and Jones 1988), a delineation between Bering Sea and western North Pacific stocks has been recognized. However, similar data are not available for the eastern North Pacific; thus, one stock of Dall's porpoise is recognized in Alaskan waters. Dall's porpoise along the west coast of the continental U.S. from California to Washington comprise a separate stock and are reported separately in the Stock Assessment Reports for the U.S. Pacific Region.

POPULATION SIZE

Data collected from vessel surveys, performed by both U.S. fishery observers and U.S. researchers from 1987 to 1991, were analyzed to provide population estimates of Dall's porpoise throughout the North Pacific and the Bering Sea (Hobbs and Lerczak 1993). The quality of data used in analyses was determined by the procedures recommended by Boucher and Boaz (1989). Survey effort was not well distributed throughout the U.S. Exclusive Economic Zone (EEZ) in Alaska and, as a result, Bristol Bay and the northern Bering Sea received little survey effort. Only three sightings were reported between 1987 and 1991 in this area by Hobbs and Lerczak (1993), resulting in an estimate of 9,000 (CV = 0.91). In the U.S. EEZ north and south of the Aleutian Islands, Hobbs and Lerczak (1993) reported an estimated abundance of 302,000 (CV = 0.11), whereas, for the Gulf of Alaska EEZ, they reported 106,000 (CV = 0.20). Combining these three estimates (9,000 + 302,000 + 106,000) results in a total abundance estimate of 417,000 (CV = 0.097) for the Alaska stock of Dall's porpoise. Turnock and Quinn (1991) estimate that abundance estimates of Dall's porpoise are inflated by as much as five times because of vessel attraction behavior. Therefore, a corrected population estimate from 1987-1991 is 83,400 (417,000 × 0.2) for this stock. Surveys for this stock are more than 8 years old, consequently there are no reliable abundance data for the Alaska stock of Dall's porpoise. No reliable abundance estimates for British Columbia are currently available.

Sighting surveys for cetaceans were conducted during NMFS pollock stock assessment surveys in 1999, 2000, 2002, 2004, 2008, and 2010 on the eastern Bering Sea shelf (Moore et al. 2002; Friday et al. 2012, 2013). The entire range of the survey was completed in three of those years (2002, 2008, and 2010) and Dall's porpoise estimates were calculated for each of these surveys (Friday et al. 2013). The abundance estimate was 35,303 (CV = 0.53) in 2002, 14,543 (CV = 0.32) in 2008, and 11,143 (CV = 0.32) in 2010. Although the 2010 estimate is the lowest of the three years, it is not significantly different from the 2002 and 2008 estimates (Friday et al. 2013). These estimates have not been corrected for animals missed on the trackline (perception bias) or animals submerged when the ship passed (availability bias). They are also uncorrected for potential biases from responsive movements (ship attraction) and are, therefore, not used as minimum population estimates.

Minimum Population Estimate

The minimum population estimate (N_{MIN}) for this stock is calculated using Equation 1 from the potential biological removal (PBR) guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. However, since the abundance estimate is based on data older than 8 years, the N_{MIN} is considered unknown.

Current Population Trend

At present, there is no reliable information on trends in abundance for the Alaska stock of Dall's porpoise.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is not currently available for the Alaska stock of Dall's porpoise. Hence, until additional data become available, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% be employed for the Alaska stock of Dall's porpoise (Wade and Angliss 1997). However, based on life-history analyses in Ferrero and Walker (1999), Dall's porpoise reproductive strategy is not consistent with the delphinid pattern on which the default R_{MAX} for cetaceans is based. In contrast to the delphinids, Dall's porpoise mature earlier and reproduce annually which suggest that a higher R_{MAX} may be warranted.

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. Wade and Angliss (1997) recommend that abundance estimates older than 8 years no longer be used to calculate a PBR level; thus, because the abundance estimate for this stock is more than 8 years old, the N_{MIN} is unknown and therefore the PBR level is undetermined.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*." Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fisheries Information

Detailed information (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

Until 2003, there were six different federally-regulated commercial fisheries in Alaska that could have interacted with Dall's porpoise and were monitored for incidental mortality and serious injury by fishery observers. As of 2003, changes in fishery definitions in the MMPA List of Fisheries have resulted in separating these 6 fisheries into 22 fisheries (69 FR 70094, 2 December 2004). This change does not represent a change in fishing effort but provides managers with better information on the component of each fishery that is responsible for the incidental serious injury or mortality of marine mammal stocks in Alaska. For the fisheries with observed takes, the range of observer coverage in 2009-2013, as well as the annual observed and estimated mortality and serious injury, are presented in Table 1.

The Alaska Peninsula/Aleutian Islands salmon drift gillnet fishery was monitored in 1990 (Wynne et al. 1991). One Dall's porpoise mortality was observed, which extrapolated to an annual (total) incidental mortality and serious injury rate of 28 Dall's porpoise (Table 1).

In 2012 and 2013, the Alaska Marine Mammal Observer Program (AMMOP) placed observers on independent vessels in the state-managed Southeast Alaska salmon drift gillnet fishery to assess mortality and serious injury of marine mammals. Areas around and adjacent to Wrangell and Zarembo Islands (ADF&G Districts 6, 7, and 8) were observed during the 2012-2013 program (Manly 2015). In 2012, one Dall's porpoise was seriously injured. Based on the one observed serious injury, 18 serious injuries were estimated for Districts 6, 7, and 8 in 2012, resulting in an estimated mean annual mortality and serious injury rate of 9 Dall's porpoise in 2012-2013 (Table 1). Since these three districts represent only a portion of the overall fishing effort in this fishery, we expect this to be a minimum estimate of mortality for the fishery. Note that the AMMOP has not observed the Southeast Alaska salmon drift gillnet fishery in the other districts; additionally, NMFS has not observed several other gillnet fisheries that are known to interact with this stock, therefore, the total estimated mortality and serious injury is unavailable. However, due to the large stock size, it is unlikely that unreported mortality and serious injury from those fisheries are a significant source of mortality. Combining the estimates from the Bering Sea and Gulf of Alaska fisheries (0.5) with the estimate from the Alaska Peninsula/Aleutian Islands salmon drift gillnet fishery (28) and the Southeast Alaska salmon drift gillnet fishery (9) results in an estimated average annual mortality and serious injury rate in observed fisheries of 38 Dall's porpoise from this stock.

Table 1. Summary of incidental mortality and serious injury of the Alaska stock of Dall's porpoise due to U.S. commercial fisheries from 2009 to 2013 (or the most recent data available) and calculation of the mean annual mortality and serious injury rate (Wynne et al. 1991; Breiwick 2013; Manly 2015; NMML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Is. pollock trawl	2009 2010 2011 2012 2013	obs data	86 86 98 98 97	1 0 0 0 0	1.04 0 0 0 0	0.2 (CV = 0.19)
Bering Sea/Aleutian Is. Pacific cod longline	2009 2010 2011 2012 2013	obs data	60 64 57 51 67	1 0 0 0 0	1.5 0 0 0 0	0.3 (CV = 0.77)
SE Alaska salmon drift gillnet (Districts 6, 7, 8)	2012 2013	obs data	6.4 6.6	1 0	18 0	9 (CV = 1.0)
AK Peninsula/Aleutian Is. salmon drift gillnet	1990	obs data	4	1	28	28 (CV = 0.585)
Minimum total estimated annual mortality						38 (CV = 0.498)

From 2009 to 2013, no mortality or serious injury of Dall's porpoise was reported to the NMFS Alaska Region stranding database (Helker et al. 2015).

Alaska Native Subsistence/Harvest Information

There are no reports of subsistence take of Dall's porpoise in Alaska.

STATUS OF STOCK

Dall's porpoise are not designated as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act. The level of human-caused mortality and serious injury (38) is not known to exceed the PBR, which is undetermined as the most recent abundance estimate is more than 8 years old. Because the PBR is undetermined, the annual level of U.S. commercial fishery-related mortality and serious injury that can be considered insignificant and approaching zero mortality and serious injury rate is unknown. The Alaska stock of Dall's porpoise is not classified as a strategic stock. Population trends and status of this stock relative to its Optimum Sustainable Population are currently unknown.

HABITAT CONCERNS

While the majority of Dall's porpoise are found throughout the North Pacific, there are also significant numbers found in shelf break and deeper nearshore areas. Thus, they are subject to a variety of habitat impacts. Of particular concern are nearshore areas, bays, channels, and inlets where some Dall's porpoise are vulnerable to physical modifications of nearshore habitats (resulting from urban and industrial development, including waste management and nonpoint source runoff) and noise (Linnenschmidt et al. 2013). Climate change and changes to sea-ice coverage may be opening up new habitats, or resulting in shifts in habitat, as evident by an increase in the number of reported sightings of Dall's porpoise in the Chukchi Sea (Funk et al. 2010, 2011). Shipping and noise from oil and gas activities may also be a habitat concern for Dall's porpoise, particularly in the Chukchi Sea.

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SPERM WHALE (*Physeter macrocephalus*): North Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The sperm whale is one of the most widely distributed marine mammal species, perhaps exceeded in its global range only by the killer whale (Rice 1989). In the North Pacific Ocean, sperm whales were depleted by extensive commercial whaling over a period of more than a hundred years, and the species was the primary target of illegal Soviet whaling in the second half of the 20th century (Ivashchenko et al. 2013, 2014). Systematic illegal catches were also made on a large scale by Japan in at least the late 1960s (Ivashchenko and Clapham 2015).

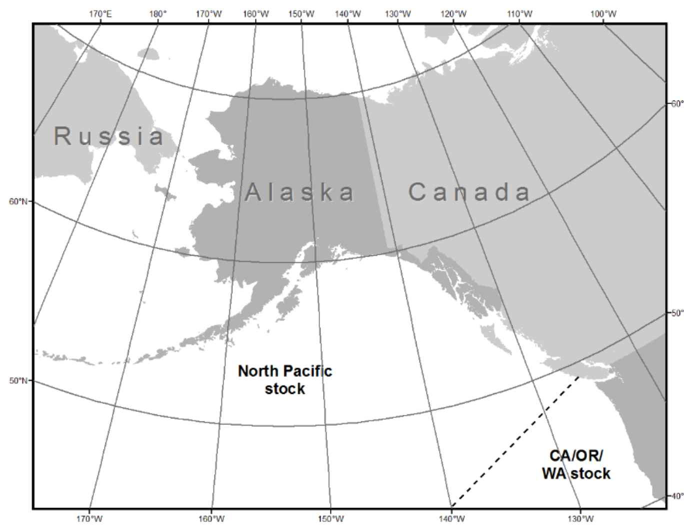

Figure 1. The approximate distribution of sperm whales in the North Pacific includes deep waters south of 62°N to the equator.

Sperm whales feed primarily on medium-sized to large-sized squids but also take substantial quantities of large demersal and mesopelagic sharks, skates, and fishes (Rice 1989). In the North Pacific, sperm whales are distributed widely (Fig. 1), with the northernmost boundary extending from Cape Navarin (62°N) to the Pribilof Islands (Omura 1955). Although females and young sperm whales were thought to remain in tropical and temperate waters year-round, Mizroch and Rice (2006) and Ivashchenko et al. (2014) showed that there were extensive catches of female sperm whales above 50°N, in the western Bering Sea and in the western Aleutian Islands. Mizroch and Rice (2013) also showed female movements into the Gulf of Alaska and western Aleutians. Males are found in the summer in the Gulf of Alaska, Bering Sea, and waters around the Aleutian Islands (Kasuya and Miyashita 1988, Mizroch and Rice 2013, Ivashchenko et al. 2014). Sighting surveys conducted by the Alaska Fisheries Science Center's Marine Mammal Laboratory (MML) in the summer months between 2001 and 2010 have found sperm whales to be the most frequently sighted large cetacean in the coastal waters around the central and western Aleutian Islands (MML, unpubl. data). Acoustic surveys detected the presence of sperm whales year-round in the Gulf of Alaska, although they appear to be more common in summer than in winter (Mellinger et al. 2004). These seasonal detections are consistent with the hypothesis that sperm whales move to higher latitudes in summer and to lower latitudes in winter (Whitehead and Arnbom 1987).

Mizroch and Rice (2013) examined 261 Discovery mark recoveries from the days of commercial whaling and found extensive movements from U.S. and Canadian coastal waters into the Gulf of Alaska and Bering Sea. The U.S. marked 176 sperm whales from 1962 to 1969 off southern California and northern Baja California (Mizroch and Rice 2013). Seven of those marked whales were recovered in locations ranging from offshore California, Oregon, and British Columbia waters to the western Gulf of Alaska. A male whale marked by Canadian researchers moved from near Vancouver Island, British Columbia, to the Aleutian Islands near Adak. A whale marked by Soviet researchers moved from coastal Michoacán, mainland Mexico, to a location about 1,300 km offshore of Washington State. Similar extensive movements have also been demonstrated by recent satellite-tagging studies (Straley et al. 2014). Three adult males satellite-tagged off southeastern Alaska moved far south, one to coastal Baja California, one into the north-central Gulf of California, and the third to a location near the Mexico-Guatemala border (Straley et al. 2014). Marking data show extensive movements throughout the North Pacific and along the U.S. west coast into the Gulf of Alaska and Bering Sea/Aleutian Islands region.

Mizroch and Rice (2013) also analyzed whaling data and found that males and females concentrated seasonally along oceanic frontal zones, for example, in the subtropical frontal zone (ca. 28-34°N) and the subarctic frontal zones (ca. 40-43°N). Males also concentrated seasonally near the Aleutian Islands and along the Bering Sea shelf edge. Their analyses of marking and whaling data indicate that there are no apparent divisions between separate demes or stocks within the North Pacific. Analysis of Soviet catch data by Ivashchenko et al. (2014) showed broad agreement with these results, although a sharp division was evident at Amchitka Pass in the Aleutians, with mature males to the east and males and family groups to the west, including in the Commander Islands. There were four main areas of concentration in the Soviet catches: a large pelagic area (30-50°N) in the eastern North Pacific, including the Gulf of Alaska and western coast of North America; the northeastern and southwestern central North Pacific; and the southern Kuril Islands. Some of the catch distribution was similar to that of 19th-century Yankee whaling catches plotted by Townsend (1935), notably in the "Japan Ground" (in the pelagic western Pacific) and the "Coast of Japan Ground." Many females were caught in Olyutorsky Bay (western Bering Sea) and around the Commander Islands.

The following information was considered in classifying stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: no apparent discontinuities based on whale marking data; 2) Population response data: unknown; 3) Phenotypic data: unknown; and 4) Genotypic data: genetic studies indicate the possibility of a "somewhat" discrete U.S. coastal stock (Mesnick et al. 2011). For management purposes, the International Whaling Commission (IWC) recognizes two management units of sperm whales in the North Pacific (eastern and western). However, the IWC has not reviewed its sperm whale stock boundaries in recent years (Donovan 1991). For management purposes, three stocks of sperm whales are currently recognized in U.S. waters: 1) Alaska (North Pacific stock), 2) California/Washington/Oregon, and 3) Hawaii. Information from Mizroch and Rice (2013) suggests that this structure should be reviewed and updated to reflect current data. The California/Oregon/Washington and Hawaii sperm whale stocks are reported separately in the Stock Assessment Reports for the U.S. Pacific Region.

POPULATION SIZE

Current and historical estimates of the abundance of sperm whales in the North Pacific are considered unreliable, and caution should be exercised in interpreting published estimates. The abundance of sperm whales in the North Pacific was reported to be 1,260,000 prior to exploitation, which by the late 1970s was estimated to have been reduced to 930,000 whales (Rice 1989). Confidence intervals for these estimates were not provided. These estimates include whales from the California/Oregon/Washington stock, for which a separate abundance estimate is currently available (see the Stock Assessment Reports for the U.S. Pacific Region). Estimates for a large area of the eastern temperate North Pacific were produced from line-transect and acoustic survey data by Barlow and Taylor (2005), but no recent estimate exists for other areas, including for the central or western North Pacific.

Although Kato and Miyashita (1998) believe their estimate to be positively biased, their analysis suggested 102,112 (CV = 0.155) sperm whales in the western North Pacific. The number of sperm whales occurring within Alaska waters is unknown.

As the data used in estimating the abundance of sperm whales in the entire North Pacific are more than 8 years old, and there are no available estimates for numbers of sperm whales in Alaska waters, a reliable estimate of abundance for the North Pacific stock is not available.

Minimum Population Estimate

At this time, it is not possible to produce a reliable estimate of minimum abundance for this stock, as a current estimate of abundance is not available.

Current Population Trend

No current estimate of abundance exists for this stock; therefore, reliable information on trends in abundance for this stock is currently not available (Braham 1992).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is not currently available for the North Pacific stock of sperm whales. Hence, until additional data become available, it is recommended that the cetacean maximum net productivity rate (R_{MAX}) of 4% be employed for this stock at this time (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate (N_{MIN}), one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.1, the value for cetacean stocks which are classified as endangered (Wade and Angliss 1997). However, because a reliable estimate of N_{MIN} is currently not available, the PBR for this stock is unknown.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

In 2010-2014, there were five serious injuries of sperm whales observed in the Gulf of Alaska sablefish longline fishery (two each in 2012 and 2013 and one in 2014). Each of these injuries was prorated at a value of 0.75, resulting in a minimum average annual estimated mortality and serious injury rate of 2.2 sperm whales in U.S. commercial fisheries in 2010-2014 (Table 1; Breiwick 2013; MML, unpubl. data).

Table 1. Summary of incidental mortality and serious injury of North Pacific sperm whales due to U.S. commercial fisheries in 2010-2014 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Gulf of Alaska sablefish longline	2010 2011 2012 2013 2014	obs data	15 14 14 14 19	0 0 1.5 0.75 (+0.75)[a] 0 (+0.75)[c]	0 0 3.4 6.2 (+0.75)[b] 0 (+0.75)[d]	1.9 (+0.3)[e] (CV = 0.63)
Minimum total estimated annual mortality						2.2 (CV = 0.63)

[a]Total mortality and serious injury observed in 2013: 0.75 whales in sampled hauls + 0.75 whales in an unsampled haul.
[b]Total estimate of mortality and serious injury in 2013: 6.2 whales (extrapolated estimate from 0.75 whales observed in sampled hauls) + 0.75 whales (0.75 whales observed in an unsampled haul).
[c]Total mortality and serious injury observed in 2014: 0 whales in sampled hauls + 0.75 whales in an unsampled haul.
[d]Total estimate of mortality and serious injury in 2014: 0 whales (extrapolated estimate from 0 whales observed in sampled hauls) + 0.75 whales (0.75 whales observed in an unsampled haul).
[e]Mean annual mortality and serious injury for fishery: 1.9 whales (mean of extrapolated estimates from sampled hauls) + 0.3 whales (mean of number observed in unsampled hauls).

Alaska Native Subsistence/Harvest Information

Sperm whales have never been reported to be taken by subsistence hunters (Rice 1989).

Other Mortality

Sperm whales were the dominant species killed by the commercial whaling industry as it developed in the North Pacific in the years after World War II (Mizroch and Rice 2006, Ivashchenko et al. 2014). Between 1946 and 1967, most of the sperm whales were caught in waters near Japan and in the Bering Sea/Aleutian Islands (BSAI) region. The BSAI catches were dominated by males. After 1967, whalers moved out of the BSAI region and began to catch even larger numbers of sperm whales further south in the North Pacific between 30° and 50°N (Mizroch and Rice 2006: Figs. 7-9). The reported catch of sperm whales taken by commercial whalers operating in the North Pacific between 1912 and 2006 was 261,148 sperm whales, of which, 259,120 were taken between 1946 and 1987 (IWC, Bureau of International Whaling Statistics (BIWS) catch data, February 2008 version, unpubl.). This value underestimates the actual kill in the North Pacific as a result of under-reporting by U.S.S.R. and Japanese pelagic whaling operations. Berzin (2008) described extreme under-reporting and misreporting of Soviet sperm whale catches from the mid-1960s into the early 1970s, including enormous (and under-reported) whaling pressure on female sperm whales in the latter years of whaling. More recently, Ivashchenko et al. (2013, 2014) estimate that 157,680 sperm whales were killed by the U.S.S.R. in the North Pacific between 1948 and 1979, of which 25,175 were unreported; the Soviets also extensively misreported the sex and length of catches. In addition, it is known that Japanese land-based whaling operations also misreported the number and sex of sperm whale catches during the post-World War II era (Kasuya 1999), and other studies indicate that falsifications also occurred on a large scale in the Japanese pelagic fishery (Cooke et al. 1983, Ivashchenko and Clapham 2015). The last year that the U.S.S.R. reported catches of sperm whales was in 1979 and the last year that Japan reported substantial catches was in 1987, but Japanese whalers reported catches of 48 sperm whales between 2000 and 2009 (IWC, BIWS catch data, October 2010 version, unpubl.). Although the Soviet data on catches of this species in the North Pacific have now been largely corrected (Ivashchenko et al. 2013), the North Pacific sperm whale data in the IWC's Catch Database (Allison 2012) are known to be unreliable because of falsified catch information from both the Japanese coastal and pelagic fisheries (Kasuya 1999, Ivashchenko and Clapham 2015).

From 2010 to 2014, one suspected human-related sperm whale mortality was reported to the NMFS Alaska Region stranding network (Helker et al. 2016). A beachcast sperm whale was found in 2012 on a beach near Yakutat with a net from an unknown fishery wrapped around its lower jaw. However, due to the advanced decomposition of this whale, the cause of death could not be determined.

Other Issues

NMFS observers aboard longline vessels targeting both sablefish and halibut have documented sperm whales feeding off longline gear in the Gulf of Alaska (Hill and Mitchell 1998, Hill et al. 1999, Perez 2006, Sigler et al. 2008). Fishery observers recorded several instances during 1995-1997 in which sperm whales were deterred by fishermen (i.e., yelling at the whales or throwing seal bombs in the water).

Annual longline surveys have been recording sperm whale predation on catch since 1998 (Hanselman et al. 2008). Sperm whale depredation in the sablefish longline fishery is widespread in the central and eastern Gulf of Alaska but rarely observed in the Bering Sea; the majority of interactions occur in the West Yakutat and East Yakutat/Southeast Alaska areas (Perez 2006, Hanselman et al. 2008). Sigler et al. (2008) analyzed catch data from 1998 to 2004 and found that catch rates were about 2% less at locations where depredation occurred, but the effect was not significant ($p = 0.34$). Hill et al. (1999) analyzed data collected by fisheries observers in Alaska waters and also found no significant effect on catch. A small, significant effect on catch rates was found in a study using data collected in Southeast Alaska, in which longline fishery catches in sets with sperm whales present were compared to catches in sets with sperm whales absent (3% reduction, t-test, 95% CI of 0.4-5.5%, $p = 0.02$: Straley et al. 2005). Undamaged catches may also occur when sperm whales are present; in these cases, sperm whales apparently feed off the discard.

STATUS OF STOCK

Sperm whales are listed as endangered under the Endangered Species Act of 1973, and therefore designated as depleted under the MMPA. As a result, this stock is classified as a strategic stock. However, on the basis of total abundance, current distribution, and regulatory measures that are currently in place, it is unlikely that this stock is in danger of extinction (Braham 1992). Reliable estimates of the minimum population, population trends, PBR, and status of the stock relative to its Optimum Sustainable Population are currently not available. A minimum estimate of the total annual level of human-caused mortality and serious injury is 2.2 whales. Because the PBR is unknown, it is not known if the minimum estimate of the mean annual U.S. commercial fishery-related mortality and serious injury rate (2.2 whales) can be considered insignificant and approaching zero mortality and serious injury rate.

HABITAT CONCERNS

Potential habitat concerns for this stock include elevated levels of sound from anthropogenic sources (e.g., shipping, military exercises), possible changes in prey distribution and quality with climate change, entanglement in fishing gear, ship strikes due to increased vessel traffic (e.g., from increased shipping in higher latitudes), and oil and gas activities.

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BAIRD'S BEAKED WHALE (*Berardius bairdii*): Alaska Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Baird's beaked, or giant bottlenose, whale inhabits the North Pacific Ocean and adjacent seas (Bering Sea, Okhotsk Sea, Sea of Japan, and the Sea of Cortez in the southern Gulf of California, Mexico), with the best-known populations occurring in the coastal waters around Japan (Balcomb 1989) and the Commander Islands (Fedutin et al. 2012). Within the North Pacific Ocean, Baird's beaked whales have been sighted in virtually all areas north of 30°N in deep waters over the continental shelf, particularly in regions with submarine escarpments and seamounts (Ohsumi 1983, Kasuya and Ohsumi 1984, Kasuya 2002). The range of the species extends north from Cape Navarin (62° N) and the central Sea of Okhotsk (57° N) to St. Matthew Island, the Pribilof Islands in the Bering Sea, and the northern Gulf of Alaska (Rice 1986, Rice 1998, Kasuya 2002) (Fig. 1). An apparent break in distribution occurs in the eastern Gulf of Alaska, but from the mid-Gulf to the Aleutian Islands and in the southern Bering Sea there are numerous sighting records (Kasuya and Ohsumi 1984, Forney and Brownell 1996, Moore et al. 2002). In the Sea of Okhotsk and the Bering Sea, Baird's beaked whales arrive in April-May, are numerous during the summer, and decrease in October (Tomilin 1957, Kasuya 2002). Observations during 2007-2011 in the western Bering Sea were made in all months except winter (December to March) around the Commander Islands, with encounters peaking in April-June and to a lesser extent in August-November (Fedutin et al. 2012). During winter months, they are rarely found in offshore waters and their winter distribution is unknown (Kasuya 2002). However, acoustic detections of Baird's beaked whales from November through January (and no detections in July-October) in the northern Gulf of Alaska suggest that this region may be wintering habitat for some Baird's beaked whales (Baumann-Pickering et al. 2012b). There were no detections of this species from early June to late August 2010 off Kiska Island (Baumann-Pickering et al. 2012a). They are the most commonly seen beaked whales within their range, perhaps because they are relatively large and gregarious, traveling in schools of a few to several dozen, making them more noticeable to observers than other beaked whale species. Baird's beaked whales are migratory, arriving in continental slope waters during summer and fall months when surface water temperatures are the highest (Dohl et al. 1983, Kasuya 1986). Photo-identification analysis of animals sighted between 2007-2011 revealed resightings of some individuals around the Commander Islands and confirmed associations of individuals over several years in this species (Fedutin et al. 2012).

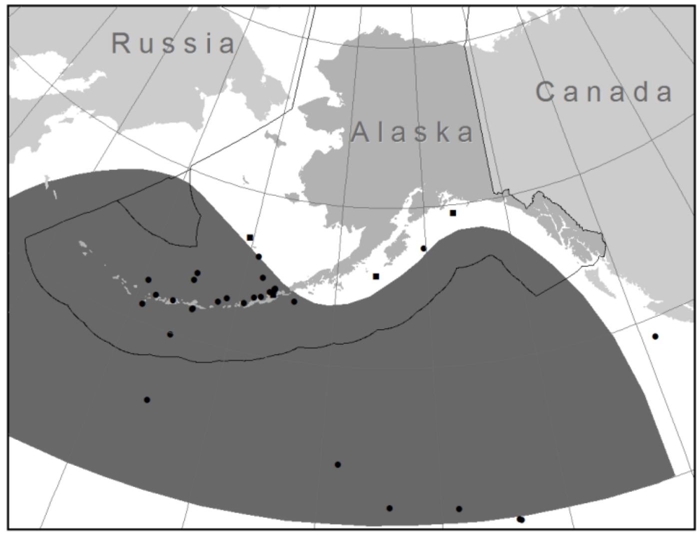

Figure 1. Approximate distribution of Baird's beaked whales in the eastern North Pacific (shaded area). Sightings (circles) and strandings (squares) within the last 10 years are also depicted. (Forney and Brownell 1996, Moore et al. 2002, NMFS unpublished data). Note: Distribution updated based on Kasuya 2002.

There are insufficient data to apply the phylogeographic approach to stock structure (Dizon et al. 1992) for Baird's beaked whale. Therefore, Baird's beaked whale stocks are defined as the two non-contiguous areas within Pacific U. S. waters where they are found: 1) Alaska and 2) California/Oregon/Washington. These two stocks were defined in this manner because of: 1) the large distance between the two areas in conjunction with the lack of any information about whether animals move between the two areas, 2) the somewhat different oceanographic habitats found in the two areas, and 3) the different fisheries that operate within portions of those two areas, with bycatch of Baird's beaked whales only reported from the California/Oregon thresher shark and swordfish drift gillnet fishery. The California/Oregon/Washington Baird's beaked whale stock is reported separately in the Stock Assessment Reports for the Pacific Region.

POPULATION SIZE

Reliable estimates of abundance for this stock are currently unavailable.

Minimum Population Estimate

At this time, it is not possible to produce a reliable minimum population estimate (N_{MIN}) for this stock, as current estimates of abundance are unavailable.

Current Population Trend

No reliable estimates of abundance are available for this stock; therefore, reliable data on trends in population abundance are unavailable.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for the Alaska stock of Baird's beaked whale. Hence, until additional data become available, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% be employed (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for these stocks is 0.5, the value for cetacean stocks with unknown population status (Wade and Angliss 1997). However, in the absence of a reliable estimate of minimum abundance, the PBR for this stock is unknown.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*." Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fisheries Information

Twenty-two different commercial fisheries operating within the potential range of the Alaska stock of Baird's beaked whale were monitored for incidental take by fisheries observers from 2007-2011 (see 76 FR 73912, final List of Fisheries for 2012) . There were no serious injuries or mortalities of Baird's beaked whales incidental to observed commercial fisheries reported between 2007-2011 (Breiwick 2013). The estimated annual mortality rate incidental to commercial fisheries is zero.

Subsistence/Native Harvest Information

There is no known subsistence harvest of Baird's beaked whales by Alaska Natives.

Other Mortality

Between 1925 and 1987, 618 Baird's beaked whales were reported taken throughout the North Pacific (International Whaling Commission, BWIS catch data, February 2003 version, unpublished). The annual quota of Baird's beaked whales for small-type whaling in Japan was 62 from 1999-2004, which increased temporarily to 66 from 2005-2010 and will remain a permanent increase (Kasuya 2011). Due to the unknown stock structure and migratory patterns in the North Pacific, it is unclear whether these animals belong to the Alaska stock of Baird's beaked whales.

STATUS OF STOCK

Baird's beaked whales are not designated as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act. Reliable estimates of the minimum population, population trends, PBR, and status of the stock relative to its Optimum Sustainable Population size are currently not available. Because the PBR is unknown, the level of annual U.S. commercial fishery-related mortality that can be considered insignificant and approaching zero mortality and serious injury rate is unknown. However, the estimated annual rate of human-caused mortality and serious injury seems minimal for this stock. Thus, the Alaska stock of Baird's beaked whale is not classified as strategic.

Habitat concerns

Disturbance by anthropogenic noise is an increasing habitat concern for most species of beaked whales, particularly in areas of oil and gas activities or where shipping or military activities are high. Shipping noise and the use of military sonars have been found to alter dive behavior and movements, as well as vocal activity in some species of beaked whales (Aguilar de Soto et al. 2006, McCarthy et al. 2011, Tyack et al. 2011). Little is known about the effects of noise on beaked whales in Alaska. Ingestion of marine debris, particularly plastics, is a concern; plastic is occasionally found in the stomach contents of stranded beaked whales, including Baird's beaked whales (Smithsonian Institution, Cetacean Distributional Database, accessed 04 June 2012).

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CUVIER'S BEAKED WHALE (*Ziphius cavirostris*): Alaska Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The distribution of Cuvier's beaked, or goosebeak, whale (Fig. 1) is known primarily from strandings, which indicate that it is the most widespread of the beaked whales and is distributed in all oceans and most seas except in the high polar waters (Moore 1963). In the Pacific, they range north to the northern Gulf of Alaska, the Aleutian Islands, and the Commander Islands (Rice 1986, 1998). In the northeastern Pacific from Alaska to Baja California, no obvious pattern of seasonality to strandings has been identified (Mitchell 1968). Strandings of Cuvier's beaked whales are the most numerous of all beaked whales, indicating that they are probably not as rare as originally thought (Heyning 1989). Observations reveal that the blow is low, diffuse, and directed forward (Backus and Schevill 1961, Norris and Prescott 1961), making sightings more difficult, and there is some evidence that they avoid vessels by diving (Heyning 1989). Relatively few (4 total) acoustic detections of Cuvier's beaked whales were recorded off Kiska Island (1 in summer) and in the offshore Gulf of Alaska (3 total detections, 1 in October and 2 in January; Baumann-Pickering et al. 2012a, 2012b).

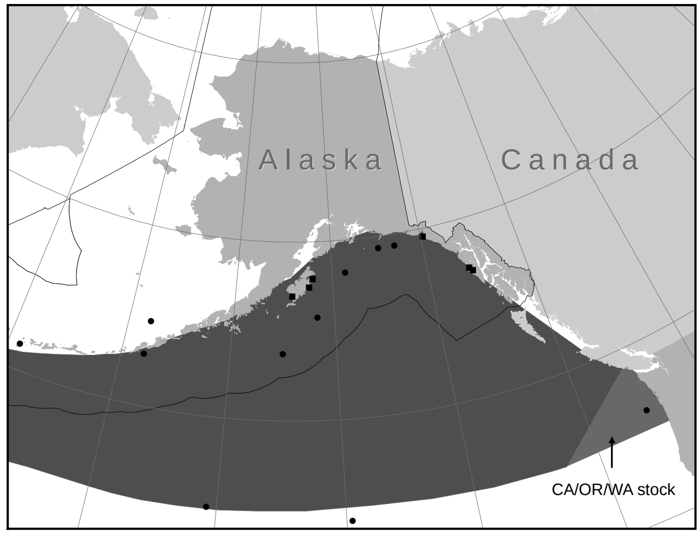

Figure 1. Approximate distribution of Cuvier's beaked whales in the eastern North Pacific (shaded area). Sightings (circles) and strandings (squares) within the last 10 years are also depicted (Forney and Brownell 1996, NMFS unpublished data).

Mitchell (1968) examined skulls of stranded whales for geographical differences and thought that there was probably one panmictic population in the northeastern Pacific. Otherwise, there are insufficient data to apply the phylogeographic approach to stock structure (Dizon et al. 1992) for the Cuvier's beaked whale. Therefore, Cuvier's beaked whale stocks are defined as the three non-contiguous areas within Pacific U. S. waters where they are found: 1) Alaska, 2) California/Oregon/Washington, and 3) Hawaii. These three stocks were defined in this way because of: 1) the large distance between the areas in conjunction with the lack of any information about whether animals move between the three areas, 2) the different oceanographic habitats found in the three areas, and 3) the different fisheries that operate within portions of those three areas, with bycatch of Cuvier's beaked whales only reported from the California/Oregon thresher shark and swordfish drift gillnet fishery. The California/Oregon/Washington and Hawaiian Baird's beaked whale stocks are reported separately in the Stock Assessment Reports for the Pacific Region.

POPULATION SIZE

Reliable estimates of abundance for this stock are currently unavailable.

Minimum Population Estimate

At this time, it is not possible to produce a reliable minimum population estimate (N_{MIN}) for this stock, as current estimates of abundance are unavailable.

Current Population Trend

No reliable estimates of abundance are available for this stock; therefore, reliable data on trends in population abundance are unavailable.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for the Alaska stock of Cuvier's beaked whale. Hence, until additional data become available, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% be employed (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for cetacean stocks with unknown population status (Wade and Angliss 1997). However, in the absence of a reliable estimate of minimum abundance, the PBR for this stock is unknown.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fisheries Information

Twenty-two different commercial fisheries operating within the potential range of the Alaska stock of Cuvier's beaked whale were monitored for incidental take by fishery observers from 2007-2011 (see 76 FR 73912, final List of Fisheries for 2012) . There were no serious injuries or mortalities of Cuvier's beaked whales incidental to observed commercial fisheries reported between 2007-2011 (Breiwick 2013). The estimated annual mortality rate incidental to commercial fisheries is zero.

Subsistence/Native Harvest Information

There is no known subsistence harvest of Cuvier's beaked whales.

Other Mortality

Unknown levels of injuries and mortality of Cuvier's beaked whales may occur as a result of anthropogenic noise, such as military sonars (U.S. Dept. of Commerce and Secretary of the Navy 2001) or other commercial and scientific activities producing high-energy sound. The use of active sonar from military vessels has been implicated or coincident with mass strandings of beaked whales (Cox et al. 2006, Frantzis 1998, Martel 2002, Jepson et al. 2003, Simmonds and Lopez-Jurado 1991, U.S. Dept. of Commerce and Secretary of the Navy 2001), and all atypical single and mixed-species mass strandings involved Cuvier's beaked whales (D'Amico et al. 2009). There is concern regarding the potential effects of underwater sounds from seismic operations on beaked whales, although investigations of causation of atypical strandings of Cuvier's beaked whales and nearby seismic air gun operations have been inconclusive (Gentry 2002, Gordon et al. 2003/2004, Malakoff 2002). Changes in dive behavior, particularly a quick ascent from deep dives, in response to sound exposure may result in injuries related to bubble growth during decompression (Cox et al. 2006, Tyack et al. 2011, Hooker et al. 2011). Such injuries or mortality would rarely be documented due to the remote nature of many of these activities and the low probability that an injured or dead beaked whale would strand. No estimates of potential mortality or serious injury are available for Cuvier's beaked whales in Alaska waters.

STATUS OF STOCK

Cuvier's beaked whales are not designated as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act. Reliable estimates of the minimum population, population trends, PBR, and status of the stock relative to its Optimum Sustainable Population size are currently not available. Because the PBR is unknown, the level of annual U.S. commercial fishery-related mortality that can be considered insignificant and approaching zero mortality and serious injury rate is unknown. However, the estimated annual rate of human-caused mortality and serious injury seems minimal for this stock. Thus, the Alaska stock of Cuvier's beaked whale is not classified as strategic.

Habitat concerns

Disturbance by anthropogenic noise is an increasing habitat concern for most species of beaked whales, particularly in areas of oil and gas activities or where shipping or military activities are high. Shipping noise may disrupt the behavior of Cuvier's beaked whales (Aguilar de Soto et al. 2006), and the use of military sonars has been found to alter dive behavior and movements, as well as vocal activity in some species of beaked whales (McCarthy et al. 2011, Tyack et al. 2011). Moore and Barlow (2013) report impacts of anthropogenic sound and ecosystem change as the most plausible hypotheses for declining abundance of *Ziphius* and *Mesoplodon* spp. in the California Current large marine ecosystem. Little is known about the effects of noise or ecosystem change on beaked whales in Alaska, and the lack of abundance estimates hinder the detection of any population trends. Ingestion of marine debris, particularly plastics, is a concern; plastic is occasionally found in the stomach contents of stranded beaked whales, including Cuvier's beaked whales. (Smithsonian Institution, Cetacean Distributional Database, accessed 04 June 2012).

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STEJNEGER'S BEAKED WHALE (*Mesoplodon stejnegeri*): Alaska Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Stejneger's, or Bering Sea, beaked whale is rarely seen at sea, and its distribution generally has been inferred from stranded specimens (Loughlin and Perez 1985, Mead 1989, Walker and Hanson 1999). It is endemic to the cold-temperate waters of the North Pacific Ocean, Sea of Japan, and deep waters of the southwest Bering Sea (Fig. 1). The range of Stejneger's beaked whale extends along the coast of North America from Cardiff, California, north through the Gulf of Alaska to the Aleutian Islands, into the Bering Sea to the Pribilof Islands and Commander Islands, and, off Asia, south to Akita Beach on Noto Peninsula, Honshu, in the Sea of Japan (Loughlin and Perez 1985). Near the central Aleutian Islands, groups of 3-15 Stejneger's beaked whales have been sighted on a number of occasions (Rice 1986). The species is not known to enter the Arctic Ocean and is the only species of *Mesoplodon* known to occur in Alaska waters. The distribution of *M. stejnegeri* in the North Pacific corresponds closely, in occupying the same cold-temperate niche and position, to that of *M. bidens* in the North Atlantic. It lies principally between 50°and 60°N and extends only to about 45°N in the eastern Pacific, but to about 40°N in the western Pacific (Moore 1963, 1966). Acoustic signals believed to be produced by Stejneger's beaked whales (based on frequency characteristics, interpulse interval and geographic location, Baumann-Pickering et al. 2012a) were recorded 2-5 times a week in July off Kiska Island and almost weekly from July 2011 to February 2012 in the northern Gulf of Alaska (Baumann-Pickering et al. 2012b).

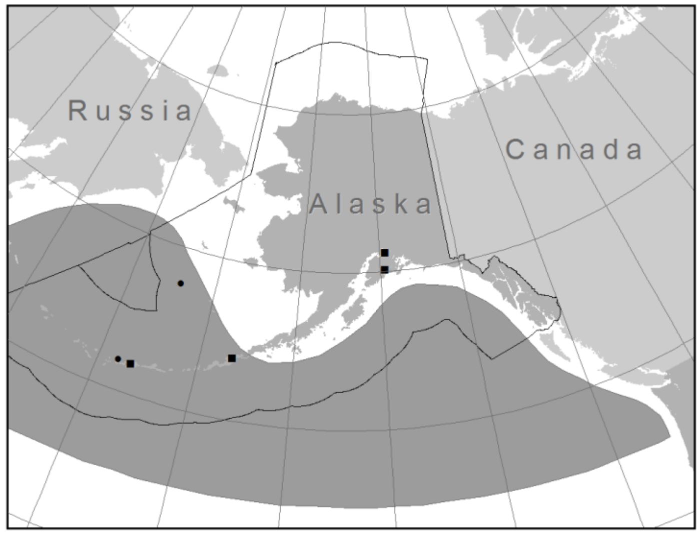

Figure 1. Approximate distribution of Stejneger's beaked whales in the eastern North Pacific (shaded area). Sightings (circles) and strandings (squares) within the last 10 years are also depicted (Walker and Hanson 1999, NMFS unpublished data).

There are insufficient data to apply the phylogeographic approach to stock structure (Dizon et al. 1992) for Stejneger's beaked whale. The Alaska Stejneger's beaked whale stock is recognized separately from *Mesoplodon* spp. off California, Oregon, and Washington because of: 1) the distribution of Stejneger's beaked whale and the different oceanographic habitats found in the two areas, 2) the large distance between the two non-contiguous areas of U.S. waters in conjunction with the lack of any information about whether animals move between the two areas, and 3) the different fisheries that operate within portions of those two areas, with bycatch of *Mesoplodon* spp. only reported from the California/Oregon thresher shark and swordfish drift gillnet fishery. The California/Oregon/Washington stock of all *Mesoplodon* spp. and a *Mesoplodon densirostris* stock in Hawaiian waters are reported separately in the Stock Assessment Reports for the Pacific Region.

POPULATION SIZE

Reliable estimates of abundance for this stock are currently unavailable.

Minimum Population Estimate

At this time, it is not possible to produce a reliable minimum population estimate (N_{MIN}) for this stock, as current estimates of abundance are unavailable.

Current Population Trend

No reliable estimates of abundance are available for this stock; therefore, reliable data on trends in population abundance are unavailable.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for the Alaska stock of Stejneger's beaked whale. Hence, until additional data become available, it is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% be employed (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for cetacean stocks with unknown population status (Wade and Angliss 1997). However, in the absence of a reliable estimate of minimum abundance, the PBR for this stock is unknown.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*." Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fisheries Information

Twenty-two different commercial fisheries operating within the potential range of the Alaska stock of Cuvier's beaked whale were monitored for incidental take by fishery observers from 2007-2011 (see 76 FR 73912, final List of Fisheries for 2012) . There were no serious injuries or mortalities of Stejneger's beaked whales incidental to observed commercial fisheries reported between 2007-2011 (Breiwick 2013). The estimated annual mortality rate incidental to commercial fisheries is zero.

Subsistence/Native Harvest Information

There is no known subsistence harvest of Stejneger's beaked whales.

STATUS OF STOCK

Stejneger's beaked whales are not designated as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act. Reliable estimates of the minimum population, population trends, PBR, and status of the stock relative to its Optimum Sustainable Population size are currently not available. Because the PBR is unknown, the level of annual U.S. commercial fishery-related mortality that can be considered insignificant and approaching zero mortality and serious injury rate is unknown. However, the estimated annual rate of human-caused mortality and serious injury seems minimal for this stock. Thus, the Alaska stock of Stejneger's beaked whale is not classified as strategic.

Habitat concerns

Disturbance by anthropogenic noise is an increasing habitat concern for most species of beaked whales, particularly in areas of oil and gas activities or where shipping or military activities are high. Shipping noise and the use of military sonars have been found to alter dive behavior and movements, as well as vocal activity in some species of beaked whales (Aguilar de Soto et al. 2006, McCarthy et al. 2011, Tyack et al. 2011). Moore and Barlow (2013) report impacts of anthropogenic sound and ecosystem change as the most plausible hypotheses for declining abundance of *Ziphius* and *Mesoplodon* spp., including *M. stejnegeri*, in the California Current large marine ecosystem. Little is known about the effects of noise on beaked whales in Alaska. Ingestion of marine debris, particularly plastics, is a concern; plastic is occasionally found in the stomach contents of stranded beaked whales, including Stejneger's beaked whales. (Smithsonian Institution, Cetacean Distributional Database, accessed 04 June 2012).

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HUMPBACK WHALE (*Megaptera novaeangliae*): Western North Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The humpback whale is distributed worldwide in all ocean basins. In winter, most humpback whales occur in the subtropical and tropical waters of the Northern and Southern Hemispheres. Humpback whales in the high latitudes of the North Pacific Ocean are seasonal migrants that feed on euphausiids and small schooling fishes (Nemoto 1957, 1959; Clapham and Mead 1999). The humpback whale population was considerably reduced as a result of intensive commercial exploitation during the 20th century.

A large-scale study of humpback whales throughout the North Pacific was conducted in 2004-2006 (the Structure of Populations, Levels of Abundance, and Status of Humpbacks (SPLASH) project). Initial results from this project (Calambokidis et al. 2008, Barlow et al. 2011), including abundance estimates and movement information, have been reported in Baker et al. (2008, 2013) and are also summarized in Fleming and Jackson (2011); however, these results are still being considered for stock structure analysis.

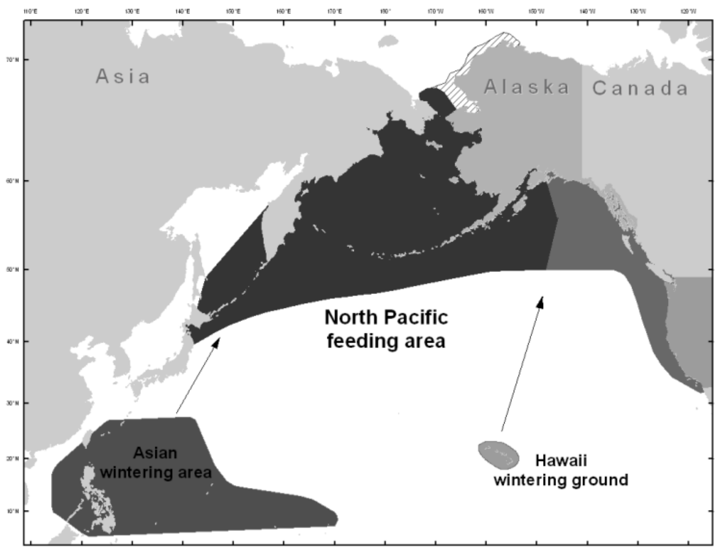

Figure 1. Approximate distribution of humpback whales in the western North Pacific (dark shaded areas). Feeding and wintering grounds are presented above (see text). Area within the hash lines is a probable distribution area based on sightings in the Beaufort Sea (Hashagen et al. 2009). See Figure 1 in the Central North Pacific humpback whale Stock Assessment Report for humpback whale distribution in the eastern North Pacific.

The historical summer feeding range of humpback whales in the North Pacific encompassed coastal and inland waters around the Pacific Rim from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk and north of the Bering Strait (Zenkovich 1954, Nemoto 1957, Tomlin 1967, Johnson and Wolman 1984). Historically, the Asian wintering area extended from the South China Sea east through the Philippines, Ryukyu Retto, Ogasawara Gunto, Mariana Islands, and Marshall Islands (Rice 1998). Humpback whales are currently found throughout this historical range (Clarke et al. 2013b), with sightings during summer months occurring as far north as the Beaufort Sea (Hashagen et al. 2009). Most of the current winter range of humpback whales in the North Pacific is relatively well known, with aggregations of whales in Japan, the Philippines, Hawaii, Mexico, and Central America. The winter range includes the main islands of the Hawaiian archipelago, with the greatest concentration along the west side of Maui. In Mexico, the winter breeding range includes waters around the southern part of the Baja California peninsula, the central portions of the Pacific coast of mainland Mexico, and the Revillagigedo Islands off the mainland coast. The winter range also extends from southern Mexico into Central America, including Guatemala, El Salvador, Nicaragua, and Costa Rica (Calambokidis et al. 2008).

Photo-identification data, distribution information, and genetic analyses have indicated that in the North Pacific there are at least three breeding populations (Asia, Hawaii, and Mexico/Central America) that all migrate between their respective winter/spring calving and mating areas and their summer/fall feeding areas (Calambokidis et al. 1997, Baker et al. 1998). Calambokidis et al. (2001) further suggested that there may be as many as six subpopulations on the wintering grounds. From photo-identification and Discovery tag mark information there are known connections between Asia and Russia, between Hawaii and Alaska, and between Mexico/Central America and California (Darling 1991, Darling and Cerchio 1993, Calambokidis et al. 1997, Baker et al. 1998). This information led to the designation of three stocks of humpback whales in the North Pacific: 1) the California/Oregon/Washington and Mexico stock, consisting of winter/spring populations in coastal Central

America and coastal Mexico which migrate to the coast of California and as far north as southern British Columbia in summer/fall (Calambokidis et al. 1989, 1993; Steiger et al. 1991); 2) the Central North Pacific stock, consisting of winter/spring populations of the Hawaiian Islands which migrate primarily to northern British Columbia/Southeast Alaska, the Gulf of Alaska, and the Bering Sea/Aleutian Islands (Baker et al. 1990, Perry et al. 1990, Calambokidis et al. 1997); and 3) the Western North Pacific stock, consisting of winter/spring populations off Asia which migrate primarily to Russia and the Bering Sea/Aleutian Islands (Fig. 1).

Information from the SPLASH project largely confirms this view of humpback whale distribution and movements in the North Pacific. For example, the SPLASH results confirm low rates of interchange between the three principal wintering regions (Asia, Hawaii, and Mexico). However, the full SPLASH results suggest that the current view of population structure is incomplete. The overall pattern of movements is complex but indicates a high degree of population structure. Whales from wintering areas at the extremes of their range on both sides of the Pacific migrate to coastal feeding areas that are on the same side of the Pacific: whales from Asia in the west migrate to Russia and whales from mainland Mexico and Central America in the east migrate to coastal waters off California/Oregon.

The SPLASH data now show the Revillagigedo whales are seen in all sampled feeding areas except northern California/Oregon and the south side of the Aleutians. They are primarily distributed in the Bering Sea, Gulf of Alaska, and Southeast Alaska/northern British Columbia but are also found in Russia and southern British Columbia/Washington. The migratory destinations of humpback whales from Hawaii were found to be quite similar, and a number of matches (14) were seen during SPLASH between Hawaii and the Revillagigedos (Calambokidis et al. 2008).

The winter distribution of humpback whales in the Western stock includes several island chains in the western North Pacific. In the Ogasawara Islands, humpback whale sampling during SPLASH was conducted at the three main island groups of Chichi-jima, Haha-jima, and Muko-jima, separated from each other by ~50-70 km. SPLASH sampling in Okinawa (southwest of Honshu) occurred at the Okinawa mainland and Zamami in the Kerama Islands (40 km from the Okinawa mainland), and in the Philippines SPLASH sampling occurred only at the northern tip of the archipelago around the Babuyan Islands. Humpback whales are reported to also occur in the South China Sea north of the Philippines near Taiwan, and east of Ogasawara in the Marshall and Mariana Islands (Rice 1998), but as yet there are no known areas of high density in these regions that could be efficiently sampled.

The SPLASH project also found that whales from the Aleutian Islands and Bering Sea, and perhaps the Gulf of Anadyr and the Chukotka Peninsula on the west side of the Bering Strait in Russia, have an unusually low resighting rate in winter areas compared to whales from other feeding areas. It is now believed that some of these whales have a winter migratory destination that was not sampled during the SPLASH project. Given the location of these feeding areas, the most parsimonious explanation would be that some of these whales winter somewhere between Hawaii and Asia, which would include the possibility of the Mariana Islands (southwest of the Ogasawara Islands), the Marshall Islands (approximately half-way between the Mariana Islands and the Hawaiian Islands), and the Northwestern Hawaiian Islands. Subsequent to the SPLASH project, a survey in 2007 documented humpback whales from a number of locations in the Northwestern Hawaiian Islands at relatively low densities (Johnston et al. 2007), but no sampling occurred there during the SPLASH project. Some humpback whales, including mother/calf pairs, have also been found in the Mariana Islands (Hill et al. 2016). Both of these locations are plausible migratory destinations for whales from the Aleutian Islands and Bering Sea. Which stock that whales in these locations would belong to is currently unknown.

The migratory destination of Western North Pacific humpback whales is not completely known. Discovery tag recaptures have indicated movement of whales between Ogasawara and Okinawa and feeding areas in the Bering Sea, on the southern side of the Aleutian Islands, and in the Gulf of Alaska (Omura and Ohsumi 1964, Nishiwaki 1966, Ohsumi and Masaki 1975). Research on humpback whales at the Ogasawara Islands has documented recent movements of whales between there and British Columbia (Darling et al. 1996), the Kodiak Archipelago in the central Gulf of Alaska (Calambokidis et al. 2001), and the Shumagin Islands in the western Gulf of Alaska (Witteveen et al. 2004), but no photo-identification studies had previously been conducted in Russia. Individual movement information from the SPLASH study documents that Russia is likely the primary migratory destination for whales in Okinawa and the Philippines but also reconfirms that some Asian whales go to Ogasawara, the Aleutian Islands, Bering Sea, and Gulf of Alaska (Calambokidis et al. 2008). A small amount of inter-yearly interchange was also found between the wintering areas (Philippines, Okinawa, and Ogasawara).

During the SPLASH study in Russia, humpback whales were primarily found along the Pacific east side of the Kamchatka Peninsula, near the Commander Islands between Kamchatka and the Aleutian Islands, and in the Gulf of Anadyr just southwest of the Bering Strait. Analysis of whaling data shows historical catches of humpback whales well into the Bering Sea and catches in the Bering Strait and Chukchi Sea in August-October in the 1930s

(Mizroch and Rice 2007), but no survey effort occurred during SPLASH north of the Bering Strait. Humpback whales are increasingly seen north of the Bering Strait into the northeastern Chukchi Sea (Clarke et al. 2013a, 2013b), with some indication that more humpback whales are seen on the Russian side north of the Bering Strait (Clarke et al. 2013b). Humpback whales are the most commonly recorded cetacean on hydrophones just north of the Bering Strait and occurred from September into early November from 2009 to 2012 (K. Stafford, Applied Physics Laboratory-University of Washington, Seattle, WA, pers. comm.). Other locations in the far western Pacific where humpback whales have been seen in summer include the northern Kuril Islands (V. Burkanov, NMFS-AFSC-MML, pers. comm.), far offshore southeast of the Kamchatka Peninsula and south of the Commander Islands (Miyashita 2006), and along the north coast of the Chukotka Peninsula in the Chukchi Sea (Melnikov 2000).

These results indicate humpback whales from the Western North Pacific (Asian) breeding stock overlap broadly on summer feeding grounds with whales from the Central North Pacific breeding stock, as well as with whales that winter in the Revillagigedos in Mexico. Given the relatively small size of the Asian population, Asian whales probably represent a small fraction of all the whales found in the Aleutian Islands, Bering Sea, and Gulf of Alaska, which are primarily whales from Hawaii and the Revillagigedos. The only feeding area that appears to be primarily (or exclusively) composed of Asian whales is along the Kamchatka Peninsula in Russia. The initial SPLASH abundance estimates for Asia ranged from about 900 to 1,100, and the estimates for Kamchatka in Russia ranged from about 100 to 700, suggesting a large portion of the Asian population migrates to Kamchatka. This also shows that Asian whales that migrate to feeding areas besides Russia would be only a small fraction of the total number of whales in those areas, given the much larger abundance estimates for the Bering Sea and Aleutian Islands (6,000-14,000) and the Gulf of Alaska (3,000-5,000) (Calambokidis et al. 2008). A full description of the distribution and density of humpback whales in the Aleutian Islands, Bering Sea, and Gulf of Alaska is in the Stock Assessment Report for the Central North Pacific stock of humpback whales.

In summary, information from a variety of sources indicates that humpback whales from the Western and Central North Pacific stocks mix to a limited extent on summer feeding grounds ranging from British Columbia through the central Gulf of Alaska and up to the Bering Sea.

NMFS has conducted a global Status Review of humpback whales (Bettridge et al. 2015) and recently revised the ESA listing of the species (81 FR 62259, 8 September 2016). NMFS is evaluating the stock structure of humpback whales under the MMPA, but no changes to current stock structure are presented at this time. However, effects of the ESA-listing final rule on the status of the stock are discussed below.

POPULATION SIZE

In the SPLASH study, fluke photographs were collected by over 400 researchers in all known feeding areas from Russia to California and in all known wintering areas from Okinawa and the Philippines to the coast of Central America and Mexico during 2004-2006. Over 18,000 fluke identification photographs were collected, and these have been used to estimate the abundance of humpback whales in the entire North Pacific Basin. A total of 566 unique individuals were seen in the Asian wintering areas during the 2-year period (3 winter field seasons) of the SPLASH study. Based on a comparison of all winter identifications to all summer identifications, the Chapman-Petersen estimate of abundance is 21,808 (CV=0.04) (Barlow et al. 2011). A simulation study identifies significant biases in this estimate from violations of the closed population assumption (+5.3%), exclusion of calves (-10.3%), failure to achieve random geographic sampling (+1.5%), and missed matches (+9.8%) (Barlow et al. 2011). Sex-biased sampling favoring males in wintering areas does not add significant bias if both sexes are proportionately sampled in the feeding areas. The bias-corrected estimate is 20,800 after accounting for a net positive bias of 4.8%. This estimate is likely to be lower than the true abundance due to two additional sources of bias: individual heterogeneity in the probability of being sampled (unquantified) and the likely existence of an unknown and unsampled wintering area (-7.2%).

During the SPLASH study, surveys were conducted in three winter field seasons (2004-2006). The total numbers of unique individuals found in each area during the study were 77 in the Philippines, 215 in Okinawa, and 294 in the Ogasawara Islands. There was a total of 20 individuals seen in more than one area, leaving a total of 566 unique individuals seen in the Asian wintering areas (Calambokidis et al. 2008). For abundance in winter or summer areas, a multistrata Hilborn mark-recapture model was used, which is a form of a spatially-stratified model that explicitly estimates movement rates between winter and summer areas. Two broad categories of models were used making different assumptions about the movement rates, and four different models were used for capture probability. Point estimates of abundance for Asia (combined across the three areas) were relatively consistent across models, ranging from 938 to 1,107. The model that fit the data the best (as selected by AICc) gave an estimate of 1,107 for the Ogasawara Islands, Okinawa, and the Philippines. Confidence limits or coefficients of variation (CVs) have not yet been calculated for the SPLASH abundance estimates. Although no other high density aggregations of humpback whales are known on the Asian wintering ground, whales have been seen in other locations, indicating this is likely to represent an underestimate of the stock's true abundance to an unknown degree. This estimate is more than 8 years old and is outdated for use in stock assessments; however, because this population is growing (Calambokidis et al. 2008), this is still a valid minimum population estimate.

On the summer feeding grounds, the initial SPLASH abundance estimates for Kamchatka in Russia ranged from about 100 to 700, suggesting a large portion of the Asian population occurs near Kamchatka. No separate estimates are available for the other areas in Russia, the Gulf of Anadyr and the Commander Islands; abundance from those areas is included in the estimate of abundance for the Bering Sea and Aleutian Islands, which ranged from about 6,000 to 14,000. Abundance estimates for the Gulf of Alaska and for Southeast Alaska/northern British Columbia both ranged from 3,000 to 5,000 (Calambokidis et al. 2008).

Minimum Population Estimate

As discussed above, point estimates of abundance for Asia ranged from 938 to 1,107 (for 2004-2006), but no associated CV has yet been calculated. The 1991-1993 abundance estimate for Asia using similar (though likely less) data had a CV of 0.084. Therefore, it is unlikely the CV of the SPLASH estimate, once calculated, would be greater than 0.300. The minimum population estimate (N_{MIN}) for this stock is calculated according to Equation 1 from the potential biological removal (PBR) guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the SPLASH population estimate (N) of 1,107 from the best fit model and an assumed conservative CV(N) of 0.300 would result in an N_{MIN} for this humpback whale stock of 865.

Current Population Trend

The SPLASH abundance estimate for Asia represents a 6.7% annual rate of increase over the 1991-1993 abundance estimate (Calambokidis et al. 2008). However, the 1991-1993 estimate was for Ogasawara and Okinawa only, whereas the SPLASH estimate includes the Philippines, so the annual rate of increase is biased high to an unknown degree.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Utilizing a birth-interval model, Barlow and Clapham (1997) have estimated a population growth rate of 6.5% (SE = 1.2%) for the well-studied humpback whale population in the Gulf of Maine, although there are indications that this rate has slowed in recent years (Clapham et al. 2003). Mobley et al. (2001) estimated a trend of 7% per year for 1993-2000 using data from aerial surveys that were conducted in a consistent manner for several years across all of the Hawaiian Islands and were developed specifically to estimate a trend for the Central North Pacific stock. Mizroch et al. (2004) estimated survival rates for North Pacific humpback whales using mark-recapture methods, and a Pradel model fit to data from Hawaii for the years 1980-1996 resulted in an estimated rate of increase of 10% per year (95% CI: 3-16%). For shelf waters of the northern Gulf of Alaska, Zerbini et al. (2006) estimated an annual rate of increase for humpback whales from 1987 to 2003 of 6.6% (95% CI: 5.2-8.6%). The SPLASH abundance estimate for the total North Pacific represents an annual increase of 4.9% over the most complete estimate for the North Pacific for 1991-1993. Comparisons of SPLASH abundance estimates for Hawaii to estimates for 1991-1993 gave estimates of annual increase that ranged from 5.5 to 6.0% (Calambokidis et al. 2008). No confidence limits were calculated for these rates of increase from SPLASH data.

Estimates of observed rates of increase can be used to estimate maximum net productivity rates, although in most cases these estimates may be biased low, as maximum net productivity rates are only achieved at very low population sizes. However, if the observed rates of increase are greater than the default value recommended for R_{MAX}, it would be reasonable to use a higher value based on those observations. The rates of increase summarized above include estimates for the North Pacific of 7%, 10%, and 6.6%. Although there is no estimate of the maximum net productivity rate for just the Western stock (i.e., from trends in abundance in the Asia breeding areas), it is reasonable to assume that R_{MAX} for this stock would be at least 7% based on the other observations from the North Pacific. Hence, until additional data become available for the Western North Pacific humpback whale stock, it is recommended that 7% be employed as the maximum net productivity rate (R_{MAX}) for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized MMPA, the PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.1, the value for cetacean stocks listed as endangered under the ESA (Wade and Angliss 1997; see Status of Stock section below regarding ESA listing status). Using the N_{MIN} of 865 calculated from the SPLASH abundance estimate for 2004-2006, of 1,107 with an assumed CV of 0.300, the PBR is calculated to be 3.0 whales (865 × 0.035 × 0.1).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information on U.S. commercial fisheries in Alaska waters (including observer programs, observer coverage, and observed incidental takes of marine mammals) is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

During 2010-2014, mortality and serious injury of humpback whales occurred in the Bering Sea/Aleutian Islands pollock trawl fishery (1 each in 2010 and 2012) and the Bering Sea/Aleutian Islands flatfish trawl fishery (1 in 2010) (Table 1; Breiwick 2013; MML, unpubl. data). Since the stock identification of these whales is unknown, and the events occurred within the area where the Western North Pacific and Central North Pacific stocks are known to overlap, the mortality in these fisheries is assigned to both stocks of humpback whales. The estimated average annual mortality and serious injury rate from observed U.S. commercial fisheries is 0.6 Western North Pacific humpback whales in 2010-2014 (Table 1).

Table 1. Summary of incidental mortality and serious injury of Western North Pacific humpback whales due to observed U.S. commercial fisheries in 2010-2014 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports. N/A indicates that data are not available.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Is. flatfish trawl[a]	2010 2011 2012 2013 2014	obs data	99 100 99 99 99	0 (+1)[b] 0 0 0 0	0 (+1)[c] 0 0 0 0	0 (+0.2)[d] (CV = N/A)
Bering Sea/Aleutian Is. pollock trawl[a]	2010 2011 2012 2013 2014	obs data	86 98 98 97 98	1 0 1 0 0	1.0 0 1.0 0 0	0.4 (CV = 0.09)
Minimum total estimated annual mortality						0.6 (CV = 0.09)

[a]Mortality and serious injury in this fishery is assigned to both the Western North Pacific and Central North Pacific stocks of humpback whales, since the stock identification is unknown and the two stocks overlap within the area of operation of the fishery.
[b]Total mortality and serious injury observed in 2010: 0 whales in sampled hauls + 1 whale in an unsampled haul.
[c]Total estimate of mortality and serious injury in 2010: 0 whales (extrapolated estimate from 0 whales observed in sampled hauls) + 1 whale (1 whale observed in an unsampled haul).
[d]Mean annual mortality and serious injury for fishery: 0 whales (mean of extrapolated estimates from sampled hauls) + 0.2 whales (mean of number observed in unsampled hauls).

One entanglement in the ground tackle of a commercial Pacific cod jig fishery vessel in Kodiak, Alaska, was reported to the NMFS Alaska Region stranding network in 2013 (Table 2; Helker et al. 2016). Since observer data are not available for this fishery, this mortality results in a minimum mean annual mortality and serious injury rate of 0.2 humpback whales in 2010-2014 (Table 2) and, since the event occurred in the area where the two stocks overlap, the mortality is assigned to both the Western North Pacific and Central North Pacific stocks of humpback whales.

The estimated mean annual mortality and serious injury rate incidental to U.S. commercial fisheries is 0.8 Western North Pacific humpback whales (0.6 based on observed fisheries + 0.2 based on stranding data); however, this estimate is considered a minimum because there are no data concerning fishery-related mortality and serious injury in Japanese, Russian, or international waters.

Reports of swimming, floating, or beachcast humpback whales entangled in fishing gear or with injuries caused by interactions with gear, which may be from commercial, recreational, or subsistence fisheries, are another source of fishery-related mortality and serious injury data. The minimum mean annual mortality and serious injury rate from fishery-related gear entanglements and interactions reported to the NMFS Alaska Region stranding network in 2010-2014, in which the events have not been attributed to a specific fishery listed on the MMPA List of Fisheries (76 FR 73912, 29 November 2011), is 0.6 humpback whales (Table 2; Helker et al. 2016). Since these events occurred in the area where the two stocks overlap, this mortality is assigned to both the Western North Pacific and Central North Pacific stocks of humpback whales. These estimates are considered a minimum because not all entangled animals strand and not all stranded animals are found, reported, or have the cause of death determined.

One additional humpback whale, initially considered seriously injured due to entanglement in Gulf of Alaska/Kodiak Dungeness crab pot gear, was disentangled in Alaska waters in 2012 and released with non-serious injuries (Helker et al. 2016); therefore, it was not included in the mean annual mortality and serious injury rate for 2010-2014. Since this event occurred in the area where the two stocks overlap, this injury was also assigned to the Central North Pacific stock.

The minimum average annual mortality and serious injury rate due to interactions with all fisheries in 2010-2014 is 1.4 Western North Pacific humpback whales (0.8 in commercial fisheries + 0.6 in unknown fisheries).

Table 2. Summary of mortality and serious injury of Western North Pacific humpback whales, by year and type, reported to the NMFS Alaska Region marine mammal stranding network in 2010-2014 (Helker et al. 2016). Injury events lacking detailed injury information are assigned prorated values following injury determination guidelines described in NOAA (2012). All events occurred within the area of known overlap between the Western North Pacific and Central North Pacific humpback whale stocks. Since the stock identification is unknown, the mortality and serious injury is reflected in both Stock Assessment Reports. A summary of information used to determine whether an injury was serious or non-serious, as well as a table of prorate values used for large whale reports with incomplete information, is reported in Helker et al. (2016).

Cause of injury	2010	2011	2012	2013	2014	Mean annual mortality
Entangled in ground tackle of Kodiak commercial Pacific cod jig vessel	0	0	0	1	0	0.2
Entangled in Bering Sea pot gear*	0	0.75	0	0	0	0.2
Entangled in Prince William Sound shrimp pot gear*	0	0	0	0	1	0.2
Entangled in gillnet*	0	0.75	0	0	0	0.2
Entangled in marine debris	0	2.5	0.75	0	0.75	0.8
Ship strike	0	0	1.2	0	1	0.4
Total in commercial fisheries						0.2
*Total in unknown (commercial, recreational, or subsistence) fisheries						0.6
Total in marine debris						0.8
Total due to other sources (ship strike)						0.4

Brownell et al. (2000) compiled records of bycatch in Japanese and Korean commercial fisheries between 1993 and 2000. During the period 1995-1999, there were six humpback whales indicated as "bycatch." In addition, two strandings were reported during this period. Furthermore, analysis of four samples from meat found in markets indicated that humpback whales are being sold. At this time, it is not known whether any or all strandings were caused by incidental interactions with commercial fisheries; similarly, it is not known whether the humpback whales identified in market samples were killed as a result of incidental interactions with commercial fisheries. It is also not known which fishery may be responsible for the bycatch. Regardless, these data indicate a minimum mortality level of 1.1 per year (using bycatch data only) to 2.4 per year (using bycatch, stranding, and market data) in the waters of Japan and Korea. Because many mortalities pass unreported, the actual rate in these areas is likely much higher. An analysis of entanglement rates from photographs collected for SPLASH found a minimum entanglement rate of 31% for humpback whales from the Asia breeding grounds (Cascadia Research NFWF Report #2003-0170-019).

Alaska Native Subsistence/Harvest Information

There were no reported takes of humpback whales from this stock by Native subsistence hunters in Alaska or Russia in 2010-2014.

Other Mortality

In 2015, increased mortality of large whales (including 11 fin whales, 14 humpback whales, 1 gray whale, and 4 unidentified cetaceans from May to mid-August 2015) was observed along the western Gulf of Alaska, including the areas around Kodiak Island, Afognak Island, Chirikof Island, the Semidi Islands, and the southern shoreline of the Alaska Peninsula (http://www.nmfs.noaa.gov/pr/health/mmume/faqs_2015_large_whale.html, accessed December 2016). On 20 August 2015, NMFS declared an Unusual Mortality Event for large whales in the western Gulf of Alaska; however, to date, no specific cause for the increased mortality has been identified.

Other sources of human-caused mortality and serious injury include ship strikes and entanglement in marine debris. The minimum mean annual mortality and serious injury rate of 1.2 Western North Pacific humpback whales in 2010-2014 is based on ship strikes (0.4) and entanglement in marine debris (0.8) reported to the NMFS Alaska Region stranding network (Table 2; Helker et al. 2016). Since these events occurred in the area where the stocks overlap, this mortality is assigned to both the Western North Pacific and Central North Pacific stocks of humpback whales.

HISTORICAL WHALING

Rice (1978) estimated that the number of humpback whales in the North Pacific may have been approximately 15,000 individuals prior to exploitation; however, this was based upon incomplete data and, given the level of known catches (legal and illegal) since World War II, may be an underestimate. Intensive commercial whaling removed more than 28,000 animals from the North Pacific during the 20th century (Rice 1978). A total of 3,277 reported catches occurred in Asia between 1910 and 1964, with 817 catches from Ogasawara between 1924 and 1944 (Nishiwaki 1966, Rice 1978). After World War II, substantial catches occurred in Asia near Okinawa (including 970 between 1958 and 1961), as well as around the main islands of Japan and the Ogasawara Islands. On the feeding grounds, substantial catches occurred around the Commander Islands and western Aleutian Islands, as well as in the Gulf of Anadyr (Springer et al. 2006).

Humpback whales in the North Pacific were theoretically fully protected in 1965, but illegal catches by the U.S.S.R. continued until 1972 (Ivashchenko et al. 2007). From 1961 to 1971, 6,793 humpback whales were killed illegally by the U.S.S.R. Many animals during this period were taken from the Gulf of Alaska and Bering Sea (Doroshenko 2000); however, additional illegal catches were made across the North Pacific, from the Kuril Islands to the Queen Charlotte Islands, and other takes in earlier years may have gone unrecorded.

STATUS OF STOCK

The total estimated annual level of human-caused mortality and serious injury of 2.6 Western North Pacific humpback whales is less than the calculated conservative PBR level for this stock (3.0). The minimum estimate of the mean annual U.S. commercial fishery-related mortality and serious injury rate for this stock (0.8 whales) exceeds 10% of the PBR (10% of PBR = 0.3) and cannot be considered insignificant and approaching a zero mortality and serious injury rate. In addition, there is a lack of information about fisheries bycatch from Russia, Japan, Korea, and international waters, as well as earlier evidence of bycatch in Japan and Korea (Brownell et al. 2000: 1.1 to 2.4 whales per year based on bycatch, stranding, and market data). The humpback whale ESA listing final rule (81 FR 62259, 8 September 2016) established 14 Distinct Population Segments (DPSs) with different listing statuses. The DPSs that occur in waters under the jurisdiction of the United States do not necessarily equate to the existing MMPA stocks. Some of the listed DPSs partially coincide with the currently defined Western North Pacific stock. Because we cannot manage one portion of an MMPA stock as ESA-listed and another portion of a stock as not ESA-listed, until such time as the MMPA stock delineations are reviewed in light of the DPS designations, NMFS considers this stock to be endangered and depleted for MMPA management purposes (e.g., selection of a recovery factor, stock status). As a result, the Western North Pacific stock of humpback whale is classified as a strategic stock.

HABITAT CONCERNS

Elevated levels of sound from anthropogenic sources (e.g., shipping, military sonars) are a potential concern for humpback whales in the North Pacific, but no specific habitat concerns have been identified for this stock. Other potential impacts include possible changes in prey distribution with climate change, entanglement in fishing gear, and ship strikes due to increased vessel traffic (e.g., from increased shipping in higher latitudes and through the Bering Sea with changes in sea-ice coverage).

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HUMPBACK WHALE (*Megaptera novaeangliae*): Central North Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The humpback whale is distributed worldwide in all ocean basins. In winter, most humpback whales occur in the subtropical and tropical waters of the Northern and Southern Hemispheres. Humpback whales in the high latitudes of the North Pacific Ocean are seasonal migrants that feed on euphausiids and small schooling fishes (Nemoto 1957, 1959; Clapham and Mead 1999). The humpback whale population was considerably reduced as a result of intensive commercial exploitation during the 20th century.

A large-scale study of humpback whales throughout the North Pacific was conducted in 2004-2006 (the Structure of Populations, Levels of Abundance, and Status of Humpbacks (SPLASH) project). Initial results from this project (Calambokidis et al. 2008, Barlow et al. 2011), including abundance estimates and movement information, have been reported in Baker et al. (2008, 2013) and are also summarized in Fleming and Jackson (2011); however, these results are still being considered for stock structure analysis.

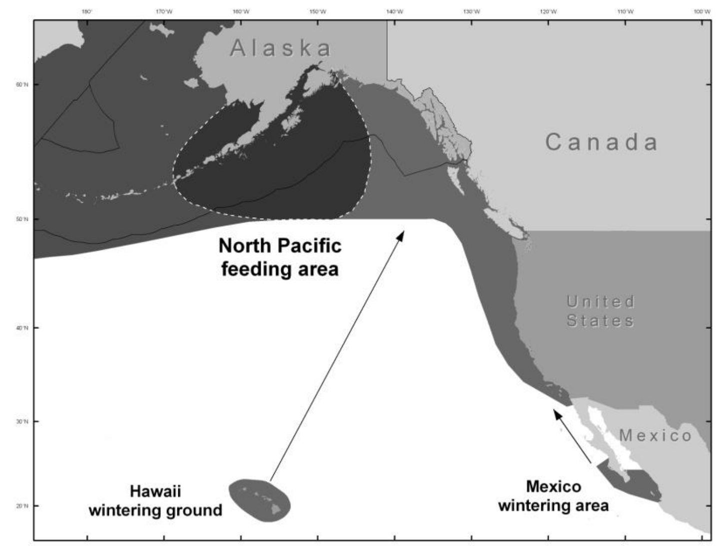

Figure 1. Approximate distribution of humpback whales in the eastern North Pacific (dark shaded areas). Feeding and wintering areas are presented above (see text). Area within the dotted line is known to be an area where the Central North Pacific and Western North Pacific stocks overlap. See Figure 1 in the Western North Pacific humpback whale Stock Assessment Report for distribution of humpback whales in the western North Pacific.

The historical summer feeding range of humpback whales in the North Pacific encompassed coastal and inland waters around the Pacific Rim from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk and north of the Bering Strait (Zenkovich 1954, Nemoto 1957, Tomlin 1967, Johnson and Wolman 1984). Historically, the Asian wintering area extended from the South China Sea east through the Philippines, Ryukyu Retto, Ogasawara Gunto, Mariana Islands, and Marshall Islands (Rice 1998). Humpback whales are currently found throughout this historical range. Most of the current winter range of humpback whales in the North Pacific is relatively well known, with aggregations of whales in Japan, the Philippines, Hawaii, Mexico, and Central America. The winter range includes the main islands of the Hawaiian archipelago, with the greatest concentration along the west side of Maui. In Mexico, the winter breeding range includes waters around the southern part of the Baja California peninsula, the central portions of the Pacific coast of mainland Mexico, and the Revillagigedo Islands off the mainland coast. The winter range also extends from southern Mexico into Central America, including Guatemala, El Salvador, Nicaragua, and Costa Rica (Calambokidis et al. 2008).

Photo-identification data, distribution information, and genetic analyses have indicated that in the North Pacific there are at least three breeding populations (Asia, Hawaii, and Mexico/Central America) that all migrate between their respective winter/spring calving and mating areas and their summer/fall feeding areas (Calambokidis et al. 1997, Baker et al. 1998). Calambokidis et al. (2001) further suggested that there may be as many as six subpopulations on the wintering grounds. From photo-identification and Discovery tag mark information there are known connections between Asia and Russia, between Hawaii and Alaska, and between Mexico/Central America and California (Darling 1991, Darling and Cerchio 1993, Calambokidis et al. 1997, Baker et al. 1998). This information led to the designation of three stocks of humpback whales in the North Pacific: 1) the California/Oregon/Washington and Mexico stock, consisting of winter/spring populations in coastal Central America and coastal Mexico which migrate to the coast of California and as far north as southern British Columbia in summer/fall (Calambokidis et al. 1989, 1993; Steiger et al. 1991); 2) the Central North Pacific stock, consisting of winter/spring populations of the Hawaiian Islands which migrate primarily to northern British Columbia/Southeast Alaska, the Gulf of Alaska, and the Bering Sea/Aleutian Islands (Baker et al. 1990, Perry et al. 1990, Calambokidis et al. 1997) (Fig. 1); and 3) the Western North Pacific stock, consisting of winter/spring populations off Asia which migrate primarily to Russia and the Bering Sea/Aleutian Islands.

Information from the SPLASH project largely confirms this view of humpback whale distribution and movements in the North Pacific. For example, the SPLASH results confirm low rates of interchange between the three principal wintering regions (Asia, Hawaii, and Mexico). However, the full SPLASH results suggest that the current view of population structure is incomplete. The overall pattern of movements is complex but indicates a high degree of population structure. Whales from wintering areas at the extremes of their range on both sides of the Pacific migrate to coastal feeding areas that are on the same side of the Pacific: whales from Asia in the west migrate to Russia and whales from mainland Mexico and Central America in the east migrate to coastal waters off California/Oregon.

The SPLASH data now show the Revillagigedo whales are seen in all sampled feeding areas except northern California/Oregon and the south side of the Aleutians. They are primarily distributed in the Bering Sea, Gulf of Alaska, and Southeast Alaska/northern British Columbia but are also found in Russia and southern British Columbia/Washington. The migratory destinations of humpback whales from Hawaii were found to be quite similar, and a significant number of matches (14) were seen during SPLASH between Hawaii and the Revillagigedos (Calambokidis et al. 2008). The SPLASH project also found that whales from the Aleutian Islands and Bering Sea, and perhaps the Gulf of Anadyr and the Chukotka Peninsula on the west side of the Bering Strait in Russia, have an unusually low resighting rate in winter areas compared to whales from other feeding areas. It is now believed that some of these whales have a winter migratory destination that was not sampled during the SPLASH project. Given the location of these feeding areas, the most parsimonious explanation would be that some of these whales winter somewhere between Hawaii and Asia, which would include the possibility of the Mariana Islands (southwest of the Ogasawara Islands), the Marshall Islands (approximately half-way between the Mariana Islands and the Hawaiian Islands), and the Northwestern Hawaiian Islands. Subsequent to the SPLASH project, a survey in 2007 documented humpback whales from a number of locations in the Northwestern Hawaiian Islands at relatively low densities (Johnston et al. 2007), but no sampling occurred there during the SPLASH project. Some humpback whales, including mother/calf pairs, have also been found in the Mariana Islands (Hill et al. 2016). Both of these locations are plausible migratory destinations for whales from the Aleutian Islands and Bering Sea. Which stock that whales in these locations would belong to is currently unknown.

The winter distribution of the Central North Pacific stock is primarily in the Hawaiian archipelago. In the SPLASH study, sampling occurred on Kauai, Oahu, Penguin Bank (off the southwest tip of the island of Molokai), Maui, and the island of Hawaii (the Big Island). Interchange within Hawaii was extensive. Although most of the Hawaii identifications came from the Maui sub-area, identifications from the Big Island and Kauai at the eastern and western end of the region showed a high rate of interchange with Maui.

In summer, the majority of whales from the Central North Pacific stock are found in the Aleutian Islands, Bering Sea, Gulf of Alaska, and Southeast Alaska/northern British Columbia. High densities of humpback whales are found in the eastern Aleutian Islands, particularly along the northern side of Unalaska Island, and along the Bering Sea shelf edge and break to the north towards the Pribilof Islands. Small numbers of humpback whales are known from a few locations not sampled during the SPLASH study, including northern Bristol Bay and the Chukchi and Beaufort seas. In the Gulf of Alaska, high densities of humpback whales are found in the Shumagin Islands, south and east of Kodiak Island, and from the Barren Islands through Prince William Sound. Although densities in any particular location are not high, humpback whales are also found in deep waters south of the continental shelf from the eastern Aleutians through the Gulf of Alaska. Relatively high densities of humpback whales occur throughout much of Southeast Alaska and northern British Columbia.

NMFS has conducted a global Status Review of humpback whales (Bettridge et al. 2015) and recently revised the ESA listing of the species (81 FR 62259, September 8, 2016). NMFS is evaluating the stock structure of humpback whales under the MMPA, but no changes to current stock structure are presented at this time. However, effects of the ESA-listing final rule on the status of the stock are discussed below.

POPULATION SIZE

Prior to the SPLASH study, the most complete estimate of abundance for humpback whales in the North Pacific was from data collected in 1991-1993, with a best mark-recapture estimate of 6,010 (CV = 0.08) for the entire North Pacific, using a winter-to-winter comparison (Calambokidis et al. 1997). Estimates for Hawaii and Mexico were higher, using marks from summer feeding areas with recaptures on the winter grounds, and totaled almost 10,000 summed across all winter areas. In the SPLASH study, fluke photographs were collected by over 400 researchers in all known feeding areas from Russia to California and in all known wintering areas from Okinawa and the Philippines to the coast of Central America and Mexico during 2004-2006. Over 18,000 fluke identification photographs were collected, and these have been used to estimate the abundance of humpback whales in the entire North Pacific Basin. Based on a comparison of all winter identifications to all summer identifications, the Chapman-Petersen estimate of abundance is 21,808 (CV = 0.04) (Barlow et al. 2011). A simulation study identifies significant biases in this estimate from violations of the closed population assumption (+5.3%), exclusion of calves (-10.3%), failure to achieve random geographic sampling (+1.5%), and missed matches (+9.8%) (Barlow et al. 2011). Sex-biased sampling favoring males in wintering areas does not add significant bias if both sexes are proportionately sampled in the feeding areas. The bias-corrected estimate is 20,800 after accounting for a net positive bias of 4.8%. This estimate is likely to be lower than the true abundance due to two additional sources of bias: individual heterogeneity in the probability of being sampled (unquantified) and the likely existence of an unknown and unsampled wintering area (-7.2%).

The Central North Pacific stock of humpback whales winters in Hawaiian waters (Baker et al. 1986). Preliminary mark-recapture abundance estimates from the SPLASH data were calculated in Calambokidis et al. (2008), using a multistrata Hilborn model. The best estimate for Hawaii (as chosen by AICc) was 10,103; no confidence limit or coefficient of variation (CV) was calculated for that estimate. This estimate is more than 8 years old and is outdated for use in stock assessments; however, because this population is growing (Calambokidis et al. 2008), this is still a valid minimum population estimate.

In the SPLASH study, the number of unique identifications in different regions during 2004 and 2005 included 63 in the Aleutian Islands (defined as everything on the south side of the islands), 491 in the Bering Sea, 301 in the western Gulf of Alaska (including the Shumagin Islands), and 1,038 in the northern Gulf of Alaska (including Kodiak and Prince William Sound), with a few whales seen in more than one area (Calambokidis et al. 2008). The SPLASH combined estimates ranged from 6,000 to 19,000 for the Aleutian Islands, Bering Sea, and Gulf of Alaska, a considerable increase from previous estimates that were available (e.g., Waite et al. 1999, Moore et al. 2002, Witteveen et al. 2004, Zerbini et al. 2006). However, the SPLASH surveys covered areas not covered in those previous surveys, such as parts of Russian waters (Gulf of Anadyr and Commander Islands), the western and central Aleutian Islands, offshore waters in the Gulf of Alaska and Aleutian Islands, and Prince William Sound. Additionally, mark-recapture estimates can be higher than line-transect estimates because they estimate the total number of whales that have used the study area during the study period, whereas, line-transect surveys provide a snapshot of average abundance in the survey area at the time of the survey. For the Aleutian Islands and Bering Sea (including the Commander Islands and Gulf of Anadyr in Russia), the SPLASH estimates ranged from 2,889 to 13,594; for the Gulf of Alaska (from Prince William Sound to the Shumagin Islands, including Kodiak Island), the SPLASH estimates ranged from 2,845 to 5,122. Given known overlap in the distribution of the Western and Central North Pacific humpback whale stocks, estimates for these feeding areas may include whales from the Western North Pacific stock.

The SPLASH study showed a relatively high rate of interchange between Southeast Alaska and northern British Columbia, so they are considered together. Humpback whale studies have been conducted since the late 1960s in Southeast Alaska. Baker et al. (1992) estimated an abundance of 547 (95% CI: 504-590) using data collected in 1979-1986. Straley (1994) recalculated the estimate using a different analytical approach (Jolly-Seber open model for capture-recapture data) and obtained a mean population estimate of 393 animals (95% CI: 331-455) using the same 1979-1986 data set. Using 1986-1992 data and the Jolly-Seber approach, Straley et al. (1995) estimated that the annual abundance of humpback whales in Southeast Alaska was 404 animals (95% CI: 350-458). Straley et al. (2009) examined data for the northern portion of Southeast Alaska in 1994-2000 and provided an updated abundance estimate of 961 (CV=0.12). Using 1992-2006 photo-identification data and an SIR Jolly-Seber model, Ford et al. (2009) estimated an abundance of 2,145 humpback whales (95% CI: 1,970-2,331) in British Columbia waters. During the SPLASH study, 1,115 unique identifications were made in Southeast Alaska and 583 in northern British Columbia, for a total of 1,669 individual whales, after subtracting whales seen in both areas (1,115+583-13-16 = 1,669) (Calambokidis et al. 2008). From the SPLASH study, the estimates of abundance for Southeast Alaska/northern British Columbia ranged from 2,883 to 6,414. The estimates from SPLASH are considerably larger than the estimate from Straley et al. (2009). This is because the SPLASH estimates included areas not part of the Straley et al. (2009) estimate, including southern Southeast Alaska, northern British Columbia, and offshore waters of both British Columbia and Southeast Alaska.

Minimum Population Estimate

A total of 2,367 unique individuals were seen in the Hawaiian wintering areas during the 2-year period (3 winter field seasons, 2004-2006) of the SPLASH study. As discussed above, point estimates of abundance for

Hawaii from SPLASH ranged from 7,469 to 10,103: the estimate from the best model was 10,103, but no associated CV has yet been calculated. The 1991-1993 abundance estimate for Hawaii using similar (but less) data had a CV of 0.095. Therefore, it is unlikely the CV of the SPLASH estimate, once calculated, would be greater than 0.300. The minimum population estimate (N_{MIN}) for this stock is calculated according to Equation 1 from the potential biological removal (PBR) guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the population estimate (N) of 10,103 from the best fit model and an assumed conservative CV(N) of 0.300 results in an N_{MIN} for the Central North Pacific humpback whale stock of 7,890.

Although the Southeast Alaska/northern British Columbia feeding aggregation is not formally considered a stock, the calculation of what a PBR would be for this area is useful for management purposes. The total number of unique individuals seen during the SPLASH study was 1,669 (1,115 in Southeast Alaska). The abundance estimate of Straley et al. (2009) had a CV of 0.12, and the SPLASH abundance estimates are unlikely to have a much higher CV. Using the lowest population estimate (N) of 2,883 and an assumed worst case CV(N) of 0.300, N_{MIN} for this aggregation is 2,251. Similarly, for the Aleutian Islands and Bering Sea, using the lowest SPLASH estimate of 2,889 with an assumed worst-case CV of 0.300 results in an N_{MIN} of 2,256. For the Gulf of Alaska (from Prince William Sound to the Shumagin Islands, including Kodiak Island), using the lowest SPLASH estimate of 2,845 with an assumed worst-case CV of 0.300 results in an N_{MIN} of 2,222. Estimates for these feeding areas may include whales from the Western North Pacific stock and the Mexican breeding population.

Current Population Trend

Comparison of the estimate for the entire stock provided by Calambokidis et al. (1997) with the 1981 estimate of 1,407 (95% CI: 1,113-1,701) from Baker et al. (1987) suggests that abundance increased in Hawaii between the early 1980s and early 1990s. Mobley et al. (2001) estimated a trend of 7% per year for 1993-2000 using data from aerial surveys that were conducted in a consistent manner for several years across all of the Hawaiian Islands and were developed specifically to estimate a trend for the Central North Pacific stock. Mizroch et al. (2004) estimated survival rates for North Pacific humpback whales using mark-recapture methods, and a Pradel model fit to data from Hawaii for the years 1980-1996 resulted in an estimated rate of increase of 10% per year (95% CI: 3-16%). For shelf waters of the northern Gulf of Alaska, Zerbini et al. (2006) estimated an annual rate of increase for humpback whales from 1987 to 2003 of 6.6% (95% CI: 5.2-8.6%). The SPLASH abundance estimate for the total North Pacific represents an annual increase of 4.9% over the most complete estimate for the North Pacific for 1991-1993. Comparisons of SPLASH abundance estimates for Hawaii to estimates for 1991-1993 gave estimates of annual increase that ranged from 5.5 to 6.0% (Calambokidis et al. 2008). No confidence limits were calculated for these rates of increase from SPLASH data. It is also clear that the abundance has increased in Southeast Alaska, though a trend for the Southeast Alaska portion of this stock cannot be estimated from the data because of differences in methods and areas covered.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Using a birth-interval model, Barlow and Clapham (1997) have estimated a population growth rate of 6.5% (SE = 1.2%) for the well-studied humpback whale population in the Gulf of Maine, although there are indications that this rate has slowed over the last decade (Clapham et al. 2003). Estimated rates of increase for the Central North Pacific stock include values for Hawaii of 7.0% (from aerial surveys), 5.5-6.0% (from mark-recapture abundance estimates), and 10% (95% CI: 3-16%) (from a model fit to mark-recapture data) and a value for the northern Gulf of Alaska of 6.6% (95% CI: 5.2-8.6%) from ship surveys (Calambokidis et al. 2008). Although there is no estimate of the maximum net productivity rate for the Central North Pacific stock, it is reasonable to assume that R_{MAX} for this stock would be at least 7%. Hence, until additional data become available for the Central North Pacific humpback whale stock, it is recommended that 7% be employed as the maximum net productivity rate (R_{MAX}) for this stock.

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized MMPA, the PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The default recovery factor (F_R) for this stock is 0.1, the recommended value for cetacean stocks listed as endangered under the ESA (Wade and Angliss 1997; see Status of Stock section below regarding ESA listing status). A recovery factor of 0.3 is used in calculating the PBR based on the suggested guidelines of Taylor et al. (2003). The default value of 0.04 for the maximum net productivity rate is replaced by 0.07, which is the best estimate of the current rate of increase and is considered a conservative estimate of the maximum net productivity rate. For the Central North Pacific stock of humpback whales, using the SPLASH study abundance estimate from the best fit model for 2004-2006 for Hawaii of 10,103 with an assumed CV of 0.300 and its associated N_{MIN} of 7,890, PBR is calculated to be 83 animals (7,890 x 0.035 x 0.3).

At this time, stock structure of humpback whales is under consideration and revisions may be proposed within the next few years. Just for information purposes, PBR calculations are completed here for the feeding area aggregations. For Southeast Alaska and northern British Columbia, the smallest abundance estimates from the SPLASH study were used with an assumed worst-case CV of 0.300 to calculate PBRs for feeding areas. Using the suggested guidelines presented in Taylor et al. (2003), it would be appropriate to use a recovery factor of 0.3 for the Southeast Alaska/northern British Columbia feeding aggregation since this aggregation has an N_{MIN} greater than 1,500 and less than 5,000 and has an increasing population trend. A recovery factor of 0.1 is appropriate for the Aleutian Islands and Bering Sea feeding aggregation and the Gulf of Alaska feeding aggregation because the N_{MIN} is greater than 1,500 and less than 5,000 and has an unknown population trend. If we calculated a PBR for the Southeast Alaska/northern British Columbia feeding aggregation it would be 24 (2,251 x 0.035 x 0.3). If we calculated a PBR for the Aleutian Islands and Bering Sea, it would be 7.9 (2,256 x 0.035 x 0.1). If we calculated a PBR for the Gulf of Alaska, it would be 7.8 (2,222 x 0.035 x 0.1). However, note that the actual PBR for the Central North Pacific stock is 83 based on the breeding population size in Hawaii, as calculated above.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

Between 2010 and 2014, mortality and serious injury of humpback whales occurred in the Bering Sea/Aleutian Islands flatfish trawl fishery (1 in 2010) and the Bering Sea/Aleutian Islands pollock trawl fishery (1 each in 2010 and 2012) (Table 1; Breiwick 2013; MML, unpubl. data). Since the stock identification of these whales is unknown, and the events occurred within the area where the Central North Pacific and Western North Pacific stocks are known to overlap, the mortality in these fisheries is assigned to both stocks of humpback whales. Two Central North Pacific humpback whales were injured in Hawaii longline fisheries in 2010-2014: one in the Hawaii shallow-set longline fishery in 2011 (prorated at 0.75 under the injury determination guidelines for large whales, since the severity of its injury is unknown) and one in the Hawaii deep-set longline fishery in 2014 (Table 1; Bradford and Forney 2014; NMFS-PIFSC, unpubl. data).

In 2012 and 2013, the Alaska Marine Mammal Observer Program (AMMOP) placed observers on independent vessels in the state-managed Southeast Alaska salmon drift gillnet fishery to assess mortality and serious injury of marine mammals. Areas around and adjacent to Wrangell and Zarembo Islands (ADF&G Districts 6, 7, and 8) were observed during the 2012-2013 program (Manly 2015). In 2013, one humpback whale was seriously injured. Based on the one observed serious injury, 11 serious injuries were estimated for Districts 6, 7, and 8 in 2013, resulting in an estimated mean annual mortality and serious injury rate of 5.5 Central North Pacific humpback whales in 2012-2013 (Table 1). Since these three districts represent only a portion of the overall fishing effort in this fishery, we expect this to be a minimum estimate of mortality and serious injury for the fishery.

Humpback whale mortality and serious injury due to entanglement in the commercial Southeast Alaska salmon drift gillnet fishery was reported to the NMFS Alaska Region stranding network in 2010-2014. Prorated values for serious injuries resulted in a total of 3 whales in 2010, 0.75 whales in 2011, 1.75 whales in 2012, 0.75 whales in 2013, and 2.5 whales in 2014 (Helker et al. 2016); however, this mortality and serious injury is accounted for by the AMMOP observer data for this fishery (in Table 1). One entanglement in the ground tackle of a commercial Pacific cod jig fishery vessel in Kodiak, Alaska, was also reported to the NMFS Alaska Region in 2013 (Table 2; Helker et al. 2016). Since observer data are not available for this fishery, this mortality results in a minimum mean annual mortality and serious injury rate of 0.2 humpback whales in 2010-2014 (Table 2) and, since the event occurred in the area where the two stocks overlap, the mortality is assigned to both the Central North Pacific and Western North Pacific stocks of humpback whales.

The minimum estimate of the mean annual mortality and serious injury rate incidental to U.S. commercial fisheries for the entire Central North Pacific stock in 2010-2014 is 7.4 humpback whales, based on observer data from Alaska (Table 1: 0.6 in federal fisheries + 5.5 in the state-managed Southeast Alaska salmon drift gillnet fishery) and Hawaii (Table 1: 1.1) and on reports, in which the commercial fishery is confirmed, to the NMFS Alaska Region stranding network (Table 2: 0.2).

Table 1. Summary of incidental mortality and serious injury of Central North Pacific humpback whales due to observed U.S. commercial fisheries in 2010-2014 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; Bradford and Forney 2014; Manly 2015; NMFS-PIFSC, unpubl. data; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports. N/A indicates that data are not available.

Fishery name	**Years**	**Data type**	**Percent observer coverage**	**Observed mortality**	**Estimated mortality**	**Mean estimated annual mortality**
Bering Sea/Aleutian Is. flatfish trawl[a]	2010 2011 2012 2013 2014	obs data	99 100 99 99 99	0 (+1)[b] 0 0 0 0	0 (+1)[c] 0 0 0 0	0 (+0.2)[d] (CV = N/A)
Bering Sea/Aleutian Is. pollock trawl[a]	2010 2011 2012 2013 2014	obs data	86 98 98 97 98	1 0 1 0 0	1.0 0 1.0 0 0	0.4 (CV = 0.09)
SE Alaska salmon drift gillnet (Districts 6, 7, 8)	2012 2013		6.4 6.6	0 1	0 11	5.5 (CV = 1.0)
Hawaii shallow-set longline	2010 2011 2012 2013 2014	obs data	100 100 100 100 100	0 1[e] 0 0 0	0 0.75[e] 0 0 0	0.2
Hawaii deep-set longline	2010 2011 2012 2013 2014	obs data	20 20 20 20 20	0 0 0 0 1	0 0 0 0 5	0.9 (CV = 2.1)
Minimum total estimated annual mortality					Bering Sea/Aleutian Is.: SE Alaska: Hawaii: Total:	0.6 5.5 1.1 7.2 (CV = 0.86)

[a]Mortality and serious injury in this fishery is assigned to both the Western North Pacific and Central North Pacific stocks of humpback whales, since the stock identification is unknown and the two stocks overlap within the area of operation of the fishery.
[b]Total mortality and serious injury observed in 2010: 0 whales in sampled hauls + 1 whale in an unsampled haul.
[c]Total estimate of mortality and serious injury in 2010: 0 whales (extrapolated estimate from 0 whales observed in sampled hauls) + 1 whale (1 whale observed in an unsampled haul).
[d]Mean annual mortality and serious injury for fishery: 0 whales (mean of extrapolated estimates from sampled hauls) + 0.2 whales (mean of number observed in unsampled hauls).
[e]A humpback whale was entangled and cut free with trailing gear. Due to the unknown configuration of the entanglement, this injury was prorated at a value of 0.75 (Bradford and Forney 2014).

Reports of swimming, floating, or beachcast humpback whales entangled in fishing gear or with injuries caused by interactions with gear, which may be from commercial, recreational, or subsistence fisheries, are another source of information on fishery-related mortality and serious injury. One whale with a serious injury (prorated at 0.75 under the injury determination guidelines for large whales) entangled in subsistence Southeast Alaska halibut longline gear was reported to the NMFS Alaska Region in 2012, resulting in a minimum mean annual mortality and serious injury rate of 0.2 humpback whales in 2010-2014 in this fishery (Table 2; Helker et al. 2016). Two whales (each with a serious injury prorated at 0.75) entangled in recreational troll gear were reported to the NMFS Pacific Islands Region in 2011, resulting in a minimum mean annual mortality and serious injury rate of 0.3 Central North Pacific humpback whales in recreational gear in 2010-2014 (Table 3; Bradford and Lyman 2015; NMFS-PIFSC, unpubl. data). Based on events that have not been attributed to a specific fishery listed on the MMPA List of Fisheries (76 FR 73912, 29 November 2011), the minimum mean annual mortality and serious injury rate from gear entanglements in unknown (commercial, recreational, or subsistence) fisheries is 7.7 humpback whales in 2010-2014: 1.7 reported to the NMFS Alaska Region stranding network (Table 2; Helker et al. 2016) and 6 reported to the NMFS Pacific Islands Region stranding network (Table 3; Bradford and Lyman 2015; NMFS-PIFSC, unpubl. data). These estimates are considered a minimum because not all entangled animals strand and not all stranded animals are found, reported, or have the cause of death determined.

Five humpback whales that were initially considered seriously injured due to entanglement in Southeast Alaska commercial Dungeness crab pot gear (1 in 2010), Southeast Alaska crab pot gear (1 in 2011 and 1 in 2012), Southeast Alaska shrimp pot gear (1 in 2011), and Gulf of Alaska/Kodiak Island Dungeness crab pot gear (1 in 2012) were disentangled in Alaska waters and released with non-serious injuries (Helker et al. 2016). Since the 2012 event occurred in the area where the two stocks overlap, this injury was also assigned to the Western North Pacific stock. Three additional whales that were initially considered seriously injured due to entanglement in Hawaii crab pot gear (1 in 2013) and unidentified fishing gear (1 each in 2013 and 2014) were disentangled in Hawaii waters and released with non-serious injuries (NMFS-PIFSC, unpubl. data). None of the whales released with non-serious injuries in Alaska or Hawaii waters were included in the mean annual mortality and serious injury rate for 2010-2014.

The minimum average annual mortality and serious injury rate due to interactions with all fisheries in 2010-2014 is 16 Central North Pacific humpback whales (7.4 in commercial fisheries + 0.2 in subsistence fisheries + 0.3 in recreational fisheries + 7.7 in unknown fisheries).

Table 2. Summary of mortality and serious injury of Central North Pacific humpback whales reported to the NMFS Alaska Region marine mammal stranding network in 2010-2014 (Helker et al. 2016). Injury events lacking detailed information on the injury are assigned prorated values following injury determination guidelines described in NOAA (2012). A summary of information used to determine whether an injury was serious or non-serious, as well as a table of prorate values used for large whale reports with incomplete information, is reported in Helker et al. (2016).

Cause of injury	**2010**	**2011**	**2012**	**2013**	**2014**	**Mean annual mortality**
Entangled in ground tackle of Kodiak commercial Pacific cod jig vessel	0	0	0	1	0	0.2
Entangled in subsistence SE Alaska halibut longline gear	0	0	0.75	0	0	0.2
Entangled in Bering Sea pot gear*	0	0.75	0	0	0	0.2
Entangled in Prince William Sound shrimp pot gear*	0	0	0	0	1	0.2
Entangled in SE Alaska longline gear*	0	0.75	0	0	0	0.2
Entangled in SE Alaska golden king crab pot gear*	0	0.75	0	0	0	0.2
Entangled in SE Alaska pot gear*	1.5	0	0	0	0	0.3
Entangled in gillnet*	0	0.75	1	0	0	0.4
Entangled in unidentified net*	0	0	0	0.75	0	0.2
Entangled in marine debris	2.25	5.5	0.75	1.5	4.5	2.9
Ship strike	4	2	2.6	0.14	4.52	2.7
Total in commercial fisheries						0.2
Total in subsistence fisheries						0.2
*Total in unknown (commercial, recreational, or subsistence) fisheries						1.7
Total in marine debris						2.9
Total due to other sources (ship strike)						2.7

Table 3. Summary of mortality and serious injury of Central North Pacific humpback whales reported to the NMFS Pacific Islands Region stranding network in 2010-2014 (Bradford and Lyman 2015; NMFS-PIFSC, unpubl. data).

Cause of injury	2010	2011	2012	2013	2014	Mean annual mortality
Entangled in recreational troll gear	0	1.5	0	0	0	0.3
Entangled in Alaska king crab pot gear*	0	0.75	0	0	0	0.2
Entangled in Alaska tanner crab pot gear*	0	0	1	0	0	0.2
Entangled in Alaska shrimp pot gear*	0	0	0	0	1	0.2
Entangled in Alaska king crab, tanner crab, or finfish pot gear*	0	0	0	0	0.75	0.2
Entangled in longline gear*	0	0	0	1	1	0.4
Entangled in unidentified fishing gear*	5	3.25	4.25	5.25	6.25	4.8
Ship strike	2.0	1.72	1.72	3.56	1	2
Total in recreational fisheries						0.3
*Total in unknown (commercial, recreational, or subsistence) fisheries						6
Total due to other sources (ship strike)						2

However, these estimates of mortality and serious injury levels should be considered a minimum. No observers have been assigned to several fisheries that are known to interact with this stock, making the estimated mortality and serious injury rate unreliable. Further, due to limited Canadian observer program data, mortality and serious injury incidental to Canadian commercial fisheries (i.e., those similar to U.S. fisheries known to interact with humpback whales) is uncertain. Though interactions are thought to be minimal, data regarding the level of humpback whale mortality and serious injury related to commercial fisheries in northern British Columbia are not available, again indicating that the estimated mortality and serious injury incidental to commercial fisheries is underestimated for this stock.

Alaska Native Subsistence/Harvest Information

Subsistence hunters in Alaska are not authorized to take from this stock of humpback whales, and no takes have been reported.

Other Mortality

In 2015, increased mortality of large whales (including 11 fin whales, 14 humpback whales, 1 gray whale, and 4 unidentified cetaceans from May to mid-August 2015) was observed along the western Gulf of Alaska, including the areas around Kodiak Island, Afognak Island, Chirikof Island, the Semidi Islands, and the southern shoreline of the Alaska Peninsula (http://www.nmfs.noaa.gov/pr/health/mmume/faqs_2015_large_whale.html, accessed December 2016). On 20 August 2015, NMFS declared an Unusual Mortality Event for large whales in the western Gulf of Alaska; however, to date, no specific cause for the increased mortality has been identified.

Ship strikes and other interactions with vessels unrelated to fisheries occur frequently with humpback whales (Tables 2 and 3). Neilson et al. (2012) summarized 108 large whale ship-strike events in Alaska from 1978 to 2011, 25 of which are known to have resulted in the whale's death. Eighty-six percent of these reports involved humpback whales. The minimum mean annual mortality and serious injury rate due to ship strikes reported in Alaska (Table 2: 2.7) and Hawaii (Table 3: 2) in 2010-2014 is 4.7 humpback whales. Most ship strikes of humpback whales are reported from Southeast Alaska; however, there are also reports from the Southcentral and Kodiak areas of Alaska (Helker et al. 2016). Many of the ship strikes occurring off Hawaii are reported from waters near Maui (Bradford and Lyman 2015; NMFS-PIFSC, unpubl. data). It is not known whether the difference in ship-strike rates between Southeast Alaska and the northern portion of this stock is due to differences in reporting, amount of vessel traffic, densities of animals, or other factors. Entanglements in marine debris reported to the NMFS Alaska Region account for a minimum mean annual mortality and serious injury rate of 2.9 Central North Pacific humpback whales in 2010-2014 (Table 2; Helker et al. 2016).

HISTORICAL WHALING

Rice (1978) estimated that the number of humpback whales in the North Pacific may have been approximately 15,000 individuals prior to exploitation; however, this was based upon incomplete data and, given the level of known catches (legal and illegal) since World War II, may be an underestimate. Intensive commercial whaling removed more than 28,000 animals from the North Pacific during the 20th century. Humpback whales in the North Pacific were theoretically protected in 1965, but illegal catches by the U.S.S.R. continued until 1972 (Ivashchenko et al. 2007). From 1961 to 1971, 6,793 humpback whales were killed illegally by the U.S.S.R. Many animals during this period were taken from the Gulf of Alaska and Bering Sea (Doroshenko 2000); however, additional illegal catches were made across the North Pacific, from the Kuril Islands to the Queen Charlotte Islands, and other takes in earlier years may have gone unrecorded.

On the feeding grounds of the Central North Pacific stock after World War II, the highest densities of catches occurred around the western Aleutian Islands, in the eastern Aleutian Islands (and adjacent Bering Sea to the north and Pacific Ocean to the south), and British Columbia (Springer et al. 2006). Lower but still relatively high densities of catches occurred south of the Commander Islands, along the south side of the Alaska Peninsula, and around Kodiak Island. Lower densities of catches also occurred in the Gulf of Anadyr, in the central Aleutian Islands, in much of the offshore Gulf of Alaska, and in Southeast Alaska. No catches were reported in the winter grounds of the Central North Pacific stock in Hawaii nor in Mexican winter areas.

STATUS OF STOCK

NMFS recently concluded a global humpback whale Status Review (Bettridge et al. 2015). Although the estimated annual level of human-caused mortality and serious injury for the entire Central North Pacific stock (24 whales) is considered a minimum, it is unlikely that the total level of human-caused mortality and serious injury exceeds the PBR level (83) for the entire stock. The minimum estimate of the mean annual U.S. commercial fishery-related mortality and serious injury rate for this stock (7.4 whales) is less than 10% of the calculated PBR for the entire stock (10% of PBR = 8.3) and, therefore, can be considered to be insignificant and approaching a zero mortality and serious injury rate. The humpback whale ESA listing final rule (81 FR 62259, 8 September 2016) established 14 Distinct Population Segments (DPSs) with different listing statuses. The DPSs that occur in waters under the jurisdiction of the United States do not necessarily equate to the existing MMPA stocks. Some of the listed DPSs partially coincide with the currently defined Central North Pacific stock. Because we cannot manage one portion of an MMPA stock as ESA-listed and another portion of a stock as not ESA-listed, until such time as the MMPA stock delineations are reviewed in light of the DPS designations, NMFS considers this stock to be endangered and depleted for MMPA management purposes (e.g., selection of a recovery factor, stock status). As a result, the Central North Pacific stock of humpback whales is classified as a strategic stock. Humpback whale mortality and serious injury in Hawaii-based fisheries involves whales from the Hawaii DPS; this DPS is not listed as threatened or endangered under the ESA.

HABITAT CONCERNS

This stock is the focus of a large whale-watching industry in its wintering grounds (Hawaii) and summering grounds (Alaska). Regulations concerning minimum distance to keep from whales and how to operate vessels when in the vicinity of whales have been developed for Hawaii and Alaska waters in an attempt to minimize the impact of whale watching. Additional concerns have been raised in Hawaii about the impact of jet skis and similar fast waterborne tourist-related traffic, notably in nearshore areas inhabited by mothers and calves. In Alaska, NMFS issued regulations in 2001 to prohibit approaches to humpback whales within 100 yards (91.4 m; 66 FR 29502, 31 May 2001). In 2015, NMFS introduced a voluntary responsible viewing program called Whale SENSE to Juneau area whale-watch operators to provide additional protections for whales in Alaska (https://whalesense.org, accessed December 2016). The growth of the whale-watching industry is an ongoing concern as preferred habitats may be abandoned if disturbance levels are too high. Other potential concerns include elevated levels of sound from anthropogenic sources (e.g., shipping, military sonars), possible changes in prey distribution with climate change, entanglement in fishing gear, ship strikes due to increased vessel traffic (e.g., from increased shipping in higher latitudes), and oil and gas activities.

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FIN WHALE (*Balaenoptera physalus*): Northeast Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Within the U.S. waters in the Pacific Ocean, fin whales are found seasonally off the coast of North America and in the Bering Sea during the summer (Fig. 1). Recent information on seasonal fin whale distribution has been gleaned from the reception of fin whale calls by bottom-mounted, offshore hydrophone arrays along the U.S. Pacific coast, in the central North Pacific, and in the western Aleutian Islands (Moore et al. 1998, 2006; Watkins et al. 2000; Stafford et al. 2007; Širović et al. 2013; Soule and Wilcock 2013). Moore et al. (1998, 2006), Watkins et al. (2000), and Stafford et al. (2007) documented high rates of fin whale calling along the U.S. Pacific coast beginning in August/September and lasting through February, suggesting that these may be important feeding areas during the winter. Širović et al. (2013) speculated that both resident and migratory fin whales may occur off southern California based on shifts in peaks in fin whale calling data. Širović et al. (2015) noted that fin whales were detected in the Southern California Bight year-round and found an increase in the fin whale call index from 2006 to 2012. Soule and Wilcock (2013) documented fin whale call rates in a presumed feeding area along the Juan de Fuca Ridge, offshore of northern Washington State, and found that some whales appear to head northwest from August to October. They speculate that some fin whales may migrate northward in fall and southward in winter. While peaks in call rates occurred during late summer, fall, and winter in the central North Pacific and the Aleutian Islands, fin whale calls were seldom detected during summer months even though fin whales are regularly seen in summer months in the Gulf of Alaska (Stafford et al. 2007). Fin whale calls were detected in the southeast Bering Sea using an instrument moored there, from April 2006 through April 2007, which showed peaks in fin whale call detections from September through November 2006 and also in February and March 2007 (Stafford et al. 2010). In addition, fin whale calls were detected in the northeastern Chukchi Sea using instruments moored there in July through October from 2007 through 2010 (Delarue et al. 2013). Call data collected from the Bering Sea suggest that several fin whale stocks may feed in the Bering Sea, but call data collected in the northeast Chukchi Sea suggest that only one of the putative Bering Sea stocks appears to migrate that far north to feed (Delarue et al. 2013). Some fin whale calls have also been recorded in the Hawaiian portion of the U.S. Exclusive Economic Zone in all months except June and July (Thompson and Friedl 1982, McDonald and Fox 1999). Sightings of fin whales in Hawaii are extremely rare: there was a sighting in 1976 (Shallenberger 1981), a sighting in 1979 (Mizroch et al. 2009), a sighting during an aerial survey in 1994 (Mobley et al. 1996), and five sightings during a survey in 2002 (Barlow 2006).

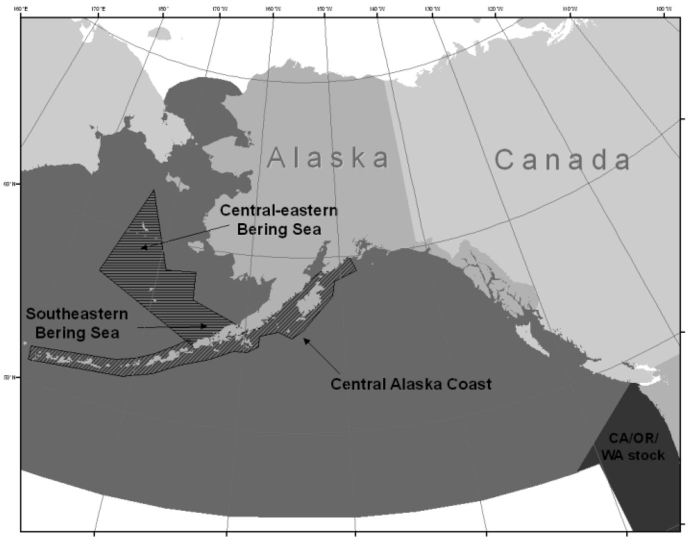

Figure 1. Approximate distribution of fin whales in the eastern North Pacific (dark shaded areas). Striped areas indicate where vessel surveys occurred in 1999-2000 (Moore et al. 2002) and 2001-2003 (Zerbini et al. 2006).

Surveys on the Bering Sea shelf in 1997, 1999, 2000, 2002, 2004, 2008, and 2010 and in coastal waters of the Aleutian Islands and the Alaska Peninsula from 2001 to 2003 provided information about the distribution and relative abundance of fin whales in these areas (Moore et al. 2000, 2002; Zerbini et al. 2006; Friday et al. 2012, 2013). Fin whales were the most common large whale sighted during the Bering Sea shelf surveys in all years except for 1997 and 2004 (Friday et al. 2012, 2013). Fin whales were consistently distributed both in the "green belt," an area of high productivity along the edge of the eastern Bering Sea (EBS) continental shelf (Springer et al. 1996), and in the middle shelf with the highest abundances occurring in the "green belt." Abundance estimates for fin whales in the Bering Sea were consistently higher in cold years than in warm years (Friday et al. 2012, 2013) indicating a shift in distribution. This is consistent with a fine-scale comparison of fin whale occurrence on the middle shelf between a cold year (1999) and a warm year (2002), which found that the group and individual encounter rates were 7-12 times higher in the cold year (Stabeno et al. 2012).

Based on historical whaling data, fin whales were found to range into the southern Sea of Okhotsk and Chukchi Sea. It was assumed that they passed through the Bering Strait into the southwestern Chukchi Sea during August and September. Many were taken as far west as Mys (Cape) Shmidta (68°55'N, 179°24'E) and as far north as 69°04'N, 171°06'W (Mizroch et al. 2009). Fin whale sightings have been increasing during sighting surveys in the U.S. portion of the northern Chukchi Sea in summer (Funk et al. 2010, Aerts et al. 2012, Clarke et al. 2013) and fin whale calls have been recorded each year from 2007 to 2010 in August and September on bottom-mounted hydrophones in the northeastern Chukchi Sea (Delarue et al. 2013), suggesting they may be re-occupying habitat used prior to large-scale commercial whaling. In August 2012, fin whale calls were recorded in the Alaska Chukchi Sea at a location 280 km northeast of the closest prior acoustic detection and 365 km northeast of the closest confirmed visual sighting of a fin whale, suggesting a possible range expansion over time as sea ice has retreated (Crance et al. 2015).

The following information was considered in classifying stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution continuous in winter, possibly isolated in summer; 2) Population response data: unknown; 3) Phenotypic data: unknown; and 4) Genotypic data: unknown. Based on this limited information, the International Whaling Commission (IWC) considers fin whales in the North Pacific to all belong to the same stock (Mizroch et al. 1984), although those authors cited additional evidence that supported the establishment of subpopulations in the North Pacific. Further, Fujino (1960) described eastern and western groups, which are isolated though may intermingle around the Aleutian Islands. Discovery mark recoveries (Rice 1974, Mizroch et al. 2009) indicate that animals wintering off the coast of southern California range from central California to the Gulf of Alaska during the summer months.

Mizroch et al. (2009) provided a comprehensive summary of whaling catch data, Discovery mark recoveries, and opportunistic sightings data and found evidence that suggests there may be at least six populations of fin whales: two that are migratory (eastern and western North Pacific) and 2-4 more that are resident year-round in peripheral seas such as the Gulf of California, East China Sea, Sanriku-Hokkaido, and possibly the Sea of Japan. It appears likely that the two migratory stocks mingle in the Bering Sea in July and August, rather than in the Aleutian Islands as Fujino (1960) concluded (Mizroch et al. 2009). During winter months, fin whales have been seen over a wide geographic area from 23°N to 60°N, but winter distribution and location of primary wintering areas (if any) are poorly known and need further study. As a result, stock structure of fin whales remains uncertain.

For management purposes, three stocks of fin whales are currently recognized in U.S. Pacific waters: 1) Alaska (Northeast Pacific), 2) California/Washington/Oregon, and 3) Hawaii. Mizroch et al. (2009) suggest that this structure should be reviewed and updated, if appropriate, to reflect recent analyses, but the absence of any substantially new data on stock structure makes this difficult. The California/Oregon/Washington and Hawaii fin whale stocks are reported separately in the Stock Assessment Reports for the U.S. Pacific Region.

POPULATION SIZE

Reliable estimates of current and historical abundance for the entire Northeast Pacific fin whale stock are currently not available. Two studies provide some information on the distribution and occurrence of fin whales, although they do not provide estimates of population size. A survey conducted in August of 1994 covering 2,050 nautical miles of trackline south of the Aleutian Islands encountered only four fin whale groups (Forney and Brownell 1996). However, this survey did not include all of the waters off Alaska where fin whale sightings have been reported, thus no population estimate could be made.

Visual shipboard surveys for cetaceans were conducted on the eastern Bering Sea shelf during summer in 1997, 1999, 2000, 2002, 2004, 2008, and 2010 (Moore et al. 2000, 2002; Friday et al. 2012, 2013). These surveys were conducted in conjunction with the Alaska Fisheries Science Center echo-integrated trawl surveys for walleye pollock which determined the survey area and timing. The surveys included from 789 km to 3,752 km of effort depending on the year and whether the entire area was surveyed for cetaceans. Results of the surveys in 2002, 2008, and 2010, years when the entire pollock area was surveyed, provided provisional estimates of 419 (CV = 0.33), 1,368 (CV = 0.34), and 1,061 (CV = 0.38) fin whales (Friday et al. 2013). These estimates are considered provisional because they have not been corrected for animals missed on the trackline, animals submerged when the ship passed, and responsive movement; no data are currently available to make these corrections. However, they are expected to be robust as previous studies have shown that only small correction factors are needed for this species (Barlow 1995). This estimate cannot be used as an estimate of the entire Northeast Pacific stock of fin whales because it is based on a survey in only a small part of the stock's purported range.

Dedicated line-transect cruises were conducted in coastal waters (as far as 85 km offshore) of western Alaska and the eastern and central Aleutian Islands in July-August 2001-2003 (Zerbini et al. 2006). Over 9,053 km of tracklines were surveyed between the Kenai Peninsula (150°W) and Amchitka Pass (178°W). Fin whale sightings (n = 276) were observed from east of Kodiak Island to Samalga Pass, with high aggregations recorded near the Semidi Islands. Zerbini et al. (2006) estimated that 1,652 (95% CI: 1,142-2,389) fin whales occurred in the area.

Minimum Population Estimate

Although the full range of the Northeast Pacific stock of fin whales in Alaska waters has not been surveyed, a rough estimate of the size of the population west of the Kenai Peninsula has been calculated in previous Stock Assessment Reports by summing the estimates from Moore et al. (2002) and Zerbini et al. (2006) (n = 5,700). However, based on analyses presented in Mizroch et al. (2009), whales surveyed in the Aleutians (Zerbini et al. 2006) could migrate into the Bering Sea and be counted during the Bering Sea surveys. There are also indications that fin whale distribution in the Bering Sea is related to oceanographic conditions (Stabeno et al. 2012, Friday et al. 2013), making it possible that whales could be double counted when estimates from different years are summed (Moore et al. 2002). Therefore, our best provisional estimate of the fin whale population west and north of the Kenai Peninsula in U.S. waters would be 1,368, the greater of the minimum estimates from the 2008 and 2010 surveys (Friday et al. 2013). A minimum population estimate (N_{MIN}) for this stock can be calculated according to Equation 1 from the potential biological removal (PBR) guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the best provisional estimate (N) of 1,368 from the 2010 surveys and the associated coefficient of variation CV(N) of 0.34 results in an N_{MIN} of 1,036 whales. However, this is an under-estimate for the entire stock because it is based on surveys which covered only a small portion of the stock's purported range.

Current Population Trend

Zerbini et al. (2006) estimated rates of increase of fin whales in coastal waters south of the Alaska Peninsula (Kodiak and Shumagin Islands). An annual increase of 4.8% (95% CI: 4.1-5.4%) was estimated for the period 1987-2003. This estimate is the first available for North Pacific fin whales and is consistent with other estimates of population growth rates of large whales. It should be used with caution, however, due to uncertainties in the initial population estimate for the first trend year (1987) and due to uncertainties about the population structure of fin whales in the area. Also, the study represented only a small fraction of the range of the Northeast Pacific stock.

Friday et al. (2013) estimated a 14% (95% CI: 1.0-26.5%) annual rate of change in abundance of fin whales during the period from 2002 to 2010. However, this apparent rate of change in abundance is higher than most plausible estimates of rates of change for large whale populations (see Zerbini et al. 2010 for a discussion of maximum rates of increase for humpback whale populations). It is likely that the apparent rate of change in abundance in the study area is due at least in part to changes in distribution and not just to changes in overall population size. Friday et al. (2013) found that the abundance of fin whales in the survey area increased in colder years, likely due to shifts in the distribution of prey. Stafford et al. (2010) provided evidence of prey-driven distribution where fin and right whale call rates in the vicinity of mooring M2 (approximate location: 57.9°N, 164.1°W) increased following peaks in euphausiid and copepod biomass.

Moore and Barlow (2011) analyzed trends in fin whale abundance from 1991 to 2008 from surveys conducted off California and found sufficient variability in trend estimates to conclude that the estimates were likely demonstrating dispersal of new individuals into the study area rather than actual population trends.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Zerbini et al. (2006) estimated an annual increase in coastal waters south of the Alaska Peninsula of 4.8% (95% CI: 4.1-5.4%) for the period 1987-2003. However, there are uncertainties in the initial population estimate from 1987, as well as uncertainties regarding fin whale population structure in this area. A reliable estimate of the maximum net productivity rate is currently unavailable for the Northeast Pacific fin whale stock. Hence, until additional data become available, it is recommended that the cetacean maximum net productivity rate (R_{MAX}) of 4% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.1, the recommended value for cetacean stocks which are listed as endangered (Wade and Angliss 1997). Using the best provisional estimate of 1,368 (CV = 0.34) from the 2010 surveys and the associated N_{MIN} of 1,036, PBR is calculated to be 2.1 (1,036 × 0.02 × 0.1) fin whales. However, because the estimate of minimum abundance is for only a small portion of the stock's purported range, the calculated PBR is considered unreliable for the entire Northeast Pacific fin whale stock.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

One incidental mortality of a fin whale due to entanglement in the ground tackle of a commercial mechanical jig fishing vessel was reported to the NMFS Alaska Region in 2012 (Table 1; Helker et al. 2016). Since observer data are not available for this fishery, this mortality results in a mean annual mortality and serious injury rate of 0.2 fin whales in 2010-2014 (Table 1).

Table 1. Summary of mortality and serious injury of Northeast Pacific fin whales, by year and type, reported to the NMFS Alaska Region marine mammal stranding network in 2010-2014 (Helker et al. 2016). Only cases of serious injury were recorded in this table; animals with non-serious injuries have been excluded.

Cause of injury	2010	2011	2012	2013	2014	Mean annual mortality
Entangled in ground tackle of commercial mechanical jig fishing vessel	0	0	1	0	0	0.2
Ship strike	1	0	0	0	1	0.4
Total in commercial fisheries						0.2
Total due to other causes (ship strike)						0.4

Alaska Native Subsistence/Harvest Information

Subsistence hunters in Alaska and Russia have not been reported to take fin whales from this stock.

Other Mortality

In 2015, increased mortality of large whales (including 11 fin whales, 14 humpback whales, 1 gray whale, and 4 unidentified cetaceans from May to mid-August 2015) was observed along the western Gulf of Alaska, including the areas around Kodiak Island, Afognak Island, Chirikof Island, the Semidi Islands, and the southern shoreline of the Alaska Peninsula (http://www.nmfs.noaa.gov/pr/health/mmume/faqs_2015_large_whale.html, accessed December 2016). On 20 August 2015, NMFS declared an Unusual Mortality Event for large whales in the western Gulf of Alaska; however, to date, no specific cause for the increased mortality has been identified.

Between 1911 and 1985, 49,936 fin whales were reported taken in commercial whaling operations throughout the North Pacific (Mizroch et al. 2009), although newly revealed information about illegal Soviet catches indicates that the Soviets over-reported catches of about 1,200 fin whales, presumably to hide catches of other protected species (Doroshenko 2000). Fin whale mortality due to ship strikes in Alaska waters (one each in 2010 and 2014) has also been reported to the NMFS Alaska Region stranding network (Helker et al. 2016), resulting in a mean annual mortality and serious injury rate of 0.4 fin whales due to ship strikes in 2010-2014 (Table 1).

STATUS OF STOCK

The fin whale is listed as endangered under the Endangered Species Act of 1973, and therefore designated as depleted under the MMPA. As a result, the Northeast Pacific stock is classified as a strategic stock. While reliable estimates of the minimum population size and population trends are available for a portion of this stock, much of the North Pacific range has not been surveyed. Therefore the status of the stock relative to its Optimum Sustainable Population is currently not available. The total estimated annual level of human-caused mortality and serious injury for Northeast Pacific fin whales (0.6 whales) does not exceed the calculated PBR (2.1 whales), and the minimum mean annual rate of U.S. commercial fishery-related mortality and serious injury (0.2 whales) is less than

10% of the calculated PBR (10% of PBR = 0.21). However, the calculated PBR is considered unreliable for the entire stock because it is based on an estimate from surveys of only a small portion of the stock's purported range.

HABITAT CONCERNS

Changes in ocean conditions that affect the seasonal distribution and quality of prey may affect fin whale movements, distribution, and foraging energetics. Ship strikes are a known source of mortality, and reductions in sea-ice coverage may lead to range extension and concomitant exposure to increased shipping and oil/gas activities in the Chukchi and Beaufort seas. Ocean warming may increase the frequency of algal blooms that produce biotoxins known to be associated with large whale mortality. However, few or no data are available to assess the likelihood or extent of such impacts.

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MINKE WHALE (*Balaenoptera acutorostrata*): Alaska Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the North Pacific, minke whales occur from the Bering and Chukchi seas south to near the Equator (Leatherwood et al. 1982). The following information was considered in classifying stock structure according to the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution continuous; 2) Population response data: unknown; 3) Phenotypic data: unknown; and 4) Genotypic data: unknown. Based on this limited information, in 1991 the International Whaling Commission (IWC) recognized three stocks of minke whales in the North Pacific: one in the Sea of Japan/East China Sea, one in the rest of the western Pacific west of 180°N, and one in the "remainder" of the Pacific (Donovan 1991). The "remainder" stock designation reflects the lack of exploitation in the eastern Pacific and does not indicate that only one population exists in this area (Donovan 1991). In the "remainder" area, minke whales are relatively common in the Bering and Chukchi seas and in the inshore waters of the Gulf of Alaska (Moore et al 2000, Friday et al. 2012, Clarke et al. 2013) but are not considered abundant in any other part of the eastern Pacific (Leatherwood et al. 1982, Brueggeman et al. 1990). Recent visual and acoustic data found minke whales in the Chukchi Sea north of Bering Strait in July and August (Clarke et al. 2013), and minke whale "boing" sounds have been detected in the northeast Chukchi Sea in August, October, and November (Delarue 2013). There are two types of geographically distinct "boing" sounds produced by minke whales in the North Pacific (Rankin and Barlow 2005). Those recorded in the Chukchi Sea matched "central Pacific" boings leading the authors to hypothesize that minke whales from the Chukchi Sea might winter in the central North Pacific, not near Hawaii (Delarue et al. 2013).

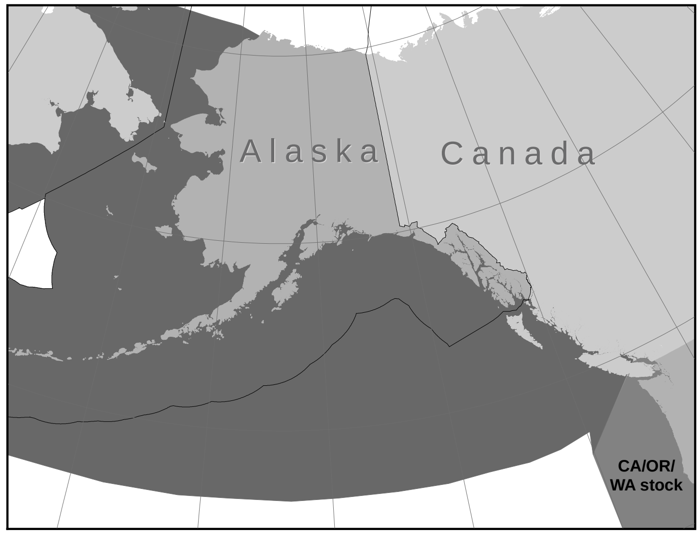

Figure 1. Approximate distribution of minke whales in the eastern North Pacific (dark shaded areas).

Ship surveys on the eastern Bering Sea shelf in 1999, 2000, 2002, 2004, 2008, and 2010 resulted in new information about the distribution and relative abundance of minke whales in this area (Moore et al. 2002; Friday et al. 2012, 2013). When comparing distribution and abundance in years when the entire study area was surveyed (2002, 2008, and 2010), Friday et al. (2013) found that minke whales were scattered throughout the study area in all oceanographic domains (coastal, middle shelf, and outer shelf/slope) in 2002 and 2008 but were concentrated in the outer shelf and slope in 2010. The highest minke whale abundance in the study area occurred in 2010 and abundance was greater in cold years (2008 and 2010) than a warm year (2002); however, changes in abundance were thought to be due at least in part to changes in distribution (Friday et al. 2013).

So few minke whales were seen during two offshore Gulf of Alaska surveys for cetaceans in 2009 and 2013 that a population estimate for this species in this area could not be determined (Rone et al. 2010, 2014).

In the northern part of their range, minke whales are believed to be migratory, whereas, they appear to establish home ranges in the inland waters of Washington and along central California (Dorsey et al. 1990). Because the "resident" minke whales from California to Washington appear behaviorally distinct from migratory whales farther north, minke whales in Alaska are considered a separate stock from minke whales in California, Oregon, and Washington (Dorsey et al. 1990). Accordingly, two stocks of minke whales are recognized in U.S. waters: 1) Alaska, and 2) California/Washington/Oregon (Fig. 1). The California/Oregon/Washington minke whale stock is reported separately in the Stock Assessment Reports for the U.S. Pacific Region.

POPULATION SIZE

No estimates have been made for the number of minke whales in the entire North Pacific. However, some information is available on the numbers of minke whales in some areas of Alaska. Visual surveys for cetaceans were conducted on the eastern Bering Sea shelf in 2002, 2008, and 2010 in cooperation with research on commercial fisheries (Friday et al. 2013). The surveys included 3,752 km, 3,253 km, and 1,638 km of effort in 2002, 2008, and 2010, respectively. Results of the surveys in 2002, 2008, and 2010 provide provisional abundance estimates of 389 (CV = 0.52), 517 (CV = 0.69), and 2,020 (CV = 0.73) minke whales on the eastern Bering Sea shelf, respectively (Friday et al. 2013). These estimates are considered provisional because they have not been corrected for animals missed on the trackline, animals submerged when the ship passed, or responsive movement. Additionally, line-transect surveys were conducted in shelf and nearshore waters (within 30-45 nautical miles of land) in 2001-2003 from the Kenai Fjords in the Gulf of Alaska to the central Aleutian Islands. Minke whale abundance was estimated to be 1,233 (CV = 0.34) for this area (Zerbini et al. 2006). This estimate has also not been corrected for animals missed on the trackline. The majority of the sightings were in the Aleutian Islands, rather than in the Gulf of Alaska, and in water shallower than 200 m. These estimates cannot be used as an estimate of the entire Alaska stock of minke whales because only a portion of the stock's range was surveyed.

Minimum Population

At this time, it is not possible to produce a reliable estimate of minimum abundance for this stock, as current estimates of abundance are not available.

Current Population Trend

There are no data on trends in minke whale abundance in Alaska waters.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

There are no estimates of the growth rate of minke whale populations in the North Pacific (Best 1993). Hence, until additional data become available, it is recommended that the cetacean maximum net productivity rate (R_{MAX}) of 4% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. Given the status of this stock is unknown, the appropriate recovery factor is 0.5 (Wade and Angliss 1997). However, because an estimate of minimum abundance is not available, the PBR for the Alaska minke whale stock is unknown at this time.

ANNUAL HUMAN-CAUSED MORTALITY

New Serious Injury Guidelines

NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historical injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*." Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.

Fisheries Information

Detailed information on U.S. commercial fisheries in Alaska waters (including observer programs, observer coverage, and observed incidental takes of marine mammals) is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

Six different commercial fisheries operating in Alaska waters within the range of the Alaska minke whale stock were monitored for incidental take by NMFS observers during 2009-2013: the Bering Sea/Aleutian Islands groundfish trawl, longline, and pot fisheries and the Gulf of Alaska groundfish trawl, longline, and pot fisheries. However, no mortality or serious injury of minke whales occurred in observed U.S. commercial fisheries in 2009-2013.

Alaska Native Subsistence/Harvest Information

No minke whales were ever taken by the modern shore-based whale fishery in the eastern North Pacific, which lasted from 1905 to 1971 (Rice 1974). Subsistence takes of minke whales by Alaska Natives are rare but have been known to occur. Only seven minke whales are reported to have been taken for subsistence by Alaska

Natives between 1930 and 1987 (C. Allison, International Whaling Commission, UK, pers. comm.). The most recent reported catches (two whales) in Alaska occurred in 1989 (Anonymous 1991), but reporting is likely incomplete. Based on this information, the average annual subsistence take was zero minke whales in 2009-2013.

Other Mortality

From 2009 to 2013, no human-related mortality or serious injury of minke whales was reported to the NMFS Alaska Region stranding database (Helker et al. 2015).

STATUS OF STOCK

Minke whales are not designated as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act. The greatest uncertainty regarding the status of the Alaska minke whale stock has to do with the uncertainty pertaining to the stock structure of this species in the eastern North Pacific. Because minke whales are considered common in the waters off Alaska and, because the number of human-related removals is currently thought to be minimal, this stock is presumed to not be a strategic stock. Reliable estimates of the minimum population size, population trends, PBR, and status of the stock relative to its Optimum Sustainable Population are currently not available. Because the PBR is unknown, the level of annual U.S. commercial fishery-related mortality and serious injury that can be considered insignificant and approaching zero mortality and serious injury rate is unknown.

HABITAT CONCERNS

Potential concerns include elevated levels of sound from anthropogenic sources (e.g., shipping, military sonars), possible changes in prey distribution with climate change, entanglement in fishing gear, ship strikes due to increased vessel traffic (e.g., from increased shipping in higher latitudes), and oil and gas activities.

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NORTH PACIFIC RIGHT WHALE (*Eubalaena japonica*): Eastern North Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

A review of all 20th-century sightings, catches, and strandings of North Pacific right whales was conducted by Brownell et al. (2001). Data from this review were subsequently combined with historical whaling records to map the known distribution of the species (Fig. 1; Clapham et al. 2004, Shelden et al. 2005). Although whaling records initially indicated that right whales ranged across the entire North Pacific north of 35°N and occasionally as far south as 20°N (Fig. 1; Scarff 1986, 1991), recent analysis shows a pronounced longitudinally bimodal distribution (Josephson et al. 2008a). Before right whales in the North Pacific were heavily exploited by commercial whalers, concentrations were found in the Gulf of Alaska, eastern Aleutian Islands, south-central Bering Sea, Sea of Okhotsk, and Sea of Japan (Braham and Rice 1984). An analysis conducted on the North Pacific right whale fishery by Josephson et al. (2008b) showed that within the course of a decade (1840s), right whale abundance was severely depleted, particularly in the eastern portion of their range. Following large illegal catches (primarily from 1962 to 1968) by the U.S.S.R. (Ivashchenko and Clapham 2012, Ivashchenko et al. 2013), only 82 sightings of right whales in the entire eastern North Pacific were reported from 1962 to 1999, with the majority of these occurring in the Bering Sea and adjacent areas of the Aleutian Islands (Brownell et al. 2001). Additional sightings have been reported as far south as central Baja California and as far east as Yakutat Bay and Vancouver Island in the eastern North Pacific, as far south as Hawaii in the central North Pacific, and as far north as the subarctic waters of the Bering Sea and Sea of Okhotsk in the summer (Herman et al. 1980, Rowntree et al. 1980, Berzin and Doroshenko 1982, Salden and Mickelsen 1999, Brownell et al. 2001, Ford et al. 2016). However, most right whale sightings in the past 20 years have occurred in the southeastern Bering Sea, with a few in the Gulf of Alaska, near Kodiak, Alaska (Waite et al. 2003; Shelden et al. 2005; Wade et al. 2011a, 2011b).

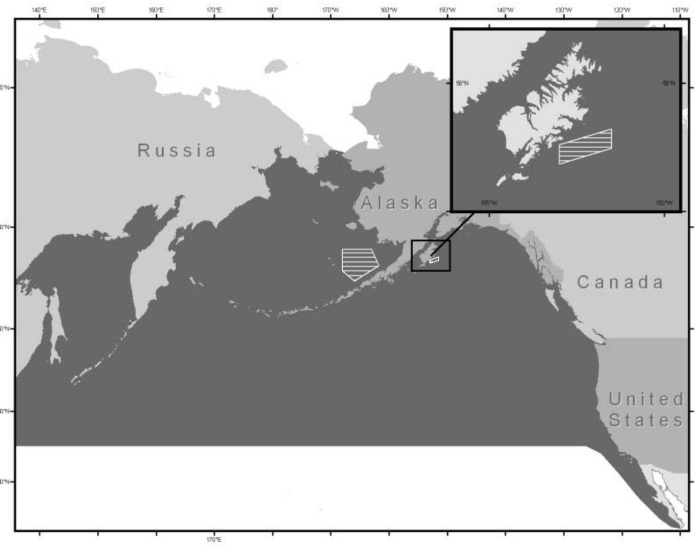

Figure 1. Approximate historical distribution of North Pacific right whales in the eastern North Pacific (dark shaded area). Striped areas indicate northern right whale critical habitat (71 FR 38277, 6 July 2006).

North Atlantic (*E. glacialis*) and Southern Hemisphere (*E. australis*) right whales calve in coastal waters during the winter months. However, in the eastern North Pacific no such calving grounds have been identified (Scarff 1986). Migratory patterns of North Pacific right whales are unknown, although it is thought they migrate from high-latitude feeding grounds in summer to more temperate waters during the winter, possibly well offshore (Braham and Rice 1984, Scarff 1986, Clapham et al. 2004). A right whale sighted off Maui in April 1996 (Salden and Michelsen 1999) was identified 119 days later and 4,111 km north in the Bering Sea (Kennedy et al. 2011). While the photographic match confirms that Bering Sea animals occasionally travel south, there is currently no reason to believe that either Hawaii or tropical Mexico have ever been anything except extra-limital habitats for this species (Brownell et al. 2001).

Passive acoustic monitoring from 2011 to 2014 of the northern Bering Sea revealed detections of calls matching the North Pacific right whale up call criterion in late winter (Wright 2015), suggesting that North Pacific right whales may occur in the northern Bering Sea during winter months. An individual North Pacific right whale was visually identified north of St. Lawrence Island in November 2012 (G. Sheffield, University of Alaska Fairbanks, Nome, AK), confirming their recent presence at higher latitudes late in the season. However, the winter upsweeps were observed during bowhead whale song and heavy ice conditions. As a result, these calls were termed ambiguous because there is some chance they were bowhead whale calls; further analysis is underway to clarify which species are making these calls (Wright 2015).

Information on the summer and autumn distribution of right whales is available from dedicated vessel and aerial surveys, bottom-mounted acoustic recorders, and vessel surveys for fisheries ecology and management that have also included dedicated marine mammal observers. Aerial and vessel surveys for right whales have occurred in a portion of the southeastern Bering Sea (Fig. 1) where right whales have been observed most summers since 1996 (Goddard and Rugh 1998, Rone et al. 2012). North Pacific right whales are observed consistently in this area, although it is clear from historical and Japanese sighting survey data that right whales often range outside this area and occur elsewhere in the Bering Sea (Moore et al. 2000, 2002; LeDuc et al. 2001; Clapham et al. 2004). Bottom-mounted acoustic recorders were deployed in the southeastern Bering Sea and the northern Gulf of Alaska starting in 2000 to document the seasonal distribution of right whale calls (Mellinger et al. 2004). Analysis of the data from those recorders deployed between October 2000 and January 2006 indicates that right whales remain in the southeastern Bering Sea from May through December with peak call detection in September (Munger and Hildebrand 2004). Data from recorders deployed between May 2006 and April 2007 show the same trends (Stafford and Mellinger 2009, Stafford et al. 2010). Recorders deployed from 2007 to the present time have not been fully analyzed, but 2012-2013 data indicate the presence of right whales in the southeastern Bering Sea in July-January, with a peak in September and a sharp decline in detections by mid-November (C. Berchok, NMFS-AFSC-MML, unpubl. data; Wright 2015). The probability of acoustically detecting right whales in the Bering Sea has been found to be strongly influenced by the abundance of the copepod *Calanus marshallae* (Baumgartner et al. 2013), and those authors propose that *C. marshallae* is the primary prey for right whales on the Bering Sea shelf. The seasonal development of these copepods into later life-history stages that can be exploited by right whales closely matches the peak timing of right whale call detections (Munger et al. 2008, Baumgartner et al. 2013). Additionally, right whale "gunshot" call detections increased shortly after peaks in copepod biovolume (Stafford et al. 2010). Baumgartner et al. (2013) suggest that the availability of *C. marshallae* on the middle shelf of the southeast Bering Sea is the reason right whales aggregate there annually. Satellite-telemetry data from four whales tagged in 2008 and 2009 provide further indication of this area's importance as foraging habitat for Eastern North Pacific right whales (Zerbini et al. 2015). Right whales were not observed outside the localized area in the southeastern Bering Sea during surveys conducted for fishery management purposes that covered a broader area of Bristol Bay and the Bering Sea (Moore et al. 2000, 2002; see Fig. 1 in the Northeast Pacific fin whale Stock Assessment Report for locations of tracklines for these surveys).

There are fewer recent sightings of right whales in the Gulf of Alaska than in the Bering Sea (Brownell et al. 2001); although, until the summer of 2015 there was little survey effort in this region, notably in the offshore areas where right whales commonly occurred during whaling days (Ivashchenko and Clapham 2012). Waite et al. (2003) summarized sightings from the Platforms of Opportunity Program from 1959 to 1997. Additional lone animals were observed off Kodiak Island in the Barnabas Canyon area from NOAA surveys in August 2004, 2005, and 2006 (A. Zerbini, NMFS-AFSC-MML, unpubl. data). A single right whale was reported in Pasagshak Bay by a kayaker in May of 2010, and one was sighted in December 2011 by humpback whale researchers in Uganik Bay (A. Kennedy, NMFS-AFSC-MML, pers. comm., 7 October 2012). A single right whale was sighted south of the Alaska Peninsula (53.5°N, 156.5°W) during a seismic survey in July 2011 (Davis et al. 2011). Acoustic monitoring from May 2000 to July 2001 at seven sites in the Gulf of Alaska detected right whale calls at only two sites: one off eastern Kodiak and the other in deep water south of the Alaska Peninsula (detection distance in 10s of kilometers) (Mellinger et al. 2004). More recently, right whale up and gunshot calls were detected in Unimak Pass in May-September and December-February on recorders deployed in 2009-2014. Similarly, gunshot calls were detected at Umnak Pass in July-September on a recorder deployed in 2009 (Wright 2015). Additionally, right whale up calls were detected on a recorder deployed near Quinn Seamount in the Gulf of Alaska on a few days each in June, July, August, and September 2013 (Širović et al. 2015).

A dedicated vessel survey for right whales was conducted by NMFS in August 2015 aboard the NOAA ship *Reuben Lasker*; the cruise used visual and acoustic survey techniques and followed tracklines on the shelf and in deeper waters to the south and east of Kodiak (B. Rone, NMFS-AFSC-MML, unpubl. data). Right whales were acoustically detected twice on the shelf, but none were visually observed.

Most of the illegal Soviet catches of right whales occurred in offshore areas, including a large area to the east and southeast of Kodiak (Doroshenko 2000, Ivashchenko and Clapham 2012); the Soviet catch distribution closely parallels that seen in plots of 19th-century American whaling catches by Townsend (1935). Whether this region remains an important habitat for this species, or whether cultural memory of its existence has been lost, is currently unknown. The sightings and acoustic detection of right whales in coastal waters east of Kodiak indicate at least occasional continuing use of this area; however, the lack of visual detections of right whales during the *Reuben Lasker* cruise in August 2015 adds to the concern that the Gulf of Alaska population may be extremely small.

In recent years, there have been two sightings of single right whales in the waters of British Columbia. The first was observed off Haida Gwaii on 9 June 2013 and the second, a large adult, was seen in the Strait of Juan de Fuca on 25 October 2013; this second animal had an apparently healed major wound across the rostrum, which may have been caused by a previous entanglement in fishing gear (Ford et al. 2016). Two right whale calls were detected on a bottom-mounted hydrophone off the Washington Coast on 29 June 2013. No right whale calls were detected in previous years at this site (Širović et al. 2015).

The following information was considered in classifying stock structure according to the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: distinct geographic distribution; 2) Population response data: unknown; 3) Phenotypic data: unknown; and 4) Genotypic data: evidence for some isolation of populations. Based on this limited information, two stocks of North Pacific right whales are currently recognized: a Western North Pacific and an Eastern North Pacific stock (Rosenbaum et al. 2000, Brownell et al. 2001, LeDuc et al. 2012). The former is believed to feed primarily in the Sea of Okhotsk.

POPULATION SIZE

The former U.S.S.R. made illegal catches of an estimated 772 total right whales in the eastern and western North Pacific, with the majority (662) killed between 1962 and 1968. These takes severely impacted the two populations concerned, notably in the east (Ivashchenko and Clapham 2012, Ivashchenko et al. 2013). Based on sighting data, Wada (1973) estimated a total population of 100-200 in the North Pacific. Rice (1974) stated that only a few individuals remained in the Eastern North Pacific stock and that for all practical purposes the stock was extinct because no sightings of a mature female with a calf had been confirmed since 1900. However, confirmed sightings over the last 14 years, starting in 1996 (Goddard and Rugh 1998), have invalidated this view (Wade et al. 2006). Brownell et al. (2001) suggested from a review of sighting records that the abundance of this species in the western North Pacific was likely in the "low hundreds," including the population in the Okhotsk Sea.

There were several sightings of North Pacific right whales in the mid-1990s, which renewed interest in conducting dedicated surveys for this species that included the collection of photo-identifications and biopsies. Right whales can be individually identified by photographs of the unique callosity patterns on their heads. In April 1996, a right whale was sighted off Maui (Salden and Mickelsen 1999), and that same animal was identified 119 days later and 4,111 km north (in the Bering Sea); this represents the first high- to low-latitude match of a North Pacific right whale (Kennedy et al. 2011). The Maui sighting in April was the first documented sighting of a right whale in Hawaiian waters since 1979 (Herman et al. 1980, Rowntree et al. 1980) and, even though the photographic match confirms that Bering Sea animals occasionally travel south, there is little reason to believe that either Hawaii or tropical Mexico have ever been anything except extra-limital habitats for this species (Brownell et al. 2001).

A group of 3-4 right whales, that may have included a juvenile animal, was sighted in western Bristol Bay, southeastern Bering Sea, in July 1996 (Goddard and Rugh 1998). In July 1997, a group of 4-5 individuals was encountered one evening in Bristol Bay, followed by a second sighting of 4-5 whales the following morning in approximately the same location (Tynan 1999). During dedicated surveys in July 1998, July 1999, and July 2000, 5, 6, and 13 right whales were again found in the same general region of the southeastern Bering Sea (LeDuc et al. 2001). Biopsy samples of right whales encountered in the southeastern Bering Sea were taken in 1997 and 1999. Genetic analyses identified three individuals in 1997 and four individuals in 1999; of the animals identified, one was identified in both years, resulting in a total genetic count of six individuals (LeDuc et al. 2001). Genetic analyses of samples from all six whales sampled in 1999 determined that the animals were male (LeDuc et al. 2001). Two right whales were observed during a vessel-based survey in the central Bering Sea in July 1999 (Moore et al. 2000).

During the southeast Bering Sea survey in 2002, there were seven sightings of right whales (LeDuc 2004). One of the sightings in 2002 included a right whale calf; this is the first confirmed sighting of a calf in decades (a possible calf or juvenile sighting was also reported in Goddard and Rugh 1998). This concentration also included two probable calves. In the southeastern Bering Sea during September 2004, multiple right whales were acoustically located and subsequently sighted by another survey vessel approaching a near-real-time position of an individual located with a satellite tag (Wade et al. 2006). An analysis of photographs confirmed at least 17 individual whales (not including the tagged whales). Genetic analysis of biopsy samples identified 17 individuals: 10 males and 7 females. The discovery of seven females was significant as only one female had been identified previously, and at least two calves were present. From 2007 to 2011, 12 individual right whales were seen (some individuals were seen many times over all survey years).

Photographic and genotype data through 2008 were used to calculate the first mark-recapture estimates of abundance for right whales in the Bering Sea and Aleutian Islands, resulting in estimates of 31 (95% CL: 23-54; CV

= 0.22) and 28 (95% CL: 24-42), respectively (Wade et al. 2011a). The abundance estimates are for the last year of each study, corresponding to 2008 for the photo-identification estimate and 2004 for the genetic identification estimates. Wade et al. (2011a) also estimate the population consists of 8 females (95% CL: 7-18) and 20 males (95% CL: 17-37). Wade et al. (2011a) summarized the photo-identification and genetic-identification catalogues as follows: twenty-one individuals were identified from genotyping from the Aleutian Islands and Bering Sea from 1997 to 2004, comprising 15 males and 6 females. In aggregate, there were eight photo matches of individual whales across years involving five individuals. Wade et al. (2006) reported 17 individuals (including 7 females) identified from genotyping in 2004; that number was revised to 16 individuals (including 6 females) because a typographical error was subsequently discovered that masked a duplicate sample. There were four biopsies taken in 2008 and 2009 of two males and two females; three of these animals had been sampled in previous years. These samples were unavailable and not included in the Wade et al. (2011a) abundance estimate (A. Kennedy, NMFS-AFSC-MML, pers. comm., 21 September 2011).

The photo-identification catalogue, for purposes of abundance estimation, was restricted to aerial or left-side oblique photographs of good or excellent photo quality. After this restriction, there was a total of 18 unique individuals identified from photographs of callosity patterns and scars from 1998 to 2008, with 10 resightings across years involving 5 individuals.

Another seven individuals were observed in the summer of 2009, and one individual was seen in the summer of 2010 (A. Kennedy, NMFS-AFSC-MML, pers. comm., 3 November 2010). Four individuals were seen in the summer of 2011 (B. Rone, NMFS-AFSC-MML, pers. comm., 7 October 2012). The two sightings noted above of right whales (one in June and one in October) in British Columbia waters in 2013 were the first sightings of this species in this region in decades. Comparisons with the photo-identification catalogue curated at the Marine Mammal Laboratory showed that neither individual had been previously photographed elsewhere. Whether this indicates that right whales are returning to these coastal waters where they were once hunted is unclear.

LeDuc et al. (2012) analyzed 49 biopsy samples from right whales identified as being from 24 individuals, of which all but one were from the eastern North Pacific. The analysis revealed a male-biased sex ratio and a loss of genetic diversity that appeared to be midway between that observed for right whales in the North Atlantic and the Southern Hemisphere. The analysis also suggested a degree of separation between eastern and western populations, a male:female ratio of 2:1, and a low effective population size for the Eastern North Pacific stock, which LeDuc et al. (2012) considered to be at "extreme risk" of extirpation.

Detections of right whales have been very rare in the Gulf of Alaska, even though large numbers of whales were caught there in the 1800s and 1960s. With the exception of the Soviet catches, primarily in 1963-1964 (Ivashchenko and Clapham 2012), from the 1960s through 2002, only two sightings of right whales occurred in the Gulf of Alaska: an opportunistic sighting in March 1979 near Yakutat Bay in the eastern Gulf (Shelden et al. 2005) and a sighting during an aerial survey for harbor porpoise in July 1998 south of Kodiak Island (Waite et al. 2003). Both sightings occurred in shelf waters less than 100 m deep. However, from 2004 to 2006, four sightings of right whales occurred in the Barnabus Trough region on Albatross Bank, south of Kodiak Island (Wade et al. 2011b). Sightings of right whales occurred at locations within the trough with the highest density of zooplankton, as measured by active-acoustic backscatter. Photo-identification (of two whales) and genotyping (of one whale) failed to reveal a match to Bering Sea right whales. Fecal hormone metabolite analysis from one whale estimated levels consistent with an immature male, indicating either recent reproduction in the Gulf of Alaska or movements between the Bering Sea and Gulf of Alaska. The survey conducted off Kodiak in the summer of 2015 made two acoustic (and no visual) detections of right whales (B. Rone, NMFS-AFSC-MML, unpubl. data).

In recent decades, the only detections of right whales in pelagic waters of the Gulf of Alaska came from passive acoustic recorders. These detections of calls were exceptionally rare; instruments in seven widespread locations detected right whale calls from only two of the locations on only 6 days out of a total of 80 months of recordings (Mellinger et al. 2004) and on only 5 days out of a total of 70 months of recordings from the five deep-water stations. The calls were heard at the deep-water station in the Gulf of Alaska ~500 km southwest of Kodiak Island on 5 days in August and September of 2000, but no calls were detected from four other instruments deployed in deep water farther east during 2000 and 2001 (Mellinger et al. 2004). Calls classified as "probable" right whales were detected from an instrument deployed on the shelf at the location of the aerial visual detection on Albatross Bank on 6 September 2000 (Waite et al. 2003), but no calls were detected from two instruments deployed at the base of the continental slope off Albatross Bank just northeast of Barnabus Trough (Mellinger et al. 2004, Munger et al. 2008). Twenty sonobuoy deployments in 2004 throughout the Gulf of Alaska resulted in the detection of right whale calls only in Barnabus Trough, near the location of the visual sightings mentioned above (Wade et al. 2011b). Right whale up-calls were detected far offshore in the Gulf of Alaska in 2013 on a bottom-mounted recorder at Quinn Seamount during a total of 3 hours on 2 days (21 June and 3 August 2013). Right whale down calls were detected during 50 hours from 27 July to 5 September 2013 (Širović et al. 2015). The lack of detection of right whales from passive acoustic recorders does not provide indisputable evidence there were no right whales in the area, as the whales may not always vocalize or their calls may not always be detected by the automatic algorithms used or the call type targeted for detection. Until very recently, only a single call type, the "up call" was used to automatically detect right whales. The "gunshot" call has recently been identified as another candidate for right whale detections (Stafford et al. 2010, Rone et al. 2012). However, it is interesting to note the contrasting data from the southeastern Bering Sea, where similar instruments on the middle shelf (<100 m depth) detected right whale calls on >6 days per month in July-October (Munger et al. 2008), despite a population estimated to be only 31 whales (Wade et al. 2011a). The lack of detections of right whales in pelagic waters of the Gulf of Alaska may still be partially due to a lack of survey and recording effort in those areas, but the lack of calls in passive-acoustic monitoring suggests that right whales are very rare in at least the monitored pelagic areas today. More extensive coverage of shelf and nearshore waters of the Gulf of Alaska during previous ship and airplane surveys for cetaceans (summarized in Wade et al. 2011b) detected a single right whale near Kodiak Island (Waite et al. 2003) and two acoustic detections from the *Reuben Lasker* survey in August 2015 (B. Rone, NMFS-AFSC-MML, unpubl. data). Therefore, the Barnabus Trough/Albatross Bank area represents the only location in the Gulf of Alaska where right whales have been repeatedly detected in the last 4 decades, and those detections add only a minimum of two additional whales (from photo-identification in 2005 and 2006) to the total Eastern North Pacific population. However, with the exception of the August 2015 study off Kodiak, there has been virtually no survey coverage of the offshore waters in which right whales commonly occurred during historical and recent whaling periods (Townsend 1935, Ivashchenko and Clapham 2012).

Minimum Population Estimate

The minimum estimate of abundance of Eastern North Pacific right whales is 26 based on the 20th percentile of the photo-identification estimate of 31 (CV = 0.226; Wade et al. 2011a). The photo-identification catalogue used in the mark-recapture abundance estimate has a minimum of 20 unique individuals seen from 1998 to 2013, yet this number could be higher given that there are many animals with poor quality photos or poor coverage (one side only). The genetic-identification catalogue has a total of 23 individuals identified from 1997 to 2011 (LeDuc et al. 2012).

Current Population Trend

No estimate of trend in abundance is currently available.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Due to insufficient information, the default cetacean maximum net productivity rate (R_{MAX}) of 4% is used for this stock (Wade and Angliss 1997). However, given the small apparent size, male bias, and low observed calving rate of this population, this rate is likely to be unrealistically high.

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.1, the recommended value for cetacean stocks which are listed as endangered (Wade and Angliss 1997). A reliable estimate of minimum abundance for this stock is 26 based on the mark-recapture estimate of 31 (CV = 0.226; Wade et al. 2011a). The calculated PBR level for this stock is therefore 0.05 which would be equivalent to one take every 20 years. However, because the Eastern North Pacific right whale population is far below historical levels and considered to include fewer than 30 mature females, the calculated value for PBR is considered unreliable.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

Gillnets were implicated in the death of a right whale off the Kamchatka Peninsula (Russia) in October of 1989 (Kornev 1994), which was presumably from the Western North Pacific population. No other incidental takes of right whales are known to have occurred in the North Pacific, although one photograph from the catalogue shows potential fishing gear entanglement (A. Kennedy, NMFS-AFSC-MML, pers. comm., 21 September 2011). The right whale photographed on 25 October 2013 off British Columbia and northern Washington State, showed potential fishing gear entanglement (Ford et al. 2016). Vessel collisions are considered the primary source of human-caused mortality and serious injury of right whales in the North Atlantic (Cole et al. 2005). Given the very small estimate of abundance, any mortality or serious injury incidental to commercial fisheries would be considered significant. Entanglement in fishing gear, including lobster pot and sink gillnet gear, is a significant source of mortality and serious injury for the North Atlantic right whale stock (Waring et al. 2004).

There are no records of mortality or serious injury of Eastern North Pacific right whales in any U.S. fishery. Overall, given the remote nature of the known and likely habitats of North Pacific right whales, it is very unlikely that any mortality in this population would be observed. Consequently, it is possible that the current absence of reported deaths in this stock is not a reflection of the true situation.

Alaska Native Subsistence/Harvest Information

Subsistence hunters in Alaska and Russia are not reported to take animals from this stock.

Other Mortality

Ship strikes are a significant source of mortality and serious injury for the North Atlantic stock of right whales, and it is possible that right whales in the North Pacific are also vulnerable to this source of mortality. However, due to their rare occurrence and scattered distribution, it is impossible to assess the threat of ship strikes to the Eastern North Pacific stock of right whales at this time. There is concern regarding the effects of increased shipping through arctic waters and the Bering Sea with retreating sea ice, which may increase the potential risk to right whales from shipping.

Overall, given the remote nature of the known and likely habitats of North Pacific right whales, it is very unlikely that any mortality in this population would be observed. Consequently, it is possible that the current absence of reported deaths in this stock is not a reflection of the true situation.

STATUS OF STOCK

The right whale is listed as endangered under the Endangered Species Act of 1973, and therefore designated as depleted under the MMPA. In 2008, NMFS relisted the North Pacific right whale as endangered as a separate species (*Eubalaena japonica*) from the North Atlantic species, *E. glacialis* (73 FR 12024, 06 March 2008). As a result, the stock is classified as a strategic stock. The abundance of this stock is considered to represent only a small fraction of its pre-commercial whaling abundance (i.e., the stock is well below its Optimum Sustainable Population). The total estimated annual level of human-caused mortality and serious injury is considered minimal for this stock. The reason(s) for the apparent lack of recovery for this stock is (are) unknown. Brownell et al. (2001) and Ivashchenko and Clapham (2012) noted the devastating impact of extensive illegal Soviet catches in the eastern North Pacific in the 1960s, and both suggested that the prognosis for right whales in this area was poor. Biologists working aboard the Soviet factory ships which killed right whales in the eastern North Pacific in the 1960s considered that the fleets had caught close to 100% of the animals they encountered (Ivashchenko and Clapham 2012); accordingly, it is quite possible that the Soviets wiped out the great majority of the animals in the population at that time. In its review of the status of right whales worldwide, the International Whaling Commission expressed “considerable concern” over the status of this population (IWC 2001), which is currently the most endangered stock of large whales in the world for which an abundance estimate is available.

HABITAT CONCERNS

NMFS conducted an analysis of right whale distribution in historical times and in recent years and stated that principal habitat requirements for right whales are dense concentrations of prey (Clapham et al. 2006) and, on this basis, proposed two areas of critical habitat: one in the southeastern Bering Sea and another south of Kodiak Island (70 FR 66332, 2 November 2005). In 2006, NMFS issued a final rule designating these two areas as northern right whale critical habitat, one in the Gulf of Alaska and one in the Bering Sea (71 FR 38277, 6 July 2006; Fig. 1). In 2008, NMFS redesignated the same two areas as Eastern North Pacific right whale critical habitat under the newly recognized species name, *E. japonica*.

Potential threats to the habitat of this population derive primarily from commercial shipping and fishing vessel activity. There is considerable fishing activity within portions of the critical habitat of this species, increasing the risk of entanglement, although photographs of right whales taken to date have shown no evidence of entanglement scars. The high volume of large vessels transiting Unimak Pass (e.g., 1,961 making 4,615 transits in 2012 (Nuka Research and Planning Group, LLC 2014a, 2014b), a subset of which continue north through the Bering

Sea, increases both the risk of ship strikes and the risk of a large or very large oil spill in areas in which right whales may occur. The risk of accidents in Unimak Pass, specifically, is predicted to increase in the coming decades, and studies indicate that more accidents are likely to involve container vessels (Wolniakowski et al. 2011). The U.S. Department of the Interior has designated areas within the southeastern Bering Sea, including areas designated as right whale critical habitat, as an outer continental shelf oil and gas lease area. This planning area, referred to as the North Aleutian Basin, was not included in the current 2012-2017 national lease schedule by the Bureau of Ocean Energy Management, and there are no residual active leases from past sales. On December 16, 2014, President Obama announced that, under authority granted him by Section 12(a) of the Outer Continental Lands Act (OCSLA), he was withdrawing the North Aleutian Basin from future oil and gas leasing, development or production "for a time period without specific expiration." Thus, oil and gas leasing in federal waters in this area is not likely for the foreseeable future.

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BOWHEAD WHALE (*Balaena mysticetus*): Western Arctic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Western Arctic bowhead whales are distributed in seasonally ice-covered waters of the Arctic and near-Arctic, generally north of 60°N and south of 75°N in the western Arctic Basin (Braham 1984, Moore and Reeves 1993). For management purposes, four stocks of bowhead whales have been recognized worldwide by the International Whaling Commission (IWC 2010). Small stocks, comprised of only a few hundred individuals occur in the Sea of Okhotsk and the offshore waters of Spitsbergen (Zeh et al. 1993, Shelden and Rugh 1995, Wiig et al. 2009, Shpak et al. 2014, Boertmann et al. 2015). Bowhead whales occur in western Greenland (Hudson Bay and Foxe Basin) and eastern Canada (Baffin Bay and Davis Strait), and evidence suggests that these should be considered one stock based on genetics (Postma et al. 2006, Bachmann et al. 2010, Heide-Jørgensen et al. 2010, Wiig et al. 2010), aerial surveys (Cosens et al. 2006), and tagging data (Dueck et al. 2006; Heide-Jørgensen et al. 2006; IWC 2010, 2011). This stock, previously thought to include only a few hundred animals, may number over a thousand (Heide-Jørgensen et al. 2006, Wiig et al. 2011), and perhaps over 6,000 (IWC 2008). The only stock found within U.S. waters is the Western Arctic stock (Figs. 1 and 2), also known as the Bering-Chukchi-Beaufort stock (Rugh et al. 2003) or Bering Sea stock (Burns et al. 1993). Although Jorde et al. (2007) suggested there might be multiple stocks of bowhead whales in U.S. waters, several studies (George et al. 2007, Taylor et al. 2007, Rugh et al. 2009) and the IWC Scientific Committee concluded that data are most consistent with one stock that migrates throughout waters of northern and western Alaska (IWC 2008).

The majority of the Western Arctic stock migrates annually from wintering areas (December to March) in the northern Bering Sea, through the Chukchi Sea in the spring (April through May), to the eastern Beaufort Sea (Fig. 1) where they spend much of the summer (June through early to mid-October) before returning again to the Bering Sea (Fig. 2) in the fall (September through December) to overwinter (Braham et al. 1980, Moore and Reeves 1993, Quakenbush et al. 2010a, Citta et al. 2015). Some bowhead whales are found in

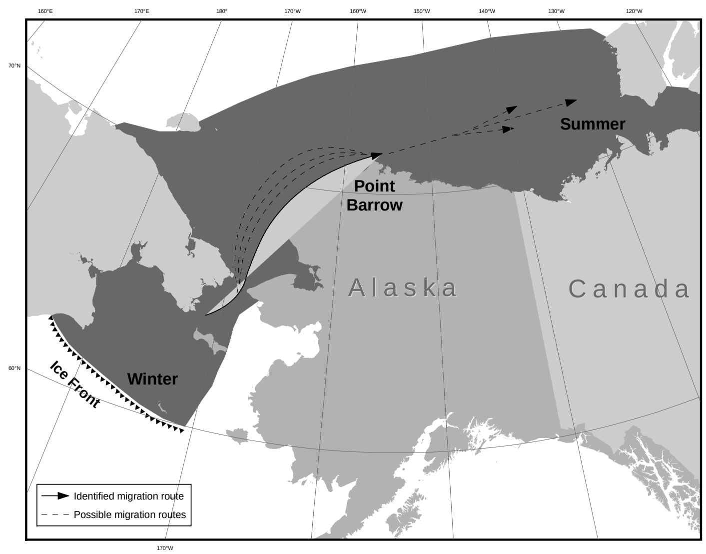

Figure 1. Dark areas depict the approximate distribution of the Western Arctic stock of bowhead whales. The spring migration represented here by lines and arrows follows a route from the Bering Sea wintering area to the Beaufort Sea summering area, mostly along a coastal tangent that constricts somewhat as it goes east past Point Barrow.

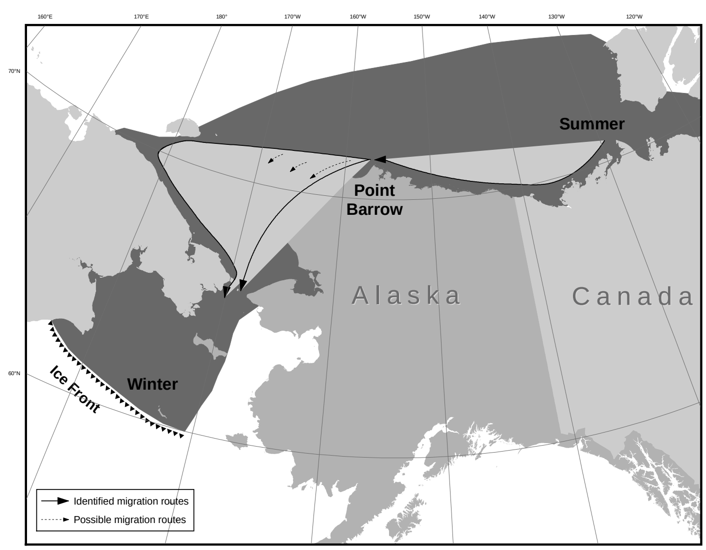

Figure 2. Dark areas depict the approximate distribution of the Western Arctic stock of bowhead whales. The fall migration is represented here by lines and arrows showing generalized routes used to travel from the Beaufort Sea (summering area) to the Bering Sea (wintering area).

the western Beaufort, Chukchi, and Bering seas in summer, and these are thought to be a part of the expanding Western Arctic stock (Rugh et al. 2003; Clarke et al. 2013, 2014, 2015; Citta et al. 2015).

During winter and spring, bowhead whales are closely associated with sea ice (Moore and Reeves 1993, Quakenbush et al. 2010a, Citta et al. 2015). The bowhead whale spring migration follows fractures in the sea ice around the coast of Alaska, generally in the shear zone between the shorefast ice and the mobile pack ice. During summer, most of the population is in relatively ice-free waters in the southeastern Beaufort Sea (Citta et al. 2015), an area often exposed to industrial activity related to petroleum exploration (e.g., Richardson et al. 1987, Davies 1997). Summer aerial surveys conducted in the western Beaufort Sea during July and August of 2012-2014 have had relatively high sighting rates of bowhead whales, including cows with calves and feeding animals (Clarke et al. 2013, 2014; MML, unpubl. data, available online: http://www.afsc.noaa.gov/nmml/cetacean/bwasp/flights_2014.php, accessed December 2016). During the autumn migration through the Beaufort Sea, bowhead whales select shelf waters in all but "heavy ice" conditions, when they select slope habitat (Moore 2000). Heavy ice years in autumn in the Beaufort Sea are becoming less common because of climate change and the resulting trend of delayed seasonal sea ice formation and dramatic reduction in volume of multi-year ice. In winter in the Bering Sea, bowhead whales often use areas with ~100% sea-ice cover, even when polynas are available (Quakenbush et al. 2010a, Citta et al. 2015).

Evidence suggests that bowhead whales feed on concentrations of zooplankton throughout their range. Likely or confirmed feeding areas include Amundsen Gulf and the eastern Canadian Beaufort Sea; the central and western U.S. Beaufort Sea; Wrangel Island; and the coast of Chukotka, between Wrangel Island and the Bering Strait (Lowry et al. 2004; Ashjian et al. 2010; Clarke and Ferguson 2010a; Quakenbush et al. 2010a, 2010b; Okkonen et al. 2011; Clarke et al. 2012, 2013, 2014, 2015; MML, unpubl. data, available online: http://www.afsc.noaa.gov/nmml/cetacean/bwasp/flights_2014.php, accessed December 2016). Bowhead whales have also been observed feeding during the summer in the northeastern Chukchi Sea (Clarke and Ferguson 2010b).

POPULATION SIZE

All stocks of bowhead whales were severely depleted during intense commercial whaling, starting in the early 16th century near Labrador (Ross 1993) and spreading to the Bering Sea in the mid-19th century (Braham 1984, Bockstoce and Burns 1993, Bockstoce et al. 2007). Woodby and Botkin (1993) summarized previous efforts to estimate bowhead whale population size prior to the onset of commercial whaling. They reported a minimum worldwide population estimate of 50,000, with 10,400-23,000 in the Western Arctic stock (dropping to less than 3,000 at the end of commercial whaling). Brandon and Wade (2006) used Bayesian model averaging to estimate that the Western Arctic stock consisted of 10,960 (9,190-13,950; 5th and 95th percentiles, respectively) bowhead whales in 1848 at the start of commercial whaling.

Since 1978, systematic counts of bowhead whales have been conducted from sites on sea ice near Point Barrow during the whales' spring migration (Krogman et al. 1989). These counts have been corrected for whales missed due to distance offshore (since the mid-1980s, using acoustical methods described in Clark et al. 1994), whales missed when no watch was in effect (through interpolations from sampled periods), and whales missed during a watch (estimated as a function of visibility, number of observers, and distance offshore: Zeh et al. 1993). A summary of the resulting abundance estimates is provided in Table 1 and Figure 3. These estimates of abundance have not been

Table 1. Summary of abundance estimates for the Western Arctic stock of bowhead whales. The historical estimates were made by back-projecting using a simple recruitment model. All other estimates were developed by corrected ice-based census counts. Historical estimates are from Woodby and Botkin (1993); 1978-2001 estimates are from George et al. (2004) and Zeh and Punt (2004). The 2011 estimate is reported in Givens et al. (2013).

Year	Abundance estimate (CV)	Year	Abundance estimate (CV)
Historical estimate	10,400-23,000	1985	5,762 (0.253)
End of commercial whaling	1,000-3,000	1986	8,917 (0.215)
1978	4,765 (0.305)	1987	5,298 (0.327)
1980	3,885 (0.343)	1988	6,928 (0.120)
1981	4,467 (0.273)	1993	8,167 (0.017)
1982	7,395 (0.281)	2001	10,545 (0.128)
1983	6,573 (0.345)	2011	16,892 (0.058)

corrected for a small portion of the population that may not migrate past Point Barrow during the period when counts are made. Attempts to count migrating whales near Point Barrow in 2009 and 2010 were unsuccessful due to sea-ice conditions (IWC 2010, George et al. 2011) but were successful in 2011.

Bowhead whales were identified from aerial photographs taken in 1985 and 1986, and the results were used in a sight-resight analysis. This approach provided estimates of 4,719 (95% CI: 2,382-9,343; SE 1,696) to 7,022 (95% CI: 4,701-12,561; SE 2,017), depending on the model used (daSilva et al. 2000). These population estimates and their associated error ranges are comparable to the estimates obtained from the combined ice-based visual and acoustic data for 1985 (6,039; 95% CI: 2,286-9,792; SE 1,915) and 1986 (7,734; 95% CI: 4,892-10,576; SE 1,450; Raftery and Zeh 1998). Aerial photographs provided another sampling of the bowhead whale population in 2003 and 2004. Sight-resight results provided estimates of 8,250 whales (95% CI: 3,150-15,450) in 2001 (Schweder et al. 2009) and 12,631 whales (95% CI: 7,900-19,700) in 2004 (Koski et al. 2010), which are consistent with trends in abundance estimates made from ice-based counts. An aerial photographic survey was conducted near Point Barrow concurrently with the ice-based spring census in 2011; these data are currently being analyzed to produce a revised abundance estimate based on sight-resight data (Mocklin et al. 2012).

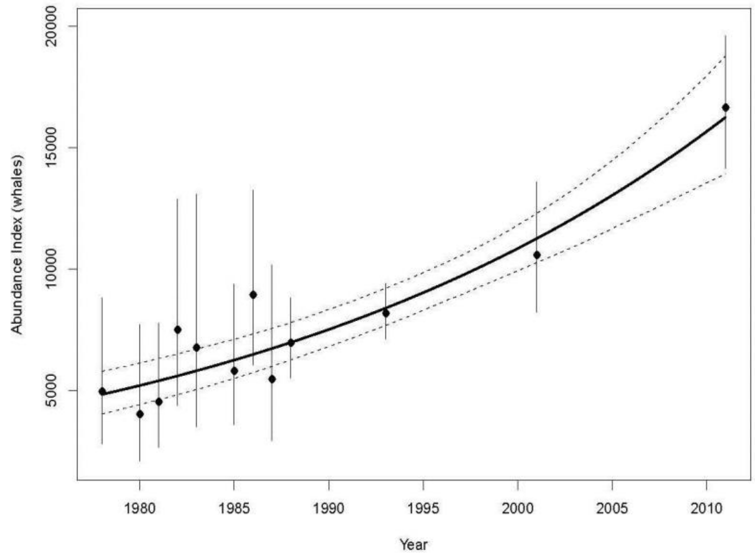

Figure 3. Abundance estimates for the Western Arctic stock of bowhead whales, 1978-2011 (Givens et al. 2013), as computed from ice-based counts, acoustic data, and aerial transect data collected during bowhead whale spring migrations past Point Barrow, Alaska.

Minimum Population Estimate

The minimum population estimate (N_{MIN}) for this stock is calculated from Equation 1 from the potential biological removal (PBR) guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the 2011 population estimate (N) of 16,892 and its associated coefficient of variation CV(N) of 0.058, N_{MIN} for the Western Arctic stock of bowhead whales is 16,091.

Current Population Trend

Based on concurrent passive acoustic and ice-based visual surveys, Givens et al. (2013) reported that the Western Arctic stock of bowhead whales increased at a rate of 3.7% (95% CI = 2.8-4.7%) from 1978 to 2011, during which time abundance tripled from approximately 5,000 to approximately 16,000 whales (Givens et al. 2013). Schweder et al. (2009) estimated the yearly growth rate to be 3.2% (95% CI = 0.5-4.8%) between 1984 and 2003 using a sight-resight analysis of aerial photographs.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

The current estimate for the rate of increase for this stock of bowhead whales (3.2-3.7%) should not be used as an estimate of (R_{MAX}) because the population is currently being harvested. It is recommended that the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% be used for the Western Arctic stock of bowhead whales (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the PBR level is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock has been set at 0.5 rather than the default value of 0.1 for endangered species because population levels are increasing in the presence of a known take (see Wade and Angliss 1997, p. 27-28). Thus, PBR = 161 animals (16,091 × 0.02 × 0.5). The calculation of a PBR level for the Western Arctic bowhead whale stock is required by the MMPA even though the subsistence harvest quota is established under the authority of the IWC based on an extensively tested strike limit algorithm (IWC 2003). The quota is based on subsistence need or the ability of the bowhead whale population to sustain a harvest, whichever is smaller. The IWC bowhead whale quota takes precedence over the PBR estimate for the purpose of managing the Alaska Native subsistence harvest from this stock. For 2013-2018, the IWC established a block quota of 306 landed bowhead whales. Because some whales are struck and lost, a strike limit of 67 (plus up to 15 previously unused strikes) is permitted each year. This quota includes an allowance of five animals to be taken by Chukotka Natives in Russia. The 2013-2018 quota maintains the *status quo* of the previous 5-year block quota (2008-2012) but was extended for 6 years.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

Several cases of line or net entanglement have been reported from whales taken in the subsistence hunt (Philo et al. 1993). George et al. (2015b) examined records for 904 bowhead whales harvested between 1990 and 2012. Of these, 521 records were examined for at least one of the three types of scars indicating injuries from line entanglement wounds (515 records), attacks by killer whales (378 records), and ship strikes (and/or propeller injuries) (505 records). Their best estimate of the occurrence of entanglement scars was ~12.1% (59/486; an additional 29 records with possible entanglement scars were excluded from the analysis) with the cause most likely from fishing/crab gear in the Bering Sea. Most entanglement injuries occurred on the peduncle and were rare on smaller subadult and juvenile whales (<10 m).

There are no observer program records of bowhead whale mortality incidental to U.S. commercial fisheries in Alaska. However, some bowhead whales have had interactions with crab pot gear and fishing nets. One dead whale was found floating in Kotzebue Sound in early July 2010, entangled in crab pot gear similar to that used by commercial crabbers in the Bering Sea (Table 2; Suydam et al. 2011), and one entangled bowhead whale was photographed during the 2011 spring aerial photographic survey of bowhead whales near Point Barrow (Mocklin et al. 2012), but it was not considered to be seriously injured. More recently, Citta et al. (2014) found that the distribution of satellite-tagged bowhead whales in the Bering Sea spatially and temporally overlapped areas where commercial pot fisheries occurred and noted the potential risk of entanglement in lost gear. The minimum estimated average annual mortality and serious injury rate in U.S. commercial fisheries in 2010-2014 is 0.2 bowhead whales; however, the actual rate is currently unknown.

Table 2. Summary of mortality and serious injury of Western Arctic bowhead whales, by year and type, reported to the NMFS Alaska Region marine mammal stranding network in 2010-2014 (Helker et al. 2016). Only cases of mortality and serious injury were recorded in this table; animals with non-serious injuries have been excluded.

Cause of injury	2010	2011	2012	2013	2014	Mean annual mortality
Entangled in commercial pot gear	1	0	0	0	0	0.2
Total in commercial fisheries						0.2

Alaska Native Subsistence/Harvest Information

Eskimos have been taking bowhead whales for subsistence purposes for at least 2,000 years (Marquette and Bockstoce 1980, Stoker and Krupnik 1993). Subsistence takes have been regulated by a quota system under the authority of the IWC since 1977. Alaska Native subsistence hunters, primarily from 11 Alaska communities, take approximately 0.1-0.5% of the population per annum (Philo et al. 1993, Suydam et al. 2011). Under this quota, the number of kills in any one year has ranged between 14 and 72. The maximum number of strikes per year is set by a quota which is determined by subsistence needs and bowhead whale abundance and trend estimates (Stoker and Krupnik 1993). Suydam and George (2012) summarized Alaska subsistence harvests of bowhead whales from 1974 to 2011 and reported a total of 1,149 whales landed by hunters from 12 villages, with Barrow landing the most whales (n = 590) and Shaktoolik landing only one. Alaska Natives landed 45 whales in 2010 (Suydam et al. 2011), 38 in 2011 (Suydam et al. 2012), 55 in 2012 (Suydam et al. 2013), 46 in 2013 (George and Suydam 2014, Suydam et al. 2014), and 38 in 2014 (Suydam et al. 2015). The number of whales landed at each village varies greatly from year to year, as success is influenced by village size and ice and weather conditions. The efficiency of the hunt (the percent of whales struck that are retrieved) has increased since the implementation of the bowhead whale quota in 1978. In 1978, the efficiency was about 50%. In 2014, 38 of 53 whales struck were landed, resulting in an efficiency of 72% (Suydam et al. 2015). Suydam et al. (2015) reported that the current mean efficiency, from 2005 through 2014, is 76.5%.

Canadian and Russian Natives also take whales from this stock. Hunters from the western Canadian Arctic community of Aklavik harvested one whale in 1991 and one in 1996. No catches for Western Arctic bowhead whales were reported by either Canadian or Russian hunters for 2006-2007 (IWC 2008, 2009) or by Russia in 2009, 2011, 2012, or 2014 (IWC 2011, Ilyashenko 2013, Ilyashenko and Zharikov 2015), but two bowhead whales were taken in Russia in 2008 (IWC 2010), two in 2010 (IWC 2012), and one in 2013 (Ilyashenko and Zharikov 2014). The average annual subsistence take (by Natives of Alaska, Russia, and Canada) during the 5-year period from 2010 through 2014 is 44 bowhead whales.

Other Mortality

Pelagic commercial whaling for bowhead whales was conducted from 1849 to 1914 in the Bering, Chukchi, and Beaufort seas (Bockstoce et al. 2007). During the first two decades of the fishery (1850-1870), over 60% of the estimated pre-whaling population was killed, and effort remained high into the 20th century (Braham 1984). Woodby and Botkin (1993) estimated that the pelagic whaling industry harvested 18,684 whales from this stock. During 1848-1919, shore-based whaling operations (including landings as well as struck and lost estimates from the U.S., Canada, and Russia) took an additional 1,527 animals (Woodby and Botkin 1993). An unknown percentage of the animals taken by the shore-based operations were harvested for subsistence and not commercial purposes. Historical harvest estimates likely underestimate the actual harvest as a result of under-reporting of the Soviet catches (Yablokov 1994) and incomplete reporting of struck and lost animals.

Transient killer whales are the only known predators of bowhead whales. In a study of marks on bowhead whales taken in the subsistence harvest between spring 1976 and fall 1992, 4.1% to 7.9% had scars indicating that they had survived attacks by killer whales (George et al. 1994). Of 378 complete records for killer whale scars collected from 1990 to 2012, 30 whales (7.9%) had scarring "rake marks" consistent with orca/killer whale injuries and another 10 had possible injuries (George et al. 2015b). A higher rate of killer whale rake mark scars occurred during 2002-2012 than in the previous decade. George et al. (2015b) noted this may be due to better reporting and/or sampling bias, an increase in killer whale population size, an increase in occurrence of killer whales at high latitudes (Clarke et al. 2013), or a longer open water period offering more opportunities to attack bowhead whales.

With increasing ship traffic and oil and gas activities in the Chukchi and Beaufort seas, bowhead whales may become increasingly at risk from ship strikes. Currently, ship-strike injuries appear to be uncommon on bowhead whales in Alaska (George et al. 2015b). Only 10 whales harvested between 1990 and 2012 (~2% of the total sample) showed clear evidence of scarring from ship propeller injuries.

STATUS OF STOCK

Based on currently available data, the estimated mean annual mortality and serious injury rate incidental to U.S. commercial fisheries (0.2 whales) is not known to exceed 10% of the PBR (10% of PBR = 16.1) and, therefore, can be considered to be insignificant. The total annual level of human-caused mortality and serious injury (44 whales) is not known to exceed the PBR (161) nor the IWC annual maximum strike limit (67). The Western Arctic bowhead whale stock has been increasing; the estimate of 16,892 from 2011 is between 31% and 170% of the pre-exploitation abundance of 10,000 to 55,000 estimated by Brandon and Wade (2004, 2006). However, the stock is classified as a strategic stock because the bowhead whale is listed as endangered under the U.S. Endangered Species Act and is therefore also designated as depleted under the MMPA.

HABITAT CONCERNS

Vessel traffic in arctic waters is increasing, largely due to an increase in oil and gas activities and commercial shipping. This increase in vessel traffic could result in an increased number of vessel collisions with bowhead whales (Huntington et al. 2015).

Increasing oil and gas development in the Arctic has led to an increased risk of various forms of pollution in bowhead whale habitat, including oil spills. Also of concern is noise produced by seismic surveys and vessel traffic resulting from shipping and offshore energy exploration, development, and production operations. Evidence indicates that bowhead whales are sensitive to noise from offshore drilling platforms and seismic survey operations (Richardson and Malme 1993, Richardson 1995, Davies 1997) and that bowhead whales often avoid sound sources associated with active drilling (Schick and Urban 2000) and seismic operations (Miller et al. 1999). Studies in the

1980s indicated that bowhead whales reacting to seismic activity in feeding areas appeared to recover from behavioral changes within 30-60 minutes following the end of the activity (Richardson et al. 1986, Ljungblad et al. 1988). However, more recent monitoring studies of 3-D seismic exploration in the nearshore Beaufort Sea during 1996-1998 demonstrated that nearly all fall-migrating bowhead whales avoided an area within 20 km of an active seismic source (Richardson et al. 1999). Furthermore, the studies also suggested that the bowhead whales' offshore displacement may have begun roughly 35 km (19 nautical miles or 22 statute miles) east of the activity and may have persisted more than 30 km to the west (Richardson et al. 1999). Richardson et al. (1986) observed that some feeding bowhead whales started to turn away from a 30-airgun array with a source level of 248 dB re 1 μPa at a distance of 7.5 km (4.7 mi) and swam away when the vessel was within about 2 km (1.2 mi); other whales in the area continued feeding until the seismic vessel was within 3 km (1.9 mi). More recent studies have similarly shown that feeding bowhead whales had a greater tolerance of higher sound levels than did migrating whales (Miller et al. 2005, Harris et al. 2007). Data from an aerial monitoring program in the Alaska Beaufort Sea during 2006-2008 also indicated that bowhead whales feeding during late summer and autumn did not exhibit large-scale distribution changes in relation to seismic operations (Funk et al. 2010). Persistent feeding behavior in the presence of seismic survey noise does not necessarily mean that the feeding bowhead whales are unaffected by the noise. Feeding bowhead whales may be sufficiently motivated to continue feeding in a given area despite noise-induced stress or physiological effects (MMS 2008). A study by Blackwell et al. (2015) found that bowhead whales react differently to different thresholds of seismic noise. At relatively low cumulative exposure levels (as soon as airguns were just detectable), bowhead whales almost doubled their call rates. Once cumulative exposure levels exceeded 127 dB re 1 μPa^2-s, call rates decreased. Bowhead whales went completely silent at received levels over 160 dB re 1 μPa^2-s. These authors note that the existence of two behavioral thresholds for calling by bowhead whales can explain results of previous studies that found variability in bowhead whale call rates in the presence or absence of airgun pulses (i.e., Greene et al. 1998).

Climate change is resulting in warming of northern latitudes at about twice the rate of more temperate latitudes, increasing the immediacy of this threat for bowhead whales and other arctic species. Global climate model projections for the next 50-100 years consistently show pronounced warming over the Arctic, accelerated sea-ice loss, and continued permafrost degradation (IPCC 2007, USGS 2011, Jeffries et al. 2015). Within the Arctic, some of the largest changes are projected to occur in the Bering, Beaufort, and Chukchi seas (Chapman and Walsh 2007, Walsh 2008). Ice-associated animals, including the bowhead whale, may be sensitive to changes in arctic weather, sea-surface temperatures, sea-ice extent, and the concomitant effect on prey availability. Laidre et al. (2008) concluded that on a worldwide basis, bowhead whales were likely to be moderately sensitive to climate change based on an analysis of various life-history features that could be affected by climate. Currently, there are insufficient data to make reliable projections of the effects of arctic climate change on bowhead whales. George et al. (2006) showed that landed bowhead whales had better body condition during years of light ice cover. Similarly, George et al. (2015a) found an overall improvement in bowhead whale body condition and a positive correlation between body condition and summer sea ice loss over the last 2.5 decades in the Pacific Arctic. George et al. (2015a) speculated that sea ice loss has positive effects on secondary trophic production within the Western Arctic bowhead whale's summer feeding region.

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Appendix 1. Summary of changes to the 2016 stock assessments (last revised 12/30/2016). An 'X' indicates sections where the information presented has been updated since the 2015 stock assessments were released. Stock Assessment Reports for those stocks in boldface were updated in 2016.

Stock	Stock definition	Population size	PBR	Fishery mortality	Subsistence mortality	Status
Steller sea lion (Western U.S.)	X	X	X	X	X	X
Steller sea lion (Eastern U.S.)	X	X	X	X	X	X
Northern fur seal (Eastern Pacific)	X	X	X	X	X	X
Harbor seal (Aleutian Islands)						
Harbor seal (Pribilof Islands)						
Harbor seal (Bristol Bay)						
Harbor seal (North Kodiak)						
Harbor seal (South Kodiak)						
Harbor seal (Prince William Sound)						
Harbor seal (Cook Inlet/Shelikof Strait)						
Harbor seal (Glacier Bay/Icy Strait)						
Harbor seal (Lynn Canal/Stephens Passage)						
Harbor seal (Sitka/Chatham Strait)						
Harbor seal (Dixon/Cape Decision)						
Harbor seal (Clarence Strait)						
Spotted seal (Alaska)						
Bearded seal (Alaska)			X	X	X	X
Ringed seal (Alaska)	X	X	X	X	X	X
Ribbon seal (Alaska)						
Beluga whale (Beaufort Sea)						
Beluga whale (Eastern Chukchi Sea)						
Beluga whale (Eastern Bering Sea)						
Beluga whale (Bristol Bay)						
Beluga whale (Cook Inlet)	X	X		X	X	X
Narwhal (Unidentified)	X			X		
Killer whale (ENP Alaska Resident)				X		X
Killer whale (ENP Northern Resident)						
Killer whale (ENP Gulf of Alaska, Aleutian Islands, and Bering Sea Transient)				X		X
Killer whale (AT1 Transient)		X				
Killer whale (West Coast Transient)						
Pacific white-sided dolphin (North Pacific)						
Harbor porpoise (Southeast Alaska)	X	X	X	X		X
Harbor porpoise (Gulf of Alaska)	X	X		X		X
Harbor porpoise (Bering Sea)	X	X		X		X
Dall's porpoise (Alaska)						
Sperm whale (North Pacific)	X			X		X
Baird's beaked whale (Alaska)						
Cuvier's beaked whale (Alaska)						
Stejneger's beaked whale (Alaska)						
Humpback whale (Western North Pacific)	X			X	X	X
Humpback whale (Central North Pacific)	X	X		X		X
Fin whale (Northeast Pacific)	X	X	X	X		X
Minke whale (Alaska)						
North Pacific right whale (Eastern North Pacific)	X	X		X		X
Bowhead whale (Western Arctic)	X	X		X	X	X

Appendix 2. Stock summary table (last revised 12/30/2016). Stock Assessment Reports for those stocks in boldface were updated in 2016. N/A indicates data are unknown. UNDET (undetermined) PBR indicates data are available to calculate a PBR level but a determination has been made that calculating a PBR level using those data is inappropriate (see stock assessment for details).

Species	Stock	N_{EST}	CV	N_{MIN}	Year of last survey	R_{MAX}	F_R	PBR	Commer. fishery mort.	Native subsist. mort.	Total mort.	Status
Steller sea lion	**Western U.S.**	**50,983**[a]		**50,983**	**2015**	**0.12**	**0.1**	**306**	**30**	**201**	**236**	**S**
Steller sea lion	**Eastern U.S.**	**41,638**[a]		**41,638**	**2015**	**0.12**	**1.0**	**2,498**	**14**	**11**	**108**	**NS**
Northern fur seal	**Eastern Pacific**	**626,734**	**0.2**	**530,474**	**2014**	**0.086**	**0.5**	**11,405**	**3.5**	**426**	**437**	**S**
Harbor seal	Aleutian Islands	6,431		5,772	2011	0.12	0.5	173	0	90	90	NS
Harbor seal	Pribilof Islands	232		232	2010	0.12	0.5	7	0	0	0	NS
Harbor seal	Bristol Bay	32,350		28,146	2011	0.12	0.7	1,182	0.6	141	142	NS
Harbor seal	North Kodiak	8,321		7,096	2011	0.12	0.7	298	0	37	37	NS
Harbor seal	South Kodiak	19,199		17,479	2011	0.12	0.3	314	1.9	126	128	NS
Harbor seal	Prince William Sound	29,889		27,936	2011	0.12	0.5	838	24	255	279	NS
Harbor seal	Cook Inlet/Shelikof Strait	27,386		25,651	2011	0.12	0.5	770	0.4	233	234	NS
Harbor seal	Glacier Bay/Icy Strait	7,210		5,647	2011	0.12	0.5	169	0	104	104	NS
Harbor seal	Lynn Canal/Stephens Passage	9,478		8,605	2011	0.12	0.3	155	0	50	50	NS
Harbor seal	Sitka/Chatham Strait	14,855		13,212	2011	0.12	0.7	555	0	77	77	NS
Harbor seal	Dixon/Cape Decision	18,105		16,727	2011	0.12	0.7	703	0	69	69	NS
Harbor seal	Clarence Strait	31,634		29,093	2011	0.12	0.7	1,222	0	40	41	NS
Spotted seal	Alaska	460,268		391,000	2012	0.12	0.5	11,730	1.5	5,265	5,267	NS
Bearded seal	**Alaska**	[b]		[b]	**2013**	**0.12**	**0.5**	[b]	**1.4**	**390**	**391**	**NS**
Ringed seal	**Alaska**	[b]		[b]	**2013**	**0.12**	**0.5**	[b]	**3.9**	**1,050**	**1,054**	**NS**
Ribbon seal	Alaska	184,000		163,086	2013	0.12	1.0	9,785	0.6	3.2	3.8	NS

Species	Stock	N_{EST}	CV	N_{MIN}	Year of last survey	R_{MAX}	F_R	PBR	Commer. fishery mort.	Native subsist. mort.	Total mort.	Status
Beluga whale	Beaufort Sea	39,258	0.229	32,453	1992	0.04	1.0	649	0	166	166	NS
Beluga whale	Eastern Chukchi Sea	3,710	N/A	N/A	1991	0.04	1.0	UNDET	0	57.4	57.4	NS
Beluga whale	Eastern Bering Sea	19,186	0.32	N/A	2000	0.04	1.0	UNDET	0	181	181	NS
Beluga whale	Bristol Bay	2,877	0.2	2,435	2005	0.048	1.0	58	0.2	24	24.2	NS
Beluga whale	**Cook Inlet**	**312**	**0.10**	**287**	**2014**	**0.04**	**0.1**	**UNDET**	**0**	**0**	**0**	**S**
Narwhal	**Unidentified**	**N/A**		**N/A**		**0.04**	**0.5**	**N/A**	**0**	**0**	**0**	**NS**
Killer whale	**Eastern North Pacific Alaska Resident**	**2,347[c]**	**N/A**	**2,347**	**2012**	**0.04**	**0.5**	**24**	**1**	**0**	**1**	**NS**
Killer whale	Eastern North Pacific Northern Resident (British Columbia)	261[c]	N/A	261	2011	0.03	0.5	1.96	0	0	0	NS
Killer whale	**Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient**	**587[c]**	**N/A**	**587**	**2012**	**0.04**	**0.5**	**5.9**	**1**	**0**	**1**	**NS**
Killer whale	**AT1 Transient**	**7[c]**	**N/A**	**7**	**2015**	**0.04**	**0.1**	**0**	**0**	**0**	**0**	**S**
Killer whale	West Coast Transient	243[c]	N/A	243	2009	0.04	0.5	2.4	0	0	0	NS
Pacific white-sided dolphin	North Pacific	26,880	N/A	N/A	1990	0.04	0.5	UNDET	0	0	0	NS
Harbor porpoise	**Southeast Alaska**	**[b]**	**[b]**	**[b]**	**2012**	**0.04**	**0.5**	**[b]**	**34**	**0**	**34**	**S**
Harbor porpoise	**Gulf of Alaska**	**31,046**	**0.214**	**N/A**	**1998**	**0.04**	**0.5**	**UNDET**	**72**	**0**	**72**	**S**
Harbor porpoise	**Bering Sea**	**48,215**	**0.223**	**N/A**	**1999**	**0.04**	**0.5**	**UNDET**	**0.2**	**0**	**0.4**	**S**
Dall's porpoise	Alaska	83,400	0.097	N/A	1993	0.04	1.0	UNDET	38	0	38	NS
Sperm whale	**North Pacific**	**N/A**		**N/A**		**0.04**	**0.1**	**N/A**	**2.2**	**0**	**2.2**	**S**
Baird's beaked whale	Alaska	N/A		N/A		0.04	0.5	N/A	0	0	0	NS
Cuvier's beaked whale	Alaska	N/A		N/A		0.04	0.5	N/A	0	0	0	NS
Stejneger's beaked whale	Alaska	N/A		N/A		0.04	0.5	N/A	0	0	0	NS
Humpback whale	**Western North Pacific**	**1,107**	**0.300**	**865**	**2006**	**0.07**	**0.1**	**3.0**	**0.8**	**0**	**2.6**	**S**

Species	Stock	N_{EST}	CV	N_{MIN}	Year of last survey	R_{MAX}	F_R	PBR	Commer. fishery mort.	Native subsist. mort.	Total mort.	Status
Humpback whale	**Central North Pacific - entire stock**	**10,103**	**0.300**	**7,890**	**2006**	**0.07**	**0.3**	**83**	**7.4**	**0**	**24**	**S**
Fin whale	**Northeast Pacific**	[b]	[b]	[b]	**2010**	**0.04**	**0.1**	[b]	**0.2**	**0**	**0.6**	**S**
Minke whale	Alaska	N/A		N/A		0.04	0.5	N/A	0	0	0	NS
North Pacific right whale	**Eastern North Pacific**	**31**	**0.226**	**26**	**2013**	**0.04**	**0.1**	**0.05**	**0**	**0**	**0**	**S**
Bowhead whale	**Western Arctic**	**16,892**	**0.058**	**16,091**	**2011**	**0.04**	**0.5**	**161**	**0.2**	**44**	**44**	**S**

N_{EST} = the AFSC Marine Mammal Laboratory's best estimate of the size of the population.
Status: S = Strategic, NS = Not Strategic.

[a]N_{EST} is the best estimate of pup and non-pup counts, which have not been corrected to account for animals at sea during abundance surveys.
[b]See text in Stock Assessment Report.
[c]N_{EST} is based on counts of individual animals identified from photo-identification catalogues. Surveys for abundance estimates of these stocks are conducted infrequently.

Appendix 3. Summary table for Alaska **Category 2** commercial fisheries (last updated 12/30/2016). Notice of continuing effect of list of fisheries.

Fishery (area, target species, and gear type)	Mngmt	Active Permits/Vessels[1]	Soak time	Landings per day	Sets per day	Season duration	Fishery trends (2012-2016)
AK Southeast salmon drift gillnet	State	451	20 min - 3 hrs; day/night	1	6 - 20	June 18 to Early Oct	# vessels stable but may vary with price of salmon; catch - high
AK Yakutat salmon set gillnet	State	149	continuous soak during opener; day/night	1	net picked every 2 - 4 hrs/day or continuous during peak	June 4 to mid-Oct	# sites fished stable; catch - variable
AK Prince William Sound salmon drift gillnet	State	529	15 min - 3 hrs; day/night	1 or 2	10 - 14	mid-May to end of Sept	# vessels stable; catch - stable
AK Cook Inlet salmon drift gillnet	State	548	15 min - 3 hrs or continuous; day only	1	6 - 18	June 25 to end of Aug	# vessels stable; catch - variable
AK Cook Inlet salmon set gillnet	State	717	continuous soak during opener, but net dry with low tide; upper CI - day/night lower CI - day only except during fishery extensions	1	upper CI - picked on slack tide lower CI - picked every 2 - 6 hrs/day	June 2 to mid-Sept	# sites fished stable; catch - up for sockeye and kings, down for pinks
AK Kodiak salmon set gillnet	State	182	continuous during opener; day only	1 or 2	picked 2 or more times	June 9 to end of Sept	# sites fished stable; catch - variable
AK Peninsula/Aleutian Islands salmon drift gillnet	State	150	2 -5 hrs; day/night	1	3 - 8	mid-June to mid-Sept	# vessels stable; catch up
AK Peninsula/Aleutian Islands salmon set gillnet	State	108	continuous during opener; day/night	1	every 2 hrs	June 18 to mid-Aug	# sites fished stable; catch - up since 90; down in 96
AK Bristol Bay salmon drift gillnet	State	1,811	continuous soaking of part of net while other parts picked; day/night	2	continuous	June 17 to end of Aug or mid-Sept	# vessels stable; catch - variable
AK Bristol Bay salmon set gillnet	State	941	continuous during opener, but net dry during low tide; day/night	1	2 or continuous	June 17 to end of Aug or mid-Sept	# sites fished stable; catch - variable
AK Bering Sea, Aleutian Islands flatfish trawl	Federal	31	near continuous, 3-4 hours; day/night	NA	~ 4 per day	Jan 20 to end of Dec	# of vessels stable, catch variable
AK Bering Sea, Aleutian Islands pollock trawl	Federal	100	near continuous, 3-4 hours; day/night	NA	~ 3 per day	Jan 20 to Nov 1	# of vessels stable, catch variable
AK Bering Sea, Aleutian Islands rockfish trawl	Federal	18	near continuous, 2-3 hours; day/night	NA	~ 3 per day	Jan 20 to end of Dec	# of vessels stable, catch variable
AK Bering Sea, Aleutian Islands Pacific cod longline	Federal	34	near continuous, 1-hours; day/night	1	~ 3 per day	Year-round	# of vessels stable, catch variable

[1]For state-managed fisheries, this is the number of active permits in 2016. For federally-managed fisheries, this is the number of active vessels participating in the fishery in 2015.

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Appendix 4. Interaction table for Alaska **Category 2** commercial fisheries (last revised 12/30/2016). Notice of continuing effect of list of fisheries.

Fishery Name (area, target species, and gear type)	Mngmt	Active Permits/Vessels[1]	Observer data[2]	Species recorded as taken incidentally in this fishery (records dating back to 1988)	Data type
AK Southeast salmon drift gillnet	State	451	2012 - 2013	Steller sea lion, harbor seal, harbor porpoise, Dall's porpoise, Pacific white-sided dolphin, humpback whale, sea otter	logbook, observer, stranding data, self-reports
AK Yakutat salmon set gillnet	State	149	2007 - 2008	harbor seal, harbor porpoise (obs), humpback whale, gray whale (stranding)	logbook, observer, stranding
AK Prince William Sound salmon drift gillnet	State	529	1990 - 1991	Steller sea lion (obs), northern fur seal, harbor seal (obs), harbor porpoise (obs), Dall's porpoise, Pacific white-sided dolphin, sea otter	logbook, observer, stranding
AK Cook Inlet salmon drift gillnet	State	548	1999 - 2000	Steller sea lion, harbor seal, harbor porpoise, Dall's porpoise, Cook Inlet beluga whale (Note: observer program in 1999 and 2000 recorded one incidental mortality/serious injury of a harbor porpoise)	observer, logbook
AK Cook Inlet salmon set gillnet	State	717	1999 - 2000	harbor seal, harbor porpoise, Dall's porpoise, Cook Inlet beluga whale, humpback whale, Steller sea lion, sea otter (Note: observer program in 1999 and 2000 recorded one incidental mortality/serious injury of a harbor porpoise)	observer, logbook
AK Kodiak salmon set gillnet	State	182	2002, 2005	harbor seal, harbor porpoise, sea otter, Steller sea lion	observer, logbook
AK Peninsula/Aleutian Islands salmon drift gillnet	State	150	1990-1991	northern fur seal, harbor seal, harbor porpoise, Dall's porpoise (obs)	observer, logbook
AK Peninsula/Aleutian Islands salmon set gillnet	State	108	never observed	Steller sea lion, harbor porpoise, northern sea otter	logbook
AK Bristol Bay salmon drift gillnet	State	1,811	never observed	Steller sea lion, northern fur seal, harbor seal, spotted seal, Pacific white-sided dolphin, beluga whale, gray whale	logbook
AK Bristol Bay salmon set gillnet	State	941	never observed	northern fur seal, harbor seal, spotted seal, beluga whale, gray whale	logbook
AK Bering Sea, Aleutian Islands flatfish trawl	Federal	31	1976 - 2015	bearded seal, harbor porpoise (Bering Sea), harbor seal (Bering Sea), killer whale (Alaska Resident), killer whale (GOA, Aleutian Islands, and Bering Sea Transient), northern fur seal, spotted seal, ringed seal, ribbon seal, gray whale, Steller sea lion (Western U.S.), walrus, humpback whale	observer
AK Bering Sea, Aleutian Islands pollock trawl	Federal	100	1976 - 2015	Dall's porpoise, harbor seal, humpback whale (Central North Pacific), humpback whale (Western North Pacific), fin whale, killer whale (GOA, Aleutian Islands, and Bering Sea Transient), minke whale, ribbon seal, spotted seal, ringed seal, bearded seal, northern fur seal, Steller sea lion (Western U.S.), beluga whale	observer
AK Bering Sea, Aleutian Islands rockfish trawl	Federal	18	1976 - 2015	killer whale (Alaska Resident), killer whale (GOA, Aleutian Islands, and Bering Sea Transient)	observer
AK Bering Sea, Aleutian Islands Pacific cod longline	Federal	34	1976 - 2015	killer whale (Alaska Resident), killer whale (GOA, Aleutian Islands, and Bering Sea Transient), ribbon seal, northern fur seal, ringed seal, spotted seal, Steller sea lion (Western U.S.), Dall's porpoise	observer

[1]For state-managed fisheries, this is the number of active permits in 2016 and for federally-managed fisheries, this is the number of active vessels participating in the fishery in 2015.
[2]Observer data indicates the years of observer data included in these reports.

Note: Only species with positive records of being taken incidentally in a fishery since 1988 (the first year of the Marine Mammal Protection Act interim exemption program) have been included in this table. A species' absence from this table does not necessarily mean it is not taken in a particular fishery. Rather, in most fisheries, only logbook or stranding data are available which resulted in many reports of unidentified or misidentified marine mammals. Observer program indicates most recent year of observer data included in these reports.

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Appendix 5. Interaction table for Alaska **Category 3** commercial fisheries (last revised 12/30/2016). Notice of continuing effect of list of fisheries.

Fishery name (area, target species, and gear type)	Mngmt	Active Permits/Vessels[1]	Observer data[2]	Species recorded as taken incidentally in this fishery (records dating back to 1990)	Data type
AK Prince William Sound salmon set gillnet	State	29	1990-1991 only	Steller sea lion, harbor seal, sea otter	logbook
AK Peninsula/Aleutian Islands salmon set gillnet	State	1	never observed	humpback whale	stranding
AK Kuskokwim, Yukon, Norton Sound, Kotzebue salmon gillnet	State	1184	never observed	harbor porpoise	n/a
AK roe herring and food/bait herring gillnet	State	426	never observed	none documented	none
AK salmon purse seine	State	442	never observed	harbor seal, gray whale (Eastern North Pacific)	logbook
AK salmon beach seine	State	23	never observed	none documented	none
AK roe herring and food/bait herring purse seine	State	331	never observed	none documented	none
AK roe herring and food/bait herring beach seine	State	8	never observed	none documented	none
AK Metlakatla purse seine (tribal)	Tribal	17	never observed	none documented	none
AK Cook Inlet salmon purse seine	State	74	never observed	humpback whale	stranding
AK Kodiak salmon purse seine	State	324	never observed	humpback whale	stranding
AK Southeast salmon purse seine	State	293	never observed	none documented	none
AK miscellaneous finfish purse seine	State	9	never observed	none documented	none
AK miscellaneous finfish beach seine	State	0	never observed	none documented	none
AK salmon troll (includes hand and power troll)	State	1705	never observed	Steller sea lion (Western U.S.), Steller sea lion (Eastern U.S.)	logbook
AK state waters longline /setline (incl. sablefish/ rockfish/lingcod/misc. finfish)	State	775	never observed	none documented	none
AK Gulf of Alaska halibut longline	Federal	798	2013	none documented	observer
AK Gulf of Alaska rockfish longline	Federal	13	2013	none documented	observer
AK Gulf of Alaska Pacific cod longline	Federal	95	2013	Steller sea lion (Western U.S.)	observer
AK Gulf of Alaska sablefish longline	Federal	281	2013	Steller sea lion, sperm whale	observer
AK Bering Sea, Aleutian Islands Greenland turbot longline	Federal	3	2013	killer whale (Eastern North Pacific Resident), killer whale (Eastern North Pacific Transient), killer whale (Alaska Resident), killer whale (GOA, Aleutian Islands, and Bering Sea Transient)	observer
AK Bering Sea, Aleutian Islands rockfish longline	Federal	1	2013	none documented	observer
AK Bering Sea, Aleutian Islands sablefish longline	Federal	16	2013	none documented	observer
AK halibut longline/set line (state and federal waters)	State	878	2013	Steller sea lion	self-reports
AK octopus/squid longline	State	8	never observed	none documented	none
AK shrimp otter and beam trawl (statewide and Cook Inlet)	State	28	never observed	none documented	none
AK Gulf of Alaska flatfish trawl	Federal	21	2013	northern elephant seal, harbor seal	observer
AK Gulf of Alaska Pacific cod trawl	Federal	54	2013	Steller sea lion (Western U.S.), harbor seal	observer
AK Gulf of Alaska pollock trawl	Federal	63	2013	Steller sea lion (Western U.S.), fin whale, northern elephant seal, Dall's porpoise	observer
AK Gulf of Alaska rockfish trawl	Federal	37	2013	none documented	observer
AK Bering Sea, Aleutian Islands Atka mackerel trawl	Federal	14	2013	ribbon seal, Steller sea lion (Western U.S.), northern elephant seal	observer
AK Bering Sea, Aleutian Islands Pacific cod trawl	Federal	64	2013	harbor seal, Steller sea lion (Western U.S.), ringed seal, bearded seal	observer
AK State-managed waters of Cook Inlet, Kachemak Bay, Prince William Sound, Southeast AK groundfish trawl	State	18	never observed	none documented	none
AK miscellaneous finfish otter/beam trawl	State	292	never observed	none documented	none
AK food/bait herring trawl (Kodiak area only)	State	3	never observed	none documented	none
AK Bering Sea, Aleutian Islands Pacific cod pot	Federal	116	2013	possible harbor seal	observer
AK Bering Sea, Aleutian Islands crab pot	State	248	never observed	gray whale (Eastern North Pacific)	stranding
AK Gulf of Alaska crab pot	State	271	never observed	humpback whale	stranding
AK Gulf of Alaska Pacific cod pot	Federal	116	2013	harbor seal, gray whale (Eastern North Pacific)	observer, stranding

Fishery name (area, target species, and gear type)	Mngmt	Active Permits/Vessels[1]	Observer data[2]	Species recorded as taken incidentally in this fishery (records dating back to 1990)	Data type
AK Southeast Alaska crab pot	State	375	never observed	humpback whale	stranding
AK Southeast Alaska shrimp pot	State	210	never observed	humpback whale	stranding
AK octopus/squid pot	State	15	never observed	none documented	none
AK snail pot	State	1	never observed	none documented	none
AK Aleutian Islands sablefish pot	Federal	2	2013	humpback whale	observer
AK Bering Sea sablefish pot	Federal	3	2013	humpback whale	observer
AK statewide miscellaneous finfish pot	State	201	never observed	none documented	none
AK shrimp pot, except Southeast AK	State	141	never observed	none documented	none
AK North Pacific halibut handline and mechanical jig	State	71	never observed	none documented	none
AK miscellaneous finfish handline and mechanical jig	State	572	never observed	none documented	none
AK herring spawn on kelp pound net	State	291	never observed	none documented	none
AK Southeast herring roe/food/bait pound net	State	0	never observed	none documented	none
AK scallop dredge	State	6	never observed	none documented	none
AK Dungeness crab (hand pick/dive)	State	0	never observed	none documented	none
AK herring spawn-on-kelp (hand pick/dive)	State	226	never observed	none documented	none
AK urchin and other fish/shellfish (hand pick/dive)	State	214	never observed	none documented	none
AK commercial passenger fishing vessel	State	1006	never observed	killer whale (stock unknown), Steller sea lion (Western U.S.), Steller sea lion (Eastern U.S.)	n/a
AK abalone	State	0	never observed	none documented	none
AK clam	State	87	never observed	none documented	none

[1]For state-managed fisheries, this is the number of active permits in 2016. For federally-managed fisheries, this is the number of active vessels participating in the fishery in 2015. For 'AK commercial passenger fishing vessel', this is the number of active vessels in the commercial passenger fishing vessel in 2014, the most current year of data available.
[2]Observer data indicates most recent year of observer data included in these reports. Prior to 2013, there were no observer data from vessels less than 60 feet in length, regardless of fishery. Also prior to 2013, there were no observer data for the halibut Individual Fishing Quota (IFQ) fishery, regardless of vessel size.

Note: Only species with positive records of being taken incidentally in a fishery since 1990 (the first year of the MMPA interim exemption logbook program) have been included in this table. A species' absence from this table does not necessarily mean it is not taken in a particular fishery. Rather, in most fisheries, only logbook or stranding data are available which resulted in many reports of unidentified or misidentified marine mammals.

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Appendix 6. Percent observer coverage in Alaska commercial fisheries 1990-2014 (last revised 12/30/2016).

Fishery name	Method for calculating observer coverage	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Gulf of Alaska (GOA) groundfish trawl		55	38	41	37	33	44	37	33	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GOA flatfish trawl	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	39.2	35.8	36.8	40.5	35.9	40.6	76.9	29.2	24.2	31	28	22	26	31	42	46	47
GOA Pacific cod trawl	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	20.6	16.4	13.5	20.3	23.2	27.0	82.5	21.4	22.8	25	24	38	31	41	25	10	12
GOA pollock trawl	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	37.5	31.7	27.5	17.6	26.0	31.4	96.1	24.2	26.5	27	34	43					
GOA rockfish trawl	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	51.4	49.8	50.2	51.0	37.2	48.4	74.1	51.4	49.1	88	87	91					
GOA longline		21	15	13	13	8	18	16	15	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GOA Pacific cod longline	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.8	5.7	6.1	4.9	11.4	12.6	21.4	3.7	10.2	45	32	43	29	30	13	29	31
GOA Pacific halibut longline	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	51.3	47.1	51.1	43.0	41.4	9.6	36.4	6.5	2.8	N/A	N/A	N/A		2.3	0.6	4.2	11
GOA rockfish longline	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.0	1.4	0.2	1.3	4.9	2.5	0	0	3.1	N/A	N/A	83					
GOA sablefish longline	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	16.9	14.0	15.2	12.4	13.7	9.4	37.7	10.4	11.2	37	35	38	15	14	14	14	19
GOA finfish pots		13	9	9	7	7	7	5	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GOA Pacific cod pot	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.7	5.7	7.0	5.8	7.0	4.0	40.6	3.8	2.9	14	18	13					
Bering Sea/Aleutian Islands (BSAI) finfish pots		43	36	34	41	27	20	17	18	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BSAI Pacific cod pot	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	14.6	16.2	8.5	14.7	12.1	12.4	33.1	14.4	12.4	30	23	29	21	20	19	18	21
BS sablefish pot	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	42.1	44.1	62.6	38.7	40.6	21.4	72.5	44.3	35.3	N/A	N/A	N/A					
AI sablefish pot	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	100	50.3	68.2	60.6	69.4	47.5	51.2	64.4	18.7	N/A	N/A	N/A					
BSAI groundfish trawl		74	53	63	66	64	67	66	64	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BSAI Atka mackerel trawl	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	65.0	77.2	86.3	82.4	98.3	95.4	96.6	97.8	96.7	94	100	99	100	99	99	99	99
BSAI flatfish trawl	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	59.4	66.3	64.5	57.6	58.4	63.9	68.2	68.3	67.8	72	100	100	99	99	99	99	99
BSAI Pacific cod trawl	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	55.3	50.6	51.7	57.8	47.4	49.9	75.1	52.8	46.8	52	56	64	66	60	68	80	80
BSAI pollock trawl	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	66.9	75.2	76.2	79.0	80.0	82.2	92.8	77.3	73.0	85	85	86	86	98	98	97	98
BSAI rockfish trawl	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	85.4	85.6	85.1	65.3	79.9	82.6	94.1	71.0	80.6	88	98	99	99	99	100	99	99
BSAI longline		80	54	35	30	27	28	29	33	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Fishery name	Method for calculating observer coverage	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
BSAI Greenland turbot longline	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	31.6	30.8	52.8	33.5	37.3	40.9	39.3	33.7	36.2	64	74	74	59	59			
BSAI Pacific cod longline	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	34.4	31.8	35.2	29.5	29.6	29.8	25.7	24.6	26.3	63	63	61	64	57	51	66	64
BSAI Pacific halibut longline	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	38.9	48.4	55.3	67.2	57.4	20.3	44.5	27.9	26.4	N/A	N/A	N/A		16	1.8	13	11
BSAI rockfish longline	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	41.5	21.4	53.0	26.9	36.0	74.9	37.9	36.3	46.8	88	N/A	100					
BSAI sablefish longline	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	19.5	28.4	24.4	18.9	30.3	10.4	50.9	19.3	11.2	48	49	56					
Prince William Sound salmon drift gillnet	% of estimated sets observed	4	5	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.
Prince William Sound salmon set gillnet	% of estimated sets observed	3	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.
Alaska Peninsula/Aleutian Islands salmon drift gillnet (South Unimak area only)	% of estimated sets observed	4	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.
Cook Inlet salmon drift gillnet	% of fishing days observed	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	1.6	3.6	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.
Cook Inlet salmon set gillnet	% of fishing days observed	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	0.16-1.1	0.34-2.7	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.
Kodiak Island salmon set gillnet	% of fishing days observed	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	6.0	not obs.	not obs.	4.9	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.
Yakutat salmon set gillnet	% of fishing days observed	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	5.3	7.6	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.
Southeast Alaska salmon drift gillnet (Districts 6, 7, and 8)	% of fishing days observed	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	6.4	6.6	not obs.

Note: Observer coverages in the groundfish fisheries (trawl, longline, and pots) were determined by the percentage of tons caught which were observed. Observer coverage in the groundfish fisheries is assigned according to vessel length; where vessels greater than 125 feet have 100% coverage, vessels 60-125 feet have 30% coverage, and vessels less than 60 feet are not observed. Observer coverage in the groundfish fisheries varies by statistical area; the pooled percent coverage for all areas is provided here. Observer coverages in the drift gillnet fisheries were calculated as the percentage of the estimated sets that were observed. Observer coverages in the set gillnet fishery were calculated as the percentage of estimated setnet hours (determined by number of permit holders and the available fishing time) that were observed.

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Appendix 7. Self-reported fisheries information.

The Marine Mammal Exemption Program (MMEP) was initiated in mid-1989 as a result of the 1988 amendments to the Marine Mammal Protection Act (MMPA). The MMEP required fishers involved in Category I and II fisheries to register with NMFS and to complete annual logbooks detailing each day's fishing activity, including: date fished, hours fished, area fished, marine mammal species involved, injured and killed due to gear interactions, and marine mammal species harassed, injured and killed due to deterrence from gear or catch. If the marine mammal was deterred, the method of deterrence was required, as well as indication of its effectiveness. Fishers were also required to report whether there were any losses of catch or gear due to marine mammals. These logbooks were submitted to NMFS on an annual basis, as a prerequisite to renewing their registration. Fishers participating in Category III fisheries were not required to submit complete logbooks, but only to report mortalities of marine mammals incidental to fishing operations. Logbook data are available for part of 1989 and for the period covering 1990-1993. Logbook data received during the period covering part of 1994 and all of 1995 was not entered into the MMEP logbook database in order for NMFS personnel to focus their efforts on implementing the 1994 amendments to the MMPA. Thus, aside from a few scattered reports from the Alaska Region, self-reported fisheries information is not available for 1994 and 1995.

In 1994, the MMPA was amended again to implement a long-term regime for managing mammal interactions with commercial fisheries (the Marine Mammal Authorization Program, or MMAP). Logbooks are no longer required. Instead, vessel owners/operators in any commercial fishery (Category I, II, or III) are required to submit one-page pre-printed reports for all interactions resulting in an injury or mortality to a marine mammal. The report must include the owner/operator's name and address, vessel name and ID, where and when the interaction occurred, the fishery, species involved, and type of injury (if animal was released alive). These postage-paid report forms are mailed to all Category I and II fishery participants that have registered with NMFS, and must be completed and returned to NMFS within 48 hours of returning to port for trips in which a marine mammal injury or mortality occurred. This reporting requirement was implemented in April 1996. During 1996, only 5 mortality/injury reports were received by fishers participating in all of Alaska's commercial fisheries. This level of reporting was a drastic drop in the number of reports compared to the numbers of interactions reported in the annual logbooks. As a result, the Alaska Scientific Review Group (SRG) considers the MMAP reports unreliable and has recommended that NMFS not utilize the reports to estimate marine mammal mortality (see June 1998 Alaska SRG meeting minutes; DeMaster 1998). As of the stock assessment reports for 2006, these records are no longer used to estimate annual fishery-related mortalities.

Fishery	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Minimum estimated mortality
Steller sea lion (Western U.S. stock)																
Alaska Peninsula/Aleutian Islands salmon set gillnet	0	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.75
Bristol Bay salmon drift gillnet	0	4	2	8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.5
Prince William Sound set gillnet	0	0	2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5
Alaska miscellaneous finfish set gillnet	0	1	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
Alaska halibut longline (state and federal waters)	0	0	0	0	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.2
Kodiak salmon set gillnet	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	2
Steller sea lion (Eastern U. S. stock)																
Southeast Alaska salmon drift gillnet	0	1	2	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.25
Northern fur seal (Eastern Pacific stock)																
Prince William Sound salmon drift gillnet	1	1	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5
Alaska Peninsula/Aleutian Islands salmon drift gillnet	2	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5
Bristol Bay salmon drift gillnet	5	0	49	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13.5
Alaska misc. finfish pair trawl	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1
Harbor seal (Southeast Alaska stock)																
Southeast Alaska salmon drift gillnet	8	1	4	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	3.2
Yakutat salmon set gillnet	0	18	31	61	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	27.5

Fishery	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Minimum estimated mortality
Harbor seal (Gulf of Alaska stock)																
Cook Inlet salmon set gillnet	6	0	1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.75
Prince William Sound set gillnet	0	0	0	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
Kodiak salmon set gillnet	3	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.75
Alaska salmon purse seine (except for Southeast)	0	0	0	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5
Alaska Peninsula/Aleutian Islands salmon drift gillnet	9	2	12	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7
Harbor seal (Bering Sea stock)																
Bristol Bay salmon drift gillnet	38	23	2	42	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.25
Bristol Bay salmon set gillnet	0	0	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5
AK misc. finfish pair trawl	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	1
Spotted seal (Alaska stock)																
Bristol Bay salmon drift gillnet	5	1	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.5
Beluga whale (Bristol Bay stock)																
Bristol Bay salmon drift gillnet	0	1	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
Bristol Bay salmon set gillnet	1	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
Pacific white-sided dolphin (North Pacific stock)																
Prince William Sound salmon drift gillnet	1	4	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.25
Southeast Alaska salmon drift gillnet	0	0	1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
Bristol Bay salmon drift gillnet	3	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.75
Harbor porpoise (Southeast Alaska stock)																
Southeast Alaska salmon drift gillnet	2	2	7	2	N/A	N/A	2	N/A	1	N/A	N/A	N/A	N/A	N/A	N/A	2.7
Harbor porpoise (Gulf of Alaska stock)																
Cook Inlet salmon drift and set gillnet fisheries	3	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	0.8
AK Peninsula/Aleutian Island salmon drift gillnet	2	0	1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.75
Kodiak salmon set gillnet	8	4	2	1	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	N/A	N/A	3.2
Harbor porpoise (Bering Sea stock)																
AK Peninsula/Aleutian Island salmon set gillnet	0	0	2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5
Bristol Bay salmon drift gillnet	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
Bristol Bay salmon set gillnet	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
AK Kuskokwim, Yukon, Norton Sound, Kotzebue salmon gillnet	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
Dall's porpoise (Alaska stock)																
Prince William Sound salmon drift gillnet	0	2	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5
Southeast Alaska salmon drift gillnet	6	6	4	6	N/A	N/A	N/A	1	N/A	1	N/A	1	N/A	?	N/A	3.6
Cook Inlet set and drift gillnet fisheries	1	0	1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5
Eastern North Pacific gray whale																
Bristol Bay salmon drift and set gillnet fisheries	2	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5
WA/OR/CA crab pot	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	0.5
Humpback whale (Central North Pacific stock)																
Southeast Alaska salmon drift gillnet	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
Southeast Alaska salmon purse seine	0	0	0	0	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.2

CITATIONS

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POLAR BEAR (*Ursus maritimus*): Chukchi/Bering Seas Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

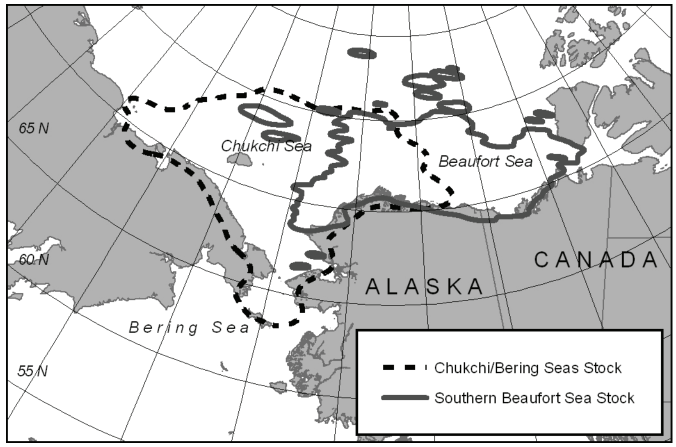

Figure 1. Map of the Southern Beaufort Sea and the Chukchi/Bering seas polar bear stocks.

Polar bears are circumpolar in their distribution in the northern hemisphere. They occur in several largely discrete stocks or populations (Harington 1968). Polar bear movements are extensive and individual activity areas are enormous (Garner *et al.* 1990, Amstrup *et al.* 2000). The parameters used by Dizon *et al.* (1992) to classify stocks based on the phylogeographic approach were considered in the determination of stock separation in Alaska. Several polar bear stocks are known to be shared between countries (Amstrup *et al.* 1986, Amstrup and DeMaster 1988). Lentfer hypothesized that in Alaska two stocks exist, the Southern Beaufort Sea (SBS) and the Chukchi/Bering seas (CBS), based upon: (a) variations in levels of heavy metal contaminants of organ tissues (Lentfer 1976, Lentfer and Galster 1987); (b) morphological characteristics (Manning 1971, Lentfer 1974, Wilson 1976); (c) physical oceanographic features which segregate the Chukchi Sea and Bering Sea stock from the Beaufort Sea stock (Lentfer 1974); and (d) movement information collected from mark and recapture studies of adult female bears (Lentfer 1974, 1983) (Figure 1). Information on contaminants (Woshner *et al.* 2001, Evans 2004a, Evans 2004b, Kannan *et al.* 2005, Smithwick *et al.* 2005, Verreault *et al.* 2005, Muir *et al.* 2006, Smithwick *et al.* 2006, Kannan *et al.* 2007, Rush *et al.* 2008) and movement data using satellite collars (Amstrup *et al.* 2004, Amstrup *et al.* 2005) continue to support the presence of these two stocks.

The CBS population is widely distributed on the pack ice in the Chukchi Sea and northern Bering Sea and adjacent coastal areas in Alaska and Russia. The northeastern boundary of the Chukchi/Bering seas stock is near the Colville Delta in the central Beaufort Sea (Garner *et al.*1990, Amstrup 1995, Amstrup *et al.* 2005) and the western boundary is near Chauniskaya Bay in the Eastern Siberian Sea. The boundary between the Eastern Siberian Sea stock and the Chukchi Sea stock is designated based on movements of adult female polar bears captured in the Bering and Chukchi seas region. Female polar bears initially captured and radio collared on Wrangel Island exhibited no movement into the Eastern Siberian Sea, while female polar bears captured and radio collared in the Eastern Siberian Sea, exhibited only limited short term movement into the western Chukchi Sea (Garner *et al.* 1990). The Chukchi/Bering seas stock extends into the Bering Sea and its southern boundary is determined by the annual extent of pack ice (Garner *et al.* 1990). Adult female polar bears captured from the Southern Beaufort Sea stock may make seasonal movements into the Chukchi Sea in an area of overlap located between Point Hope and Colville Delta, centered near Point Lay (Garner *et al.* 1990, Garner *et al.* 1994, Amstrup 1995, Amstrup *et al.* 2002, Amstrup *et al.* 2005). Probabilistic distribution information for zones of overlap between the Chukchi/Bering seas and the Southern Beaufort Sea population exist (Amstrup *et al.* 2004, Amstrup *et al.* 2005). Telemetry data indicate that these bears, marked in the Beaufort Sea, spend about 25% of their time in the northeastern Chukchi Sea, whereas females captured in the Chukchi Sea spend only 6% of their time in the Beaufort Sea (Amstrup 1995). Average activity areas of females in the Chukchi/Bering seas from 1986–1988 (244,463 km^2, range 144,659–351,369 km^2) (Garner *et al.* 1990) were more extensive than the Beaufort Sea from 1983– 1985 (96,924 km^2, range 9,739–269,622 km^2) (Amstrup 1986) or from 1985–1995 (166,694 km^2, range 14,440–616,800 km^2) (Amstrup *et al.* 2000). Radio collared adult females spent a greater proportion of their time in the Russian region than in the American region (Garner *et al.* 1990). Historically polar bears ranged as far south as St. Matthew Island (Hanna 1920) and the Pribilof Islands (Ray 1971) in the Bering Sea.

Analysis of mitochondrial DNA indicates little differentiation of the Alaska polar bear stocks (Cronin *et al.* 1991, Scribner *et al.* 1997, Cronin *et al.* 2006). Using 16 highly variable micro-satellite loci, Paetkau *et al.* (1999) determined that polar bears throughout the arctic (19 populations) are genetically similar. Genetically, polar bears in the southern Beaufort Sea differed more from polar bears in the Chukchi/Bering seas than from polar bears in the northern Beaufort Sea (Paetkau *et al.* 1999).

While genetically similar, demographic and movement data of the CBS population, indicates a high degree of site fidelity, suggesting that the stocks should be managed separately (Amstrup 2000, Amstrup *et al.* 2000, Amstrup *et al.* 2001a, Amstrup *et al.* 2002, Amstrup *et al.* 2004, Amstrup *et al.* 2005).

Past management has consistently distinguished between the southern Beaufort Sea and the Chukchi/Bering seas stocks. The Inuvialuit of the Inuvialuit Game Council (IGC), Northwest Territories, and the Inupiat of the North Slope Borough (NSB), Alaska, polar bear management agreement for the Southern Beaufort Sea stock was based on stock boundaries described previously (Brower *et al.* 2002, Nageak *et al.* 1991, Treseder and Carpenter 1989) and reaffirmed by the information in this stock assessment report.

POPULATION SIZE

Polar bears typically occur at low densities throughout their circumpolar range (DeMaster and Stirling 1981). It has been difficult to obtain a reliable population estimate for this population due to the vast and inaccessible nature of the habitat, movement of bears across international boundaries, logistical constraints of conducting studies in Russian territory, and budget limitations (Amstrup and DeMaster 1988, Garner *et al.* 1992, Garner *et al.* 1998, Evans *et al.* 2003). The Chukchi Sea population is estimated to comprise 2,000 animals, based on extrapolation of aerial den surveys (Lunn *et al.* 2002). Estimates of the population have been derived from observations of dens and aerial surveys (Chelintsev 1977, Stishov 1991a, Stishov 1991b, Stishov *et al.* 1991); however, these estimates (see below) have wide confidence intervals and are considered to be of little value for management and cannot be used to evaluate status and trends for this population.

Minimum Population Estimate

A reliable population estimate for the Chukchi/Bering seas stock currently does not exist. Lentfer, in the Administrative Law Judge (ALJ) proceeding to waive the Marine Mammal Protection Act of 1972 (MMPA) moratorium on taking and return management to the State of Alaska (ALJ 1977), estimated the size of the Chukchi/Bering seas population stock (Wrangel Island to western Alaska) at 7,000, and Chapman estimated the Alaska population (both stocks) at 5,550 to 5,700 (ALJ 1977). Lentfer and Chapman's estimates (ALJ 1977), however, were not based on rigorous statistical analysis of population data and variance estimates could not be calculated. Amstrup *et al.* (1986) estimated densities (1976–129 km^2/bear, 1981–211 km^2/bear) based on mark and recapture of 266 polar bears near Cape Lisburne on the Chukchi Sea, but a population estimate for the Chukchi Sea was not developed at that time. An August 2000 aerial survey of polar bears in the Eastern Chukchi Sea resulted in density estimates of (0.00748 bear/km^2, or 147 km^2/bear, C.V. = 0.38) (Evans *et al.* 2003). A population estimate was not derived from this density since the study area included only a portion of the total area used by the population.

Amstrup and DeMaster (1988) estimated the Alaska population (both stocks) at 3,000 to 5,000 animals based on densities calculated previously by Amstrup *et al.* (1986). The area that the estimate applied to and the variance associated with the estimate were not provided for in the 1988 population estimate (Amstrup and DeMaster 1988). A crude population estimate for the Chukchi/Bering seas stock of 1,200 to 3,200 animals was derived by subtracting the Beaufort Sea population estimate of 1,800 animals (Amstrup 1995) from the total Alaska statewide estimate of 3,000 to 5,000 (Amstrup and DeMaster 1988). The IUCN Polar Bear Specialist Group (IUCN 2006) estimated this population to be approximately 2,000 animals based on extrapolation of multiple years of denning data for Wrangel Island, assuming that 10% of the population dens annually as adult females. However, confidence in this estimate is low due to the lack of current denning estimates and reliable data with measurable levels of precision (IUCN 2006). Nonetheless, an N_{MIN} of 2,000 is the best available information we have at this time.

Current Population Trend

Prior to the 20th century, when Alaska's polar bears were hunted primarily by Alaskan Natives, both stocks probably existed at near carrying capacity (K). The size of the Beaufort Sea stock declined substantially in the late 1960's and early 1970's (Amstrup *et al.* 1986) due to excessive sport harvest. Similar declines could have occurred in the Chukchi Sea, although there are no population data to support this assumption. Since passage of the MMPA, the southern Beaufort Sea population grew during the late 1970's and 1980's and then stabilized during the 1990's (Amstrup *et al.* 2001b). Based on demographic data 2001 to 2006, the overall population growth rate in the Southern Beaufort Sea population declined approximately 0.3% per year (Hunter *et al.* 2007). Until 1992 it is likely that the Chukchi/Bering seas stock mimicked the growth pattern and later stability of Southern Beaufort Sea stock, since both stocks experienced similar management and harvest histories. However, since 1992 the CBS population has faced different stressors than the SBS population. These include increased harvest in Russia (150 – 250 bears/yr) (Kochnev 2006, Ovsyanikov 2006, Eduard Zdor personal communication) and greater loss of summer sea ice habitat from global warming (Overland and Wang 2007), which suggest that using the growth rate for the Southern Beaufort Sea may not be applicable. The status of the Chukchi/Bering seas stock was listed as data deficient (Aars *et al.* 2006) due to the lack of abundance estimates with measurable levels of precision. The population is believed to be declining and the status relative to historical levels is believed to be reduced based on harvest levels that were demonstrated to be unsustainable in the past.

MAXIMUM NET PRODUCTIVITY RATES

Polar bears are long lived, mature at a relatively old age, have an extended breeding interval, and have small litters (Lentfer *et al.* 1980, DeMaster and Stirling 1981). Population/stock specific data to estimate R_{MAX} are not available for the Chukchi/Bering seas polar bear stock. The Southern Beaufort Sea is one of four polar bear populations with long-term data sets and as it overlaps with the Chukchi/Bering seas stock using the default value for R_{MAX} for the Southern Beaufort Sea seems reasonable as it is based on empirical data. Survival rates for the Southern Beaufort Sea stock (Regehr *et al.* 2006), which can be used in a Leslie matrix model, suggest that under optimal conditions and in the absence of human perturbations the population could increase at a rate of between 4 and 6%. Amstrup (1995) projected an annual intrinsic growth rate (including natural mortality but not human-caused mortality) of 6.03% for the Southern Beaufort Sea stock using a Leslie type matrix of recapture data. Since the Chukchi/Bering seas area is one of the most productive areas in the Arctic using the 6.03% for the Chukchi/Bering seas polar bear stock seems reasonable.

POTENTIAL BIOLOGICAL REMOVAL (PBR)

Under the 1994 reauthorized MMPA, the potential biological removal (PBR) level is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $(N_{MIN})(½\ R_{MAX})(F_R)$. Wade and Angliss (1997) recommend a default recovery factor (F_R) of 0.5 for a threatened population or when the status of a population is unknown. We used 0.5 as the recovery factor since reliable population estimates to assess population trends are not available. In the following calculation: $(N_{MIN})(½\ R_{MAX})(F_r)$ = PBR (Wade and Angliss 1997) the minimum population estimate, N_{MIN} was 2,000; the maximum rate of increase R_{MAX} was 6.03%; and the recovery factor F_R was 0.50. Therefore, the PBR level for the Chukchi/Bering seas stock is 30 bears per year. However, confidence in these numbers is low due to dated and extrapolated population information and, therefore, the PBR value has little utility for management purposes.

ANNUAL HUMAN CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Polar bear stocks in Alaska have no direct interaction with commercial fisheries activities. Consequently, the total fishery mortality and serious injury rate for the Chukchi/Bering seas stock is zero.

Alaska Native Subsistence Harvest

Historically, polar bears have been killed for subsistence, handicrafts, and recreation. Based on records of skins shipped from Alaska for 1925–53, the estimated annual statewide harvest averaged 120 bears, taken primarily by Native hunters. Recreational hunting by non-native sports hunters using aircraft was common from 1951–72, increasing statewide annual harvest to 150 during 1951–60 and to 260 during 1960–72 (Amstrup *et al.* 1986, Schliebe *et al.* 1995). Hunting by non-Natives has been prohibited since 1973 when provisions of the MMPA went into effect. This reduced the mean annual statewide harvest for both populations to 98 during 1980–2007 (SD=40; range 48–242) (USFWS unpublished data). The annual harvest from the Chukchi/Bering seas stock was 92/year in the 1980s, 49/year in the 1990s, and 43/year in the 2000s. More recently, the 2003−2007 average Alaska harvest for the Chukchi/Bering seas stock in Alaska was 37 and the sex ratio was 66M:34F.

Under the MMPA, an exemption was made for Alaska Natives living in coastal communities to allow them to hunt polar bears for subsistence and making of handicrafts provided that the hunt was not done in a wasteful manner. Recently, harvest levels by Alaska Natives from the Chukchi/Bering seas stock have been declining (Figure 2). The sex ratio of known-sex bears harvested since 1980 has remained relatively consistent at 66% males and 34% females (Schliebe *et al.* 2006).

The number of unreported kills in Alaska since 1980 to the present time is approximately 7% based on: (a) tagging information; (b) interviews with local hunters; and (c) law enforcement investigations. No user agreement, similar to that between the Inuvialuit and Inupiat for the Beaufort Sea stock, exists for the Bering/Chukchi stock. Harvest levels are not limited at this time.

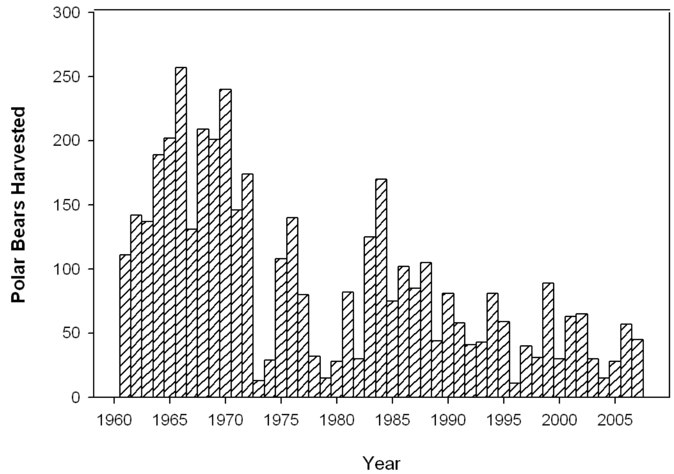

Figure 2. Annual Alaska polar bear harvest from the Chukchi/Bering Seas stock, 1961-2007.

Other Removals

Russia prohibited all hunting of polar bears in 1956 in response to perceived population declines caused by over-harvest. In Russia, only a small number of animals, less than 3–5 per year, were removed for placement in zoos prior to 1986 (Uspenski 1986) and a few were killed in defense of life. No bears were taken for zoos or circuses from 1993 to 1995 (Belikov 1998). The occurrence of increased takes of problem bears in Chukotka was acknowledged in 1992, and Belikov (1993) estimated that up to 10 problem bears were killed annually in all of the Russian Arctic. Increased illegal hunting of polar bears in the Russian Arctic was also recognized to have begun in 1992. While the magnitude of the illegal harvest in Russia from the Chukchi/Bering seas stock is unquantified, reports indicate that a substantial number of bears, 150–250/yr (Kochnev 2006), or alternatively 120–150/yr (Eduard Zdor pers. comm.), are being harvested. Combining the reported Chukotka harvest with the documented Alaska harvest indicates that up to 200 bears may have been harvested from this population in many years. Harvest levels similar to these are believed to have caused population depletion by the early 1970s. Belikov *et al.* (2006) indicated that the current level of poaching in Russia poses a serious threat to the population. No serious injuries, other than the mortalities discussed here, have been reported for the Chukchi/Bering seas stock.

No orphaned cubs from the Alaskan Chukchi/Bering seas stock were placed in zoos since 2002. Illegal harvest has not been detected in Alaska. Oil and gas exploration in the Bering/Chukchi region of Alaska, began again in 2006, primarily during the open water season has resulted in minimal interaction with polar bears; there was no evidence of mortality or serious injury.

STATUS OF STOCK

Polar bears in the Chukchi/Bering seas stock are currently classified as depleted under the MMPA and listed as threatened under the U.S. Endangered Species Act of 1973 (ESA) as amended. Reliable estimates of the minimum population, PBR level, and human-caused mortality or serious injury in Chukotka are currently not available

The ongoing level of the subsistence hunting in western Alaska and Chukotka is a concern. There is no incidental mortality or serious injury of polar bear in any U.S. commercial fishery. The primary concerns for this population are habitat loss resulting from climate change, potential over-harvest, human activities including industrial activities occurring within the near-shore environment, and potential effects of contaminants on nutritionally stressed populations. The Chukchi/Bering seas polar bear stock is designated as a strategic stock because the population is listed as threatened under the ESA.

Conservation Issues and Habitat Concerns

Oil and Gas Exploration

In 2008, the Minerals Management Service held an oil and gas lease sale for offshore blocks in the eastern Chukchi Sea. Polar bears from Chukchi/Bering seas stock seasonally use the shallow, productive, ice-covered waters of the eastern Chukchi Sea for feeding, breeding, and movements. The Fish and Wildlife Service (USFWS) works to monitor and mitigate potential impacts of oil and gas activities on polar bears through incidental take regulations (ITR) as authorized under the Marine Mammal Protection Act. Activities operating under these regulations must adopt measures to: ensure that the total of such incidental taking of polar bears remains negligible; minimize impacts to their habitat; and ensure no unmitigable adverse impact on their availability for Alaska Native subsistence use. ITR also specify monitoring requirements that provide a basis for evaluating potential impacts of current and future activities on marine mammals.

Climate Change

Polar bears evolved over thousands of years to life in a sea ice environment. They depend on the sea ice-dominated ecosystem to support essential life functions. Sea ice provides a platform for hunting and feeding, for seeking mates and breeding, for movement to terrestrial maternity denning areas and occasionally for maternity denning, for resting, and for long-distance movements. The sea ice ecosystem supports ringed seals, the primary prey for polar bears, and other marine mammals that are also part of their prey base.

Sea ice is rapidly diminishing throughout the Arctic and large declines in optimal polar bear habitat have occurred in the Southern Beaufort and Chukchi Seas between the two time periods, 1985–1995 and 1996–2006 (Durner et al 2009). In addition, it is predicted that the greatest declines in 21st century optimal polar bear habitat will occur in Chukchi and Southern Beaufort Seas (Durner *et al.* 2009a). Patterns of increased temperatures, earlier onset of and longer melting periods, later onset of freeze-up, increased rain-on-snow events, and potential reductions in snowfall are occurring. In addition, positive feedback systems (i.e., the sea-ice albedo feedback mechanism) and naturally occurring events, such as warm water intrusion into the Arctic and changing atmospheric wind patterns, can operate to amplify the effects of these phenomena. As a result, there is fragmentation of sea ice, a dramatic increase in the extent of open water areas seasonally, reduction in the extent and area of sea ice in all seasons, retraction of sea ice away from productive continental shelf areas throughout the polar basin, reduction of the amount of heavier and more stable multi-year ice, and declining thickness and quality of shore-fast ice (Parkinson et al 1999, Rothrock *et al.* 1999, Comiso 2003, Fowler *et al.* 2004, Lindsay and Zhang 2005, Holland *et al.* 2006, Comiso 2006, Serreze *et al.* 2007, Stroeve *et al.* 2008).

The Chukchi/Bering seas and the Southern Beaufort Sea population stocks are currently experiencing the initial effects of changes in sea ice conditions (Rode *et al.* 2007, Regehr *et al.* 2007, Hunter *et al.* 2007). These populations are vulnerable to large-scale dramatic seasonal fluctuations in ice movements, decreased abundance and access to prey, and increased energetic costs of hunting. The USFWS is working on measures to protect polar bears and their habitat.

Subsistence Harvest

Past differences in management regimes between the United States and Russia have made coordination of studies on the shared Alaska-Chukotka polar bear population difficult. In the former Soviet Union, hunting of polar bears was banned nationwide in 1956. Recently, Russia's ability to enforce that ban has been difficult due to logistical and financial constraints. In Alaska, subsistence hunting of polar bears by Alaska Natives is currently unrestricted under section 101(b) of the MMPA provided that the take is for subsistence purposes or creating authentic articles of Alaska Native handicrafts and conducted in a non-wasteful manner. While several joint research and management projects have been successfully undertaken in the past between the United States and Russia, today comparable efforts are either no longer occurring or are unilateral in scope.

The bilateral "Agreement between the United States and the Russian Federation on the Conservation and Management of the Alaska-Chukotka Polar Bear Population (Agreement)" was signed by the governments of the United States and the Russian Federation on October 16, 2000, with subsequent advice and consent provided by the U.S. Senate. Among other provisions the Agreement recognizes the needs of Native people to harvest polar bears for subsistence purposes and includes provisions for developing sustainable harvest limits, allocation of the harvest between jurisdictions, and compliance and enforcement. Each jurisdiction is entitled to up to one-half of a harvest limit to be determined by a future the joint Commission. The Agreement reiterates requirements of the 1973 multi-lateral agreement and includes restrictions on harvesting denning bears, females with cubs, or cubs less than one year old, and prohibitions on the use of aircraft, large motorized vessels, and snares or poison for hunting polar bears.

On January 12, 2007, President Bush signed into law H.R. 5946, the "Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006." This Act includes Title X implementing the Agreement. This action allows for the establishment of the commission and development of enforceable harvest management agreements. The Russian Federation and the United States have completed documents necessary to implement the Agreement within Russia and the United States. The USFWS is currently developing recommendations for the Bilateral Commission that will direct research and establish sustainable and enforceable harvest limits needed to address current potential population declines due to over-harvest of the population.

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POLAR BEAR (*Ursus maritimus*): Southern Beaufort Sea Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Polar bears are circumpolar in their distribution in the northern hemisphere. They occur in several largely discrete stocks or populations (Harington 1968). Polar bear movements are extensive and individual activity areas are enormous (Garner et al. 1990, Amstrup et al. 2000). The parameters used by Dizon et al. (1992) to classify stocks based on the phylogeographic approach were considered in the determination of stock separation in Alaska. Several polar bear stocks are known to be shared between countries (Amstrup et al. 1986, Amstrup and Demaster 1988). Lentfer hypothesized that two Alaska stocks exist, the Southern Beaufort Sea, and the Chukchi/Bering Seas, based upon: (a) variations in levels of heavy metal contaminants of organ tissues (Lentfer 1976, Lentfer and Galster 1987); (b) morphological characteristics (Manning 1971; Lentfer 1974; Wilson 1976); (c) physical oceanographic features which segregate stocks (Lentfer 1974) and; (d) movement information collected from mark and recapture studies of adult female bears (Lentfer 1983) (Figure 1). Information on contaminants (Woshner et al. 2001, Evans 2004a, Evans 2004b, Kannan et al. 2005, Smithwick et al. 2005, Verreault et al. 2005, Muir et al. 2006, Smithwick et al. 2006, Kannan et al. 2007, Rush et al. 2008) and movement data using satellite collars (Amstrup et al. 2004, Amstrup et al. 2005) continue to support the existence of these two stocks.

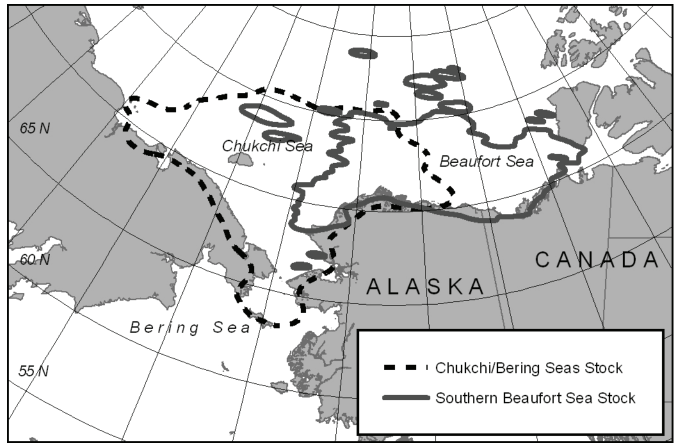

Figure 1. Map of the Southern Beaufort Sea and the Chukchi/Bering seas polar bear stocks.

Amstrup et al. (2000) demonstrated that the eastern boundary of the Southern Beaufort Sea stock occurs south of Banks Island and east of the Baillie Islands, Canada. The bears in the Northern Beaufort Sea and Southern Beaufort Sea populations spend the summer on pack ice and move toward the coast during fall, winter, and spring (Durner et al. 2004). The range of the two populations previously overlapped extensively in the vicinity of the Baille Islands, Canada (Amstrup 2000) but recent data no longer support this degree of overlap (Amstrup et al. 2005). Recent analysis of polar bear movements using satellite telemetry from 2000 to 2006 (Amstrup et al. 2004, Amstrup et al. 2005), capture and recapture data (Regehr et al. 2006, Stirling et al. 2007), and harvest information suggest that the eastern population boundary has shifted westward to near the village of Tuktoyaktuk, Canada. The assignment of this new boundary could be adjusted somewhat based on local management considerations; however, it will probably necessitate a downward readjustment of the population size of the Southern Beaufort Sea stock to correspond with the smaller geographic area. The proposed boundary change is under consideration and has not been accepted by the parties to the Polar Bear Management Agreement for the Southern Beaufort Sea between the Inuvialuit Game Council of Canada and the North Slope Borough of Alaska. For the purposes of this report, we continue to use the previously published boundaries for the Southern Beaufort Sea population delineated by Amstrup et al. (2000). The western boundary is near Point Hope. An extensive area of overlap between the Southern Beaufort Sea stock and the Chukchi/Bering seas stock occurs between Point Barrow and Point Hope, centered near Point Lay (Garner et al. 1990, Garner et al. 1994, Amstrup et al. 2000). The southern boundary of the Northern Beaufort Sea stock in the Canadian Arctic was delineated by Bethke et al. (1996). Telemetry data indicates that adult female polar bears marked in the Southern Beaufort Sea spend about 25% of their time in the northeastern Chukchi Sea, whereas females captured in the Chukchi Sea spend only 6% of their time in the Southern Beaufort Sea (Amstrup 1995). However, polar bears are not dispersed evenly throughout their range. To access ringed and bearded seals, polar bears in the Southern Beaufort Sea concentrate in shallow waters less that 300 m deep over the continental shelf and in areas with >50% ice cover (Stirling et al. 1999, Durner et al. 2004, Durner et al. 2006a, Durner et al. 2009). Polar bears from this population have historically denned on both the sea ice and land. Thinning of the sea ice in recent years has caused a decline in the number of polar bears denning on the sea ice. Fischbach et al. (2007) found that the proportion of dens on the pack ice declined from 62% from 1985—1994 to 37% in 1998-2004. The main terrestrial denning areas for the Southern Beaufort Sea population in Alaska occur on the barrier islands from Barrow to Kaktovik and along coastal areas up to 25 miles inland including the Arctic National Wildlife Refuge to Peard Bay, west of Barrow (Amstrup and Gardner 1994, Amstrup 2000, Durner et al. 2001, Durner et al. 2006b).

In response to changes in the sea ice characteristics and declines in sea ice habitat over the continental shelf during the summer and late fall, some polar bears have changed distribution to search for seals and to access the remains of subsistence harvested bowhead whales (Schliebe et al. 2008). It is expected that changes in the distribution and movements may occur with increasing frequency in the future (Durner et al. 2009, Schliebe et al. 2008) Polar bears may also become more nutritionally stressed due to global climate changes in the Arctic (Stirling and Parkinson 2006) and, thus, continued monitoring is required to document these changes.

Analysis of mitochondrial DNA and microsatellite DNA loci indicates little differentiation of the Alaska polar bear stocks (Cronin et al. 1991, Scribner et al. 1997, Cronin et al. 2006). Using 16 highly variable micro satellite loci, Paetkau et al. (1999) determined that polar bears throughout the arctic (19 populations) were genetically very similar. Genetically, polar bears in the Southern Beaufort Sea differed more from polar bears in the Chukchi/Bering Seas than from polar bears in the Northern Beaufort Sea (Paetkau et al. 1999, Thiemann et al. 2008). While genetically similar, demographic and movement data indicates a high degree of site fidelity, suggesting that the stocks should be managed separately (Amstrup 2000, Amstrup et al. 2000, Amstrup et al. 2001a, Amstrup et al. 2002, Amstrup et al. 2004, Amstrup et al. 2005).

POPULATION SIZE

Polar bears occur at low densities throughout their circumpolar range (DeMaster and Stirling 1981). They are long lived, mature late, have an extended breeding interval, and have small litters (Lentfer et al. 1980, DeMaster and Stirling 1981, Amstrup 2003). Accurate population estimates for the Alaskan populations have been difficult to obtain because of low population densities, inaccessibility of the habitat, movement of bears across international boundaries, and budget limitations (Amstrup and DeMaster 1988, Garner et al. 1992). Research on the Southern Beaufort Sea population began in 1967 and is one of only four polar bear populations with long term (>20 yrs) data.

Amstrup et al. (1986) estimated the Southern Beaufort Sea stock at 1,778 (S.D. ± 803; C.V. = 0.45) during the 1972-83 period. Amstrup (1995) estimated the Southern Beaufort Sea stock near 1,480 animals in 1992. Amstrup (USGS unpublished data) using data for the 1986-98 period (excluding 4 unsampled years), estimated the population at 2,272 in 2001. This total population estimate was based on as estimate of 1,250 females (C.V. = 0.17) and a sex ratio of 55% females (Amstrup et al. 2001b). The population estimate of 1,526 (95% CI =1211−1841; C.V. = 0.106) (Regehr et al. 2006), which is based on open population capture-recapture data collected from 2001 to 2006, is considered the most current and valid population estimate.

Minimum Population Estimate

N_{MINn} is calculated as follows $N/exp(0.842 * (ln(1+CV(N)^2))^{½})$ and is 1,397 bears for population size of 1,526 and C.V. of 0.106. This population estimate applies to an area that extends from Pt. Barrow in the west, east to the Baillie Islands in Canada.

Current Population Trend

Prior to the 20th century, when Alaska's polar bears were hunted primarily by Natives, both the Chukchi/Bering seas and Southern Beaufort Sea stocks probably existed near carrying capacity (K). Once harvest by non-Natives became common in the Southern Beaufort Sea in the early 1960s, the size of these stocks declined substantially (Amstrup et al. 1986, Amstrup 1995). Since passage of the Marine Mammal Protection Act (MMPA) in 1972, both Alaska polar bear stocks seem to have increased; this is based on: (a) mark and recapture data; (b) observations by Natives and residents of coastal Alaska and Russia; (c) catch per unit effort indices (USGS unpublished data); (d) reports from Russian scientists (Uspenski and Belikov 1991); and (e) harvest statistics on the age structure of the population. Recapture data from the stock indicated a population growth rate of 2.4% from 1981 to 1992 (Amstrup 1995).

The Southern Beaufort Sea stock experienced little or no growth during the 1990's (Amstrup et al. 2001b). Declining survival, recruitment, and body size (Regehr et al. 2006, Regehr et al. 2007), and low growth rates (λ) during years of reduced sea ice during the summer and fall (2004 and 2005), and an overall declining growth rate of 3% per year from 2001-2005 (Hunter et al. 2007) indicates that the Southern Beaufort Sea population is now declining.

MAXIMUM NET PRODUCTIVITY RATES

Population/stock specific data to estimate R_{MAX} are not available for the stock. Taylor et al. (1987) estimated the sustainable yield of the female component of the population at < 1.6% per annum. The following information is used to understand the R_{MAX} determination. From 1981-92, when the population was increasing, vital rates of polar bears in the Southern Beaufort Sea were as follows: average age of sexual maturity (females) was 6 years; average COY litter size was 1.67; average reproductive interval was 3.68 years; and average annual natural mortality (nM), which varies by age class, ranged from 1-3% for adults (Amstrup 1995).

Amstrup (1995) projected an annual intrinsic growth rate (including natural mortality but not human-caused mortality) of 6.03% for the Southern Beaufort Sea stock using a Leslie type matrix of recapture data. This analysis mimics a life history scenario where environmental resistance is low and survival high.

POTENTIAL BIOLOGICAL REMOVAL (PBR)

Under the 1994 reauthorized MMPA, the potential biological removal (PBR) level is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $(N_{MIN})(\frac{1}{2} R_{MAX})(F_R)$. Wade and Angliss (1997) recommend a default recovery factor (F_R) of 0.5 for a threatened population or when the status of a population is unknown. In the following calculation: $(N_{MIN})(\frac{1}{2} R_{MAX})(F_r)$ = PBR (Wade and Angliss 1997) the minimum population estimate, N_{MIN} was 1,397; the maximum rate of increase R_{MAX} was 6.03%; and the recovery factor F_R was 0.5. Therefore, the PBR level for the Southern Beaufort Sea stock is 22 bears per year.

ANNUAL HUMAN CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Polar bear stocks in Alaska have no direct interaction with commercial fisheries activities. Consequently, the total fishery mortality and serious injury rate for the Southern Beaufort Sea stock is zero.

Alaska Native Subsistence Harvest

Historically, polar bears have been killed for subsistence, handicrafts, and recreation (sport hunting). Based upon records of skins shipped from Alaska, the estimated annual statewide harvest (both stocks) for 1925−53 averaged 120 bears taken primarily by Native hunters. Sport hunting using aircraft was common from 1951−72, increasing annual harvest in Alaska to 150 during 1951-60 and to 260 during 1960−72 (Amstrup et al. 1986; Schliebe et al.1995). The annual harvest for the Southern Beaufort Sea stock was 81/year from 1960−1972. Although polar bear hunting was prohibited by the MMPA, an exemption was made for Alaska Natives living in coastal communities to allow them to hunt polar bears for subsistence and making of handicrafts provided that the hunt was not done in a wasteful manner. The cessation of sport hunting in 1972 reduced the mean annual combined harvest for both Alaskan stocks to 98 during 1980−2007 (SD=40; range 48−242) (USFWS unpublished data). The annual harvest from the Southern Beaufort Sea was 39/year in the 1980s, 33/year in the 1990s, and 32/year in the 2000s. More recently, the 2003−2007 average Alaska harvest for the Southern Beaufort Sea in Alaska was 33 and the sex ratio was 67M:33F. During the same time period the average Canadian harvest for the Southern Beaufort Sea was 21.0 and the sex ratio was 45M:55F. The combined average annual Alaska and Canada harvest during the past five years was 53.6. Figure 2 illustrates the annual Alaska polar bear harvest and trend for the Southern Beaufort Sea stock from 1961−2007. No serious injuries, other than the mortalities discussed here, have been reported for the Southern Beaufort Sea stock.

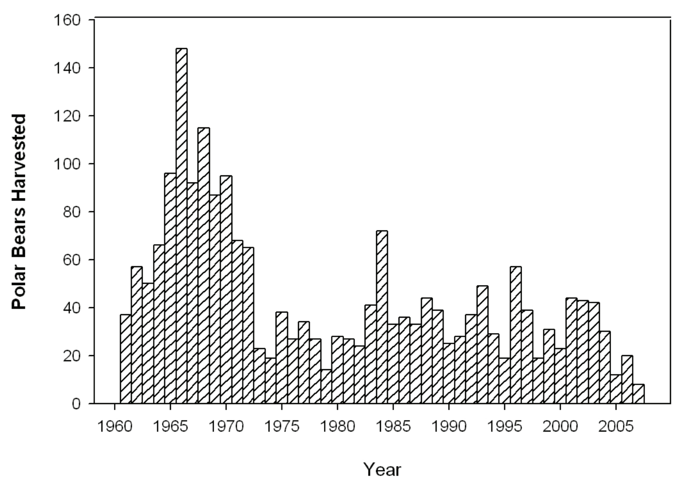

Figure 2. Annual Alaska polar bear harvest from the Southern Beaufort Sea stock, 1961-2007.

During the 1980–2007 period the Alaska harvest from the Southern Beaufort Sea accounted for 34% of the total Alaska kill (annual mean=33 bears) with the remaining 66% occurring in the Chukchi Sea. The sex ratio of the harvest from 1980–2007 in the Southern Beaufort Sea was 69M:31F.

Other Removals

Orphaned cubs are occasionally removed from the wild and placed in zoos; no cubs were placed into public display facilities during the past five years. One bear died as a result of research mortality and two bears were euthanized during the last five years. Activities operating under "incidental take" regulations, associated with the oil and gas industry, have the potential to impact polar bears and their habitat. During the past five years no lethal takes related to industrial activities of polar bears have occurred. Three lethal takes related to oil and gas activities have been documented in the Southern Beaufort Sea: one at an offshore drilling site in the Canadian Beaufort Sea (1968); one bear at the Stinson site in the Alaska Beaufort Sea (1990); and one bear that ingested ethylene glycol stored at an offshore island in the Alaska Beaufort Sea (1988). In 1993, a polar bear was killed at the Oliktok remote radar defense site when it broke into a residence and severely mauled a worker.

STATUS OF STOCK

The Southern Beaufort Sea Stock is currently classified as depleted under the MMPA and listed as threatened under the U.S. Endangered Species Act of 1973 (ESA), as amended. The primary concerns for this population are loss of the sea ice habitat due in part to climate changes in the Arctic, potential overharvest, and current and proposed human activities including industrial activities occurring in the nearshore and offshore environment. Recent data on the vital rates, population estimate, and growth rates for the Southern Beaufort Sea suggests that this population stock is declining. Because of its status as a threatened species under the ESA, the Southern Beaufort Sea population is designated as a strategic stock.

Conservation Issues and Habitat Concerns

Oil and Gas Exploration

The Minerals Management Service (MMS) (2004) estimated an 11 percent chance of a marine spill greater than 1,000 barrels in the Beaufort Sea from the Beaufort Sea Multiple Lease Sale in Alaska. Amstrup et al. (2006) evaluated the potential effects of a hypothetical 5,912-barrel oil spill (the largest spill thought possible from a pipeline spill) on polar bears from the Northstar offshore oil production facility in the southern Beaufort Sea, and found that there is a low probability that a large number of bears (i.e., 25–60) might be affected by such a spill. For the purposes of this scenario, it was assumed that a polar bear would die if it came in contact with the oil. Amstrup et al. (2006) found that 0–27 bears could potentially be oiled during the open water conditions in September; and from 0–74 bears in mixed ice conditions during October. If such a spill occurred, particularly during the broken ice period, the impact of the spill could be significant to the Southern Beaufort Sea polar bear population (Amstrup et al. 2006, 65 FR 16828; March 30, 2000). At the time that Amstrup did this analysis, the sustainable harvest yield per year for the Southern Beaufort Sea polar bear population, based on a stable population size of 1,800 bears, was estimated to be 81.1 bears (1999–2000 to 2003–2004) (Lunn et al. 2005). For the same time period, the average harvest was 58.2 bears, leaving an additional buffer of 23 bears that could have been removed from the population. Therefore, an oil spill that resulted in the death of greater than 23 bears, which was possible based on the range of oil spill-related mortalities from the previous analysis, could have had population level effects for polar bears in the southern Beaufort Sea. However, the harvest figure of 81 bears may no longer be sustainable for the Southern Beaufort Sea population so, given the average harvest rate cited above, fewer than 23 oil spill-related mortalities could result in a population decline or increase the time required for recovery.

The Fish and Wildlife Service (USFWS) works to monitor and mitigate potential impacts of oil and gas activities on polar bears through incidental take regulations (ITR) as authorized under the Marine Mammal Protection Act. Activities operating under these regulations must adopt measures to: ensure that the total taking of polar bears remains negligible; minimize impacts to their habitat; and ensure no unmitigable adverse impact on their availability for Alaska Native subsistence use. ITR also specify monitoring requirements that provide a basis for evaluating potential impacts of current and future activities on marine mammals.

Climate Change

Polar bears evolved over thousands of years to life in a sea ice environment. They depend on the sea ice-dominated ecosystem to support essential life functions. Sea ice provides a platform for hunting and feeding, for seeking mates and breeding, for movement to terrestrial maternity denning areas and occasionally for maternity denning, for resting, and for long-distance movements. The sea ice ecosystem supports ringed seals, the primary prey for polar bears, and other marine mammals that are also part of their prey base.

Sea ice is rapidly diminishing throughout the Arctic and large declines in optimal polar bear habitat have occurred in the Southern Beaufort and Chukchi Seas between the two time periods, 1985–1995 and 1996–2006 (Durner et al. 2009). In addition, it is predicted that the greatest declines in 21st century optimal polar bear habitat will occur in Chukchi and Southern Beaufort Seas (Durner et al. 2009). Patterns of increased temperatures, earlier onset of and longer melting periods, later onset of freeze-up, increased rain-on-snow events, and potential reductions in snowfall are occurring. In addition, positive feedback systems (i.e., the sea-ice albedo feedback mechanism) and naturally occurring events, such as warm water intrusion into the Arctic and changing atmospheric wind patterns, can operate to amplify the effects of these phenomena. As a result, there is fragmentation of sea ice, a dramatic increase in the extent of open water areas seasonally, reduction in the extent and area of sea ice in all seasons, retraction of sea ice away from productive continental shelf areas throughout the polar basin, reduction of the amount of heavier and more stable multi-year ice, and declining thickness and quality of shore-fast ice (Parkinson et al 1999, Rothrock et al. 1999, Comiso 2003, Fowler et al. 2004, Lindsay and Zhang 2005, Holland et al. 2006, Comiso 2006, Serreze et al. 2007, Stroeve et al. 2008).

The Chukchi/Bering Seas and the Southern Beaufort Sea population stocks are currently experiencing the initial effects of changes in sea ice conditions (Rode et al. 2007, Regehr et al. 2007, Hunter et al. 2007). These populations are vulnerable to large-scale dramatic seasonal fluctuations in ice movements, decreased abundance and access to prey, and increased energetic costs of hunting. The USFWS is working on measures to protect polar bears and their habitat.

Subsistence Harvest

Recognition that the polar bears in the southern Beaufort Sea were shared between Canada and the Alaska led to the development of the Polar Bear Management Agreement for the Southern Beaufort Sea between the Inuvialuit of the Inuvialuit Game Council (IGC), Canada and the Inupiat of the North Slope Borough (NSB) Alaska in 1988 (Nageak et al. 1991, Treseder and Carpenter 1989, Prestrud and Stirling 1994, Brower et al. 2002). Since initiation of this local user agreement in 1988, the combined Alaska/Canada mean harvest from this stock has been 56.9 bears per year (1988-2007). The harvest in Canada is limited primarily to Native hunters and is regulated by a quota system (Prestrud and Stirling 1994, Brower et al. 2002). Canada has a well regulated and controlled harvest, which has resulted in accurate harvest reporting, strict controls on the harvest, and efficient monitoring and enforcement. The harvest management system in Alaska is voluntary and is less efficient overall than the Canadian system (Brower et al 2002).

The calculation of a PBR level for the Southern Beaufort Sea stock is required by the MMPA even though the subsistence harvest quota is managed under the authority of the Polar Bear Agreement between the NSB and the IGC. Accordingly, the quota from the Board of Commissioners for the Polar Bear Agreement takes precedence over the PBR estimate for the purposes of managing the Alaska Native subsistence harvest from this stock. The Southern Beaufort Sea population is currently thought to be declining; therefore, overharvest could hasten the decline or prevent and/or slow the recovery. Analysis is currently underway to evaluate the effects of different harvest levels on the population dynamics of the Southern Beaufort Sea population.

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PACIFIC WALRUS (*Odobenus rosmarus divergens*):

Alaska Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The family Odobenidae is represented by a single modern species, *Odobenus rosmarus,* of which two subspecies are generally recognized: the Atlantic walrus (*O. r. rosmarus*) and the Pacific walrus (*O. r. divergens*). The two subspecies occur in geographically isolated populations. The Pacific walrus is the only stock occurring in United States waters and considered in this account.

Pacific walruses range throughout the continental shelf waters of the Bering and Chukchi Seas, occasionally moving into the East Siberian Sea and the Beaufort Sea (Figure 1). During the summer months most of the population migrates into the Chukchi Sea; however, several thousand animals, primarily adult males, aggregate near coastal haulouts in the Gulf of Anadyr, Russia; Bering Strait, and Bristol Bay, Alaska. During the winter breeding season walruses are found in three concentration areas of the Bering Sea where open leads, polynyas, or thin ice occur (Fay *et al.* 1984, Garlich-Miller *et al.* 2011a). While the specific location of these groups varies annually and seasonally depending upon the extent of the sea ice, generally one group occurs near the Gulf of Anadyr, another south of St. Lawrence Island, and a third in the southeastern Bering Sea south of Nunivak Island into northwestern Bristol Bay. However, Pacific walruses are currently managed as a single panmictic population. Scribner *et al.* (1997) found no difference in mitochondrial and nuclear DNA among walruses sampled shortly after the breeding season from four areas of the Bering Sea (Gulf of Anadyr, Koryak Coast, Southeast Bering Sea, and St. Lawrence Island).

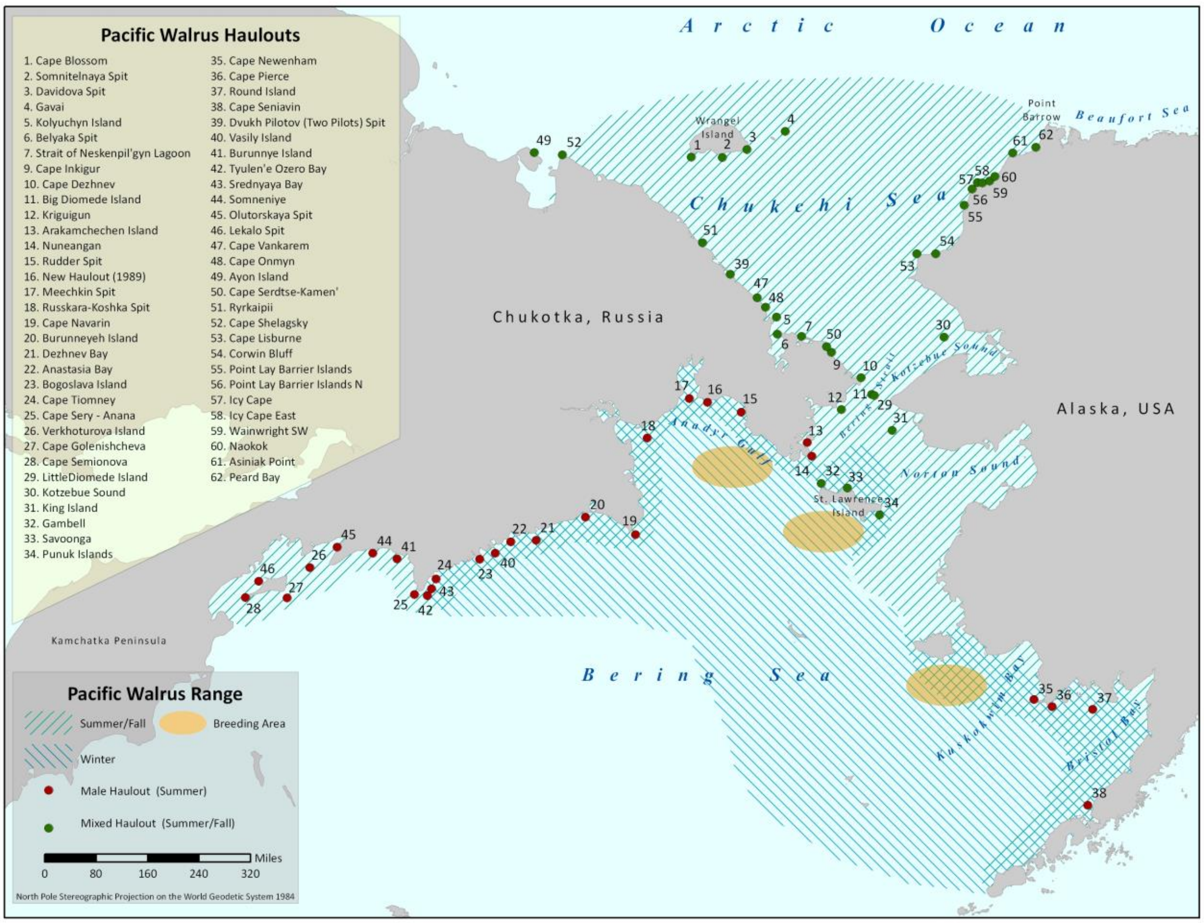

Figure 1. Seasonal distribution, breeding areas, and coastal haulouts of Pacific walruses in the Bering and Chukchi Seas. Modified from Smith 2010.

Pacific walruses typically use sea-ice as a resting platform between feeding dives, as a birthing substrate, for shelter from storms, isolation from predators, and passive transportation (Fay 1982). Historically, the summer distribution of walruses in the Chukchi Sea occurred primarily on sea ice over the continental shelf from the Alaska to Chukotka coasts with large numbers of animals near Hanna Shoal in the United States and Wrangel Island in the Russian Federation. A few animals would be observed utilizing haulouts along both the Alaska and Chukotka coasts, particularly in the fall. While the overall geographic range of Pacific walruses has not changed, over the past decade the number of walruses coming to shore along the coastline of the Chukchi Sea in both Alaska and Chukotka has increased from the hundreds to thousands to greater than 100,000 (Kavry *et al.* 2008, Garlich-Miller *et al.* 2011*a*, Jay *et al.* 2011). Additionally, adult female and young walruses are arriving at these coastal haulouts as much as a month earlier and staying at the coastal haulouts a week or two longer. In fall 2007, 2009, 2010, and 2011 large walrus aggregations (3,000 to 20,000) were observed along the Alaska coast (Garlich-Miller *et al*. 2011*a*). This increased use of coastal haulouts is a function of the loss of summer sea ice over the continental shelf (Garlich-Miller *et al.* 2011*a*). Summer sea-ice extent in the Chukchi Sea has decreased by about 12% per decade (NSIDC 2012); retreating off the shallow continental shelf and remaining only over deep Arctic Ocean waters where walruses cannot reach the benthos to feed. Declines in Chukchi Sea ice extent, duration, and thickness are projected to continue in a linear fashion into the foreseeable future (Douglas 2010).

POPULATION SIZE

The size of the Pacific walrus population has never been known with certainty. Based on large sustained harvests in the 18th and 19th centuries, Fay (1982) speculated that the pre-exploitation population was represented by a minimum of 200,000 animals. Since that time, population size has fluctuated markedly in response to varying levels of human exploitation (Fay *et al*. 1989). Large-scale commercial harvests reduced the population to 50,000 to 100,000 animals in the mid-1950s (Fay *et al.* 1997). The population is believed to have increased rapidly in size during the 1960s and 1970s in response to reductions in hunting pressure (Fay *et al.* 1989).

Between 1975 and 1990, aerial surveys were carried out by the United States and Russia at five-year intervals, producing mean population estimates ranging from 201,039 to 234,020 animals with 95% confidence intervals that include zero (Table 1). The estimates generated from these surveys are considered minimum values and because of the large associated variances they are not suitable for detecting population trends (Hills and Gilbert 1994, Gilbert *et al.* 1992). Further, these earlier figures largely underestimate the population because they were not adjusted for walruses in the water, a proportion of the population that may be as high as 65 to 87 percent (Born and Knutsen 1997, Gjertz *et al*. 2001, Jay *et al*. 2001, Born *et al*. 2005, Acquarone *et al*. 2006, Lydersen *et al*. 2008) and, because walrus tend to aggregate in large closely packed groups when hauled out on ice or land, it was difficult to obtain accurate counts of animals observed. Efforts to survey the Pacific walrus population were suspended at that time due to unresolved problems with survey methods, which produced population estimates with unknown bias and unknown or large variances that severely limited their utility (Gilbert *et al.* 1992, Gilbert 1999).

An international workshop on walrus survey methods in 2000 concluded that it would not be possible to obtain a population estimate with adequate precision for tracking trends using the existing aerial survey methods and any feasible amount of survey effort (Garlich-Miller and Jay 2000). Two major problems were identified: (1) accurately counting walruses in large groups, and (2) accounting for walruses in the water that were not available to be counted. Remote sensing systems were viewed as having great potential to address the first problem (Udevitz *et al.* 2001) as well as being able to sample larger areas per unit of time (Burn *et al*. 2006). To address the second problem U.S. Geological Survey (USGS) scientists developed satellite transmitters that recorded the haul-out status (in water or out) of individual walruses, which was used to estimate the proportion of animals in the water and correct walrus counts (Udevitz *et al.* 2009). These technological advances led to a joint United States-Russian Federation survey in March and April of 2006. This survey effort was timed to occur when the majority of Pacific walrus were hauled out on sea ice habitats across the continental shelf of the Bering Sea in order to capture as much of the population as possible.

The goal of the 2006 survey was to estimate the size of the Pacific walrus population (Speckman *et al.* 2011). However, some areas known to be important to walruses were not surveyed in 2006 because of poor weather and therefore the 2006 estimate is also considered to be an underestimate. The number of Pacific walruses within the area surveyed in 2006 was estimated at 129,000 with a 95% confidence interval of 55,000 to 507,000 (Speckman *et al.* 2011).

Table 1. Point estimates (95% confidence interval) of Pacific walrus population size, 1975-2006 from cooperative United States – Russian aerial surveys and original references.

Year	Population Estimate	References
1975	221,350 (–20,000-480,000)[a]	Gol'tsev 1976, Estes and Gilbert 1978, Estes and Gol'tsev 1984
1980	246,360 (–20,000-540,000)[a]	Johnson *et al.* 1982, Fedoseev 1984
1985	234,020 (–20,000-510,000)[a]	Gilbert 1986, 1989a, 1989b; Fedoseev and Razlivalov 1986
1990	201,039 (–19,000-460,000)[a]	Gilbert *et al.* 1992
2006	129,000 (55,000-507,000)	Speckman *et al*. 2011

[a]95% confidence intervals are from Figure 1 in Hills and Gilbert (1994).

Minimum Population Estimate

Under section 3(27) of the Marine Mammal Protection Act (MMPA), a "minimum population estimate" is defined as "an estimate of the number of animals in a stock that (A) is based on the best available scientific information on abundance, incorporating the precision and variability associated with such information and (B) provides reasonable assurance that the stock size is equal to or greater than the estimate." The estimate derived from the joint United States-Russian Federation survey conducted in March and April 2006 (Speckman *et al*. 2011) represents the minimum population estimate for the Pacific walrus. Because the 2006 survey used the most advanced technologies developed to address the problems identified in earlier aerial survey methods and was timed to capture as much of the population as possible (see above discussion under **POPULATION SIZE**), the survey's estimate of 129,000 individuals, with a 95%

confidence interval of 55,000 to 507,000 (Speckman *et al*. 2011), constitutes the best available scientific information on the size of the Pacific walrus population, taking into account the precision and variability associated with such estimates on abundance. The estimate from the 2006 survey is also negatively biased (Speckman *et al*. 2011), which provides reasonable assurance that the walrus population size is greater.

Current Population Trend

The 2006 estimate is lower than previous estimates of Pacific walrus population size (Table 1) and is known to be biased low to an unknown degree (Garlich-Miller *et al.* 2011*a*). However, estimates of population size from 1975 to the present (Table 1) are not directly comparable (Fay *et al.* 1997, Gilbert 1999) because of differences in survey methods, timing of surveys, and segments of the population surveyed. Therefore, while these estimates do not provide a good basis for inference with respect to population trends, there is other evidence supporting the hypothesis that the Pacific walrus population has declined from a peak in the late 1970s and 1980s.

Walrus researchers in the 1970s and 1980s were concerned that the population had reached or exceeded carrying capacity, and predicted that density-dependent mechanisms would begin to cause a decrease in population size (Fay and Stoker 1982b, Fay *et al*. 1986, Sease 1986, Fay *et al*. 1989). Estimates of demographic parameters from the late 1970s and 1980s support the idea that population growth was slowing (Fay and Stoker 1982a, Fay *et al*. 1986, Fay *et al*. 1989). Garlich-Miller *et al*. (2006) found that the median age of first reproduction for female walruses decreased in the 1990s, which is consistent with a reduction in density-dependent pressures. In addition, data on calf/cow ratios collected from harvested animals is consistent with a population peak in the late 1970s (i.e., low estimates in the late 1970s and 1980s) and subsequent population decline, and indicates that the population is currently below carrying capacity (MacCracken 2012).

The current working hypothesis, based on the available data, is that commercial and subsistence harvests prior to the 1960s limited the population; adoption of harvest quotas in the 1960s resulted in a population increase until the carrying capacity (about 300,000; according to Fay *et al.* (1997)) was reached in the 1970 to 1980s and productivity began to decline. The subsequent lack of harvest quotas in the United States beginning in 1979 and the reduced productivity levels resulted in another population decline, and the population is once again likely limited primarily by subsistence harvest, although other factors such as haulout mortalities may also be important (Udevitz et al. 2013). Garlich-Miller *et al*. (2011*a*) predicted that changing sea ice dynamics will result in further population declines in the future, but could not specify the magnitude or rate of decline. Given the suite of challenges associated with walrus aerial surveys, many of which cannot be overcome (e.g., poor weather, extensive area, estimate imprecision), it is clear that new approaches to evaluate population status and trend need to be explored. The U.S. Fish and Wildlife Service (Service) is developing a project to test the feasibility of genetic mark-recapture methods to estimate population size and trend. The successful development of a repeatable, unbiased, and precise estimate of population size will greatly facilitate our walrus conservation efforts including those directed at harvest management (USFWS 1994).

MAXIMUM NET PRODUCTIVITY RATES

Estimates of net productivity rates for walrus populations have ranged from 3 to 13% per year with most estimates between 5-10% (Chapskii 1936; Mansfield 1959; Krylov 1965, 1968; Fedoseev and Gol'tsev 1969; Sease 1986; DeMaster 1984; Sease and Chapman 1988; Fay *et al.* 1997). Chivers (1999) developed an individual age-based model of the Pacific walrus population using published estimates of survival and reproduction. The model yielded a maximum population growth rate (R_{MAX}) of 8%, which we use as the maximum net productivity rate in this assessment. Empirical estimates of age-specific survival rates for free ranging walruses are not available.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) of a marine mammal stock is defined in the MMPA as the maximum number of animals, not including natural mortalities that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimal sustainable population. The PBR is the product of the following factors: (A) the minimum population estimate of the stock, (B) one-half the maximum theoretical or estimated net productivity rate of the stock at a small population size, and (C) a recovery factor between 0.1-1.0 (MMPA §3(20)). Mathematically, PBR = N_{MIN} x 0.5 R_{MAX} x F_R; where N_{MIN} is minimum populations size, R_{MAX} the net productivity rate, and F_R a recovery factor. The F_R for the Pacific walrus is 0.5 (NMFS 2005) because the population is a candidate for listing under the U.S. Endangered Species Act of 1973, as amended (ESA) (USFWS 2011). The net productivity rate is estimated as 0.08 (Chivers 1999). Therefore, for the Pacific walrus population:

$$N_{MIN} = 129{,}000$$

$$R_{MAX} = 0.08$$

$$F_R = 0.5$$

$$PBR = (129{,}000 \times [0.5*0.08]*0.5) = 2{,}580$$

HUMAN CAUSED MORTALITY AND SERIOUS INJURY

Human Caused Mortalities

Subsistence Harvest

Over the past 60 years the Pacific walrus population has sustained estimated annual harvest removals ranging from 3,184 to 16,127 animals (mean = 6,440; Figure 2). Harvest levels since 2006 are 5 to 68% lower than this long-term average. It is not known whether recent reductions in harvest levels reflect changes in walrus abundance or hunting opportunities, but hunters consistently state that more frequent and severe storms are affecting hunting effort (EWC 2003, Oozeva *et al.* 2004). Other factors affecting harvest levels included: 1) the cessation of Russian commercial walrus harvests after 1990; and 2) changes in political, economic, and social conditions of subsistence hunters in Alaska and Chukotka.

The Service uses the average annual harvest over the past five years as an estimate of current harvest levels in the United States and Russia. Total U.S. annual harvest is estimated using data collected by direct observation in selected communities and through the statewide regulatory Marking, Tagging, and Reporting Program. The two sources of data are combined to calculate annual reporting compliance and to correct for any unreported harvest. Total U.S. subsistence harvest is estimated as the sum of reported and estimated unreported harvests. Harvest estimates in Russia were collected through both an observer program and a reporting program instituted by the Russian Federation.

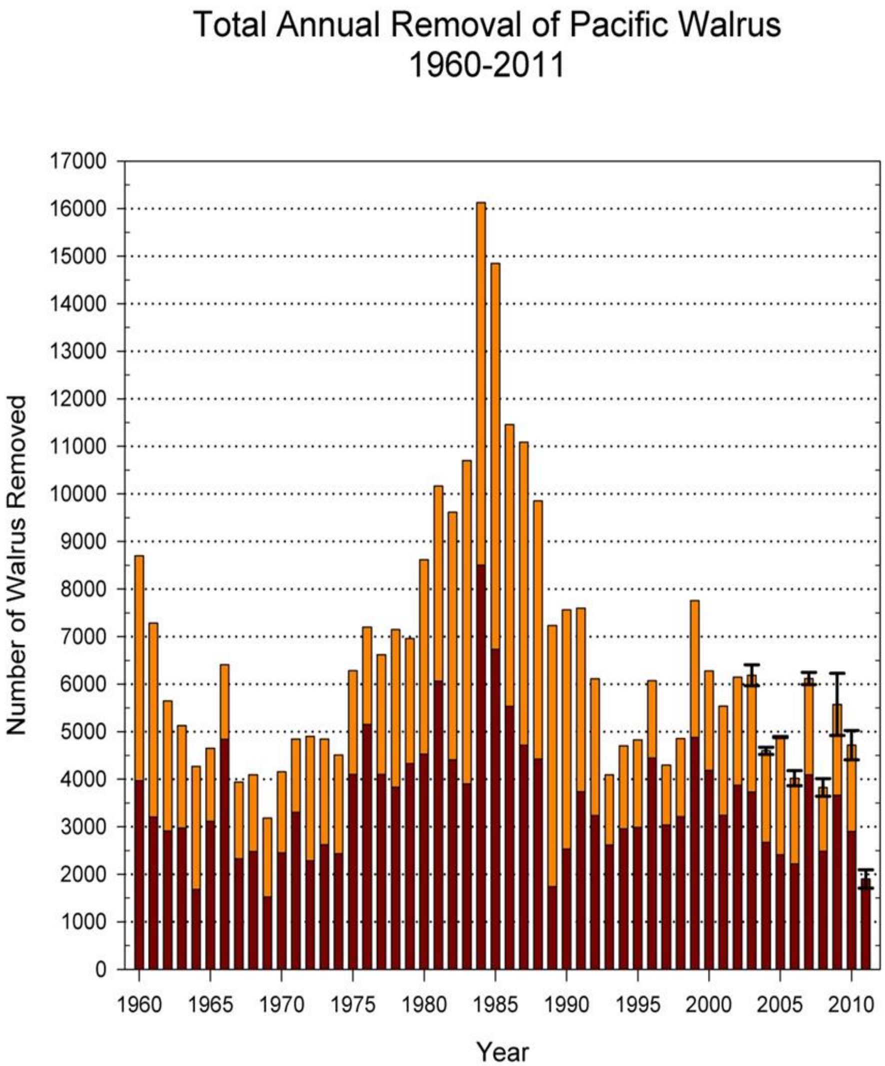

Figure 2. Total annual harvest removals for the Pacific walrus population from 1960 to 2011. Error bars for 2003-2011 denote the standard error around the estimate. Russian data for 2011 not included.

Using data collected between 1952 and 1972, Fay *et al*. (1994) estimated that 42% of walruses that were shot at were lost after being hit. All walruses that have been shot with a firearm are either killed immediately or assumed to be mortally wounded; however, they are often not retrievable if they die in the water and sink or if they are wounded and escape (Fay *et al.* 1994). We recognize that hunting equipment and techniques have improved since Fay *et al.* (1994) published their estimate; however, that estimate is still the best available. We therefore multiply the estimated harvest by 1.42 to adjust for walruses shot but not retrieved (i.e., struck and lost), resulting in a more accurate estimate of total number of walruses harvested.

Harvest mortality levels from 2006 to 2010 are estimated at 3,828 to 6,119 walruses per year (Table 2). The sex-ratio of the reported U.S. walrus harvest over this time period was 1.3:1 males to females. The sex-ratio of the reported Russian walrus harvest was 3.1:1 males to females based on harvest information collected by ChukotTINRO from 1999 to 2009 (Kochnev 2010).

Impacts of climate change on future subsistence harvests of walruses are difficult to predict (Holversrud 2008). Changes in walrus distribution, abundance, and health; sea ice characteristics and distribution; length and timing of the hunting season; and weather and sea state during the hunting season can all influence hunting success. Recent harvests are lower than historic levels and more frequent storms during the traditional hunting season, which limit hunting opportunities, appear to be a contributing factor. Holversrud (2008) predicted that climate change would result in a decline in the subsistence harvest of marine mammals. Garlich-Miller *et al*. (2011a) predicted that walrus harvest levels would remain relatively stable. Since 2006, the estimated total removal of walruses has fluctuated from year to year by an average of 3%, but is highly variable (e.g., 2006 to 2007, a 52% increase; and 2007 to 2008, a 60% decline).

Although fewer walruses are currently being harvested overall, of those animals harvested more are being harvested earlier in the spring and earlier in the winter than during the previous 20 years demonstrating that hunters will likely adapt to changing hunting and sea ice conditions. Harvest levels must be assessed within the context of the best available information on walrus population size, weather and climate, and political, economic, and social conditions of subsistence hunters in Alaska and Chukotka. Garlich-Miller et al. (2011a) assumed that summer sea ice loss would result in a reduced walrus population over time and that subsistence harvests could become unsustainable if not reduced in concert with any decline in the population. The recent adoption of trip limit ordinances by the Native Villages of Gambell and Savoonga and the acquisition of a Tribal Wildlife Grant to ensure administration of those ordinances is a positive development in this arena.

Table 2. Mean (standard error) harvest of Pacific walruses, 2006-2010. Russian harvest information was provided by ChukotTINRO and the Russian Agricultural Department. United States harvest information was collected by the U.S. Fish and Wildlife Service, and adjusted for unreported walruses using a mark-recapture method. Total harvest includes a struck and lost factor of 42% (Fay *et al*. 1994).

Year	Total harvest	United States harvest	Russian harvest
2006	4,022(157)	1,286(91)	1,047
2007	6,119(127)	2,376(74)	1,173
2008	3,828(185)	1,442(107)	778
2009	5,547(654)	2,123(379)	1,110
2010	4,716(308)	1,682(178)	1,053
Five year mean	4,852(346)	1,782(200)	1,032(67)

Cooperative Agreements have been developed annually between the Service and the Eskimo Walrus Commission since 1997 to facilitate the participation of subsistence hunters in activities related to the conservation and management of the walrus in Alaska. This co-management process is on-going. Ensuring that harvest levels remain sustainable is a goal shared by subsistence hunters and resource managers in the United States and Russian Federation. Achieving this management goal will require continued investments in co-management relationships, harvest monitoring programs, international coordination, and research.

Fisheries Related Mortalities and Injuries

A complete list of fisheries and marine mammal interactions is published annually by the National Oceanic and Atmospheric Administration (NOAA)-Fisheries, the most recent of which was published on August 29, 2013 (NOAA 2013). Pacific walruses occasionally interact with trawl and longline gear of groundfish fisheries. No data are available on incidental catch of walruses in fisheries operating in Russian waters, although trawl and longline fisheries are known to operate there. In Alaska each year, fishery observers monitor a percentage of commercial fisheries and report injury and mortality of marine mammals incidental to these operations. Overall, 13 fisheries, with observers, operate in Alaska within the range of the Pacific walrus in the Bering Sea, and could potentially interact with them.

Mortalities

Incidental mortality during 2006-2010 was observed in only one fishery, the Bering Sea/Aleutian Island flatfish non-pelagic trawl (Table 3); which, according to NOAA-Fisheries is a Category II Commercial Fishery with an estimated 34 vessels and/or persons participating. Observer coverage for this fishery averaged 88% during 2006-2010. The mean number of observed mortalities was one walrus per year, with a range of zero to three (Table 3). The total estimated annual fishery-related incidental mortality in Alaska was two walruses per year. We consider fishery related mortality to be insignificant.

Table 3. Summary of incidental mortality of Pacific walruses in the Bering Sea/Aleutian Islands flatfish trawl fishery from 2006-2010 and estimated mean annual mortality. Data provided by the National Marine Fisheries Service.

Year	Observer coverage (%)	Observed mortality	Estimated mortality	95% CI
2006	68	2	3	1 – 6
2007	72	1	3	1 – 5
2008	100	1	1	0.6 – 1.4
2009	100	0	0	
2010	100	2	2	1 – 3
Five year mean(SE[a])	88(7)	1(0.4)	2(0.6)	

[a]standard error.

Injuries

No incidental injury was observed during this time period; therefore, annual serious injury is estimated to be zero.

Other Removals

Between 2006-2011, satellite transmitters were affixed to 348 walruses, and collections of skin and blubber samples with biopsy darts were attempted from 183 walruses. No mortalities or serious injuries were directly associated with those research activities. However, in 2011, walruses at the Point Lay, Alaska haulout cleared the beach as USGS researchers, ferried by local guides, boated past resulting in the death of one calf (Jay 2012).

Up to 52 orphaned walrus calves were captured in Russia and placed on public display between 2006-2010. In addition, 3 calves were found on the beach near Barrow, Alaska in 2012 and taken into captivity. Based on this information, about 19 (standard error = 17) walruses per year were removed from the wild due to other human activities.

Total Estimated Human-Caused Mortality and Serious Injury

The average (standard error) total annual human-caused mortality or removal is 4,873 (346) walruses (2 due to fisheries interactions, 4,852 due to harvest, and 19 due to other human activities). There is no evidence that levels of human-caused serious injury are significant at this point.

Mortalities at coastal haulouts are due to several natural sources (poor condition, old age, injuries, predation, etc.) and occur at all haulouts at an unknown background level. Mortalities due to human caused stampedes also occur but are hard to quantify – most events are observed after the fact (Fay and Kelley 1980, Fischbach *et al.* 2009), some may go undetected, and carcasses can be redistributed during storms and consumed by predators. In 2007, more than 3,200 haulout mortalities were attributed to disturbance events along the Russian coast, but none were noted in Alaska. In 2008, few haulout mortalities were observed (0 in the United States, 165 in Russia) as remnant ice in the Chukchi Sea allowed walruses to stay offshore. In 2009, 131 calves were apparently trampled in a disturbance event at Icy Cape, Alaska (Fischbach *et al.* 2009) and another 53 were reported from other locations in Alaska with 453 counted in Russia. In 2010, 680 carcasses were counted at four haulouts in Russia (A. Kochnev, pers. comm.) and less than 200 were observed at Point Lay, Alaska (USFWS, unpubl. data). In 2011, 376 carcasses were counted in Russia (A. Kochnev, pers. comm.) and about 100 carcasses were found at the Point Lay haulout (USFWS, unpubl. data). Haulout management programs in Russia and the United States may be a successful management tool in reducing disturbance related mortalities compared to the extreme event in 2007.

STATUS OF STOCK

Pacific walrus are not designated as depleted under the MMPA; however, we have determined that listing the Pacific walrus as endangered or threatened under the ESA is warranted, but precluded by higher priority listing actions (USFWS 2011). Based on the best available information, the estimated incidental mortality and serious injury related to commercial fisheries (two walruses per year) is less than one percent of PBR and therefore can be considered insignificant and approaching a zero mortality and serious injury rate. However, the total human-caused removals exceed the PBR of 2,580. Therefore, the Pacific walrus is classified as a strategic stock.

EMERGING CONSERVATION ISSUES

A status review for the Pacific walrus was completed in 2011 in response to the ESA listing petition (Garlich-Miller *et al.* 2011*a*, and is available at: *http://alaska.fws.gov/fisheries/mmm/walrus/pdf/review_2011.pdf*. That review provides a comprehensive analysis of the stressors currently affecting the Pacific walrus population. The major findings of that analysis have been incorporated into this document in the appropriate sections. Readers should refer to Garlich-Miller *et al.* (2011*a*) for additional information on topics not covered by this stock assessment report.

Chukchi Coast Haulout Use

Over the past decade, the number of walruses coming to shore in summer and fall along the coastline of the Chukchi Sea in both Alaska and Russia has increased (Kavry *et al.* 2008, Garlich-Miller *et al.* 2011*a*) coincident with the earlier and more extensive melting of sea ice. In fall 2007, 2009, 2010, and 2011, large aggregations of females and young (about 3,000 to 30,000) were observed along the Alaska coast. An area of concern is the amount of walrus prey within the foraging range of coastal haulouts (Garlich-Miller *et al*. 2011*a*). As more walruses use coastal haulouts more frequently and for longer periods each year, prey populations could be depleted. Malnourished walruses have been reported from Chukotka (Ovsyanikov *et al*. 2008, A.A. Kochnev personal communication) and they are also regularly observed in Alaska (Garlich-Miller *et al.* 2011a); however, the majority of walruses observed at fall haulouts in Alaska in 2010 and 2011 were in good physical condition.

Ocean Acidification

The effect of ocean acidification (OA) on walrus prey is another issue of concern because lower pH levels can interfere with invertebrate shell formation and erode existing shells. No information is available about potential impacts on specific walrus prey species. Uncertainty regarding the general effects of ocean acidification has been summarized by the National Research Council (2010:1): "The major changes in ocean chemistry caused by increasing atmospheric CO_2 are well understood and can be precisely calculated, despite some uncertainty resulting from biological feedback processes. However, the direct biological effects of ocean acidification are less certain and will vary among organisms, with some coping well and others not at all." Consequently, although we recognize that effects to calcifying organisms that are important prey items for Pacific walruses may occur in the foreseeable future from ocean acidification, we do not know which species may be able to adapt and thrive, which may decline, or the ability of the walrus to depend on alternative prey items. The prey base of walrus includes over 100 taxa of benthic invertebrates from all major phyla (Sheffield and Grebmeier 2009). Although walruses are highly adapted for obtaining bivalves, they also have the potential to switch to other prey items if bivalves and other calcifying invertebrate populations decline. Whether other prey items would fulfill walrus nutritional needs over their life span is unknown (Sheffield and Grebmeier 2009), and there also is uncertainty about the extent to which other suitable non-bivalve prey might be available, due to uncertainty about the effects of ocean acidification and the effects of ocean warming.

Subsistence Harvest

Recent subsistence harvests are lower than historic levels due to a faster spring migration and more frequent severe storms that have limited hunting opportunities during the spring migration (Kapsch *et al.* 2010). Garlich-Miller *et al.* (2011*a*) predicted that walrus harvest levels would remain relatively stable as hunters adapt to changing hunting conditions, but that summer sea ice loss will result in a reduced walrus population over time, and therefore subsistence harvests could become unsustainable if not reduced similarly. The Service, in cooperation with the Russian Federation, has a comprehensive harvest monitoring program in place that provides detailed information on harvest trends and characteristics. We will continue to cooperatively monitor harvest levels into the future, a key component to maintaining a sustainable harvest.

Oil and Gas Exploration

In 2008, the Minerals Management Service (now the Bureau of Ocean Energy Management) held an oil and gas lease sale for offshore blocks in the eastern Chukchi Sea. In 2009, 2010, and 2011 a number of seismic surveys were conducted in the lease sale area. A significant portion of the Pacific walrus population migrates into the Chukchi Sea region each summer, and the shallow, productive, ice covered waters of the eastern Chukchi Sea are considered particularly important habitat for female walruses and their dependent young. The Hanna Shoal area seems to be particularly attractive to walruses summering in the Chukchi Sea likely due to both high prey abundance and shallow waters. The Service works to monitor and mitigate potential impacts of oil and gas activities on walruses through Incidental Take Regulations (ITR) as authorized under the MMPA. Entities operating under these regulations must adopt measures to ensure that impacts to walruses remain negligible, minimize impacts to their habitat, and ensure no unmitigable adverse impact on their availability for Alaska Native subsistence use. These regulations also specify monitoring requirements that provide a basis for evaluating potential impacts of current and future activities on marine mammals. The current ITRs were renewed in 2013 for another five years. The Service included a thorough analysis of the monitoring data collected in association with previous ITRs when it issued the current ITRs.

The Service (2011) concluded that at current levels, oil and gas exploration posed a relatively minor threat to the Pacific walrus population. However, we noted that a large oil spill could significantly impact the population depending on timing, location, amount and type of oil, efficacy of response efforts, etc.; the current ITRs also provided special considerations to limit potential impacts to walrus utilizing the Hanna Shoal area.

International Commercial Shipping

As summer sea ice melts earlier in the year and the open water extends further north, opportunities for commercial shipping through the arctic increase (Garlich-Miller *et al.* 2011*a*). Transits through the Bering Strait increased significantly between 2009 and 2010 (M. Williams, pers. comm.) and are currently outpacing regulatory efforts to define shipping channels, seasons of use, and mitigation measures to reduce ship strikes, etc. Commercial shipping is expected to increase in the future, but several scenarios are possible depending on economics and international regulatory efforts. Shipping is not currently impacting the Pacific walrus population and not expected to be a major source of mortality in the future.

Disease

During summer and fall 2011, about 130 ringed seals (*Pusa hispida*) were found on the beaches on northwest Alaska with skin lesions and hair loss suggestive of a viral infection. About 48% of those seals were found dead and the others were lethargic. During September 2011, 6% of the walruses at the Point Lay haulout had similar skin lesions, but were otherwise in good physical condition. The majority of affected walruses were subadults and some of those had healed lesions, indicating that the disorder is not necessarily fatal. However, a number of dead calves at the haulout had both skin lesions and signs of trampling trauma (Garlich-Miller *et al.* 2011*b*) and the ultimate cause of death is not known at this time.

In December 2011, the National Marine Science Fisheries (NMFS) declared the seal mortalities an unusual mortality event (UME) and, with the Service concurrence, included walrus in the UME, due to the similarities of the lesions. No causative agent has been identified and it is not known if the same agent is infecting both species. The symptoms appear to be less severe in walruses than in ringed seals in terms of prevalence and mortalities. Sampling of Pacific walrus' tissues and comprehensive laboratory analyses is continuing as part of the UME investigation.

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NORTHERN SEA OTTER (*Enhydra lutris kenyoni*):

Southeast Alaska Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Sea otters occur in nearshore coastal waters of the U.S. along the North Pacific Rim from the Aleutian Islands to California. The species is most commonly observed within the 40-meter (m) (approximately 12.2 feet) depth contour because the animals require frequent access to benthic foraging habitat in subtidal and intertidal zones (Reidman and Estes 1990). Sea otters are not migratory and generally do not disperse over long distances, although movements of tens of kilometers (km) (tens of miles [mi]) are common (Garshelis and Garshelis 1984). Annual home range sizes of adult sea otters are relatively small, with male territories ranging from 4 to 11 square kilometers (km^2) (approximately 10.5 to 28.5 square miles [mi^2]) and adult female home ranges from a few to 24 km^2 (approximately 62 mi^2) (Garshelis and Garshelis 1984; Ralls *et al*. 1988; Jameson 1989). Due to their benthic foraging, sea otter distribution is largely limited by their ability to dive to the sea floor (Bodkin *et al*. 2004).

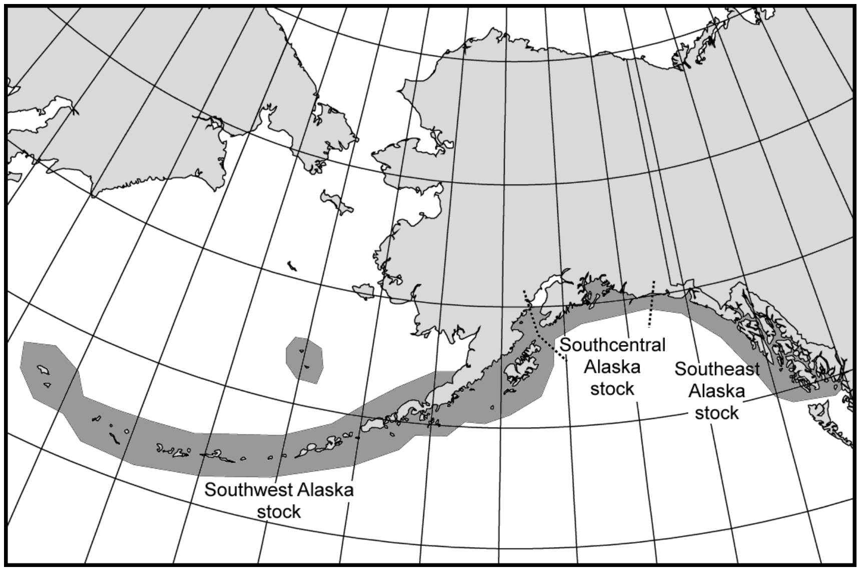

Figure 1. Approximate distribution and stock boundaries of northern sea otters in Alaska waters (shaded area).

The spatial scale at which sea otter populations are managed remains an important, although largely unexplored issue (Bodkin and Ballachey 2010) deserving further study. Bodkin and Ballachey (2010) used models of sea otter mortality to show that range-wide reductions and extirpations during the commercial fur trade of the 18th and 19th centuries occurred not simply because of excessive harvest, but because the harvest was not allocated proportional to the abundance and distribution of sea otters. This process of serial depletion was facilitated by the relatively sedentary nature of sea otters. To reduce the risk of overexploitation, sea otters must be managed on a spatial scale compatible with their well-known behavioral and reproductive biology (Bodkin and Monson 2002), incorporating traits such as home range and movements. These proposed scales for management are much smaller than the currently recognized stocks.

Gorbics and Bodkin (2001) applied the phylogeographic approach of Dizon *et al.* (1992) and used the best available data at the time to identify three sea otter stocks in Alaska: Southeast, Southcentral, and Southwest. The ranges of these stocks are defined as follows: (1) Southeast

Alaska stock extends from Dixon Entrance to Cape Yakataga; (2) Southcentral Alaska stock extends from Cape Yakataga to Cook Inlet including Prince William Sound, the Kenai Peninsula coast, and Kachemak Bay; and (3) Southwest Alaska stock includes the Alaska Peninsula and Bristol Bay coasts, and the Aleutian, Barren, Kodiak, and Pribilof Islands (Figure 1). This stock assessment report is focused on the Southeast stock of sea otters in Alaska.

POPULATION SIZE

Historically, sea otters occurred across the North Pacific Rim, ranging from Hokkaido, Japan, through the Kuril Islands, the Kamchatka Peninsula, the Commander Islands, the Aleutian Islands, peninsular and south coastal Alaska, and south to Baja California, Mexico (Kenyon 1969). In the early 1700s, the worldwide population was estimated to be between 150,000 (Kenyon 1969) and 300,000 individuals (Johnson 1982). Prior to large-scale commercial exploitation, indigenous peoples of the North Pacific hunted sea otters. Although it appears that harvests may have periodically led to local reductions of sea otters (Simenstad *et al.* 1978), the species remained abundant throughout its range until the mid-1700s. Following the arrival in Alaska of Russian explorers in 1741, extensive commercial harvest of sea otters over the next 150 years resulted in the near extirpation of the species. When sea otters were afforded protection by the International Fur Seal Treaty in 1911, probably fewer than 2,000 animals remained in thirteen remnant colonies (Kenyon 1969).

Although population recovery began following legal protection, no remnant colonies of sea otters existed in Southeast Alaska. As part of efforts to re-establish sea otters in portions of their historical range, otters from Amchitka Island and Prince William Sound were translocated to other areas (Jameson *et al.* 1982). These translocation efforts met with varying degrees of success. From 1965 to 1969, 412 otters (89% from Amchitka Island in southwest Alaska, and 11% from Prince William Sound in southcentral Alaska) were translocated to six sites in southeast Alaska (Jameson *et al.* 1982). In the first 20 years following translocation, these populations increased in numbers and expanded their range (Pitcher 1989).

Nearly all of the current population estimates for the Southeast Alaska stock were developed using the aerial survey methods of Bodkin and Udevitz (1999). The lone exception was a survey of the outer coastline from the western boundary of the stock at Cape Yakataga to Cape Spencer conducted by U.S. Geological Survey (USGS) in 2000. Thirty-two otters were estimated to be in that area (coefficient of variation [CV]=0.378). In 2005, the U.S. Fish and Wildlife Service (Service) surveyed Yakutat Bay (estimate number of otters [N]=1,582; CV=0.33; Gill and Burn 2007). In 2010, the Service surveyed the southern half (Kuiu and Kupreanof Islands south to the Canadian border) of Southeast Alaska (SSE) (N=12,873; CV=0.18; Gill and Burn unpublished data). The northern half (Admiralty and Baranof Islands north to Glacier Bay) of Southeast Alaska (NSE) was surveyed by the Service in 2011 (N=2,717; CV=0.22; Gill and Burn unpublished data). Glacier Bay (GB) National Park (NSE) was not included in the 2011 survey as USGS had separate plans to conduct replicate surveys in the Bay in 2012 to add to a long-term data set for the National Park (NP). The estimate from that 2012 survey is N=8,508; CV=0.20 (Esslinger *et al.* 2013). The most recent population estimates for the Southeast Alaska stock are presented in Table 1, which shows a total estimate of 25,712 sea otters for the stock.

Table 1. Abundance estimates for the Southeast Alaska stock of northern sea otters.

Survey Area	**Year**	**Unadjusted count**	**Adjusted Estimate**	**CV**	**N_{MIN}**	**Reference**
North Gulf of Alaska	2000	15	32	0.38	24	USGS unpublished data
Glacier Bay (NP)	2012		8,508	0.20	7,201	Esslinger, Bodkin, & Weitzman (2013)
Northern Southeast Alaska (NSE)	2011		2,717	0.22	2,270	Gill and Burn unpublished data
Southern Southeast Alaska (SSE)	2010		12,873	0.18	11,099	Gill and Burn unpublished data
Yakutat Bay	2005		1,582	0.33	1,203	Gill and Burn (2007)
Current Total			**25,712**		**21,798**	
2008 SAR Total			10,563		9,136	

Minimum Population Estimate

The minimum population estimate (N_{MIN}) for this stock is calculated using Equation 1 from the Potential Biological Removal Guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842 \times [\ln(1+[CV(N)]^2)]^{½})$. The N_{MIN} for each survey area is presented in Table 1. The estimated N_{MIN} for the entire Southeast Alaska stock is 21,798 sea otters.

Current Population Trend

The trend for this stock of sea otters has generally been one of growth (Pitcher 1989, Agler *et al.* 1995, Esslinger and Bodkin 2009). Comparing the current population estimate with that of the previous stock assessment reports suggests that this growth trend is continuing. The estimated population size (25,712) of this stock currently is more than double what was estimated in the previous (2008) stock assessment report (10,563). However, it is important to note that the population estimate published in the 2008 stock assessment report was based on survey data from 2002 and 2003. Therefore, we can only conclude that the Southeast population stock has doubled since 2003.

The 2010-2011 survey followed the same Bodkin and Udevitz (1999) methods as the 2002-2003 survey effort (Esslinger and Bodkin 2009) so results of those two surveys can be directly compared. In addition, all surveys in the GBNP time series followed the Bodkin and Udevitz (1999) method. The Service's 2010 survey of SSE showed an average annual increase of 12% per year over the last seven years and the Service's 2011 survey of NSE Alaska (minus GBNP) showed an average annual increase of 4% per year over the last nine years. The USGSs' survey of GBNP showed an average annual increase of 20% per year over the last six years. If we include the 2012 GBNP estimate with the estimate for the 2011 NSE Alaska the growth rate is about 14% per year in NSE Alaska which is in line with the growth rate for SSE Alaska. Hence, the northern and southern portions of Southeast Alaska appear to be growing at the same average annual rate; between 12-14% per year.

When compared to SSE, the sea otter population has also not appreciably expanded its range in NSE outside of GBNP since 2002 (Esslinger and Bodkin 2009, Gill and Burn unpublished data). However, otters have occupied appreciable new habitat in SSE since 2003 (Esslinger and Bodkin 2009, Gill and Burn unpublished data). There appear to be two major areas of expansion in SSE; otters have moved in large numbers along the northwest coast of Kuiu Island up into Keku Strait and then animals from this area have crossed Frederick Sound to the southern tip of Admiralty Island, and finally otters have expanded northward from the Barrier Islands through Tlevak Strait.

Sea otter abundance in Yakutat Bay has also increased, by an estimated 14.6% per year, over the last decade, likely through reproduction, although some amount of immigration cannot be ruled out (Gill and Burn 2007). During this process, otters appear to have expanded their range to include the western shores of Yakutat Bay.

Based on this information the current population trend for the Southeast Alaska stock is increasing.

MAXIMUM NET PRODUCTIVITY RATE

Estes (1990) estimated a population growth rate of 17 to 20% per year for northern sea otter populations expanding into unoccupied habitat in the Aleutian Islands, southeast Alaska, British Columbia, Washington State, and central California. Although maximum productivity rates (R_{MAX}) have not been measured through much of the sea otter's range in Alaska, in the absence of more detailed information, the rate of 20% calculated by Estes (1990) is considered the best available estimate of R_{MAX}. The Service's 2010 survey of SSE and 2011 survey of NSE shows a current growth rate of 12% and 4% respectively per year (minus GBNP). The USGS' 2012 survey of GBNP shows a current growth rate of 20% per year. Combining the data from NSE AK indicates that area is growing at a rate of 14% per year which compares to the rate of 12% per year in SSE AK. Consequently, we estimate the current net productivity rate for the entire Southeast Alaska population stock to be between 12-14% per year.

POTENTIAL BIOLOGICAL REMOVAL

Under the Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as *the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimal sustainable population.* Potential biological removal is the product of the minimum population estimate (N_{MIN}), one-half the maximum theoretical net productivity rate, and a recovery factor (F_R): PBR = N_{MIN} x 0.5 R_{MAX} x F_R. The recovery factor for this stock is 1.0 (Wade and Angliss 1997) as population levels have been stable or increasing with a known human take. Thus, for the Southeast stock of sea otters, PBR = 2,179 animals (21,798 x 0.5(0.2) x 1.0).

ANNUAL HUMAN CAUSED MORTALITY

Fisheries Information

A complete list of fisheries and marine mammal interactions is published annually by the National Oceanic and Atmospheric Administration (NOAA) Fisheries, the most recent of which was published on August 29, 2013 (78 FR 53336). Fisheries that have been known to interact with sea otters in the Southwest and Southcentral Alaska stocks do occur in Southeast Alaska, specifically the Southeast Alaska salmon drift gillnet (474 vessels) and the Yakutat salmon set gillnet (167 participants) fisheries. Sea otters are also known to interact with pot fisheries in California (Hatfield *et al*. 2011); in Southeast Alaska, there are 415 crab pot fishery participants and 274 shrimp pot participants. There are also 243 miscellaneous finfish pot fishery participants across the entire state (numbers are not available for specific areas). Available information suggests that fisheries using other types of gear, such as trawl, longline, and purse seine, are less likely to have interactions with sea otters across their entire range in Alaska due to either the areas where such fisheries operate (i.e., outside of sea otter habitat), the specific gear used (i.e., otters are not going to tangle or get trapped in a longline), or both.

Although commercial fisheries in Alaska have observer programs that monitor and report injury and mortality of marine mammals incidental to their operations, a reliable estimate of the levels of commercial fisheries incidental mortality and serious injury relative to the southeast sea otter stock cannot be made because observer coverage is not sufficient and data are not collected consistently over time. Of the observer programs in operation within the stock, no incidents of sea otter incidental take were observed in trawl, longline, or pot groundfish fisheries in Southeast Alaska from 1989 to 2010 (Perez 2003, Perez 2006, Perez 2007, Manly 2009, Bridget Mansfield 2011 personal communication). However, there has been no observer effort to document by-catch in the salmon set or drift gillnet fisheries or in the crab or shrimp pot fisheries in Southeast Alaska. Hatfield *et al*. (2011) contend that significant sea otter mortality from pot fishery by-catch might easily go undetected, even when seemingly high levels of observer effort exist.

An additional source of information on the number of sea otters killed or injured incidental to commercial fishery operations in Alaska is found in fisher self-reports required of vessel owners by NOAA Fisheries. From 1990 to 1993, self-reported fisheries data showed no sea otter kills or injuries in Southeast Alaska. Self-reports were incomplete for 1994 and not available for 1995 or 1996. Between 1997 and 2010, there were no records of incidental take of sea otters by commercial fisheries in this region. Credle *et al.* (1994) considered fisher self-reports to be a minimum estimate of incidental take as these data are most likely negatively biased. Indeed, anecdotal observations have been reported to the Service within the last five years suggesting that sea otters do interact with crab pots in Southeast Alaska. As sea otters reoccupy portions of their former habitat in Southeast Alaska, co-occurrence with pot fisheries will increase and so will the likelihood of mortalities or serious injury.

Information is insufficient to determine whether or not the total fishery mortality and serious injury for the Southeast Alaska stock of the northern sea otter is insignificant and is approaching a zero mortality and serious injury rate.

Oil Spills

Activities associated with exploration, development, and transport of oil and gas resources can adversely impact sea otters and nearshore coastal ecosystems in Alaska. Sea otters rely on air trapped in their fur for conserving body heat and buoyancy. Contamination with oil drastically reduces the insulative value of the pelage, and consequently, sea otters are among the marine mammals most likely to be detrimentally affected by contact with oil. It is believed that sea otters can survive low levels of oil contamination (< 10% of body surface), but that greater levels (>25%) will lead to death (Costa and Kooyman 1981, Siniff *et al.* 1982). Vulnerability of sea otters to oiling was demonstrated by the 1989 *Exxon Valdez* oil spill in Prince William Sound. Total estimates of mortality caused by the spill for the Prince William Sound area vary from 750 (range 600-1,000) (Garshelis 1997) to 2,650 (range 500-5,000) (Garrot *et al.* 1993) otters. Statewide, it is estimated that 3,905 sea otters (range 1,904-11,257) died in Alaska as a result of the spill (DeGange *et al.* 1994), but none of these were from the Southeast Alaska stock.

There is currently no oil and gas development in Southeast Alaska. Tankers carrying oil south from the Trans-Alaska Pipeline typically travel offshore of Southeast Alaska. Information on oil spills compiled by the Alaska Department of Environmental Conservation from 2006 to 2010 indicates that there were no reported spills of crude oil in Southeast Alaska. In addition to spills that may occur in association with the development, production, and transport of crude oil, each year numerous spills of non-crude oil products in the marine environment occur from ships and shore facilities throughout Southeast Alaska. During that same time period, there was an average of 133 spills each year, ranging in size from less than 1 and up to 17,800 gallons (approximately 4 to 64,600 liters). The vast majority of these spills were small, with a mean size of 46 gallons (1,748 liters), and there is no indication that these small-scale spills have had an impact on the Southeast Alaska stock of northern sea otters at the population level.

Subsistence/Native Harvest Information

The MMPA exempts Alaska Natives from the prohibition on take of marine mammals, provided such taking is not wasteful and is done for subsistence use or for creating and selling authentic handicrafts or clothing. According to the Service's Law Enforcement records from 2006 to 2010, individuals were prosecuted for unlawful possession, transport, or sale of 208 sea otter hides or skulls taken within the range of the Southeast Alaska stock. During the same time period, there was one prosecution for unlawful take of a single sea otter hide. Data for subsistence harvest of sea otters in Southeast Alaska are collected by a mandatory Marking, Tagging and Reporting Program administered by the Service since 1988. Figure 2 provides a summary of subsistence harvest information for the Southeast stock from 1989 to 2010. The mean reported annual subsistence take during the past five complete calendar years (2006-2010) was 447 animals. This is an increase from the annual average of 322 sea otters hunted during the previous five-year period. Reported age composition from 2006 to 2010 was the same as the previous five years; 83% adults, 14% subadults, and 3% pups. Reported sex composition from 2006 to 2010 was also the same as the previous five years; 72% males, 27% females, and 1% of unknown sex.

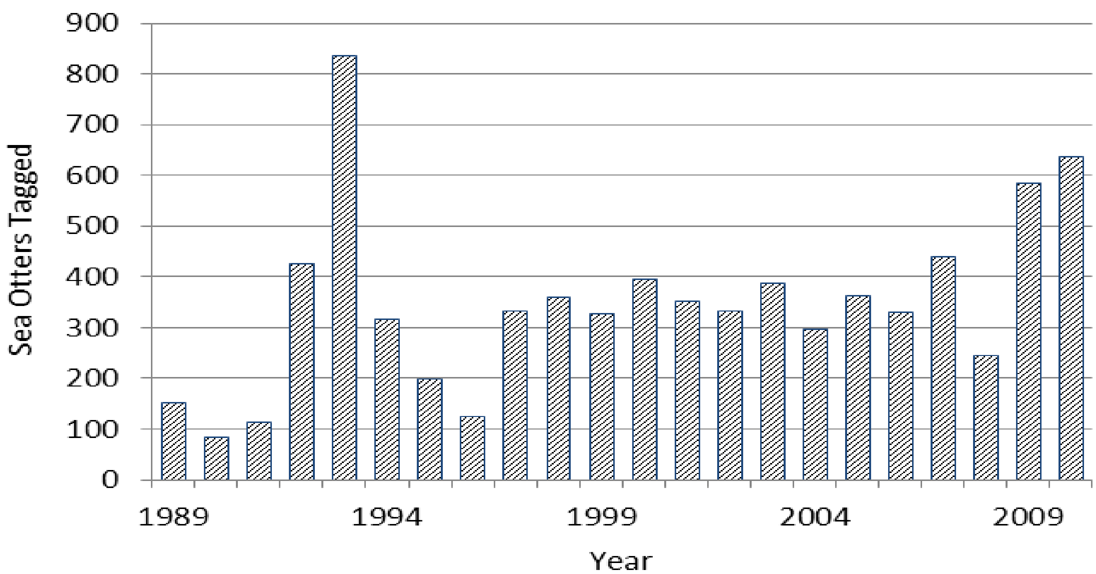

Figure 2. Reported subsistence harvest of northern sea otters from the Southeast Alaska stock, 1989 to 2010.

Research and Public Display

In the past five years, no sea otters were removed from the Southeast Alaska stock for public display. In 2011, 93 sea otters were captured and released for scientific research in the Southeast Alaska stock; the Service captured and released 31 sea otters in the Keku Strait region and the USGS captured and released 62 sea otters in Cross Sound and off of southern Baranof Island. There were no mortalities and serious injuries reported from either of these research efforts.

Other Factors

Since 2002 the Service has undertaken a health and disease study of northern sea otters from all three Alaskan stocks. On average, the Service conducts about 100 necropsies a year on sea otter carcasses to determine cause of death, disease incidence and status of general health parameters. Boat strike is a recurring cause of death across all three stocks. However, it has been determined in most of these cases that although trauma was the ultimate cause of death, there was a contributing factor, such as disease or biotoxin exposure, which incapacitated the animal and made it more vulnerable to boat strike.

In August 2006, the Working Group on Marine Mammal Unusual Mortality Events reviewed information provided by the Service, and declared that a dramatic increase in sea otter strandings in Kachemak Bay, in the Southcentral Alaska stock, since 2002 constituted an Unusual Mortality Event (UME) in accordance with section 404 of the MMPA. The disease that typifies this UME is caused by a *Streptococcus infantarius* infection and has been observed over a broad geographic range in Alaska, including a few cases from Southeast Alaska; however, the majority of cases have come from Kachemak Bay in the Southcentral Alaska stock. It is not clear if the observed stranding pattern is representative of overall sea otter mortality, or an artifact of having a well-developed stranding network in the Kachemak Bay area. The Service will continue to work with NOAA Fisheries and the Alaska SeaLife Center to develop the infrastructure for a statewide marine mammal stranding network in Alaska.

STATUS OF STOCK

The known level of direct human-caused mortality within the Southeast Alaska stock does not exceed the PBR level, and the Southeast Alaska stock is neither listed as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act of 1973, as amended, nor is it likely to be listed as such in the foreseeable future. The known level of direct human-caused mortality is 447 otters per year. It would require an annual rate of human-caused mortality from additional hunting or fisheries interactions of 1,733 more otters per year for the total amount of direct human-caused mortality to exceed PBR for this stock. Despite uncertainties regarding fishery mortality, we believe that it is unlikely this level is occurring at present. Therefore, the Southeast Alaska stock of the northern sea otter is classified as non-strategic. In addition, although the Service does not currently know the OSP for this stock, based on the known population level and our estimate of growth and considering the known level of human-caused mortality, we have determined that this stock is increasing and that human-caused mortality and serious injury is not likely to cause the stock to be reduced or to decrease its growth rate. Therefore, we would not expect the current level of human-caused mortality and serious injury to cause this stock to be reduced below its plausible OSP.

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NORTHERN SEA OTTER (*Enhydra lutris kenyoni*):

Southcentral Alaska Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Sea otters occur in nearshore coastal waters of the U.S. along the North Pacific Rim from the Aleutian Islands to California. The species is most commonly observed within the 40-meter (approximately 12.2 feet [ft]) depth contour because the animals require frequent access to benthic foraging habitat in subtidal and intertidal zones (Reidman and Estes 1990). Sea otters are not migratory and generally do not disperse over long distances, although movements of tens of kilometers (km) (tens of miles [mi]) are common (Garshelis and Garshelis 1984). Annual home range sizes of adult sea otters are relatively small, with male territories ranging from 4 to 11 square kilometers (km^2) (approximately 10.5 to 28.5 square miles[mi^2]) and adult female home ranges from a few to 24 km^2 (approximately 62 mi^2) (Garshelis and Garshelis 1984; Ralls *et al*. 1988; Jameson 1989). Due to their benthic foraging, sea otter distribution is largely limited by their ability to dive to the sea floor (Bodkin *et al*. 2004).

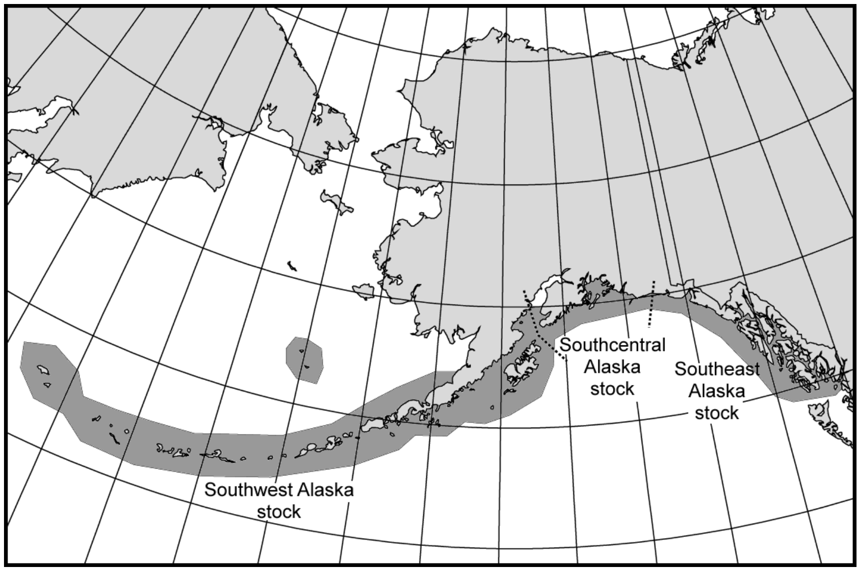

Figure 1. Approximate distribution and stock boundaries of northern sea otters in Alaska waters (shaded area).

The spatial scale at which sea otter populations are managed remains an important, although largely unexplored issue (Bodkin and Ballachey 2010) deserving further study. Bodkin and Ballachey (2010) used models of sea otter mortality to show that range-wide reductions and extirpations during the commercial fur trade of the 18th and 19th centuries occurred not simply because of excessive harvest, but because the harvest was not allocated proportional to the abundance and distribution of sea otters. This process of serial depletion was facilitated by the relatively sedentary nature of sea otters. To reduce the risk of overexploitation, sea otters must be managed on a spatial scale compatible with their well-known behavioral and reproductive biology (Bodkin and Monson 2002), incorporating traits such as home range and movements. These proposed scales for management are much smaller than the currently recognized stocks.

Gorbics and Bodkin (2001) applied the phylogeographic approach of Dizon *et al.* (1992) and used the best available data at the time to identify three sea otter stocks in Alaska: Southeast, Southcentral, and Southwest. The ranges of these stocks are defined as follows: (1) Southeast

Alaska stock extends from Dixon Entrance to Cape Yakataga; (2) Southcentral Alaska stock extends from Cape Yakataga to Cook Inlet including Prince William Sound, the Kenai Peninsula coast, and Kachemak Bay; and (3) Southwest Alaska stock includes the Alaska Peninsula and Bristol Bay coasts, and the Aleutian, Barren, Kodiak, and Pribilof Islands (Figure 1). This stock assessment report is focused on the Southcentral stock of sea otters in Alaska.

POPULATION SIZE

Historically, sea otters occurred across the North Pacific Rim, ranging from Hokkaido, Japan, through the Kuril Islands, the Kamchatka Peninsula, the Commander Islands, the Aleutian Islands, peninsular and south coastal Alaska, and south to Baja California, Mexico (Kenyon 1969). In the early 1700s, the worldwide population was estimated to be between 150,000 (Kenyon 1969) and 300,000 individuals (Johnson 1982). Prior to large-scale commercial exploitation, indigenous peoples of the North Pacific hunted sea otters. Although it appears that harvests may have periodically led to local reductions of sea otters (Simenstad *et al.* 1978), the species remained abundant throughout its range until the mid-1700s. Following the arrival in Alaska of Russian explorers in 1741, extensive commercial harvest of sea otters over the next 150 years resulted in the near extirpation of the species. When sea otters were afforded protection by the International Fur Seal Treaty in 1911, probably fewer than 2,000 animals remained in thirteen remnant colonies (Kenyon 1969). Population recovery began following legal protection. As part of efforts to re-establish sea otters in portions of their historical range, otters from Amchitka Island and Prince William Sound were translocated to other areas in the

1960s and 1970s, including to southeast Alaska (Jameson *et al.* 1982). Sea otters have since recolonized much of their historical range in Alaska.

The most recent abundance estimates for survey areas within the Southcentral Alaska stock are presented in Table 1. Estimates for Kenai Fjords and Kachemak Bay have been updated since the previous stock assessment report. In 2008, an aerial survey using the methods described in Bodkin and Udevitz (1999) was conducted within Kachemak Bay, resulting in an estimate of 3,596 sea otters (CV = 0.50; USFWS unpublished data). This method included a survey-specific correction factor to account for undetected animals. A 2010 aerial survey using the Bodkin-Udevitz method in Kenai Fjords National Park resulted in an estimate of 1,322 sea otters (CV = 0.37; Coletti *et al*. 2011). Eastern lower Cook Inlet was surveyed as part of a larger area in 2002, yielding an estimate of 962 sea otters (CV = 0.54; Bodkin *et al*. 2003b) for the areas not covered in 2008 and 2010.

In 2003, an aerial survey of Prince William Sound resulted in an abundance estimate of 11,989 sea otters (CV = 0.18; Bodkin *et al.* 2003a). Finally, an aerial survey of the northern Gulf of Alaska coastline flown in 2000 provided a minimum uncorrected count of 198 sea otters between Cape Hinchinbrook and Cape Yakataga (USGS unpublished data). Applying a correction factor of 2.16 (CV = 0.38) for this observer conducting sea otter aerial surveys produces an adjusted estimate of 428 (CV = 0.38).

The most recent population estimates for survey areas within the Southcentral Alaska stock are presented in Table 1. Combining the adjusted estimates for these areas results in a total estimate of 18,297 sea otters for the Southcentral Alaska stock.

Table 1. Population estimates for the Southcentral Alaska stock of northern sea otters. The previous stock assessment report (SAR) total is from 2008.

Survey Area	Year	Unadjusted Estimate	Adjusted Estimate	CV	N_{MIN}	Reference
Cook Inlet, Kachemak Bay excluded	2002		962	0.54	629	Bodkin *et al.* (2003b)
Kachemak Bay	2008		3,596	0.50	2,416	USFWS unpublished data
Kenai Fjords	2010		1,322	0.37	978	Coletti *et al.* (2011)
Prince William Sound	2003		11,989	0.18	10,324	Bodkin *et al.* (2003a)
North Gulf of Alaska	2000	198	428	0.38	314	USGS unpublished data
Current Total			**18,297**		**14,661**	
Previous SAR Total			15,090		12,774	

Minimum Population Estimate

The minimum population estimate (N_{MIN}) for this stock is calculated using Equation 1 from the Potential Biological Removal Guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842 \times [\ln(1+[CV(N)]^2)]^{½})$. The N_{MIN} for each survey area is presented in Table 1. The estimated N_{MIN} for the Southcentral Alaska stock is 14,661 sea otters.

Current Population Trend

All surveys analyzed for trends in abundance used methods described in Bodkin and Udevitz (1999), including use of a survey-specific correction factor to account for undetected animals, with the exception of the survey in the North Gulf of Alaska. Aerial surveys in Kachemak Bay in 2002, 2007, and 2008, indicated that the population is increasing, with an estimated annual rate of increase between 2002 and 2008 of 26% per year (USGS unpublished data, USFWS unpublished data). This rate slightly exceeds the estimated maximum productivity rates (R_{MAX}) for the species (see below). Immigration from other areas (Cook Inlet, Kenai Fjords) may have contributed to the observed increase in sea otter numbers in Kachemak Bay.

Aerial surveys in Kenai Fjords National Park in 2002, 2007, and 2010, had relatively high standard errors, but indicated overall that the population is stable and may be increasing (Coletti *et al.* 2011). Annual aerial surveys of sea otter abundance in western Prince William Sound from 1993 to 2009 (except for 2001 and 2006) identified a significant increase in abundance between 2001 and 2009 at this scale, with an average annual rate of increase from 1993 to 2009 of 2.6% (Bodkin *et al.* 2011). This trend is interpreted as strong evidence of a trajectory toward recovery of sea otter populations in Prince William Sound affected by the 1989 *Exxon Valdez* oil spill (Bodkin *et al.* 2011). Our best assessment is that the overall trend in abundance for this stock appears to be increasing at this time.

MAXIMUM NET PRODUCTIVITY RATE

Estes (1990) estimated a population growth rate of 17 to 20% per year for four northern sea otter populations expanding into unoccupied habitat. Although maximum productivity rates (R_{MAX}) have not been measured throughout much of the sea otter's range in Alaska, in the absence of more detailed information, the rate of 20% calculated by Estes (1990) is considered the best available estimate of R_{MAX}. There is insufficient information available to estimate the current net productivity rate for this population stock.

POTENTIAL BIOLOGICAL REMOVAL

Under the Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as *the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimal sustainable population.* Potential biological removal is the product of the minimum population estimate (N_{MIN}), one-half the maximum theoretical net productivity rate, and a recovery factor (F_R): PBR = N_{MIN} x 0.5 R_{MAX} x F_R. The recovery factor for this stock is 1.0 (Wade and Angliss 1997) as population levels have remained stable with a known human take. Thus, for the Southcentral stock of sea otters, PBR = 1,466 animals (14,661 x 0.5 (0.2) x 1.0).

ANNUAL HUMAN CAUSED MORTALITY

Fisheries Information

A complete list of fisheries and marine mammal interactions is published annually by the National Oceanic and Atmospheric Administration (NOAA) Fisheries, the most recent of which was published on August 29, 2013 (78 FR 53336). Numerous fisheries exist within the range of the Southcentral Alaska stock of northern sea otters. Two have been identified as interacting with this stock, the Prince William Sound drift gillnet fishery with an estimated 537 vessels and/or persons participating, and the Cook Inlet salmon set gillnet fishery, with an estimated 738 participants. Additional salmon drift gillnet fisheries occur in Cook Inlet, with 589 vessels; however, with the exception of Kachemak Bay, all of the fishing effort involving salmon drift and set gillnet fisheries in Cook Inlet occurs north of the range of sea otters from the Southcentral Alaska stock (Manly 2006). Additional salmon set gillnet fisheries occur in Prince William Sound (30 participants).

While much of the salmon set gillnet effort in Cook Inlet occurs north of the range of sea otters, interactions between sea otters and fisheries are reported from the Kachemak Bay region. In July 2009, five sea otters with slashed throats were found dead on a Seldovia beach. They were believed to have been killed after being captured in a set gillnet. In July 2011, a female and pup were successfully released from a set gillnet in the Homer area. Interactions with set gillnet gear also have been observed in the Kodiak and Prince William Sound areas within the ranges of the Southwest and Southcentral Alaska stocks. Available information suggests that fisheries using other types of gear, including trawl, longline, and purse seine, appear to be less likely to have interactions with northern sea otters due to either the areas where such fisheries operate, or the specific gear used, or both.

Although commercial fisheries in Alaska have observer programs that monitor and report injury and mortality of marine mammals incidental to their operations, a reliable estimate of the levels of commercial fisheries incidental mortality and serious injury relative to the Southcentral sea otter stock cannot be made because observer coverage is not sufficient and data are not collected consistently over time. No incidents of sea otter incidental take have been observed in trawl, longline, or pot groundfish fisheries in southcentral Alaska from 1989 to 2010 (NOAA unpublished data). Sea otters are known to interact with pot fisheries in California, however, and it is possible that observer effort for pot fisheries in Alaska has been too low to detect sea otter bycatch (Hatfield *et al.* 2011). In addition to the fisheries listed above, observers monitored the Cook Inlet set gillnet and drift gillnet fisheries from 1999 to 2000 (Manly 2006). The observer coverage during both years was approximately 2 to 5%. No mortalities or injuries of sea otters were reported by fisheries observers for the Cook Inlet set gillnet and drift gillnet fisheries for this period. On several occasions, sea otters were observed within 10 meters (approximately 33 ft) of gillnet gear, but did not become entangled. No other fisheries operating in the region of the Southcentral Alaska stock were monitored by observer programs from 1992 through 2010. Prior to the implementation of the NOAA Fisheries observer program, studies were conducted on sea otter interactions with the drift net fisheries in western Prince William Sound from 1988 to 1990, and no mortalities were observed (Wynne 1990, Wynne *et al.* 1991).

An additional source of information on the number of sea otters killed or injured incidental to commercial fishery operations in Alaska is found in fisher self-reports required of vessel owners by NOAA Fisheries. In 1990, fisher self-report records show one mortality and four injuries due to gear interaction, and three injuries due to deterrence in the Prince William Sound drift gillnet fishery. Self-reports were not available for 1994 and 1995. Credle *et al.* (1994) considered fisher self-reports to be a minimum estimate of incidental take as these data are most likely negatively biased.

In summary, between 2006 and 2010, there were five records of incidental take of sea otters by commercial fisheries within the range of the Southcentral stock, and, therefore, the estimated mean annual mortality and serious injury reported for the 5-year period from 2006 to 2010 is one. Observer coverage for fisheries within the range of the Southcentral stock of sea otters has been absent in some fisheries and low in others, particularly with respect to the set and drift gillnet fisheries that are recognized as interacting with this stock, and current estimates of sea otter bycatch are not available. Self-reporting is not sufficiently reliable to replace observer effort. Additionally, assessment of injury and mortality in sea otters that interact with fisheries is difficult. Information is, therefore, insufficient to determine whether or not the total fishery mortality and serious injury for the Southcentral Alaska stock of the northern sea otter is insignificant and is approaching a zero mortality and serious injury rate.

Oil Spills

Activities associated with exploration, development, and transport of oil and gas resources can adversely impact sea otters and nearshore coastal ecosystems in Alaska. Sea otters rely on air trapped in their fur for warmth and buoyancy. Contamination with oil drastically reduces the insulative value of the pelage, and consequently, sea otters are among the marine mammals most likely to be detrimentally affected by contact with oil. It is believed that sea otters can survive low levels of oil contamination (<10% of body surface), but that greater levels (>25%) will lead to death (Costa and Kooyman 1981, Siniff *et al.* 1982). Vulnerability of sea otters to oiling was demonstrated by the 1989 *Exxon Valdez* oil spill in Prince William Sound. Total estimates of mortality for the Prince William Sound area vary from 750 (range 600 to 1,000; Garshelis 1997) to 2,650 otters (range 500 to 5,000; Garrot *et al.* 1993). Statewide, it is estimated that 3,905 sea otters (range 1,904 to 11,257) died in Alaska as a result of the spill (DeGange *et al.*1994). At present, although abundance of sea otters in some oiled areas of Prince William Sound remains below pre-spill estimates, evidence from ongoing studies suggests that sea otters numbers are increasing, a trend interpreted as evidence of a trajectory toward recovery of spill-affected sea otter populations in western Prince William Sound (Bodkin *et al.* 2002, Stephensen *et al.* 2001, Bodkin *et al.* 2011, Monson *et al.* 2011).

Within the range of the Southcentral Alaska sea otter stock, oil and gas development and production occurs only in Cook Inlet. As of 2011, 16 offshore oil platforms operated in Cook Inlet, and two more are slated to begin operations in 2012. A Federal lease sale in Cook Inlet may be held in 2012 to 2017, if industry interest is sufficient. Tankering of North Slope crude oil occurs regularly through the waters of Prince William Sound with no major oil spills since the *Exxon Valdez*. While the catastrophic release of oil has the potential to take large numbers of sea otters, there is no evidence that other effects (such as disturbance) associated with routine oil and gas development and transport have had a direct impact on the Southcentral Alaska sea otter stock.

Information on oil spills compiled by the Alaska Department of Environmental Conservation from 2006 to 2010 indicates that an average of four spills of crude oil occurred each year in the marine environment within the range of the Southcentral Alaska stock of sea otters. Crude oil spills ranged in size from less than 4 liters to 760 liters (approximately 1 gallon to 200 gallons), with a mean size of about 41.8 liters (approximately 11 gallons). In addition to spills directly associated with the development, production, and transport of crude oil, each year numerous spills of non-crude oil products in the marine environment occur from ships and shore facilities throughout Southcentral Alaska. During the same time period and area, there was an average of about 62 spills of non-crude oil per year, ranging in size from less than 4 to 24,320 liters (approximately 1 to 6,400 gallons). The majority of the non-crude oil spills were small, with a mean size of about 380 liters (100 gallons) and a median size of 4 liters (approximately one gallon). There is no indication that these small-scale spills have an impact on the Southcentral Alaska stock of northern sea otters.

Subsistence/Native Harvest Information

The MMPA exempts Alaska Natives from the prohibition on take of marine mammals, provided such taking is not wasteful and is done for subsistence use or for creating and selling authentic handicrafts or clothing. According to the U.S. Fish and Wildlife Service's (Service) Law Enforcement records from 2006 to 2010, individuals were prosecuted for unlawful possession, transport, or sale of 14 sea otter hides or skulls taken within the range of the Southcentral Alaska stock. Data for subsistence harvest of sea otters in southcentral Alaska are collected by a mandatory Marking, Tagging and Reporting Program administered by the Service since 1988. Figure 2 provides a summary of subsistence harvest information for the Southcentral stock from 1989 to 2010. The mean reported annual subsistence take during the past five complete calendar years (2006 to 2010) was 293 animals. Reported age composition during this period was 93% adults, 6% subadults, and 1% pups. Sex composition during the past five years was 72% males, 23% females, and 5% of unknown sex. The majority of the harvest over the past five years has occurred in northern and eastern Prince William Sound.

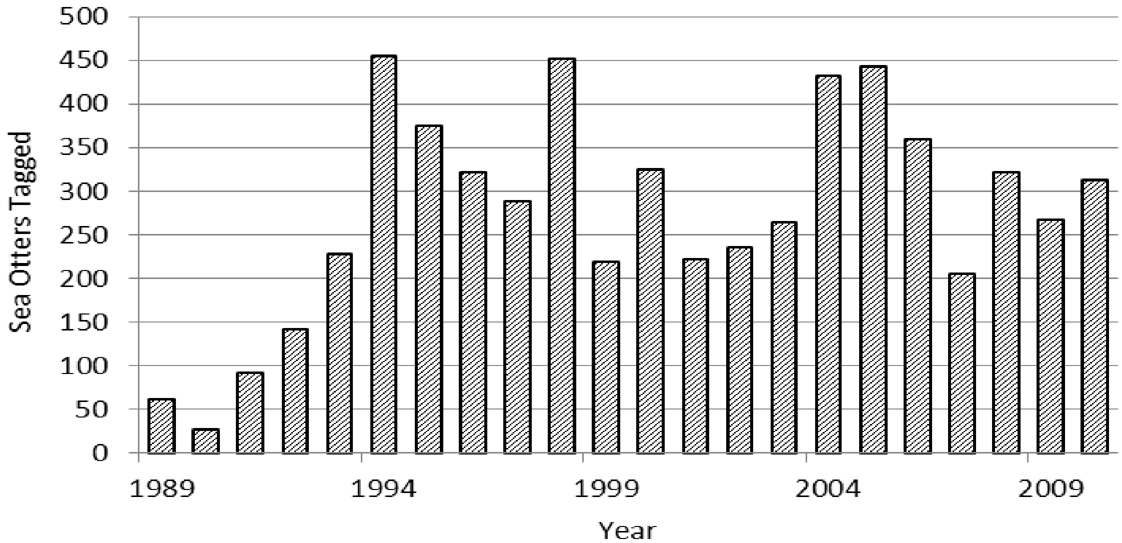

Figure 2. Reported subsistence harvest of northern sea otters from the Southcentral Alaska stock, 1989 to 2010.

Research and Public Display

During 2006 to 2010, four orphaned sea otter pups from the Southcentral Alaska stock were captured, rehabilitated, and placed for public display. During the same time period, 142 sea otters were captured and released for scientific research in Prince William Sound. There were no reported injuries and/or mortalities related to these activities.

Other Factors

In August 2006, the Working Group on Marine Mammal Unusual Mortality Events reviewed information provided by the Service and declared that a dramatic increase in sea otter strandings since 2002 constituted an Unusual Mortality Event (UME) in accordance with Section 404 of the MMPA. The disease complex that typifies this UME is caused by a *Streptococcus infantarius* infection and has been observed over a broad geographic range in Alaska, with the majority of cases identified from Kachemak Bay in the Southcentral Alaska stock. The dramatic increase of sea otter strandings in Kachemak Bay is now thought to be due to a rapidly increasing otter population in the bay combined with more community effort to report strandings. Testing and analysis are still being conducted to pinpoint the cause of this leading source of mortality. However, it is thought that the *Streptococcus infantarius* infection may be the result of immunosuppression due to an emerging virus in the Alaska population. At this time it is unclear what impact this has had, or will have, on the population.

Since 2002, the Service has undertaken a health and disease study of northern sea otters from all three Alaskan stocks. On average, the Service conducts about 100 necropsies a year on sea otter carcasses to determine cause of death, disease incidence, and status of general health parameters. Boat strike is a recurring cause of death across all three stocks. However, it has been determined in most of these cases that although trauma was the ultimate cause of death, there was a contributing factor, such as disease or biotoxin exposure, which incapacitated the animal and made it more vulnerable to boat strike.

STATUS OF STOCK

The known level of direct human-caused mortality within the Southcentral Alaska stock does not exceed the PBR level, and the Southcentral Alaska stock is neither listed as "depleted" under the MMPA nor listed as "threatened" or "endangered" under the U. S. Endangered Species Act of 1973, as amended. The known level of direct human-caused mortality is 293 otters per year. It would require an annual rate of fisheries-associated mortality and serious injury of over 1,170 otters per year for the total amount of direct human-caused mortality to exceed PBR for this stock. Despite uncertainties regarding fisheries mortality and serious injury, we believe that it is unlikely this level of take is occurring at present. Therefore, the Southcentral Alaska stock of the northern sea otter is classified as non-strategic. In addition, although the Service does not currently know the OSP for this stock, based on the known population level and our estimate of growth and considering the known level of human-caused mortality, we have determined that this stock is increasing and that human-caused mortality and serious injury is not likely to cause the stock to be reduced or to decrease its growth rate. Therefore, we would not expect the current level of human-caused mortality and serious injury to cause this stock to be reduced below its plausible OSP.

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NORTHERN SEA OTTER (*Enhydra lutris kenyoni*):

Southwest Alaska Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Sea otters occur in nearshore coastal waters of the U.S. along the North Pacific Rim from the Aleutian Islands to California. The species is most commonly observed within the 40-meter (approximately 12.2 feet) depth contour because the animals require frequent access to benthic foraging habitat in subtidal and intertidal zones (Reidman and Estes 1990). Sea otters are not migratory and generally do not disperse over long distances, although movements of tens of kilometers (tens of miles) are common (Garshelis and Garshelis 1984). Annual home range sizes of adult sea otters are relatively small, with male territories ranging from 4 to 11 square kilometers (km^2) (approximately 10.5 to 28.5 square miles [mi^2]) and adult female home ranges from a few to 24 km^2 (approximately 62 mi^2) (Garshelis and Garshelis 1984; Ralls *et al*. 1988; Jameson 1989). Due to their benthic foraging, sea otter distribution is largely limited by their ability to dive to the sea floor (Bodkin *et al.* 2004).

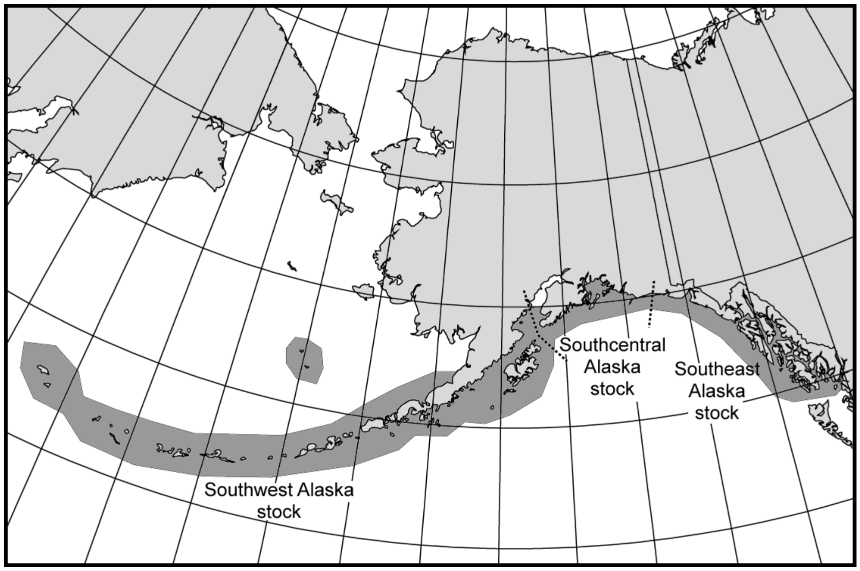

Figure 1. Approximate distribution and stock boundaries of northern sea otters in Alaska waters (shaded area).

The spatial scale at which sea otter populations are managed remains an important, although largely unexplored issue (Bodkin and Ballachey 2010) deserving further study. Bodkin and Ballachey (2010) used models of sea otter mortality to show that range-wide reductions and extirpations during the commercial fur trade of the 18th and 19th centuries occurred not simply because of excessive harvest, but because the harvest was not allocated proportional to the abundance and distribution of sea otters. This process of serial depletion was facilitated by the relatively sedentary nature of sea otters. To reduce the risk of overexploitation, sea otters must be managed on a spatial scale compatible with their well-known behavioral and reproductive biology (Bodkin and Monson 2002), incorporating traits such as home range and movements. These proposed scales for management are much smaller than the currently recognized stocks.

Gorbics and Bodkin (2001) applied the phylogeographic approach of Dizon *et al.* (1992) and used the best available data at the time to identify three sea otter stocks in Alaska: Southeast, Southcentral, and Southwest. The ranges of these stocks are defined as follows: (1) Southeast

Alaska stock extends from Dixon Entrance to Cape Yakataga; (2) Southcentral Alaska stock extends from Cape Yakataga to Cook Inlet including Prince William Sound, the Kenai Peninsula coast, and Kachemak Bay; and (3) Southwest Alaska stock includes the Alaska Peninsula and Bristol Bay coasts, and the Aleutian, Barren, Kodiak, and Pribilof Islands (Figure 1). This stock assessment report is focused on the Southwest stock of sea otters in Alaska.

POPULATION SIZE

Historically, sea otters occurred across the North Pacific Rim, ranging from Hokkaido, Japan, through the Kuril Islands, the Kamchatka Peninsula, the Commander Islands, the Aleutian Islands, peninsular and south coastal Alaska, and south to Baja California, Mexico (Kenyon 1969). In the early 1700s, the worldwide population was estimated to be between 150,000 (Kenyon 1969) and 300,000 individuals (Johnson 1982). Prior to large-scale commercial exploitation, indigenous peoples of the North Pacific hunted sea otters. Although it appears that harvests may have periodically led to local reductions of sea otters (Simenstad *et al.* 1978), the species remained abundant throughout its range until the mid-1700s. Following the arrival in Alaska of Russian explorers in 1741, extensive commercial harvest of sea otters over the next 150 years resulted in the near extirpation of the species. When sea otters were afforded protection by the International Fur Seal Treaty in 1911, probably fewer than 2,000 animals remained in thirteen remnant colonies (Kenyon 1969). Population recovery began following legal protection. As part of efforts to re-establish sea otters in portions of their historical range, otters from Amchitka Island and Prince William Sound were translocated to other areas in the

1960s and 1970s, including to southeast Alaska (Jameson *et al.* 1982). Sea otters have since recolonized much of their historical range in Alaska.

The most recent abundance estimates for survey areas within the Southwest Alaska stock are presented in Table 1. The estimate for the Katmai area has been added since the previous stock assessment report. Aerial surveys along the shorelines of the Aleutian Islands in April 2000 resulted in a count of 2,442 sea otters in the nearshore waters (Doroff *et al.* 2003). Comparison of aerial and skiff survey counts at six islands in 2000 was used to calculate a correction factor of 3.58 for this aerial survey, which resulted in an adjusted population estimate of 8,742 sea otters (CV= 0.22; Doroff *et al.* 2003).

In May 2000, a survey of offshore areas along the north Alaska Peninsula from Unimak Island to Cape Seniavin produced an abundance estimate of 4,728 sea otters (CV= 0.33; Burn and Doroff 2005). A similar survey of offshore areas along the south Alaska Peninsula from False Pass to Pavlov Bay conducted in summer 2001 resulted in a population estimate of 1,005 sea otters (CV= 0.81; Burn and Doroff 2005). Although a correction factor to account for sightability was not calculated during this survey, Evans *et al.* (1997) used a similar twin-engine aircraft flying at the same altitude and air speed to calculate a correction factor of 2.38 (CV = 0.09). Using this correction factor produced adjusted estimates of 11,253 (CV = 0.34) and 2,392 (CV = 0.82) for the north and south Alaska Peninsula offshore areas, respectively.

Table 1. Population estimates for the Southwest Alaska stock of northern sea otters. The previous stock assessment report (SAR) total is from 2008.

Survey Area	Year	Unadjusted Estimate	Adjusted Estimate	CV	N_{min}	Reference
Aleutian Islands	2000	2,442	8,742	0.22	7,309	Doroff *et al*. (2003)
North Alaska Peninsula	2000	4,728	11,253	0.34	8,535	Burn and Doroff (2005)
South Alaska Peninsula - Offshore	2001	1,005	2,392	0.82	1,311	Burn and Doroff (2005)
South Alaska Peninsula - Shoreline	2001	2,651	6,309	0.09	5,865	Burn and Doroff (2005)
South Alaska Peninsula - Islands	2001	402	957	0.09	889	Burn and Doroff (2005)
Unimak Island	2001	42	100	0.09	93	USFWS unpublished data
Kodiak Archipelago	2004		11,005	0.19	9,361	USFWS unpublished data
Katmai	2008		7,095	0.13	6,362	Coletti *et al*. (2009)
Kamishak Bay	2002		6,918	0.32	5,340	Bodkin *et al*. (2003)
Current Total			**54,771**		**45,064**	
Previous SAR Total			47,676		38,703	

In 2001, aerial surveys along the shoreline of the south Alaska Peninsula from Seal Cape to Cape Douglas recorded 2,651 sea otters (Burn and Doroff 2005). Additional aerial surveys of the south Alaska Peninsula island groups (Sanak, Caton, and Deer Islands, and the Shumagin and Pavlov Island groups) and a survey of Unimak Island, recorded 402 otters for the south Alaska Peninsula island groups and 42 animals for Unimak Island. Applying the same correction factor of 2.38 from Evans *et al.* (1997) produced adjusted estimates of 6,309 (CV = 0.09), 957 (CV = 0.09) and 100 (CV = 0.09) for the south Alaska Peninsula shoreline, south Alaska Peninsula islands, and Unimak Island, respectively.

An aerial survey of the Kodiak Archipelago conducted in 2004 resulted in an estimate of 11,005 sea otters (CV = 0.19; USFWS unpublished data). The methods used in this survey follow those of Bodkin and Udevitz (1999), which include the calculation of a survey-specific correction factor for animals undetected by observers. An aerial survey of Katmai National Park in 2009, also using the Bodkin-Udevitz method, resulted in an estimate of 7,095 sea otters (CV = 0.13; Coletti *et al.* 2009). Finally, an aerial survey of Kamishak Bay and western Cook Inlet conducted in June 2002 resulted in an estimate of 6,918 sea otters (CV = 0.32; Bodkin *et al.* 2003). This survey also used the methods of Bodkin and Udevitz (1999).

Combining the adjusted estimates for these areas, as summarized in Table 1, results in a total estimate of 54,771 sea otters for the Southwest Alaska stock. This estimated population size for the Southwest Alaska stock is slightly higher than in the 2008 stock assessment report due to the addition of an estimate for Katmai, which was surveyed in 2009 for the first time.

Minimum Population Estimate

The minimum population estimate (N_{MIN}) for this stock is calculated using Equation 1 from the Potential Biological Removal Guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842 \times [\ln(1+[CV(N)]^2)]^{½})$. The N_{MIN} for each survey area is presented in Table 1. The estimated N_{MIN} for the entire Southwest Alaska stock is 45,064 sea otters.

Current Population Trend

In spring 2000, the U.S. Fish and Wildlife Service (Service) repeated an aerial survey that had previously been conducted in 1992 and observed widespread declines throughout the Aleutian Islands, with the greatest decreases occurring in the central Aleutians. The uncorrected count for the area was 2,442 animals, indicating that sea otter populations had declined 70% since 1992 (Doroff *et al.* 2003). Burn *et al.* (2003) estimated that the sea otter population in the Aleutians in 2000 may have been reduced to less than 10% of the carrying capacity for the area. With the exception of the Kodiak Archipelago, which was surveyed in 2004, there have been no new large-scale abundance surveys for sea otters in southwest Alaska since the stock assessment report of August 2002.

On-going efforts to monitor trends in abundance include repeated skiff surveys at selected islands (index sites) in the Aleutian Islands. A Bayesian state-space trend analysis (Clark and Bjornstad 2004) developed using all available data compiled from skiff surveys around five islands in the western Aleutian Islands from 1993 to 2003 indicated that the population trends during this time period were strongly negative, with an average rate of decline of approximately 20% per year (USFWS 2013b, USGS unpublished data). Population trends changed during the period 2003 to 2011, with an average growth rate of approximately 0. Some variation in trends was evident but the trends were consistent among islands. These results suggest that population trends have stabilized in the western Aleutian Islands over the last 5 to 8 years, although there is still no evidence of recovery (USFWS 2013a, USFWS 2013b, USGS unpublished data).

Unlike in the Aleutian Islands and along the western Alaska Peninsula, sea otters in other areas within the range of the Southwest stock do not appear to have undergone a population decline over the past 20 years. Sea otter numbers in the Kodiak Archipelago, the Alaska Peninsula coast from Castle Cape to Cape Douglas, and Kamishak Bay in lower western Cook Inlet are stable and may be increasing (Coletti *et al.* 2009, Estes *et al*. 2010, USFWS 2013a, USGS unpublished data).

The estimated population size for the Southwest Alaska stock is slightly higher than in the previous stock assessment report due to the addition of Katmai, which was surveyed in 2009 for the first time. However, the overall sea otter population size in southwest Alaska has declined by more than 50% since the mid-1980s, and there is no evidence of recovery. Although current numbers are well below historical levels, the overall population trend for the Southwest Alaska stock is believed to have stabilized.

MAXIMUM NET PRODUCTIVITY RATE

Estes (1990) estimated a population growth rate of 17 to 20% per year for four northern sea otter populations expanding into unoccupied habitat. Although maximum productivity rates (R_{MAX}) have not been measured throughout much of the sea otter's range in Alaska, in the absence of more detailed information, the rate of 20% calculated by Estes (1990) is considered the best available estimate of R_{MAX}. There is insufficient information available to estimate the current net productivity rate for this population stock.

POTENTIAL BIOLOGICAL REMOVAL

Under the Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as *the maximum number of animals, not including natural mortalities, that may* *be removed from a marine mammal stock while allowing that stock to reach or maintain its optimal sustainable population.* The potential biological removal is the product of the minimum population estimate (N_{MIN}), one-half the maximum theoretical net productivity rate, and a recovery factor (F_R): PBR = N_{MIN} x 0.5 R_{MAX} x F_R. In August 2005, sea otters in southwest Alaska were listed as a threatened distinct population segment (DPS) under the Endangered Species Act of 1973, as amended (70 FR 46366; August 9, 2005) (ESA). Although Wade and Angliss (1997) provide a default recovery factor of 0.5 as a guideline for threatened species, a lower value may be considered appropriate in the case of a declining population. Therefore, for the Southwest Alaska stock, which has experienced a decline, we are taking a more conservative approach and have set the recovery factor at the default value for an endangered species (0.1). The calculated PBR for this stock is 450 sea otters per year (45,064 x 0.5 (0.2) x 0.1).

ANNUAL HUMAN CAUSED MORTALITY

Fisheries Information

A complete list of fisheries and marine mammal interactions is published annually by the National Oceanic and Atmospheric Administration (NOAA) Fisheries, the most recent of which was published on August 29, 2013 (78 FR 53336). Numerous fisheries exist within the range of the Southwest Alaska stock of northern sea otters, with the only one identified as interacting with this stock being the Kodiak salmon set gillnet fishery, with an estimated 188 vessels and/or persons participating. Additional salmon set gillnet fisheries occur in Bristol Bay (982 participants) and the Alaska Peninsula/Aleutian Islands (114 participants). Although no interactions with salmon drift gillnets have been identified for this stock, interactions have been observed in Prince William Sound with the Southcentral Alaska stock. Salmon drift gillnet fisheries occur in Bristol Bay (1,863 vessels) and the Alaska Peninsula/Aleutian Islands (162 vessels). Although both salmon set and drift gillnet fisheries occur in Cook Inlet, most of the fishing effort for these gillnet fisheries occurs north of the range of sea otters from the Southwest Alaska stock. Available information suggests that fisheries using other types of gear, including trawl, longline, and purse seine, appear to be less likely to have interactions with northern sea otters due to either the areas where such fisheries operate, or the specific gear used, or both.

Although commercial fisheries in Alaska have observer programs that monitor and report injury and mortality of marine mammals incidental to their operations, a reliable estimate of the levels of commercial fisheries incidental mortality and serious injury relative to the Southwest sea otter stock cannot be made because observer coverage is not sufficient and data are not collected consistently over time. Observer data were summarized from 1989 to 2010 (Perez 2003, Perez 2006, Perez 2007, NOAA unpublished data) for Bering Sea, Aleutian Islands, and Gulf of Alaska trawl, longline, and pot groundfish fisheries. During this period, no sea otters were taken in any trawl or longline fisheries. In 1992, a total of eight sea otters were observed caught in the Pacific cod pot fishery in the Aleutian Islands. Observer records indicate that those takes occurred in nearshore waters that had been closed to fishing. This explains why no additional take of sea otters was observed in legal pot fisheries, which took place in other areas, through 2010 (Perez 2006, Perez 2007, NOAA unpublished data). Sea otters are known to interact with pot fisheries in California, and it is possible that observer effort for pot fisheries in Alaska has been too low to detect sea otter bycatch (Hatfield *et al.* 2011).

The NOAA Fisheries conducted a marine mammal observer program for the Kodiak salmon set gillnet fishery during the 2002 and 2005 fishing seasons. This fishery has a seasonal component, occurring only during the summer months. In 2002, four entanglement events were observed in this fishery (Manly *et al.* 2003). Two of these events required intervention to untangle the otter from the net, and the other two were able to escape by themselves. In none of these instances was there any sign of external injuries. The sea otter by-catch in this fishery was estimated at 62 otters during the 2002 fishing season. Although no serious injuries or mortalities were observed in this small sample size of observed entanglements, it is reasonable to assume that some of these otters may have suffered injury as a result of entanglement in set gillnet fisheries. In fact, there was one self-report of an otter killed during the 2002 fishing season. Results from the 2005 Kodiak salmon set gillnet fishery indicate entanglement of one otter that subsequently released itself from the net, although it was not clear if this was a sea otter or river otter (Manly 2007). Assuming that this animal was a sea otter, the total by-catch in this fishery would be estimated at 28 animals during the 2005 season. Based on these results, it would appear that although entanglement of sea otters does occur in this fishery, the rate of mortality or serious injury is low.

An additional source of information on the number of sea otters killed or injured incidental to commercial fishery operations in Alaska are fisher self-reports required of vessel owners by NOAA Fisheries. In 1997, fisher self-reports indicated one sea otter caught in the Bering Sea and Aleutian Island groundfish trawl fishery; however, it is unclear if the animal was alive when caught. Credle *et al.* (1994) considered fisher self-reports to be a minimum estimate of incidental take as these data are most likely negatively biased. Observer coverage for fisheries within the range of the Southwest stock of sea otters has been absent in some fisheries and low in others, particularly with respect to the set and drift gillnet fisheries that are recognized as interacting with this stock, and current estimates of sea otter bycatch are not available. Self-reporting is not sufficiently reliable to replace observer effort. Additionally, assessment of injury and mortality in sea otters that interact with fisheries is difficult. Information is, therefore, insufficient to determine whether or not the total fishery mortality and serious injury for the Southwest Alaska stock of the northern sea otter is insignificant and is approaching a zero mortality and serious injury rate.

Oil Spills

Activities associated with exploration, development, and transport of oil and gas resources can adversely impact sea otters and nearshore coastal ecosystems in Alaska. Sea otters rely on air trapped in their fur for warmth and buoyancy. Contamination with oil drastically reduces the insulative value of the pelage, and consequently sea otters are among the marine mammals most likely to be detrimentally affected by contact with oil. It is believed that sea otters can survive low levels of oil contamination (<10% of body surface), but that greater levels (>25%) will lead to death (Costa and Kooyman 1981, Siniff *et al.* 1982). Vulnerability of sea otters to oiling was demonstrated by the 1989 *Exxon Valdez* oil spill in Prince William Sound. Estimates of mortality for the Prince William Sound area vary from 750 otters (range 600 to 1,000; Garshelis 1997) to 2,650 otters (range 500 to 5,000; Garrott *et al.* 1993). Statewide, 3,905 sea otters (range 1,904 to 11,257) were estimated to have died in Alaska as a result of the spill (DeGange *et al.* 1994). At present, although abundance of sea otters in some oiled areas of Prince William Sound remains below pre-spill estimates, evidence from ongoing studies suggests that sea otters numbers in this area are increasing, a trend interpreted as strong evidence of a trajectory toward recovery of spill-affected sea otter populations in western Prince William Sound (Bodkin *et al.* 2002, Stephensen *et al.* 2001, Bodkin *et al.* 2011).

Within the range of the Southwest Alaska sea otter stock, oil and gas development and production occurs only in Cook Inlet. As of 2011, 16 offshore oil platforms operated in Cook Inlet, and two more are slated to begin operations in 2012. A Federal lease sale in lower Cook Inlet is planned for the fall of 2013. Although the amount of oil transported in southwest Alaska is relatively small, the *Exxon Valdez* oil spill demonstrated that spilled oil can travel long distances and take large numbers of sea otters far from the point of initial release. The grounding in 2004 of the freighter *Selendang Ayu* on Unalaska Island, within the range of this stock, released 1,219,800 liters (approximately 321,000 gallons) of non-crude oil and caused at least two sea otter mortalities (USFWS unpublished data). While the catastrophic release of oil has the potential to take large numbers of sea otters, there is no evidence that other effects (such as disturbance) associated with routine oil and gas development and transport have had a direct impact on the Southwest Alaska sea otter stock.

Information on oil spills compiled by the Alaska Department of Environmental Conservation from 2006 to 2010 indicates that there were no reported spills of crude oil in southwest Alaska during that time period. In addition to spills that may occur in association with the development, production, and transport of crude oil, each year numerous spills of non-crude oil products in the marine environment occur from ships and shore facilities throughout southwest Alaska. During that same time period, an average of 64 non-crude oil spills occurred each year, ranging in size from less than 4 to 551,000 liters (approximately1 to 145,000 gallons).

The majority of these spills were small, with a mean size of about 3,500 liters (approximately 921 gallons) and a median size of 15 liters (approximately 2 gallons). There is no indication that these small-scale spills have an impact on the Southwest Alaska stock of northern sea otters.

Subsistence/Native Harvest Information

The MMPA exempts Alaska Natives from the prohibition on take of marine mammals, provided such taking is not wasteful and is done for subsistence use or for creating and selling authentic handicrafts or clothing. In addition, section 10(e) of the ESA allows for take of listed species for primarily subsistence purposes under certain circumstances. According to the Service's Law Enforcement records, there were no prosecutions from 2006 to 2010 for unlawful take, possession, transport, or sale of sea otters or sea otter hides taken within the range of the Southwest Alaska stock. Data for subsistence harvest of sea otters in southwest Alaska are collected by a mandatory Marking, Tagging and Reporting Program administered by the Service since 1988. Figure 2 provides a summary of harvest information for the Southwest stock from 1989 through 2010. The mean reported annual subsistence take during the past five complete calendar years (2006-2010) was 76 animals. Reported age composition during this period was 84% adults, 12% subadults, 1% pups, and 3% unknown. Sex composition during the past five years was 77% males, 19% females, and 4% unknown. The majority of this harvest (83%) comes from the Kodiak Archipelago; areas within the stock that show signs of continued population declines have little to no record of subsistence harvest.

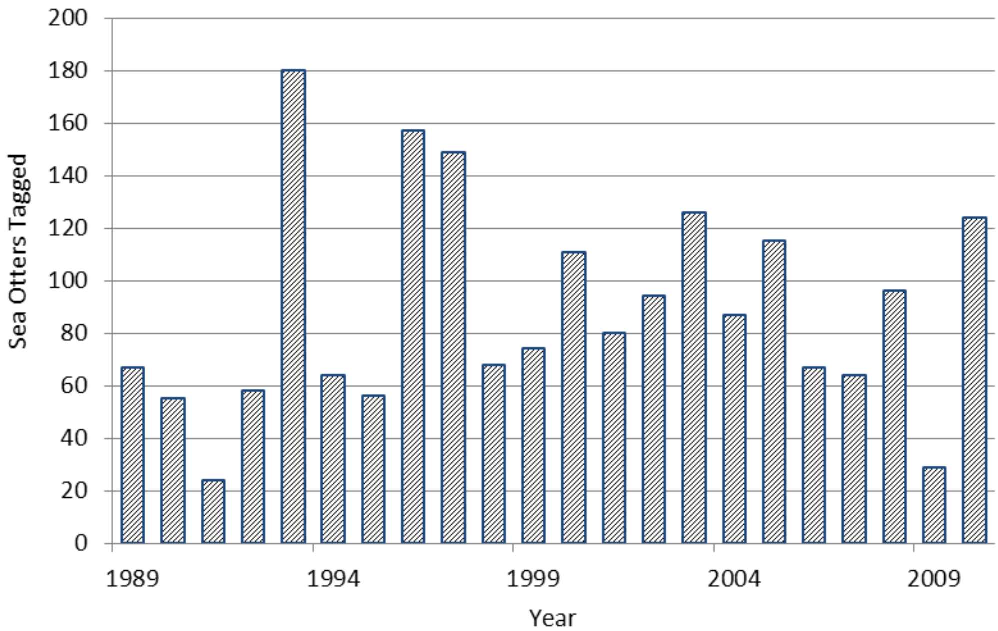

Figure 2. Reported subsistence harvest of northern sea otters from the Southwest Alaska stock, 1989-2010.

Research and Public Display

During 2006 to 2010, one orphaned sea otter pup from the Southwest Alaska stock was captured, rehabilitated, and placed for public display. During this period, a total of 65 otters were live-captured from this stock and released for research purposes. The captures occurred in the vicinities of Kukak Bay (Katmai National Park and Preserve coast), Unga Island (Shumagin Island group), and Dolgoi Island (Pavlov Island group). There were no reported injuries and/or mortalities related to these activities.

Other Factors

Each year, several thousand commercial vessels of varying sizes traverse the North Pacific Great Circle Route between North America and Asia, carrying a variety of cargoes. Vessels generally pass through the Aleutian Islands twice, through Unimak Pass to the east and near Buldir Island to the west. A risk assessment for the area concluded that while a majority of the vessel traffic along the Great Circle Route passes through the region without making any port calls, accidents involving these vessels have the potential to significantly and adversely impact coastal and marine ecosystems, economies, and human activities in the region (Aleutian Islands Risk Assessment Project Management Team 2011). Previous vessel accidents in the Aleutian Islands have resulted in loss of cargo, oil spills, and loss of life. The remoteness, limited infrastructure, and severe weather of the region often limit the potential to mitigate or respond to incidents. Overall, both the total number of accidents and the total risk of a bunker oil spill in the region are predicted to increase (Aleutian Islands Risk Assessment Project Management Team 2011).

Since 2002 the Service has undertaken a health and disease study of northern sea otters from all three Alaskan stocks. On average, the Service conducts about 100 necropsies a year on sea otter carcasses to determine cause of death, disease incidence and status of general health parameters. Boat strike is a recurring cause of death across all three stocks. However, it has been determined in most of these cases that although trauma was the ultimate cause of death, there was a contributing factor, such as disease or biotoxin exposure, which incapacitated the animal and made it more vulnerable to boat strike.

In August 2006, the Working Group on Marine Mammal Unusual Mortality Events reviewed information provided by the Service, and declared that a dramatic increase in sea otter strandings since 2002 constituted an Unusual Mortality Event (UME) in accordance with section 404 of the MMPA. The disease that typifies this UME is caused by a *Streptococcus infantarius* infection and has been observed over a broad geographic range in Alaska, including a few cases from southwest Alaska; however, the majority of cases have come from Kachemak Bay in the Southcentral Alaska stock. It is not clear if the observed stranding pattern is representative of overall sea otter mortality, or an artifact of having a well-developed stranding network in the Kachemak Bay area. The Service will continue to work with NOAA Fisheries and the Alaska Sea Life Center to develop the infrastructure for a State-wide marine mammal stranding network in Alaska.

STATUS OF STOCK

On August 9, 2005, the Southwest Alaska DPS of the northern sea otter was listed as "threatened" under the ESA, and it is, therefore, classified as a strategic stock under the MMPA.

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Protected Resources Management
Marine Mammal Protection Act -- Procedures

GUIDELINES FOR PREPARING STOCK ASSESSMENT REPORTS PURSUANT TO THE 1994 AMENDMENTS TO THE MMPA

NOTICE: This publication is available at: http://www.nmfs.noaa.gov/op/pds/index.html

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Revised based largely upon recommendations of the 2011 GAMMS III workshop. See section 5 for an overview of revisions.

Signed ___/s/_________________2/19/2015_______________
[Donna S. Wieting] Date
[Director, NMFS Office of Protected Resources]

Guidelines for Preparing Stock Assessment Reports Pursuant to Section 117 of the Marine Mammal Protection Act

1. General Guidelines

Introduction

Section 117 of the Marine Mammal Protection Act (MMPA) requires that the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (FWS) develop Stock Assessment Reports (Reports) for all marine mammal stocks in waters under U.S. jurisdiction (U.S. waters). These Reports are to be based upon the best scientific information available. Reports are not required for stocks that have a remote likelihood of occurring regularly in U.S. waters (e.g., stocks for which only the margins of the range extend into U.S. waters or that enter U.S. waters only during anomalous current or temperature shifts).

The MMPA requires Reports to include, among other things, information on how stocks were identified, a calculation of Potential Biological Removal (PBR), and an assessment of whether incidental fishery takes are "insignificant and approaching zero mortality and serious injury rate," as well as other information relevant to assessing stocks. These reports are to be reviewed annually for "strategic stocks" and stocks for which significant new information is available, and at least once every three years for all other stocks. This document provides guidance for how these topics are to be addressed in the Reports.

The MMPA provides some general guidance for developing the Reports. More detailed guidelines were developed at a PBR workshop in June 1994 and were used in writing the original draft Reports. The draft guidelines and initial draft Reports were subjected to public review and comment in August 1994. Final guidelines and Reports were completed in 1995 (Barlow et al. 1995). In 1996, representatives of NMFS, FWS, regional Scientific Review Groups, and the Marine Mammal Commission reviewed the guidelines and proposed minor changes, which after public review and comment, were made final in 1997 (Wade and Angliss 1997). The guidelines were officially updated again in 2005, following a similar revision process beginning with workshop in September 2003 (NMFS 2005). In February 2011, NMFS again convened representatives of the review groups and agencies to review and, as appropriate, recommend revisions to the guidelines. Those recommended revisions (Moore and Merrick 2011) were made available for public review and comment, and are finalized here.

It is anticipated that the guidelines themselves will be reviewed and changed based on additional scientific research and on experience gained in their application. In this regard, FWS and NMFS will meet periodically to review and revise, as needed, the guidelines. When the agencies recommend revisions to the guidelines, these revisions will be made available for public review and comment prior to acceptance. Furthermore, the guidelines in this document do not have to be followed rigidly; however, any departure from these guidelines must be discussed fully within any affected Report.

The intent of these guidelines is to: (1) provide a uniform framework for the consistent application of the amended MMPA throughout the country; (2) ensure that PBR is calculated in a manner that ensures meeting the goals of the MMPA; (3) provide guidelines for evaluating whether fishery takes are insignificant and approaching a zero mortality and serious injury rate; and (4) make the Federal government's approach clear and open to the public. Where the guidelines provided here are not incorporated into a particular Report, justification for the departure will be provided within the Report. Similarly, the Reports will explain when deviations are made from specific recommendations from the Scientific Review Groups.

The FWS and NMFS interpret the primary intent of the 1994 MMPA amendments and the PBR guidelines developed pursuant to the Act as a mechanism to respond to the uncertainty associated with assessing and reducing marine mammal mortality from incidental fisheries takes. Accordingly, this mechanism is increasingly conservative under increasing degrees of uncertainty. The MMPA requires the calculation of PBR for all stocks, including those that are considered endangered or threatened under the Endangered Species Act (ESA) and those that are managed under other authorities, such as the International Whaling Commission. However, in some cases allowable takes under these other authorities may be less than the PBR calculated under the MMPA owing to the different degrees of "risk" associated with, and the treatment of, uncertainty under each authority. Where there is inconsistency between the MMPA and ESA regarding the take of listed marine mammals, the more restrictive mortality requirement takes precedence. Nonetheless, PBR must still be calculated for these stocks, where possible, and discussed in the text of the Reports. As directed in the MMPA, the PBR is calculated as "...the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population." Therefore, a PBR is an upper limit to removals that does not imply that the entire amount should be taken.

Section 117 requires PBR, human-caused mortality, and classification as to whether a stock is "strategic" or "non-strategic" to be included in the Reports for all stocks of marine mammals in U.S. waters. However, it should be noted that the co-management, between the Federal government and Alaska Native Organizations, of removals of marine mammals for subsistence purposes between the Federal government and Alaska Native organizations is specifically addressed in Section 119. In response to Section 119, NMFS and FWS have entered into cooperative agreements with Alaska Native Organizations to conserve marine mammals and provide co-management of subsistence use by Alaska Natives. FWS and NMFS believe that it is appropriate to develop management programs for stocks subject to subsistence harvests through the co-management process provided that commercial fisheries takes are not significant and that the process includes a sound research and management program to identify and address uncertainties concerning the status of these stocks. Calculations of PBR and classification as to whether a stock is strategic will be determined from the analysis of scientific and other relevant information discussed during the co-management process.

In the sections of the Reports on Stock Definition and Geographic Range, elements of the PBR formula, Population Trend, and Annual Human-caused Mortality and Serious Injury, authors are to provide a brief description of key uncertainties in each element and evaluate the effects of these uncertainties associated with parameters in these sections. In cases where more lengthy discussions of uncertainty are necessary, they should be published separately (e.g., as NOAA Technical Memorandum) and referenced in the SAR.

Definition of "Stock"

"Population stock" is the fundamental unit of legally-mandated conservation. The MMPA defines population stock as "a group of marine mammals of the same species or smaller taxa in a common spatial arrangement, that interbreed when mature." To fully interpret this definition, it is necessary to consider the objectives of the MMPA. Section 2 (Findings and Declaration of Policy) of the MMPA states that "...species and population stocks of marine mammals...should not be permitted to diminish beyond the point at which they cease to be a significant functioning element in the ecosystem of which they are a part, and, consistent with this major objective, they should not be permitted to diminish below their optimum sustainable population." Further, it states "...the primary objective of their management should be to maintain the health and stability of the marine ecosystem. Whenever consistent with this primary objective, it should be the goal to obtain an optimum sustainable population keeping in mind the carrying capacity of the habitat." Therefore, stocks must be identified in a manner that is consistent with these goals. For the purposes of management under the MMPA, a stock is recognized as being a management unit that identifies a demographically independent biological population. It is recognized that in practice, our ability to detect stocks may fall short of this ideal because of a lack of information, or for other reasons.

Many types of information can be used to identify stocks of a species (e.g., distribution and movements, population trends, morphology, life history, genetics, acoustic call types, contaminants and natural isotopes, parasites, and oceanographic habitat). Different population responses (e.g., different trends in abundance) between geographic regions are also an indicator of stock structure, as populations with different trends are not strongly linked demographically. When different types of evidence are available to identify stock structure, the Report must discuss inferences made from the different types of evidence and how these inferences were integrated to identify the stock.

Evidence of morphological or genetic differences in animals from different geographic regions indicates that these populations are demographically independent. Demographic independence means that the population dynamics of the affected group is more a consequence of births and deaths within the group (internal dynamics) rather than immigration or emigration (external dynamics). Thus, the exchange of individuals between population stocks is not great enough to prevent the depletion of one of the populations as a result of increased mortality or lower birth rates.

Failure to detect genetic or morphological differences, however, does not necessarily mean that populations are not demographically independent. Dispersal rates, though sufficiently high to homogenize morphological or genetic differences detectable between putative populations, may still be insufficient to deliver enough recruits from an unexploited population (source) to an adjacent exploited population (sink) so that the latter remains a functioning element of its ecosystem. Insufficient dispersal between populations where one bears the brunt of exploitation coupled with their inappropriate pooling for management could easily result in failure to meet MMPA objectives. For example, it is common to have human-caused mortality restricted to a portion of a species' range. Such concentrated mortality (if of a large magnitude) could lead to population fragmentation, a reduction in range, or even the loss of undetected populations, and would only be mitigated by high immigration rates from adjacent areas.

Therefore, careful consideration needs to be given to how stocks are identified. In particular, where mortality is greater than a PBR calculated from the abundance just within the oceanographic region where the human-caused mortality occurs, serious consideration should be given to identifying an appropriate management unit in this region. In the absence of adequate information on stock structure and fisheries mortality, a species' range within an ocean should be divided into stocks that represent defensible management units. Examples of such management units include distinct oceanographic regions, semi-isolated habitat areas, and areas of higher density of the species that are separated by relatively lower density areas. Such areas have often been found to represent true biological stocks where sufficient information is available. In cases where there are large geographic areas from which data on stock structure of marine mammals are lacking, stock structure from other parts of the species' range may be used to draw inferences as to the likely geographic size of stocks. There is no intent to identify stocks that are clearly too small to represent demographically independent biological populations, but it is noted that for some species genetic and other biological information has confirmed the likely existence of stocks of relatively small spatial scale, such as within Puget Sound, WA, the Gulf of Maine, or Cook Inlet, AK.

Each Report will state in the Stock Definition and Geographic Range section whether it is plausible the stock contains multiple demographically independent populations that should be separate stocks, along with a brief rationale. If additional structure is plausible and human-caused mortality or serious injury is concentrated within a portion of the range of the stock, the Report should identify the portion of the range in which the mortality or serious injury occurs. In addition, a description of any additional key uncertainties concerning the stock definition should be provided, along with an evaluation of the potential effects of these uncertainties on the stock definition.

In transboundary situations where a stock's range spans international boundaries or the boundary of the U.S. Exclusive Economic Zone (EEZ), the best approach is to establish an international management agreement for the species and to evaluate all sources of human-caused mortality and serious injury (U.S. and non-U.S.) relative to the PBR for the entire stock range. In the interim, if a transboundary stock is migratory and it is reasonable to do so, the fraction of time the stock spends in U.S. waters should be noted, and the PBR for U.S. fisheries should be apportioned from the total PBR based on this fraction. For non-migratory transboundary stocks (e.g., stocks with broad pelagic distributions that extend into international waters), if there are estimates of mortality and serious injury from U.S. and other sources throughout the stock's range, then PBR calculations should be based upon a range-wide abundance estimate for the stock whenever possible. In general, abundance or density estimates from one area should not be extrapolated to unsurveyed areas to estimate range-wide abundance (and PBR). But, informed interpolation (e.g., based on habitat associations) may be used to fill gaps in survey coverage and estimate abundance and PBR over broader areas as appropriate and supported by existing data.[1] If estimates of mortality or abundance from outside the U.S. EEZ cannot be determined, PBR calculations should be based on abundance within the EEZ and compared to mortality within the EEZ.

Prospective Stocks

When information becomes available that appears to justify a different stock structure or stock boundaries, it may be desirable to include the new structure or boundaries as "prospective stocks" within the existing Report. The descriptions of prospective stocks would include a description of the evidence for the new stocks, calculations of the prospective PBR for each new stock, and estimates of human-caused mortality and serious injury, by source. The notice of availability of draft Reports with prospective stocks would include a request for public comment and additional scientific information specifically addressing the prospective stock structure. Prospective stocks would be expected to become separate stocks in a timely manner unless additional evidence was produced to contradict the prospective stock structure. Summary information for prospective stocks should be included in the standard table in the Reports that summarizes the minimum population estimate, the maximum net productivity rate, etc. for each stock.

PBR Elements

The 1994 amendments to the MMPA mandate that, as part of the Reports, PBR must be calculated for each marine mammal stock in U.S. waters. The PBR is defined as "the maximum number of animals, not including natural mortality, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population." In addition, the MMPA states that PBR is calculated as the product of three elements: the minimum population estimate (N_{min}); half the maximum net productivity rate (0.5 R_{max}); and a recovery factor (F_r). The guidelines for defining and applying each of these three elements are described below. Further specific guidance on the calculation of PBR is provided in part 2 (Technical Details) of this document. The Report should provide a description of any key uncertainties in the elements of the PBR equation and evaluate the effects of these uncertainties on the estimate.

An underlying assumption in the application of the PBR equation is that marine mammal stocks exhibit certain population dynamics. Specifically, it is assumed that a depleted stock will naturally grow toward OSP and that some surplus growth may be removed while still allowing recovery. There are unusual situations, however, where the formula Congress added to the MMPA to calculate PBR (N_{min}*0.5R_{max}*F_r) results in a number that is not consistent with the narrative definition of PBR (the maximum number of animals, not including natural mortality, that may be removed from a marine mammal stock while allowing that stock to reach or maintain

[1] "Informed interpolation" specifically refers to the use of a model-based method for interpolating density between transect lines, such as habitat-based density modeling and other forms of spatial modeling.

its OSP). That is, there are situations where a stock is below its OSP and is declining or stable, yet human-caused mortality is a not a major factor in the population's trend. Thus, for unknown reasons, the stock's population dynamics do not conform to the underlying model for calculating PBR. In such unusual situations, the PBR calculations should be qualified in the Report in the PBR section.

Minimum Population Estimate (N_{min})

N_{min} is defined in the MMPA amendments as an estimate of the number of animals in a stock that:

> "(A) is based on the best available scientific information on abundance, incorporating the precision and variability associated with such information; and,
>
> "(B) provides reasonable assurance that the stock size is equal to or greater than the estimate."

Consistent with these MMPA definitions, N_{min} should be calculated such that a stock of unknown status would achieve and be maintained within OSP with 95% probability. Population simulations have demonstrated (Wade 1994) that this goal can be achieved by defining N_{min} as the 20th percentile of a log-normal distribution based on an estimate of the number of animals in a stock (which is equivalent to the lower limit of a 60% 2-tailed confidence interval):

$$N_{min} = N/\exp(0.842 * (\ln(1+CV(N)^2))^{½})$$

where N is the abundance estimate and CV(N) is the coefficient of variation of the abundance estimate. If abundance estimates are believed to be biased, appropriate correction factors should be applied to obtain unbiased estimates of N. In such cases, the coefficient of variation for N should include uncertainty in the estimation of the correction factor. In cases where a direct count is available, such as for many pinniped stocks, this direct count could alternatively be used as the estimate of N_{min}. Other approaches could also be used to estimate N_{min} if they provide the same level of assurance that the stock size is equal to or greater than that estimate.

Clearly, the most recent abundance estimate becomes a less accurate population descriptor with time. When abundance estimates become many years old, at some point estimates will no longer meet the requirement that they provide reasonable assurance that the stock size is presently greater than or equal to that estimate. Therefore, unless compelling evidence indicates that a stock has not declined since the last census, the N_{min} estimate of the stock should be considered unknown if 8 years have transpired since the last abundance survey. Eight years was chosen, in part, because a population that declines at 10% per year from carrying capacity would be reduced to less than 50% of its original abundance after 8 years. A 10% decline per year over at least 8 years represents the greatest decline observed for a stock of marine mammals in U.S. waters. If N_{min} is unknown, then PBR cannot be determined, but this is not equivalent to considering PBR equal to zero. If there is known or suspected human-caused mortality of the stock, decisions about whether such stocks should be declared strategic or not should be made on a case-by-case basis. Stocks for which N_{min} becomes unknown should not move from "strategic" to "not-strategic", or v.v., solely because of an inability to estimate N_{min}.

Population Trend

The Reports will describe information on current population trend. The Report should also provide a description of any key uncertainties concerning the population trend, and evaluate the effects of these uncertainties on the trend.

Maximum Rate of Increase (R_{max})

One-half R_{max} is defined in the MMPA as "one-half of the maximum theoretical or estimated "net productivity rate of the stock at a small population size," where the term "net productivity rate" means "the annual per capita rate of increase in a stock resulting from additions due to reproduction, less losses due to natural mortality." Default values should be used for R_{max} in the absence of stock-specific measured values. To be consistent with a risk-averse approach, these default values should be near the lower range of measured or theoretical values (or 0.12 for pinnipeds and sea otters and 0.04 for cetaceans and manatees). Substitution of other values for these defaults should be made with caution, and only when reliable stock-specific information is available on R_{max} (e.g., estimates published in peer-reviewed articles or accepted by review groups such as the MMPA Scientific Review Groups or the Scientific Committee of the International Whaling Commission).

Details on rounding and precision, and on averaging more than one estimate of abundance to calculate N_{min}, can be found in part 2 (Technical Details) of this document.

Recovery Factor (F_r)

The MMPA defines the recovery factor, F_r, as being between 0.1 and 1.0. The intent of Congress in adding F_r to the definition of PBR was to ensure the recovery of populations to their OSP levels, and to ensure that the time necessary for populations listed as endangered, threatened, and/or depleted to recover was not significantly increased. The use of F_r less than 1.0 allocates a proportion of expected net production towards population growth and compensates for uncertainties that might prevent population recovery, such as biases in the estimation of N_{min} and R_{max} or errors in the determination of stock structure. Population simulation studies (Barlow et al. 1995, Wade 1998) demonstrate that the default F_r for stocks of endangered species should be 0.1, and that the default F_r for depleted and/or threatened stocks and stocks of unknown status should be 0.5.

The default status should be considered as "unknown." Stocks known to be within OSP (e.g., as determined from quantitative methods such as dynamic response or back-calculation), or stocks of unknown status that are known to be increasing, or stocks that are not known to be decreasing taken primarily by aboriginal subsistence hunters, could have higher F_r values, up to and including 1.0, provided there have not been recent increases in the levels of takes. Recovery factors for ESA-listed stocks can be changed from their default values, but only after careful consideration and where available scientific evidence confirms that the stock is not in imminent danger of extinction. Values other than the defaults for any stock should usually not be used without the approval of the regional Scientific Review Group, and scientific justification for the change should be provided in the Report.

The recovery factor can be adjusted to accommodate additional information and to allow for management discretion as appropriate and consistent with the goals of the MMPA. For example, if human-caused mortalities include more than 50% females, the recovery factor should be decreased to compensate for the greater impact of this mortality on the population (or increased if less than 50% female). Similarly, declining stocks, especially ones that are threatened or depleted, should be given lower recovery factors, the value of which should depend on the magnitude and duration of the decline. The recovery factor of 0.5 for threatened or depleted stocks or stocks of unknown status was determined based on the assumption that the coefficient of variation of the mortality estimate is equal to or less than 0.3. If the CV is greater than 0.3, the recovery factor should be decreased to: 0.48 for CVs of 0.3 to 0.6; 0.45 for CVs of 0.6 to 0.8; and 0.40 for CVs greater than 0.8.

Recovery factors could also be increased in some cases. If mortality estimates are known to be relatively unbiased because of high observer coverage, then it may be appropriate to increase the recovery factor to reflect the greater certainty in the estimates. Thus, in an instance where the observer coverage was 100% and the observed fishery was responsible for virtually all fishery mortality on a particular stock, the recovery factor for a stock of unknown status might be increased from 0.5 (reflecting less concern about bias in mortality, but continued concern about biases in other PBR parameters and errors in determining stock structure). Recovery factors of 1.0 for stocks of unknown status should be reserved for cases where there is assurance that N_{min}, R_{max}, and the estimates of mortality and serious injury are unbiased and where the stock structure is unequivocal.

Annual Human-caused Mortality and Serious Injury

A summary of all human-caused mortality and serious injury should be provided in each Report as the first paragraph under “Annual human-caused mortality and serious injury.” This summary should include information on all mortality and serious injury (e.g., U.S. commercial fishing, other fishery mortality from recreational gear and foreign fleets, strandings, vessel strikes, power plant entrainment, shooting, scientific research, after-action reports from otherwise authorized activities, etc.).

The Reports should contain a complete description of what is known about current human-caused mortality and serious injury. Information about incidental fisheries mortality should be provided, including sources such as observer programs, logbooks, fishermen’s reports, strandings, and other sources, where appropriate. It is expected that this section of the Reports will include all pertinent information that is subsequently used to categorize fisheries under Section 118. Therefore, any additional information that is anticipated to be used to categorize a fishery should be provided here.

If mortality and serious injury estimates are available for more than one year, a decision will have to be made about how many years of data should be used to estimate annual mortality. There is an obvious trade-off between using the most relevant information (the most recent data) versus using more information (pooling across a number of years) to increase precision and reduce small-sample bias. It is inappropriate to state specific guidance directing which years of data should be used, because the case-specific choice depends upon the quality and quantity of data. Accordingly, mortality estimates could be averaged over as many years as necessary to achieve statistically unbiased estimation with a CV of less than or equal to 0.3. Generally, estimates include the most recent five years for which data have been analyzed, as this accounts for inter-annual variability. However, information more than five years old can be used if it is the most appropriate information available in a particular case.

In some cases it may not be appropriate to average over as many as five years even if the CV of an estimate is greater than 0.3. For example, if within the last five years the fishery has changed (e.g., fishing effort or the mortality rate per unit of fishing effort has changed), it would be more appropriate to use only the most recent relevant data to most accurately reflect the current level of annual mortality. When mortality is averaged over years, an un-weighted average should be used, because true mortality rates vary from year-to-year. When data are insufficient to overcome small-sample bias of mortality estimates for purposes of comparing the estimates to PBR (see Technical Details), a statement acknowledging this elevated potential for small-sample bias should accompany mortality estimates in the Reports.

In some cases, mortality and serious injury occur in areas where more than one stock of marine mammals occurs. When biological information (e.g., photo-identification, genetics, morphology) is sufficient to identify the stock from which a dead or seriously injured animal came, then the mortality or serious injury should be associated only with that stock. When one or more deaths or serious injuries cannot be assigned directly to a stock, then those deaths or serious injuries may be partitioned among stocks within the appropriate geographic area, provided there is sufficient information to support such partitioning (e.g., based on the relative abundances of stocks within the area). When the mortality and serious injury estimate is partitioned among overlapping stocks, the Reports will contain a discussion of the potential for over- or under-estimating stock-specific mortality and serious injury. In cases where mortality and serious injuries cannot be assigned directly to a stock and available information is not sufficient to support partitioning those deaths and serious injuries among stocks, the total unassigned mortality and serious injuries should be assigned to each stock within the appropriate geographic area. When deaths and serious injuries are assigned to each overlapping stock in this manner, the Reports will contain a discussion of the potential for over-estimating stock-specific mortality and serious injury.

A summary of mortality and serious injury incidental to U.S. commercial fisheries should be presented in a table, providing the name of the fishery and, for each appropriate year, observed mortality and serious injury, estimated extrapolated mortality and serious injury and associated CV, and percent observer coverage in that year, with the last column providing the average annual mortality and serious injury estimate for that fishery. Information on non-serious injuries should also be provided, either in the table or the text.[2] Because U.S. commercial fisheries and foreign fisheries within the U.S. EEZ are subject to regulation under MMPA Section 118, mortality and serious injury from such fisheries should be clearly separated from other fishery-related mortality (e.g., mortality incidental to recreational fishing or foreign fishing beyond the U.S. EEZ) in the Reports.

There is a general view that marine mammal mortality information from logbook or fishermen's report data can only be considered as a minimum estimate of mortality, although exceptions may occur. Logbook or fishermen's report information can be used to determine whether the minimum mortality is greater than the PBR (or greater than 10% of the PBR), but it should not be used to determine whether the mortality is less than the PBR (or 10% of the PBR). Logbook data for fishermen's reports should not be used as the sole justification for determining that a particular stock is not strategic or that its mortality and serious injury rate is insignificant and approaching zero.

For fisheries without observer programs, information about incidental mortality and serious injury from logbooks, fishermen's self-reports, strandings, and other sources should be included where appropriate. When these other sources of data are used, particularly as a significant component of the measure of annual human-caused mortality, the following language should be added to the Report: "It is important to stress that this mortality estimate results from an actual count of verified human-caused deaths and serious injuries and should be considered a minimum." Such information should be presented in brackets to distinguish it from estimates of total mortality and serious injury in the fishery. If such information is not included in the table, but reports such as fishermen's self-reports are available, those reports should be described in the text and any concern with the quality of that report should be noted. Fishermen's self-reports of mortality or injuries should not be included if the fishery was observed and incidental mortality and serious injury was estimated based on observer records and associated coverage. Mortality and serious injury by those fisheries not regulated under MMPA Section 118 (i.e., incidental to foreign fisheries or recreational fisheries), should be distinguished from mortality and serious injury incidental to fisheries subject to Section 118. Further guidance on averaging human-caused mortality across years and across different sources of mortality can be found in the Technical Details section of these guidelines.

Because many stocks are subject to human caused mortality or serious injury that is unmonitored or not fully quantified, authors of the Reports should add a sub-section of the Human-Caused Mortality and Serious Injury section to include a summary of the most prevalent potential sources of human-caused mortality or serious injury that are not quantified (e.g., fisheries that have never

[2] In 2012, NMFS implemented a policy to distinguish serious from non-serious injuries (NOAA 2012). This policy and associated procedural directive detail the process by which NMFS evaluates injuries, documents that rationale, and reviews determinations.

been observed, or have not been observed recently, and ship strikes). If there are no major known sources of unquantifiable human-caused mortality or serious injury, this should be explicitly stated. Finally, a description of any additional key uncertainties concerning human-caused mortality or serious injury should be provided, along with an evaluation of the potential effects of these uncertainties on the mortality estimates.

Mortality Rates

Section 118 of the 1994 MMPA Amendments reaffirmed the goal set forth in the Act when it was enacted in 1972 that the take of marine mammals in commercial fisheries is to be reduced to insignificant levels approaching zero mortality and serious injury rate, and further requires that this goal be met within seven years of enactment of the 1994 Amendments (April 30, 2001). This fisheries-specific goal is referred to as the "zero mortality rate goal" (ZMRG). The Reports are not the vehicle for publishing determinations as to whether a specific fishery has achieved the ZMRG. A review of progress towards the ZMRG for all fisheries was submitted to Congress in August 2004.

However, Section 117 of the amended MMPA requires that Reports include descriptions of fisheries that interact with (i.e., kill or seriously injure) marine mammals, and these descriptions must contain "an analysis stating whether such level is insignificant and is approaching a zero mortality and serious injury rate." As a working definition for the Reports, this analysis should be based on whether the total mortality for a stock in all commercial fisheries with which it interacts is less than 10% of the calculated PBR for that stock. The following wording is recommended (typically in the "Status of Stock" section of the Report):

"The total fishery mortality and serious injury for this stock is (or is not) less than 10% of the calculated PBR and, therefore, can (or cannot) be considered to be insignificant and approaching a zero mortality and serious injury rate."

Status of Stocks

This section of the Reports should present a summary of four types of "status" of the stock: (1) current legal designation under the MMPA and ESA, (2) status relative to OSP (within OSP, below OSP, or unknown), (3) designation of strategic or non-strategic, and (4) a summary of trends in abundance and mortality. Based upon descriptions of levels of uncertainties from the Report sections on Stock Definition and Geographic Range, Elements of the PBR Formula, Population Trend, and Annual Human-Caused Mortality and Serious Injury, authors should evaluate and describe any consequences of these uncertainties on the assessment of the stock's status.

Stocks that have evidence suggesting at least a 50% decline, either based on previous abundance estimates or historical abundance estimated by back-calculation, should be noted in the Status of Stocks section as likely to be below OSP. The choice of 50% does not mean that the lower bound of a stock's OSP range is at 50% of historical numbers, but rather that a population below this level would be below OSP with high probability. However, without further analysis and completions of requirements laid out in Section 115, determination of stock status with regard to whether or not it is depleted (or, by extension, strategic based on depleted status) cannot be made. Similarly, a stock that has increased back to levels pre-dating the known decline may be within OSP; however, additional analyses may determine a population is within OSP prior to reaching historical levels.

Section 3(19) of the MMPA defines the term "strategic stock" as a marine mammal stock: (A) for which the level of direct human-caused mortality exceeds the potential biological removal level; (B) based on the best available scientific information, is declining and is likely to be listed as a threatened species under the Endangered Species Act of 1973 [16U.S.C. 1531 et seq.] within the foreseeable future; or (C) which is listed as a threatened species or endangered species under the ESA or is designated as depleted under the MMPA.

The MMPA requires a determination of a stock's status as being either strategic or non-strategic and does not include a category of unknown. If abundance or human-related mortality levels are truly unknown (or if the fishery-related mortality level is only available from self-reported data), some judgment will be required to make this determination. If the human-caused mortality is believed to be small relative to the stock size based on the best scientific judgment, the stock could be considered as non-strategic. If human-caused mortality is likely to be significant relative to stock size (e.g., greater than the annual production increment) the stock could be considered as strategic. Likewise, trend monitoring can help inform the process of determining strategic status.

The MMPA requires for strategic stocks a consideration of other factors that may be causing a decline or impeding recovery of the stock, including effects on marine mammal habitat and prey. In practice, interpretation of "other factors" may include lethal or non-lethal factors other than effects on habitat and prey. Therefore, such issues should be summarized in the Status of Stock section for all strategic stocks. If substantial issues regarding the habitat of the stock are important, a separate section titled "Habitat Issues" should be used. If data exist that indicate a problem, they should be summarized and included in the Report. If there are no known habitat issues or other factors causing a decline or impeding recovery, this should be stated in the Status of Stock section.

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2. Technical Details

In this section, technical details are given for making appropriate calculations of PBR and mortality. The first section provides details on precision and rounding issues. The second section provides details for combining more than one abundance estimate for calculating N_{min}. The third section contains details for calculating the estimate of annual human caused mortality and its associated variance.

Precision and Rounding

The following rules on precision and rounding should be applied when calculating PBR and other values:

(a) N (the abundance estimate), CV(N), R_{max}, and F_r should be reported in the Report to whatever precision is thought appropriate by the authors and involved scientists, so long as what is reported is exactly what the PBR calculation is based on.
(b) PBR should be calculated from the values for (a) to full precision, and not be calculated from an intermediary rounded off N_{min}. However, N_{min} should be reported as a rounded integer.
(c) PBR and mortality should be reported with one decimal place if they are below 10. Otherwise, PBR and mortality should be reported as a rounded integer.
(d) If PBR and mortality round to the same integer, the Report will report both values to the precision necessary to determine which is larger. This would also be done if 10% of PBR and mortality round to the same integer.

Computation of Average Abundance and its Variance

When estimates of abundance are available for more than one year or from more than one source in the same year, it may be appropriate to combine those estimates into an average abundance for the time period in question. It was agreed that a weighted mean was probably the most appropriate average to use, where the weights are equal to the inverse of the associated variance:

Error!

where:

$$w_i = \frac{1/var(a_i)}{\sum_{j=1}^{n} 1/var(a_j)} \quad .$$

The variance of a weighted mean of several abundance estimates is calculated as:

$$var(a) = w_1^2 var(a_1) + w_2^2 var(a_2) + ... w_2^2 var(a_n) = \sum_{i=1}^{n} w_i^2 var(a_i) \ .$$

Finally, the variance is parameterized as a CV in the provided equation for calculating N_{min}. The CV is calculated as:

$$CV(a) = \frac{\sqrt{var(a)}}{a}$$

Computation of Average Human-Caused Mortality and its Variance

When estimates of human-caused mortality and serious injury (called here "mortality") are available for more than one year and/or from more than one source, such as a fishery, it is necessary to calculate an estimate of the mean annual mortality along with its associated variance (or CV). The following section provides guidelines for doing this. For convenience, the section refers to averaging the incidental bycatch of fisheries, but the guidelines apply equally well to estimates of human-caused mortality from other sources.

<u>Calculating the overall mean annual bycatch</u>

First, it was agreed that it was most appropriate for the bycatch estimates from a fishery to be averaged UN-WEIGHTED across years, as the true bycatch might be different in each year, and thus is not stationary. This is just the simple average of the available estimates of bycatch. If estimates are available from more than one fishery, a mean annual bycatch from each fishery should be calculated first, and then the annual mean from each fishery should be summed to calculate an overall estimate of the mean annual bycatch.

<u>Calculating the coefficient of variation (CV) of the mean annual bycatch of a single fishery</u>

There are two potential methods for calculating the CV or variance of the mean annual bycatch of a single fishery. Method 1 involves using standard statistical formulas for combining the variances of the individual yearly bycatch estimates (assuming they are available). Method 2 involves estimating the variance empirically from the 2-5 years of point estimates of bycatch, which is done by calculating the standard deviation of the 2-5 mortality estimates and dividing it by the square root of *n*, where *n* is the number of years available. Both methods are valid. However, two points favor Method 1.

First, because the true bycatch might be different in each year, and thus is not stationary, estimating the variance using Method 2 above could over-estimate the true variance of the estimates of bycatch, and this positive bias would be related to how much the bycatch truly varied from year to year independent of observation error.

Second, Method 1 is likely to give a more precise estimate of the variance because it has more degrees of freedom. Using Method 2 involves estimating the variance from a sample size of just 2-5, and ignores the information that is known about the precision of each individual estimate.

Obviously, Method 2 is the only method that can be used if there are no estimates of the variance of the bycatch estimates available. Method 1 is the recommended method if the estimates of bycatch in each year do have an estimated variance (or CV).

<u>Method 1</u>
Table 1 outlines the computations needed for estimates of average bycatch mortality by *f* fisheries operating over *n* years. Table 2 gives an example computation for *f*=3 fisheries operating over a horizon of *n*=3 years and all of the estimates are non-zero. Most variance estimators will provide an estimate of 0 for the variance when the estimated mortality is zero; however, the true variance is non-zero. In this case, a more realistic estimate of the variance can be developed by averaging the variances for those years which have a positive variance. The variance computations in Table 1 are simply modified by dividing by the square of the number of years with a non-zero variance. The computation of the average is unaffected with the zero included in the average (Table 3). In certain circumstances a fishery may have been operating but was not monitored for mortality. Missing estimates should be dropped both from the calculation of the average and the variance (Table 4).

<u>Method 2</u>
In Method 2 the only change is in how the variance is calculated for the estimate of average bycatch mortality for each fishery over *n* years. In Method 2 the variance of the average bycatch is estimated empirically from the several point estimates of bycatch available from different years. This is done by calculating the variance of those estimates and dividing it by *n*, where *n* is the number of years used in calculating the average:

$$var(m_{i.}) = \frac{\sum_{j=1}^{n} \frac{(m_{ij}-m_{i.})^2}{n-1}}{n} \quad .$$

The above formula would thus be substituted for the formula for $var(m_{1.})$ presented in Table 1. The second step of combining variances across fisheries is identical to Method 1.

Table 1. Computation table for average mortality for *n* years with *f* fisheries. The mortality estimate for fishery *I* during year *j* is m_{ij} and the corresponding variance estimate is v_{ij}. The estimated total mortality for year *j* is $m_{.j}$, the sum of mortality estimates for each fishery and the variance is $v_{.j}$, the sum of the variances. The average mortality for fishery *I* is $m_{I.}$ and its variance is $vi_{.}$, which is the sum of the variances for each year within the fishery divided by the number of years (*n*) squared.

Fishery	Year 1	Year 2 ...	Year *n*	Average
1	m_{11} var(m_{11})	m_{12} var(m_{12})	m_{1n} var(m_{1n})	$m_{1.} = \sum_{j=1}^{n} m_{1j}/n \quad var(m_{1.}) = \sum_{j=1}^{n} var(m_{1j})/n^2$
2 . .	m_{21} var(m_{21})	m_{22} var(m_{22})	m_{2n} var(m_{2n})	$m_{2.} = \sum_{j=1}^{n} m_{2j}/n \quad var(m_{2.}) = \sum_{j=1}^{n} var(m_{2j})/n^2$
f	m_{f1} var(m_{f1})	m_{f2} var(m_{f2})	m_{fn} var(m_{fn})	$m_{f.} = \sum_{j=1}^{n} m_{fj}/n \quad var(m_{f.}) = \sum_{j=1}^{n} var(m_{fj})/n^2$
Total				$m_{..} = \sum_{i=1}^{f} m_{i.} \quad var(m_{..}) = \sum_{i=1}^{f} var(m_{i.})$

Table 2. Example computation of average mortality and its variance for 3 fisheries over 3 years.

		Year			
Fishery		**1**	**2**	**3**	**Average**
1	m	10	3	19	10.67
	v	4	2	8	1.56
2	m	2	13	6	7.00
	v	2	14	4	2.22
3	m	6	33	5	14.67
	v	8	23	4	3.89
Total	m				32.33
	v				7.67

Table 3. Example computation of average mortality and its variance for 3 fisheries over 3 years when some estimates are zero.

		Year			
Fishery		**1**	**2**	**3**	**Average**
1	m	10	0	19	9.67
	v	4	0	8	3.00
2	m	2	13	6	7.00
	v	2	14	4	2.22
3	m	0	0	5	1.67
	v	0	0	4	4.00
Total	m				18.33
	v				9.22

Table 4. Example computation of average mortality and its variance for 3 fisheries over 3 years when some estimates are zero and others are missing.

		Year			
Fishery		**1**	**2**	**3**	**Average**
1	m		0	19	9.50
	v		0	8	8.00
2	m	2		6	4.00
	v	2		4	1.50
3	m	0	0	5	1.67
	v	0	0	4	4.00
Total	m				15.17
	v				13.50

Guidelines for minimum observer sample size requirements
(Avoiding small-sample bias when PBR is small)

Table 6. Recommended data levels to attain approximately unbiased estimation of average annual fisheries-related mortality and serious injury, relative to PBR (i.e., if true annual bycatch = PBR) (from Moore and Merrick 2011). “Approximately unbiased” implies median absolute bias < 25%. The top table recommends minimum observer coverage (annual average), given a certain PBR and level of data pooling (years of information combined). The bottom table recommends minimum levels of data pooling, given a certain PBR and observer coverage. If true bycatch = PBR and sampling effort is below the recommended levels, *median* bias is always negative (i.e., true bycatch > estimate), but the combination of *very* limited sampling (≤5% coverage, ≤ 5 yrs data pooling) and *very* low bycatch (e.g., 1/yr) generates bimodal estimation bias, whereby bycatch is always either underestimated (if no bycatch is observed) or overestimated (if ≥ 1 bycatch event is observed).

	Observer program length (years)								
PBR	1	2	3	4	5	6	7	8	9
1	80%	40%	30%	30%	20%	15%	15%	10%	10%
2	40%	20%	15%	10%	10%	7.5%	7.5%	5%	5%
3	30%	15%	10%	7.5%	7.5%	5%	4%	4%	3%
4	20%	10%	7.5%	5%	4%	4%	3%	3%	3%
5	20%	7.5%	7.5%	4%	4%	3%	3%	2%	2%
6	15%	7.5%	5%	4%	3%	3%	2%	2%	2%
7	15%	7.5%	4%	3%	3%	2%	2%	2%	2%
8	10%	5%	4%	3%	2%	2%	2%	2%	2%
9	10%	5%	3%	3%	2%	2%	2%	2%	1%

Required observer coverage

	Observer coverage											
PBR	1%	2%	3%	4%	5%	7.5%	10%	15%	20%	30%	40 - 70%	80%
1	Always biased →						8	6	4	3	2	1
2	Always biased →				8	6	4	3	2	2	1	1
3	Always biased →		9	7	6	4	3	2	2	1	1	1
4	Always biased →		7	5	4	3	2	2	1	1	1	1
5	Always biased	8	6	4	4	3	2	2	1	1	1	1
6	Always biased	7	5	4	3	2	2	1	1	1	1	1
7	Always biased	6	4	3	3	2	2	1	1	1	1	1
8	Always biased	5	4	3	2	2	1	1	1	1	1	1
9	9	5	3	3	2	2	1	1	1	1	1	1

Required years of data pooling

3. Descriptions of U.S. Commercial Fisheries

Fisheries table in each stock assessment report

Sample incidental fisheries mortality table to be included in Reports. Each fishery noted as interacting with a stock should be included in the table, even if little information is available. Information on the number of incidental injuries and which injuries should be considered serious should be provided in either the table or the text, if appropriate. See discussion in 5.2 of Wade and Angliss (1997).

Table 7. Summary of incidental serious injury and mortality (SI/M) of stock ___ due to commercial fisheries from 1990 through 1994 and calculation of the mean annual SI/M rate. Mean annual SI/M in brackets represents a minimum estimate from logbooks or MMPA reports.

*Note -- numbers indicated with an asterisk are optional -- different preferences have been expressed in different regions.

Fishery Name [1]	Years	Data Type	Range of Observer Coverage	Observed SI/M (in given yrs.)	Estimated SI/M (in given yrs.)	Mean Annual SI/M
groundfish trawl fishery 1	90-94	obs data	53-74%	13, 13, 15, 4, 9	13, 19, 21, 6, 11	14 (0.32)
groundfish trawl fishery 2	90-94	obs data	33-55%	2, 0, 0, 1, 1	4, 0, 0, 3, 3	2 (0.24)
longline fishery 1	90-94	obs data	23-55%	1, 0, 0, 1, 0	2, 0, 0, 4, 1	1.4 (0.15)
drift gillnet fishery 1	90-91	obs data	4-5%	0, 2	0, 29	14.5 (0.42)
Observer program total						31.9 (0.xx)
set gillnet fishery 1	90-93	log book	n/a	0, 1, 1, 1	n/a	[≥.75]*
set gillnet fishery 2	90-93	log book	n/a	0, 0, 0, 2	n/a	[≥.5]*
longline fishery 2	94	mmap reports	n/a	1	n/a	[≥ 1]*
Minimum total annual mortality						≥ 34.2*

[1]The name should be consistent with fishery names in the List of Fisheries.

General information about a fishery (not stock-specific)

Information to provide

As discussed at the GAMMS workshop, information on U.S. commercial fisheries should be included either within each Report, as an appendix, or as a companion document. Information on U.S. commercial fisheries was collected during the preparation of the Environmental Assessment for the proposed regulations implementing Section 118 (NMFS, 1994). The following information, which was provided for each fishery whenever possible, has direct relevance to managing incidental serious injuries and mortalities of marine mammals:

Fishery name: A description of those fisheries that are classified in Category I or II in the LOF, and those fisheries in Category III that have experienced incidental mortality and serious injury of marine mammals should be provided. The Category of the fishery in the List of Fisheries should be specified in the text.

Number of permit holders: NMFS is required by the MMPA to provide the number of permit holders in each fishery included in the List of Fisheries. Information on the number of permit holders in federal fisheries can often be found in recent amendments to Fishery Management Plans. Information on fisheries that occur within state waters but are managed via an interstate commission may be found in interstate fishery management plans. Information on state fisheries that are managed by individual states can typically be found by contacting the state office responsible for licensing commercial fishing vessels.

Number of active permit holders: Because not all licensed commercial fishers participate actively in each fishery, the number of active permit holders may be different than the number of actual permit holders in a fishery. This is particularly true for fisheries that operate in state waters.

Total effort: Provide an estimate of the total fishing effort, in the number of hours fished, for each fishery. This information is typically available only for fisheries that are both federally managed and observed.

Geographic range: Provide a description of the geographic range of the fishery. The description of the geographic range of the fishery should include any major seasonal changes in the distribution of the fishing effort.

Seasons: Describe the seasons during which the fishery operates.

Gear type: Describe the gear type used in the fishery as specifically as possible. Include mesh size, soak duration, trawl type, depth of water typically fished, etc. if the information is available.

Regulations: Indicate whether the fishery is managed through regulations issued by the federal government, interstate fishery commissions, individual states, or treaty.

Management type: Indicate what types of fishery management techniques are used to manage the fishery. Some examples include limited entry, seasonal closures, and gear restrictions.

Comments: Include any additional relevant information on the fishery.

4. Additional Recommendations of the GAMMS III Workshop

The following recommendations were made by the participants of the GAMMS III Workshop:

(1) In order to provide the kind of information that is required to answer the question "is it plausible that there are multiple demographically independent population stocks (DIPS) within this stock?" (in the revised Definition of Stock section), it is recommended that a national workshop be held to review and summarize information that is relevant to population structure. The workshop should include participation from Headquarters and all Centers and Regions, at a minimum. It is unlikely that the workshop could feasibly review all stocks in all areas. Therefore, a list of priority stocks for consideration should be established prior to the workshop. This might efficiently be done by a Steering Committee with stocks to be reviewed proposed from each region. Stocks should be selected to cover a broad range of geographic and taxonomic diversity (e.g., it might be appropriate to review at least one stock each of phocids, otariids, large whales, delphinids, phocoenids, and ziphiids in each region (if presently recognized). Priority should be given to stocks that are geographically large, span multiple bioregions, or potentially experience substantial human-caused mortality in a portion of their range. It would also be appropriate to examine areas of U.S. waters where stocks have not previously been defined (e.g., Guam, Caribbean). The information to be reviewed should include (at least) all information used for defining stocks as recommended in the Guidelines. This includes distribution and movements, acoustic call types, population trends, morphological differences, differences in life history, genetic differences, contaminants and natural isotope loads, parasite differences, and oceanographic habitat differences (such as marine bioregions). It should be emphasized that the purpose of the workshop is to review and summarize relevant information. As possible and appropriate, the workshop will propose revisions to stock structure. A major objective will be to review the information for these stocks in a manner to provide a template for how to complete review of all stocks in each region.

(2) To recognize that the population dynamics of some stocks (such as Cook Inlet beluga and Hawaiian monk seal) may not conform with the underlying assumptions on which the PBR calculation is based (relevant "PBR elements" section of the guidelines), it was recommended that the next administration MMPA reauthorization bill include the explicit option for setting R_{max} (or F_r) to zero in appropriate cases.

(3) A list of regional and F/PR points-of-contact should be created, in order to implement recommendations of Topics 5 and 9 of the GAMMS III workshop pertaining to the timely annual transmission of information on non-serious injury, serious injury, and or death reported under LOAs and IHAs from F/PR to Regional Offices and Science Centers (including to Report authors).

5. Overview of changes from the 2005 Guidelines

The following additions have been made:

- In the stock assessment report (SAR) sections of the Reports on Stock Definition and Geographic Range, elements of the PBR formula, Population Trend, and Annual Human-caused Mortality and Serious Injury, authors are to provide a description of key uncertainties in each element and evaluate their effects;
- Acoustic call type was added as a type of information that can be used to identify stocks;
- Each SAR will state in the Stock Definition and Geographic Range section whether it is plausible the stock contains multiple demographically independent populations that should be separate stocks, along with a brief rationale;
- Informed interpolation may be used to fill gaps in survey coverage;
- A summary of all human-caused mortality should be included in SARs;
- Text regarding avoiding small sample bias was added;
- For mixed stocks, apportion takes among stocks where possible; otherwise, apply take to each stock in area;
- Direction regarding reporting of mortality and serious injury;
- Stocks that have evidence suggesting at least a 50% decline should be noted in the Status of Stocks section as likely to be below their optimum sustainable population level;
- Trend modeling may be used to determine stock status;
- "Other factors" leading to decline or impeding recovery should be considered, including non-lethal factors;
- Added guidelines for minimum observer sample size requirements; and
- Added section on population trends

The following deletions have been made:

- Removed "undetermined" PBR for unusual cases such as Hawaiian monk seal; instead, calculate PBR if possible and qualify in the report;
- Removed statement that default stock status should be strategic; and
- Removed "sources of information on U.S. commercial fisheries" section

The following changes to text/guidance have been made:

- "Demographic isolation" was changed to "demographic independence" and "reproductive isolation" was changed to "reproductive independence";
- Updated the reference section; and
- Replaced the recommendations from the GAMMS II workshop with recommendations from GAMMS III workshop

SC/A17/GW/07

Estimates of Eastern North Pacific Gray Whale Calf Production 1994-2016

Wayne L. Perryman, David W. Weller, John W. Durban

INTERNATIONAL WHALING COMMISSION

Estimates of Eastern North Pacific Gray Whale Calf Production 1994-2016

Wayne L. Perryman, David W. Weller, John W. Durban

Marine Mammal and Turtle Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 8901 La Jolla Shores Dr., La Jolla, CA 92037, USA.

Contact e-mail: wayne.perryman@noaa.gov

ABSTRACT

Shore based surveys of northbound eastern North Pacific gray whale calves were conducted between March and June from the Piedras Blancas Light Station on the central California coast each year from 1994-2016. Estimates of the total number of northbound calves displayed a high degree of inter-annual variability, ranging from 254 calves in 2010 to 1528 calves in 2004. Calf production has been particularly high during the past 5 years (2012-2016) with a total of >6,500 calves estimated during this period, including four of the highest years of calf production (>1,000 calves per year) since our calf counts began in 1994. The 2016 estimate of calf production (1,351) is about 5% of the reported total abundance (26,960) for the eastern North Pacific population. A trend in median migration dates was observed, indicating that the midpoint of the migration is now occurring about a week later than it did in the mid-1990s. The 23-year data set described herein serves as an excellent foundation upon which to examine the inter-play between changing environmental conditions and gray whale population dynamics.

INTRODUCTION

The majority of Eastern North Pacific gray whales *(Eschrichtius robustus)* annually migrate southward from summer feeding grounds in the Pacific Arctic to wintering areas off Baja California, Mexico (Rice and Wolman 1971, Perryman and Lynn 2002). Both the southward and northward migration is segregated, to a large extent, by age, sex and reproductive condition. During the northward migration, females with their calves of the year are the last to depart the Baja wintering areas. These mother-calf pairs are observed on the migration route between March and May and typically arrive to the summer feeding grounds between May and June.

Shore-based counts of northbound gray whale calves have been conducted off central California each spring from 1994 to 2016. This report presents an overview of results from this 23-year time series of estimates of gray whale calf production.

METHODS

Shore-based counts of northbound gray whale calves have been conducted from the Piedras Blancas Light Station (north of San Simeon, California) each spring from 1994 to 2016. Data collection methods and analytical techniques have remained consistent each year and follow those reported elsewhere (see Perryman *et al*. 2002, 2011). Briefly, counts were conducted by four observers, with two on effort at any one time, rotating through the following schedule: (a) 90-min on effort as the offshore search area observer, (b) 90-min on effort as the inshore search area observer, (c) 3-hr off effort. Weather permitting, this work was carried out for 12 hours per day; 6 days per week in 1994-2003 and 2005 and 5 days per week in 2004 and 2006-2016. Primary search effort was carried out with unaided eye but 7x50 and 25x150 binoculars were also used when needed.

Based on night/day migration rate data derived from thermal sensors (1994-1996) and aerial surveys (1994-1995) to determine offshore distribution (Perryman *et al*. 2002), we assumed that: (1) the number of gray whale calves passing the survey site far enough offshore to be undetectable by visual observers was negligible, and (2) day and night passage rates were equivalent. We also assumed that detection probabilities were the same across acceptable sighting conditions (see Reilly *et al*. 1983; Reilly 1992). To correct for imperfect probability of detection of calves by the visual observers, we corrected the observer estimates of northbound calves by the average detection probability estimates from seven consecutive years (1994-2000) of replicate counts (mean = 0.889; SE = 0.06375).

Each day of survey effort was divided into four 3-hr periods and passage rates during these periods were calculated from the observed counts multiplied by the inverse of the detection function. To correct for periods when observers were not on watch (e.g. poor weather, night time, days off), we embedded the estimators in a finite population model that was stratified by week to account for varying passage rates (Cochran 1977). A Taylor series expansion (Seber 1982) was used to calculate the variance of the estimates.

RESULTS

Estimates of the total number of northbound calves showed a high degree of inter-annual variability, ranging from 254 calves in 2010 to 1528 calves in 2004 (Table 1). Calf production has been particularly high during the past 5 years (2012-2016) with a total of >6,500 calves estimated during this period, including four of the highest years of calf production (>1,000 calves per year) since our calf counts began in 1994 (Fig. 1). The 2016 estimate of calf production (1,351) is about 5% of the reported total abundance (26,960; Durban et al. SC/67a) for the eastern North Pacific population in 2016.

A trend in median migration dates was observed in the time series, indicating that the midpoint of the migration is now occurring about a week later than it did in the mid-1990s. The slope of the migration timing is significant ($F = 6.030$, $p = 0.023$) if the outlier from 1999, the first year of an unusual mortality event for the eastern North Pacific population, is deleted from the data set (Fig. 2).

DISCUSSION

During the 23-year time series reported here, estimates of gray whale calves displayed a high degree of inter-annual variability. Based on data from 1994 to 2000, Perryman *et al*. (2002) suggested that the reliance of female gray whales on stored fat resources during pregnancy combined with sea ice regulated access to food during the beginning of a feeding season may impact their ability to carry existing pregnancies to term. When these calf estimates were examined in the context of environmental data from the northern Bering Sea, a relationship was found between the timing of seasonal ice melt and estimates of northbound gray whale calves counted the following spring. In heavy ice years, when ice extends far to the south, the temporary lack of access to foraging areas appears to have a negative impact on calf production.

The particularly high calf production observed during the past 5 years (2012-2016), including four years of the highest calf production recorded (>1,000 calves per year) since our counts began in 1994 suggests that gray whales have been experiencing a period of favorable feeding conditions in the Arctic, possibly related due to the combination of expanding ice-free habitat (Moore 2016), increased primary production (Arrigo and Dijken 2015) and increased flow of nutrient-rich waters through the Bering Strait (Woodgate *et al*. 2012). This hypothesis is further supported by the recent (2014/2015 and 2015/2016) increase in abundance of the eastern North Pacific gray whale population (Durban et al. SC/67a)

The trend in median migration dates reported here, indicating that the midpoint of the migration is now occurring about a week later than it did in the mid-1990s, is analogous to the finding of a one week delay in annual mean sighting dates of southbound whales migrating past Granite Canyon, California (Rugh *et al*. 2001). While the impacts of climate change in the Arctic environment are far from being understood, this change in migratory timing of gray whales may reflect a response to shifting habitat parameters on the summer feeding grounds. In the short term, changes in the Arctic environment may represent "boom time" for baleen whales as suggested by Moore (2016).

ACKNOWLEDGEMENTS

Our shore-based surveys of gray whales conducted from the Piedras Blancas Light Station would not be possible without the support and hospitality provided by U.S. Department of Interior, Bureau of Land Management. We are particularly indebted to the support provided by John Bogacki, Jim Boucher and Ryan Cooper. A long list of talented field biologists contributed to this study but the contribution of Richard Rowlett, Susan Chivers and Morgan Lynn stand out as exceptional. The support of NOAA Fisheries and the International Whaling Commission has been a critical component of this research.

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Table 1. Survey summary information and annual estimates of calves 1994-2016.

Year	Effort (hrs)	Calf Count	Calf Estimate	SE
1994	671	325	945	68.21
1995	610	194	619	37.19
1996	694	407	1146	70.67
1997	709	501	1431	82.02
1998	554	440	1388	94.84
1999	737	141	427	41.10
2000	704	96	279	34.79
2001	722	87	256	28.56
2002	711	302	842	78.60
2003	686	269	774	73.56
2004	562	456	1528	96.00
2005	669	343	945	86.90
2006	531	285	1020	103.30
2007	469	117	404	51.20
2008	498	171	553	53.11
2009	476	86	312	41.93
2010	487	71	254	33.94
2011	500	246	858	86.17
2012	435	330	1167	120.29
2013	483	311	1122	104.14
2014	529	429	1487	133.35
2015	522	404	1436	131.01
2016	436	367	1351	121.38

Figure 1. Estimates of Eastern North Pacific gray whale calf production 1994-2016.

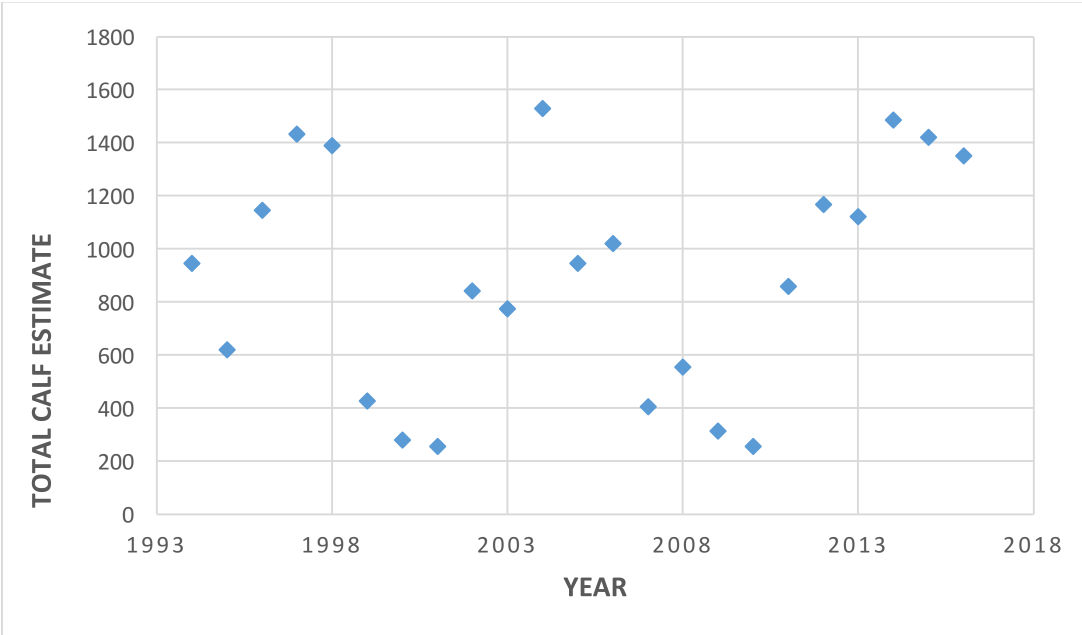
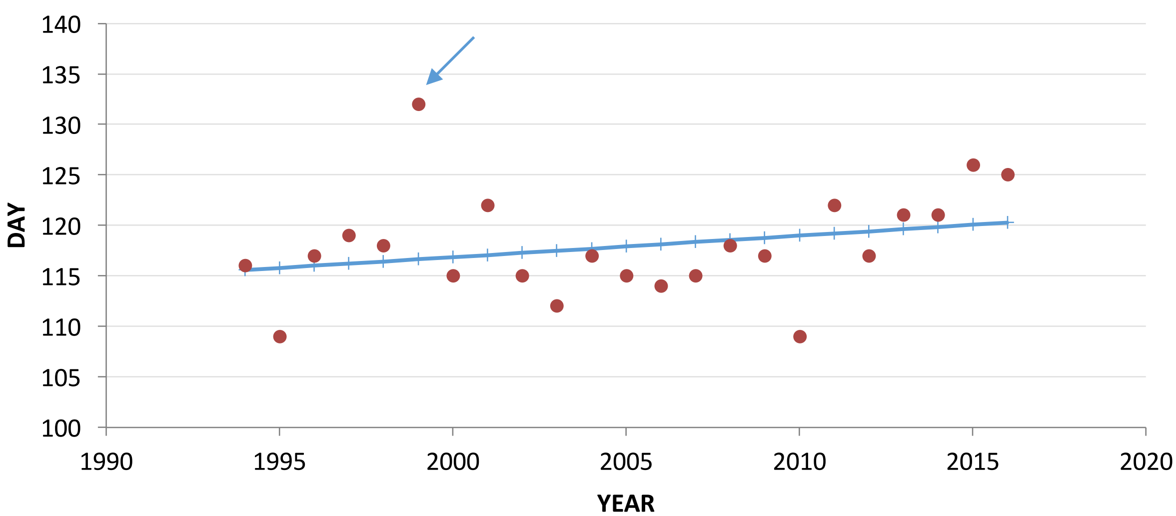


Figure 2. Annual median migration dates of northbound gray whale calves 1994-2016. Slope of linear regression is significant if 1999 point deleted (see arrow).



Annex R
A Full Description of the Standard BALEEN II Model and Some Variants Thereof

A.E. Punt

Division of Marine Research, CSIRO Marine Laboratories, GPO Box 1538, Hobart, Tas 7001, Australia

ABSTRACT

A full mathematical description of the BALEEN II population dynamics model is provided. The specifications required for alternative parameterisations of this model and to initiate projections when the population is not at its pre-exploitation equilibrium are also listed. Some new insights into the implications of different definitions for the yield curve are provided.

INTRODUCTION

The Hitter-Fitter package (de la Mare, 1989; Punt and Butterworth, 1991; de la Mare and Cooke, 1992; Punt, 1996) has been used in the assessments of a number of whale stocks (e.g. IWC, 1991a; b; Butterworth and Punt, 1992a). The BALEEN II population dynamics model underlying this package is age- and sex-structured, and can take age-specific recruitment and maturation ogives into account. Both maximum likelihood (e.g. Butterworth and Punt, 1992a) and Bayesian estimators (e.g. Givens *et al.*, 1993; 1995) have been used to estimate the parameters of this population model.

This paper provides a full description of the BALEEN II population dynamics model[1]. It also describes the implementation details of a subset of the various possible parameterisations of the model (primarily those related to the assessment of the Bering-Chukchi-Beaufort (B-C-B) Seas stock of bowhead whales), provides full specifications for the case in which the population projection does not start at pre-exploitation equilibrium, lists the specifications of the output from the model, and contrasts a variety of ways of defining *MSYL* and *MSYR* in terms of population components other than that from which harvests are removed (i.e. other than the 'recruited'[2] component of the population as modelled).

THE BALEEN II POPULATION DYNAMICS MODEL

Basic dynamics

BALEEN II is age- and sex-structured, and considers animals as being either 'recruited' or 'unrecruited'. It assumes that all whaling takes place at the start of the year, and that all animals are 'recruited' (and have reached the age at first parturition) by age $x - 1$. The dynamics of the population are assumed to be governed by the equations:

$$N^s_{t+1,a} = \begin{cases} 0.5\,\alpha^s_0\,P^{\mathrm{M,f}}_{t+1}\,f_{t+1} & \text{if } a = 0 \\ N^s_{t,a-1}(1-F^s_{\mathrm{r},t,a-1})S^s_{a-1} \\ \quad + U^s_{t,a-1}(1-F^s_{\mathrm{u},t})\,S^s_{a-1}\,\delta^s_a & \text{if } 1 \le a \le x-1 \\ N^s_{t,x}(1-F^s_{\mathrm{r},t,x})S^s_x \\ \quad + N^s_{t,x-1}(1-F^s_{\mathrm{r},t,x-1})S^s_{x-1} & \text{if } a = x \end{cases} \tag{1}$$

$$U^s_{t+1,a} = \begin{cases} 0.5(1-\alpha^s_0)P^{\mathrm{M,f}}_{t+1}\,f_{t+1} & \text{if } a = 0 \\ U^s_{t,a-1}(1-F^s_{\mathrm{u},t})\,S^s_{a-1}(1-\delta^s_a) & \text{if } 1 \le a \le x-2 \end{cases} \tag{2}$$

where

$N^s_{t,a}$ is the number of 'recruited' animals of age a and sex s (m/f) at the start of year t,

$U^s_{t,a}$ is the number of 'unrecruited' animals of age a and sex s at the start of year t,

δ^s_a is the proportion of 'unrecruited' animals of sex s and age a-1 which recruit at age a,

S^s_a is the annual survival rate of animals of sex s and age a, and is equal to $\exp(-M^s_a)$

where M^s_a is the instantaneous rate of natural mortality on animals of sex s and age a,

$F^s_{\mathrm{r},t,a}$ is the exploitation rate on 'recruited' animals of sex s and age a during year t,

$F^s_{\mathrm{u},t}$ is the exploitation rate (uniform over age) on 'unrecruited' animals of sex s during year t,

α^s_a is the proportion of animals of sex s and age a which would be 'recruited' if the population were at pre-exploitation equilibrium,

$P^{\mathrm{M,f}}_t$ is the number of females that have reached the age at first parturition by the start of year t,

f_t is pregnancy rate (number of calves per 'mature' female) during year t (note that Equations (1) and (2) assume an equal male : female sex ratio at birth), and

x is the maximum (lumped) age-class.

Note that in the interests of generalisation, f_t is defined as in Punt (1996), which differs from convention in some earlier papers (de la Mare, 1989; Punt and Butterworth, 1991; de la

[1] W.K. de la Mare wrote the core code for BALEEN II for the Hitter-Fitter package.

[2] 'Recruited' and 'unrecruited' are placed in quotes because there are cases in which some of the catch is taken from the 'unrecruited' component of the population because the catch exceeds the size of the 'recruited' component of the population.

Mare and Cooke, 1992) in that it applies to both sexes born rather than to females only. Note also that the convention of referring to $P_t^{M,f}$ as the 'mature' female component of the population is used here, although it actually refers to animals no younger than their true age-at-maturity plus the gestation period, which is assumed to be one year. The survival rate S is assumed to depend on sex and age but to be independent of time. Punt (1996) provides a description of an extension to the BALEEN II model that allows for the possibility of density-dependent natural mortality and Punt and Butterworth (1996) include assessments of the B-C-B bowhead stock under the assumption that density-dependence impacts natural mortality rather than fecundity.

The possibility that age 0 animals (calves) are 'recruited' is allowed. However, for most applications (including the assessment of the B-C-B bowhead stock), the value of α_0^s is set equal to zero[3]. The values of $U_{t,x-1}^s$ and $U_{t,x}^s$ are not defined by Equation (2) because it is assumed that all animals of ages x-1 and x are 'recruited' (i.e. $\alpha_{x-1}^s = \alpha_x^s = 1$).

Density dependence

Density dependence on fecundity can be modelled by writing the pregnancy rate, f_t, as follows:

$$f_t = \max\left(f_{eq}\left[1+A\left\{1-\left(P_t^D / K_t^D\right)^z\right\}\right],0\right) \qquad (3)$$

where f_{eq} is the pregnancy rate at the pre-exploitation equilibrium, $f(0)$[4]:

$$f(F) = 2\left\{\sum_{a=\text{mat}_{\min}}^{x} \beta_a\left[\tilde{N}_a^f(F)+\tilde{U}_a^f(F)\right]\right\}^{-1} \qquad (4)$$

A is the resilience parameter:

$$A = \frac{f_{\max} - f_{eq}}{f_{eq}} \qquad (5)$$

$f_{\max}$ is the maximum (theoretical) pregnancy rate,

z is the degree of compensation,

P_t^D is the size, at the start of year t, of the component of the population to which density dependence is functionally related (either total (1+) population size, P_t^{1+}, 'recruited' population size[5], $P_b^{E'}$, or the number of females that have reached the age at first parturition $P_t^{M,f}$:

$$P_t^{1+} = \sum_s \sum_{a=1}^{x}\left(N_{t,a}^s + U_{t,a}^s\right) \qquad (6a)$$

$$P_t^E = \sum_s \sum_{a=1}^{x} N_{t,a}^s \qquad (6b)$$

$$P_t^{M,s} = \sum_{a=\text{mat}_{\min}}^{x} \beta_a (N_{t,a}^s + U_{t,a}^s) \qquad (6c)$$

$\text{mat}_{\min}$ is the lowest age that a female can reach first parturition (constrained to be at least 2),

β_a is the fraction of females of age a which have reached the age at first parturition,

K_t^D is the pre-exploitation equilibrium size (carrying capacity) at the start of year t of the component of the population to which density dependence is functionally related,

$\tilde{N}_a^s(F)$ is the number of animals of sex s and age a that are 'recruited' when the exploitation rate is fixed at F, expressed as a fraction of the number of calves of the same sex s (see Appendix 1), and

$\tilde{U}_a^s(F)$ is the number of animals of sex s and age a that are 'unrecruited' when the exploitation rate is fixed at F, expressed as a fraction of the number of calves of the same sex s.

Note that although these equations are written formally as if only the pregnancy rate component of 'fecundity' as defined here is density-dependent, exactly the same equations follow if some or all of this dependence occurs in the infant survival rate. Note that the dependence of K^D on t allows for the possibility that carrying capacity has varied over time. Butterworth *et al.* (1990) examine the implications of changes in carrying capacity for the assessment of the Eastern North Pacific gray whale.

Catches

BALEEN II allows for two series of sex-specific catches. One series of catches is taken uniformly from the 'recruited' component of the population while the other series is taken uniformly from the component of the population that is both 'recruited' and 'mature', which is termed 'mature-recruited' below. The equations which define $F_{r,t,a}^s$ and $F_{u,t}^s$ depend upon which of four cases applies. Of the four cases, Case 1 represents the normal situation; Cases 2 - 4 cover situations in which the catch in a given year exceeds the size of the component of the population from which it is assumed to be taken.

Case 1 - The total catch is less than the total number of 'recruited' animals and the 'mature-recruited' catch is less than the number of 'mature' animals (after the catch of 'recruited' animals is removed) (i.e. $C_t^{E,s} + C_t^{M,s} < P_t^{E,s}$ and $C_t^{M,s} < P_t^{M,s}(1 - C_t^{E,s}/P_t^{E,s})$). For this case, the catch can be taken as desired:

$$F_{r,t,a}^s = C_t^{E,s} / P_t^{E,s} + \beta_a C_t^{M,s} / P_t^{M,s}$$

$$F_{u,t}^s = 0 \qquad (7a)$$

where

$C_t^{E,s}$ is the total catch of animals of sex s during year t taken uniformly from the 'recruited' component of the population,

$C_t^{M,S}$ is the total catch of animals of sex s during year t taken uniformly from the 'mature-recruited' component of the population[6], and

$P_t^{E,s}$ is the total number of 'recruited' animals of sex s at the start of year t:

$$P_t^{E,s} = \sum_{a=0}^{x} N_{t,a}^s \qquad (8)$$

To understand Equation (7a) further, consider the sum over all age-classes of the product of the number of recruited animals and the exploitation rate:

[3] The current Baleen II software actually prohibits age 0 animals from being 'recruited'.

[4] The pregnancy rate at the pre-exploitation equilibrium can be considered to be the equilibrium pregnancy rate when the exploitation rate, F, is fixed at zero.

[5] The contribution of 'recruited' animals of age 0 to Equation (6b) is ignored to avoid the need for solving a non-linear equation for the number of births.

[6] The calculation of the exploitation rate assumes that all 'mature' animals are 'recruited'.

$$\sum_{a=0}^{x} F^s_{r,t,a} N^s_{t,a} = \sum_{a=0}^{x} (C^{E,s}_t / P^{E,s}_t + \beta_a C^{M,s}_t / P^{M,s}_t) N^s_{t,a} =$$

$$\frac{C^{E,s}_t}{P^{E,s}_t} \sum_{a=0}^{x} N^s_{t,a} + \frac{C^{M,s}_t}{P^{M,s}_t} \sum_{a=0}^{x} \beta_a N^s_{t,a} = C^{E,s}_t + C^{M,s}_t$$

Case 2 - The total catch is less than the total number of 'recruited' animals but the 'mature-recruited' catch is greater than the number of 'mature' animals (after the catch of 'recruited' animals is removed) (i.e. $C^{E,s}_t + C^{M,s}_t < P^{E,s}_t$ and $C^{M,s}_t > P^{M,s}_t(1 - C^{E,s}_t/P^{E,s}_t)$). For this case, the total catch is assumed to be removed uniformly from the 'recruited' component of the population:

$$F^s_{r,t,a} = (C^{E,s}_t + C^{M,s}_t) / P^{E,s}_t$$
$$F^s_{u,t} = 0 \qquad (7b)$$

Case 3 - The total catch is greater than the total number of 'recruited' animals but is less than the total (0+) population size (i.e. $C^{E,s}_t + C^{M,s}_t > P^{E,s}_t$ and $C^{E,s}_t + C^{M,s}_t < P^{T,s}_t$). For this case, the 'recruited' component is extirpated and the difference between the total catch and the size of 'recruited' component of the population is removed with uniform selectivity from the 'unrecruited' component of the population:

$$F^s_{r,t,a} = 1$$
$$F^s_{u,t} = (C^{E,s}_t + C^{M,s}_t - P^{E,s}_t) / (P^{T,s}_t - P^{E,s}_t) \qquad (7c)$$

where $P^{T,s}_t$ is the size of the total (0+) component of the population for sex s:

$$P^{T,s}_t = \sum_{a=0}^{x} (N^s_{t,a} + U^s_{t,a}) \qquad (9)$$

Case 4 - The total catch is greater than the total (0+) population size (i.e. $C^{E,s}_t + C^{M,s}_t > P^{T,s}_t$). For this case, the entire population (both 'recruited' and 'unrecruited' components) is extirpated:

$$F^s_{r,t,a} = 1$$
$$F^s_{u,t} = 1 \qquad (7d)$$

These equations are based on the assumption that the harvest occurs in a pulse at the start of the year (before natural mortality). It would be straightforward to generalise Equation (7) to allow the harvest to occur at any time during the year.

Recruitment and maturity

The fraction of 'unrecruited' animals of sex s and age a which 'recruit' at age a+1, α^s_{a+1}, is given by:

$$\alpha^s_{a+1} = \begin{cases} (\alpha^s_{a+1} - \alpha^s_a)/(1-\alpha^s_a) & \text{if } \alpha^s_a < 1 \\ 1 & \text{if } \alpha^s_a = 1 \end{cases} \qquad (10)$$

where α^s_a is the proportion of animals of sex s and age a which would be 'recruited' if the population were at pre-exploitation equilibrium:

$$\alpha^s_a = \begin{cases} 0 & \text{if } a < \text{rec}_{\min} \\ \left[1+\exp\{-(a-r^s_{50})/\sigma^s_r\}\right]^{-1} & \text{if rec}_{\min} \le a \le x-2 \\ 1 & \text{if } a \ge x-1 \end{cases} \qquad (11)$$

r^s_{50} is the age at 50% recruitment for animals of sex s,

σ^s_r is the parameter which determines the width of the recruitment ogive for animals of sex s[7], and

$\text{rec}_{\min}$ is the lowest age at which an animal may be 'recruited'.

The component of the population which may reproduce in a given year is the females that have reached the age at first parturition; this is the age at sexual maturity plus the gestation period (taken in BALEEN II to be one year). The proportion of females of age a which have reached the age at first parturition is given by:

$$\beta_a = \begin{cases} 0 & \text{if } a < \text{mat}_{\min} \\ \left[1+\exp\{-(a-p_{50})/\sigma_p\}\right]^{-1} & \text{if mat}_{\min} \le a \le x-2 \\ 1 & \text{if } a \ge x-1 \end{cases} \qquad (12)$$

where p_{50} is the age at 50% maturity plus one year, and σ_p is the parameter which determines the width of the maturation ogive.

Initial conditions

The population is assumed either to be at pre-exploitation equilibrium or to have a stable age-structure at the start of the projection period (year $t_{\rm INIT}$). For the former case, a value for $K^E_{t_{INIT}}$, the pre-exploitation equilibrium size of the 'recruited' component of the population at the start of year $t_{\rm INIT}$, is used to calculate the numbers at each age[8]:

$$U^s_{t_{INIT},a} = K^E_{t_{INIT}} \tilde{U}^s_a(0) / \sum_{s'} \sum_{a'=0}^{x} \tilde{N}^{s'}_{a'}(0)$$
$$N^s_{t_{INIT},a} = K^E_{t_{INIT}} \tilde{N}^s_a(0) / \sum_{s'} \sum_{a'=0}^{x} \tilde{N}^{s'}_{a'}(0) \qquad (13)$$

For the case in which the population is assumed to have a stable age structure (corresponding to uniform harvesting on the 0+ population[9]) at the start of year t_{INIT}, the numbers at each age are given by:

$$U^s_{t_{INIT},a} = N^E_{t_{INIT}} \tilde{U}^s_a(F_{INIT}) / \sum_{s'} \sum_{a'=0}^{x} \tilde{N}^{s'}_{a'}(F_{INIT})$$
$$N^s_{t_{INIT},a} = N^E_{t_{INIT}} \tilde{N}^s_a(F_{INIT}) / \sum_{s'} \sum_{a'=0}^{x} \tilde{N}^{s'}_{a'}(F_{INIT}) \qquad (14)$$

where $N^E_{t_{INIT}}$ is the size of the 'recruited' component of the population at the start of year t_{INIT}.

The value of F_{INIT} is selected numerically so that:

$$N^E_{t_{INIT}} = 0.5 N_0(F_{INIT}) \sum_{s} \sum_{a=0}^{x} \tilde{N}^s_a(F_{INIT}) \; ^{10} \qquad (15)$$

where $N_0(F_{INIT})$ is the number of calves (of both sexes) at the start of the year when $F = F_{INIT}$ (Appendix 2 for a derivation):

$$N_0(F_{INIT}) = \left(1 - \frac{1}{A}\left[\frac{f(F_{INIT})}{f_{\rm eq}} - 1\right]\right)^{1/z} \frac{K^D_{t_{INIT}}}{\tilde{P}^D(F_{INIT})} \qquad (16)$$

$\tilde{P}^D(F)$ is the size of the component of the population to which density dependence is functionally related as a function of F (either the total (1+) population size, the 'recruited'

[7] BALEEN II allows for the possibility that recruitment (and maturity) are knife-edged functions of age (i.e. $\sigma^s_r \to 0 (\sigma_p \to 0)$).

[8] Equation (13) is based on $K^E_{t_{INIT}}$ rather than, say, the pre-exploitation equilibrium size of the total population because $K^E_{t_{INIT}}$ is the parameter which for which a value is specified/estimated in the Hitter-Fitter package.

[9] The stable age-structure applies to the 0+ component of the population because F_{INIT} should be considered to be an increase rate rather than an exploitation rate.

[10] The 0.5 is needed to correct for the equations in Appendix 1 being defined in terms of one animal of each sex at birth.

population size, or the number of females that have reached the age at first parturition), expressed as a fraction of the number of calves (of both sexes).

The value for K^D_{tINIT} needed to apply Equation (16) is computed straightforwardly from K^E_{tINIT}. This calculation does not involve the values for the parameters that determine the extent of density dependence (*A* and *z*).

Determination of the resilience and degree of compensation parameters

The values of the parameters *A* and *z* are obtained by assigning values to the quantities *MSYL* and *MSYR*, and then solving the set of equations relating these quantities to *z* and *A*. *MSYL* and *MSYR* may be chosen to refer either to the 'recruited' component of the population, that component which has reached the age at first parturition (the 'mature' component), or the 1+ population with uniform selectivity harvesting. Sex-structure is ignored when calculating the resilience and degree of compensation from *MSYR* and *MSYL*. The recruitment ogive and the age-specific natural mortality rates for females are thus assumed to apply to both sexes for the purposes of this calculation. In reality, male and female recruitment ogives will not always be identical which will lead to some error in evaluating *A* and *z* (and hence *MSY*).

The (normalised) sustainable yield as a function of the exploitation rate, *C*(*F*), is given by:

$$C(F) = F\,P(F) = F\,B(F)\,\tilde{P}(F) \qquad (17)$$

where *P*(*F*) is the equilibrium number of 'recruited' animals when the exploitation rate is fixed at *F* (either the number of animals defined by the female recruitment ogive, the number which have reached the age at first parturition, or the number of age 1+ animals),

B(*F*) is the normalised number of births when the exploitation rate is fixed at *F*, and

$\tilde{P}(F)$ is the number of 'recruited' animals per birth when the exploitation rate is fixed at *F*.

The normalisation is provided by dividing by the number of births at pre-exploitation equilibrium.

For *MSY*:

$$\left.\frac{dC}{dF}\right|_{F=F_{MSY}} = \left.\frac{d\{F\,B(F)\tilde{P}(F)\}}{dF}\right|_{F=F_{MSY}} = 0 \qquad (18)$$

i.e.:

$$P(F_{MSY}) + F_{MSY}\left\{ B(F_{MSY})\left.\frac{d\tilde{P}(F)}{dF}\right|_{F=F_{MSY}} + \tilde{P}(F_{MSY})\left.\frac{dB(F)}{dF}\right|_{F=F_{MSY}} \right\} = 0 \qquad (19)$$

The values for the resilience and degree of compensation parameters are obtained by solving Equation (19) given a value for *MSYR* (= F_{MSY} - see Equation (17)) subject to the constraint that *MSYL* is equal to a pre-specified value.

Now, the population component (*H*) chosen for defining *MSYL* will not necessarily be the same as that to which density dependence is functionally related (*D*). For the calculations that follow, the value of $MSYL^D = P^D(F_{MSY})/K^D$ is required. This is obtained from the formula (Punt and Butterworth, 1991):

$$MSYL^D = \left[MSYL^H\,\tilde{K}^H\,\tilde{P}^D(F_{MSY})\right] / \left[\tilde{P}^H(F_{MSY})\,\tilde{K}^D\right] \qquad (20)$$

where $\tilde{K}$ is defined as $\tilde{P}(0)$ for the relevant component of the population.

The left-hand side of Equation (19) can be simplified to a form that does not involve the parameter (see Appendix 3):

$$1 + F_{MSY}\left(\frac{1}{\tilde{P}(F_{MSY})}\left.\frac{d\tilde{P}(F)}{dF}\right|_{F=F_{MSY}} - \frac{1}{\tilde{P}^D(F_{MSY})}\left.\frac{d\tilde{P}^D(F)}{dF}\right|_{F=F_{MSY}} - \frac{1}{z}\frac{(MSYL^D)^{-z}-1}{f(F_{MSY})-f_{eq}}\left.\frac{df(F)}{dF}\right|_{F=F_{MSY}} \right) \qquad (21)$$

where the required derivatives are determined by taking finite differences. The value of *z* is determined by solving Equation (21).

To calculate *MSYR* ($=F_{MSY}$) and *MSYL* for alternative harvesting patterns (e.g. uniform selectivity harvesting of the 1+ component of the population) than that used when calculating *A* and *z*, Equation (21) is solved for F_{MSY} where the alternative harvesting pattern is used to calculate the vectors $\tilde{U}^f$ and $\tilde{N}^f$ and hence the functions $\tilde{P}(F)$, $\tilde{P}^D(F)$ and *f*(*P*). The value of *MSYL* is then calculated using an appropriate modification of Equation (20).

OUPUT STATISTICS

Population components

BALEEN II stores time-trajectories of the following population components:

(a) Total (1+) population size, P_t^{1+}.
(b) Total (0+) population size, P_t^T.
(c) Total 'mature' population size, $P_t^{M,f} + P_t^{M,m}$.
(d) 'Mature' female population size, $P_t^{M,f}$.
(e) Total 'recruited' population size, $P_t^{E,f} + P_t^{E,m}$.
(f) 'Recruited' male population size, $P_t^{E,m}$.
(g) 'Recruited' female population size, $P_t^{E,f}$.
(h) Calves, $P_t^{M,f} f_t$.

These model outputs can be used to calculate a variety of output statistics, e.g., the depletion in any year, trends in population size over various years, the maximum (realised) pregnancy rate over the projection period, and the fraction of the total (0+) population size in a given year consisting of, for example, calves.

Replacement yield

The replacement yield for year *t* is defined as the catch, at the start of year *t*, which will leave the size of the 'recruited' component of the population the same at the start of year *t*+1 as at the start of year *t*:

$$RY_t = \frac{P_t^E}{\sum_s \sum_{a=0}^{x} S_a^s N_{t,a}^s}\left[\sum_s\left(N_{t,0}^s + \sum_{a=0}^{x-2} S_a^s U_{t,a}^s \delta_{a+1}^s\right) + \sum_s \sum_{a=0}^{x} S_a^s N_{t,a}^s - P_t^E\right] \qquad (22)$$

The term in square parenthesis is almost[11] the difference between the size of the 'recruited' component at the start of year *t* and the size of this component at the end of year *t* in

[11] Almost, because the $N_{t,0}^s$ term should be replaced by $N_{t+1,0}^s$ - this is not needed here because the computation of *RY* assumes that population is in steady state and that the harvest will be equal to the replacement yield so that $N_{t+1,0}^s = N_{t,0}^s$. Note that for most applications, calves are not recruited so this complication does not arise.

the absence of harvesting (i.e. accounts for the impact of recruitment and natural mortality). The first term accounts for the fact that the catch is assumed to occur in a pulse at the start of the year, and is equal to $1/S$ if survival is assumed to be independent of age for all 'recruited' animals.

Productivity

The productivity of the resource can be assessed through *MSYR* and *MSYL* (defined in terms of harvesting of the 'recruited', total (1+) or 'mature' components of the population). The maximum sustainable yield, *MSY*, can be calculated as *MSYR.MSYL.K* where *K* is the pre-exploitation size of that component of the population in terms of which *MSYR* and *MSYL* are defined. Other measures of productivity are the maximum theoretical pregnancy rate, $f_{\max}$, and the maximum steady rate of increase, $\lambda_{\max}$. The latter is the positive real root of the equation:

$$1 = f_{\max}\left[\sum_{a=\mathrm{mat}_{\min}}^{x-1} \frac{\beta_a}{\lambda_{\max}^{a+1}} \prod_{a'=0}^{a-1} S^{\mathrm{f}}_{a'} + \frac{\beta_x \prod_{a'=0}^{x-1} S^{\mathrm{f}}_{a'}}{\lambda_{\max}^{x}(\lambda_{\max} - S^{\mathrm{f}}_{x})}\right] \qquad (23)$$

Equations (1) and (2) of Breiwick *et al.* (1984) can be shown to be special cases of Equation (23).

ALTERNATIVE PARAMETERISATIONS

The most common method for parameterising the BALEEN II model involves providing specifications for the following.

(a) The historical catches.
(b) Natural mortality for each combination of sex and age.
(c) The parameters of the recruitment ogive.
(d) The parameters of the maturity ogive.
(e) The pre-exploitation equilibrium size of the 'recruited' component of the population at the start of year, t_{INIT}, $K^E_{t_{INIT}}$.
(f) The size of the 'recruited' component of the population at the start of year, t_{INIT}, $N^E_{t_{INIT}}$, if it is assumed that the population was not at its pre-exploitation equilibrium size at the start of year t_{INIT}.
(g) *MSYR*, *MSYL* and the components to which these quantities apply.
(h) The component to which density dependence is functionally related.

However, alternative paramerisations are possible. The following three sections outline three alternatives that may be appropriate for an assessment of the B-C-B bowhead stock.

'Forwards' vs. 'Backwards'

The 'backwards' parameterisation of the BALEEN II model is based on the 'Hitting-with-fixed-MSYR' option of the Hitter-Fitter package. It involves specifying the size of some component of the population in some given year, N_{targ}, and selecting the value of $N^E_{t_{INIT}}$ (or $K^E_{t_{INIT}}$ if it is assumed that the population was at its pre-exploitation equilibrium level at the start of year t_{INIT}) so that if the population is projected from year t_{INIT} to the current year, the projected size of that component of the population in the specified year is equal to N_{targ}. Brent's method (Press *et al.*, 1988) is used to solve the non-linear equation relating N_{targ} to $N^E_{t_{INIT}}$. Note that for some choices of N_{targ} (e.g. $N_{\mathrm{targ}} >> K$) there is no solution to this non-linear equation while for some choices for *MSYR*, there may be multiple solutions (Butterworth and Punt, 1995).

Using the maximum theoretical pregnancy rate

Equation (5) shows that the maximum theoretical pregnancy rate, $f_{\max}$, is closely related to the resilience parameter *A*. Therefore, instead of specifying a value for *MSYR* it is possible to specify a value for $f_{\max}$ instead. Within BALEEN II, this involves solving the non-linear equation $f_{\max} = f_{\max}(MSYR, MSYL)$, i.e. *MSYR* is chosen so that the implied value for $f_{\max}$ is equal to the specified value.

Another possible use for introducing the parameter $f_{\max}$ is to eliminate the juvenile natural mortality rate, M_J. M_J may apply solely to calves (e.g. Wade, 1996). However, for the B-C-B bowhead case, M_J has been assumed to apply from age 0 to a transition age (Givens *et al.*, 1995; IWC, 1995). Given values for *MSYR*, *MSYL* and $f_{\max}$, it is possible, using the following algorithm, to solve for *A*, *z* and M_J.

(a) Guess a value for M_J.
(b) Calculate $\tilde{U}(0)$, $\tilde{N}(0)$, $\tilde{U}(F_{MSY})$ and $\tilde{N}(F_{MSY})$.
(c) Calculate f_{eq} using Equation (4).
(d) Calculate *A* and *z* from *MSYL* and *MSYR* as described above.
(e) Calculate $f_{\max}$ using Equation (5).
(f) Compare this value of $f_{\max}$ with the input value and repeat steps (a) - (f) until convergence is achieved.

When solving for M_J, it is common to impose biologically sensible bounds such as that M_J is greater than the natural mortality rate for adults. Punt and Butterworth (1997) note that it is possible to use this approach to eliminate any of the other 'biological' parameters (age-at-maturity, adult natural mortality rate, etc.), but it seems most sensible to eliminate M_J because direct information about this parameter is seldom (if ever) available.

Using the maximum increase rate

The parameter $\lambda_{\max}$ can be used to replace *MSYR*[12]. For the case in which $f_{\max}$ is also used to specify M_J, the calculation procedure is as follows:

(a) Solve Equation (23) for M_J given $f_{\max}$, $\lambda_{\max}$ and the remaining biological parameters.
(b) Calculate $\tilde{U}(0)$ and $\tilde{N}(0)$, and hence f_{eq} (see Equation (4)).
(c) Guess a value for F_{MSY}.
(d) Calculate $\tilde{U}(F_{MSY})$ and $\tilde{N}(F_{MSY})$.
(e) Calculate *A* and *z* from *MSYL* and *MSYR* ($=F_{MSY}$) as described above.
(f) Calculate $f_{\max}$ using Equation (5).
(g) Compare this value of $f_{\max}$ with the input value and repeat steps (c) - (g) until convergence is achieved.

IMPLICATIONS FOR DEFINING *MSYR* AND *MSYL* IN TERMS OF OTHER POPULATION COMPONENTS

There has been considerable debate in the Scientific Committee regarding the appropriate component to which the assumption $MSYL = 0.6$ should be assumed to apply (e.g. Butterworth and Punt, 1992b; Cooke and de la Mare, 1994; IWC, 1994; 1998). To examine this issue further, yield curves have been produced for representative choices for the biological parameters for the East Greenland-Iceland fin

[12] In principle, $\lambda_{\max}$ can replace $f_{\max}$ but this option is ignored here.

whales and the B-C-B bowhead whales (see Table 1)[13]. Fig. 1(a) show plots of sustainable yield against 'mature' female and total (1+) depletion for the B-C-B bowhead stock when harvesting is assumed to be uniform on the 'mature' component of the population, $MSYL_{mat} = 0.6$ and $MSYR_{mat} = 3/5/7\%$. Fig. 1(b) shows the same quantities except that harvesting is assumed to be uniform on the 1+ component of the population (the values for the parameters A and z for Fig. 1(b) are computed using the specifications for Fig. 1(a)). Fig. 2 shows the same quantities as Fig. 1 except that A and z are computed for the case $MSYL_{1+} = 0.6$. Fig. 3 shows the same quantities as Fig. 1, except that the results pertain to the East Greenland-Iceland fin whales.

The most notable feature of Fig. 1(a) is that, for some choices for *MSYR*, if *MSYL* is defined in terms of the 'mature' component of the population, the size of the 1+ component at *MSYL* can be above *K*. This occurs because the stock-recruitment relationship exhibits strong super-compensation (i.e. the number of births drops as the population approaches carrying capacity – Holt, 1985; Butterworth and Best, 1990; Fig. 4) and so that the age-structure of the population at *MSY* is markedly skewed towards animals younger than the age at first parturition. The same qualitative result (quantitatively less marked) occurs if harvesting occurs on 1+ component of the population (Fig. 1b) or if the biological parameters for the East Greenland - Iceland fin whales are assumed instead (Fig. 3). The difference between the depletion of the 'mature' and 1+ components at *MSYL* is also reduced if density dependence is assumed to be functionally related to the 1+ rather than the 'mature' component of the population. As expected, defining *MSYL* in terms of the 1+ component of the population leads to *MSYL* for the 'mature' component of the population occurring at sizes well below 0.6 (Fig. 2). The

[13] For simplicity, density dependence is assumed to act on the mature female component of the population in all of the calculations of this section.

Table 1

Values for the biological and technological parameters for the East Greenland-Iceland stock of fin whales and the Bering-Chukchi-Beaufort Seas stock of bowhead whales used as inputs for the BALEEN II computations for Figures 1-4.

Parameter	East Greenland-Iceland fin whales[1]	Bering-Chukchi-Beaufort Seas bowhead whales[2]
Natural mortality (yr^{-1})	0.04 for all ages	0.04 (a=0,...,4); 0.02 (a=5+)
Age at 50% recruitment (males) (yr)	5	1
Age at 95% recruitment (males) (yr)	7	1
Age at 50% recruitment (females) (yr)	4	1
Age at 95% recruitment (females) (yr)	5	1
Age at 50% maturity[3] (yr)	8.5	20
Age at 95% maturity[3] (yr)	9.5	20

[1] Source: Butterworth and Punt (1992a).
[2] The adult natural mortality rate and the ages defining the parturition ('maturity') ogive are chosen to lie close to the medians of priors selected by IWC (1995).
[3] The corresponding age at first parturition is taken to be one year older than this.

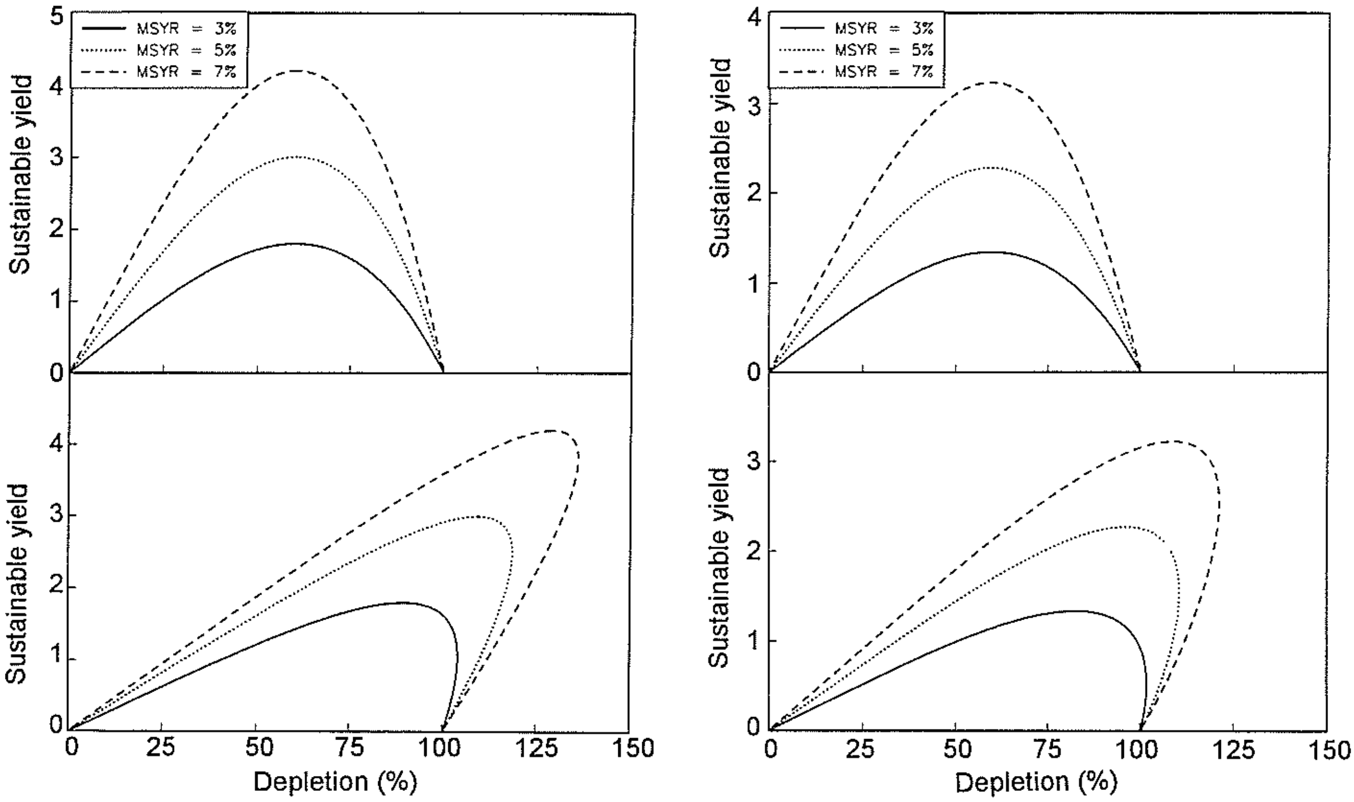


Fig. 1. Yield curves for the Bering-Chukchi-Beaufort Seas stock of bowhead whales. Each plot shows results for $MYSR_{mat}$ = 3%, 5%, and 7%. The upper panels show yield expressed as a function of the depletion of the 'mature' female component of the population, while the lower panels show yield expressed as a function of the depletion of the 1+ component of the population. Results are shown in (a) for harvesting of the 'mature' component of the population and in (b) for harvesting of the 1+ component of the population. The results in this figure pertain to $MSYL_{mat} = 0.6$ and density dependence acting on the 'mature' female component of the population.

results in Figs 1-3 therefore show that the relationship between $MSYL_{1+}$ and $MSYL_{mat}$ does not depend strongly on the exploitation pattern assumed when calculating *MSY*.

The implications of Figs 1-3 need to be taken into consideration when output statistics are defined for assessments (e.g. if *MSYL* for the B-C-B bowhead stock is defined to be 0.6 in terms of the total (1+) component of the population, the 'target level' for the 'mature' component of the population may be 0.4 or less) and performance statistics for simulation trials.

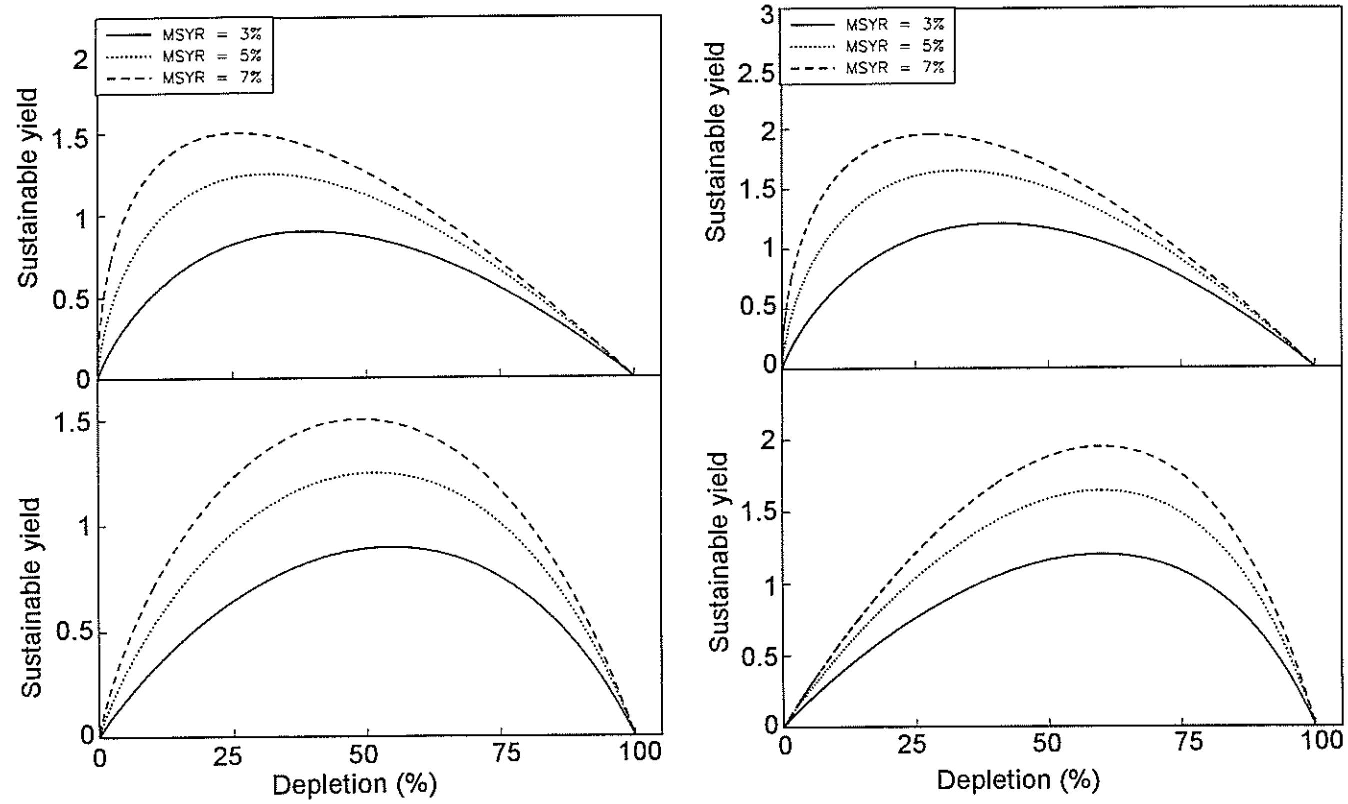


Fig. 2. As for Fig. 1 except that $MSYL_{1+}=0.6$.

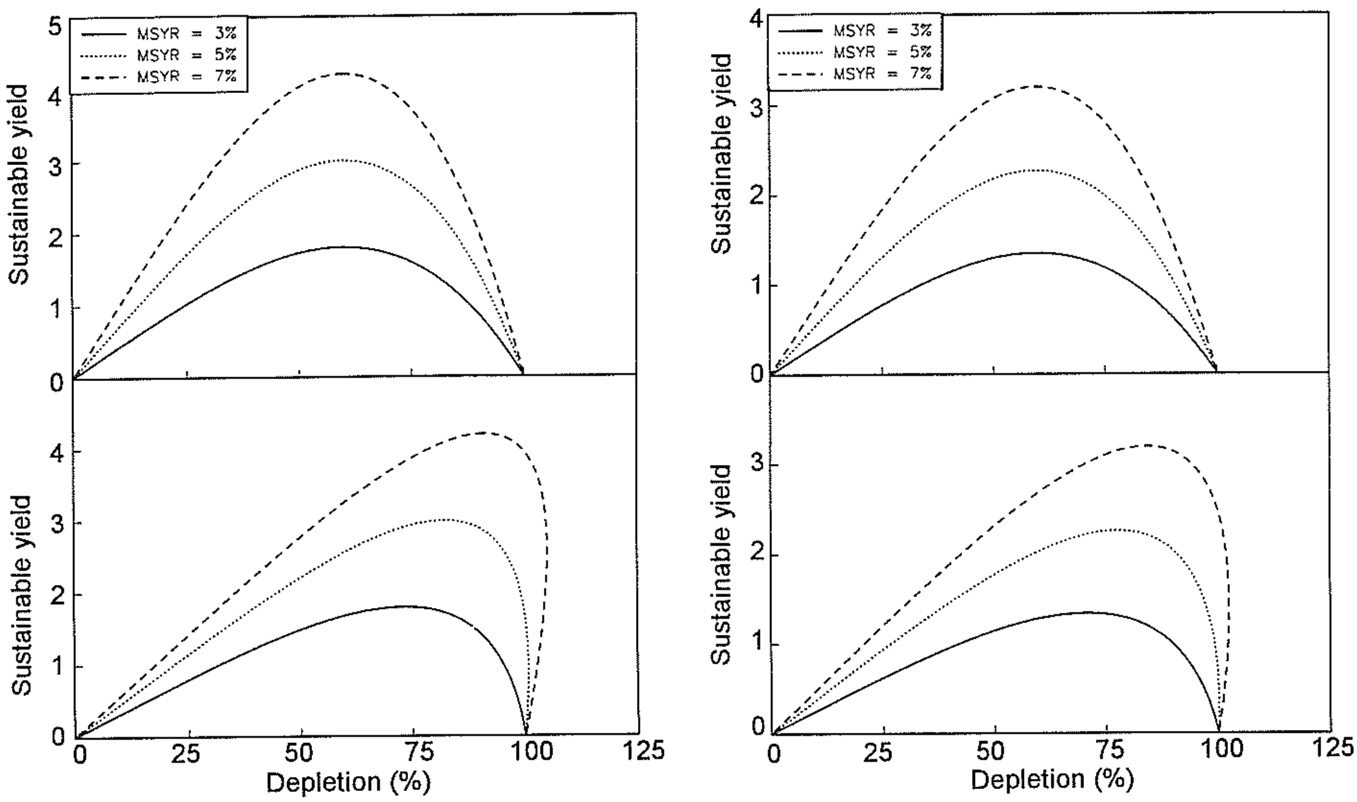


Fig. 3. As for Fig. 1 except that results are shown for the East Greenland-Iceland fin whale stock.

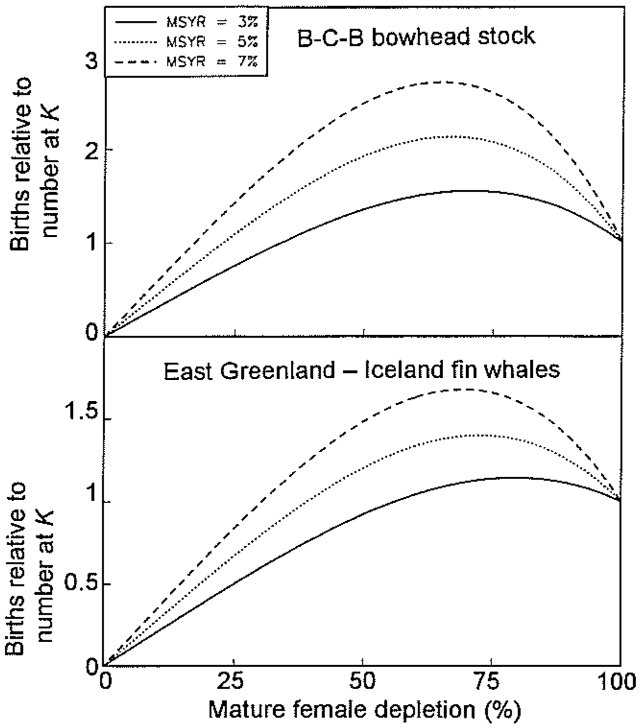


Fig. 4. Stock recruitment relationships for the Bering-Chukchi-Beaufort Seas stock of bowhead whales and the East Greenland-Iceland fin whale stock. Results in this figure pertain to $MSYL_{mat} = 0.6$ and density dependence acts on the 'mature' female component of the population. The number of births is shown relative to the number when the resource is at its pre-exploitation equilibrium level.

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Appendix 1

EQUILIBRIUM AGE-STRUCTURES

(A) Harvesting of the 'recruited' component of the population

$$\tilde{U}_a^s(F) = \begin{cases} 1-\alpha_0^s & \text{if } a=0 \\ S_{a-1}^s \tilde{U}_{a-1}^s(F)(1-\delta_a^s) & \text{otherwise} \end{cases} \quad \text{(A1.1a)}$$

$$\tilde{N}_a^s(F) = \begin{cases} \alpha_0^s & \text{if } a=0 \\ S_{a-1}^s (\tilde{N}_{a-1}^s(F)(1-F) + \tilde{U}_{a-1}^s(F)\delta_a^s) & \text{if } 1 \le a < x \\ S_{x-1}^s \tilde{N}_{x-1}^s(F)(1-F)/(1-S_x^s(1-F)) & \text{if } a = x \end{cases} \quad \text{(A1.1b)}$$

(B) Harvesting of the 1+ component of the population

$$\tilde{U}_a^s(F) = \begin{cases} 1-\alpha_0^s & \text{if } a=0 \\ S_0^s(1-\alpha_0^s)(1-\delta_1^s) & \text{if } a=1 \\ S_{a-1}^s(1-F)\tilde{U}_{a-1}^s(F)(1-\delta_a^s) & \text{otherwise} \end{cases} \quad \text{(A1.2a)}$$

$$\tilde{N}_a^s(F) = \begin{cases} \alpha_0^s & \text{if } a=0 \\ S_0^s(\alpha_0^s + (1-\alpha_0^s)\delta_1^s) & \text{if } a=1 \\ S_{a-1}^s(1-F)(\tilde{N}_{a-1}^s(F) + \tilde{U}_{a-1}^s(F)\delta_a^s) & \text{if } 2 \le a < x \\ S_{x-1}^s(1-F)\tilde{N}_{x-1}^s(F)/(1-S_x^s(1-F)) & \text{if } a = x \end{cases} \quad \text{(A1.2b)}$$

(C) Harvesting of the 'mature' component of the population

$$\tilde{U}_a^s(F) = \begin{cases} 1-\alpha_0^s & \text{if } a=0 \\ S_{a-1}^s(1-F\beta_{a-1})\tilde{U}_{a-1}^s(F)(1-\delta_a^s) & \text{otherwise} \end{cases} \quad \text{(A1.3a)}$$

$$\tilde{N}_a^s(F) = \begin{cases} \alpha_0^s & \text{if } a=0 \\ S_{a-1}^s(1-F\beta_{a-1})(\tilde{N}_{a-1}^s(F) + \tilde{U}_{a-1}^s(F)\delta_a^s) & \text{if } 1 \le a < x \\ S_{x-1}^s(1-F\beta_{a-1})\tilde{N}_{x-1}^s(F)/(1-S_x^s(1-F)) & \text{if } a = x \end{cases} \quad \text{(A1.3b)}$$

Appendix 2

THE DERIVATION OF EQUATION (16)

The equation defining fecundity as a function of density is given by:

$$f(F) = f_{eq}[1 + A\{1-(P^D(F)/K^D)^z\}] \quad \text{(A2.1)}$$

Substituting $N_0(F)\tilde{P}^D(F)$ for $P^D(F)$ gives:

$$f(F) = f_{eq}[1 + A\{1-(N_0(F)\tilde{P}^D(F)/K^D)^z\}] \quad \text{(A2.2)}$$

Solving Equation (A2.2) for leads to Equation (16)

Appendix 3

THE DERIVATION OF EQUATION (21)

The equation defining *MSY* is:

$$P(F_{MSY}) + F_{MSY}\left\{B(F_{MSY})\frac{d\tilde{P}(F)}{dF}\bigg|_{F=F_{MSY}} + \tilde{P}(F_{MSY})\frac{dB(F)}{dF}\bigg|_{F=F_{MSY}}\right\} = 0 \quad \text{(A3.1)}$$

Dividing Equation (A3.1) by gives:

$$1 + F_{MSY}\left\{\frac{1}{\tilde{P}(F_{MSY})}\frac{d\tilde{P}(F)}{dF}\bigg|_{F=F_{MSY}} + \frac{1}{B(F_{MSY})}\frac{dB(F)}{dF}\bigg|_{F=F_{MSY}}\right\} = 0 \quad \text{(A3.2)}$$

Now, differentiating $P^D(F) = B(F)\tilde{P}^D(F)$ with respect to F gives:

$$\frac{dP^D(F)}{dF} = B(F)\frac{d\tilde{P}^D(F)}{dF} + \tilde{P}^D(F)\frac{dB(F)}{dF}$$

Therefore:

$$\frac{dB(F)}{dF} = \frac{1}{\tilde{P}^D(F)}\frac{dP^D(F)}{dF} - \frac{B(F)}{\tilde{P}^D(F)}\frac{d\tilde{P}^D(F)}{dF} \qquad \text{(A3.3)}$$

Now, $f(F) = f_{eq}[1 + A\{1-(P^D(F)/K^D)^z\}]$

$$\text{i.e.} \quad \frac{df(F)}{dF} = \frac{-f_{eq}Az}{K^D}\left[P^D(F)/K^D\right]^{z-1}\frac{dP^D(F)}{dF} \qquad \text{(A3.4)}$$

Solving Equation (A3.4) for $\frac{dP^D(F)}{dF}$ then gives:

$$\frac{dP^D(F)}{dF} = \frac{-K^D}{f_{eq}Az}\left[P^D(F)/K^D\right]^{1-z}\frac{df(F)}{dF} \qquad \text{(A3.5)}$$

Substituting Equation (A3.5) into equation (A3.3) then gives:

$$\frac{dB(F)}{dF} = -\frac{B(F)}{\tilde{P}^D(F)}\frac{d\tilde{P}^D(F)}{dF} - \frac{1}{\tilde{P}^D(F)}\frac{K^D}{f_{eq}Az}\left[P^D(F)/K^D\right]^{1-z}\frac{df(F)}{dF} \qquad \text{(A3.6)}$$

Now, $MSYL^D = P^D(F_{MSY})/K^D = B(F_{MSY})\tilde{P}^D(F_{MSY})/K^D$ (A3.7a)

or $K^D = B(F_{MSY})\tilde{P}^D(F_{MSY})/MSYL^D$ (A3.7b)

Evaluating Equation (A3.6) at $F = F_{MSY}$, substituting Equation (A3.7) into the resulting equation, dividing by $B(F_{MSY})$, and then simplifying gives:

$$\frac{1}{B(F_{MSY})}\frac{dB(F)}{dF}\bigg|_{F=F_{MSY}} = -\frac{1}{\tilde{P}^D(F_{MSY})}\frac{d\tilde{P}^D(F)}{dF}\bigg|_{F=F_{MSY}} - \frac{(MSYL^D)^{-z}}{f_{eq}Az}\frac{df(F)}{dF}\bigg|_{F=F_{MSY}} \qquad \text{(A3.8)}$$

Now, from Equation (3), A is related to z and $MSYR^D$ according to the formula:

$$A = \frac{f(F_{MSY})/f_{eq} - 1}{1-(MSYL^D)^z} \qquad \text{(A3.9)}$$

Thus, substituting Equation (A3.9) into Equation (A3.8) and simplifying gives:

$$\frac{1}{B(F_{MSY})}\frac{dB(F)}{dF}\bigg|_{F=F_{MSY}} = -\frac{1}{\tilde{P}^D(F_{MSY})}\frac{d\tilde{P}^D(F)}{dF}\bigg|_{F=F_{MSY}} - \frac{1}{z}\frac{(MSYL^D)^{-z}-1}{f(F_{MSY})-f_{eq}}\frac{df(F)}{dF}\bigg|_{F=F_{MSY}} \qquad \text{(A3.10)}$$

Substituting Equation (A3.10) into Equation (A3.2) gives Equation (21) of the main text.

A15/GW/1

An Age-Structured Model or Exploring the Conceptual Models Developed for Gray Whales in the North Pacific

AE Punt

INTERNATIONAL
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An Age-Structured Model or Exploring the Conceptual Models Developed for Gray Whales in the North Pacific

ANDRÉ E. PUNT
School of Aquatic and Fishery Sciences, University of Washington, Box 355020, Seattle, WA 98195-5020, USA
Contact e-mail: aepunt@uw.edu

ABSTRACT
A sex- and age-structured population dynamics model which can represent the stock hypotheses developed during the April 2014 rangewide review of population structure and status of North Pacific gray whales is outlined. The model allows for multiple stocks, each of which can have sub-stocks, multiple feeding and wintering grounds, as well as migratory corridors. Animals can move between sub-stocks in a pulse or diffusively. The values for the parameters of the model can be estimated by fitting it to data on trends in relative and absolute abundance, in addition to mixing proportions based on telemetry and mark-resight data. The model is generic, but the specifications in this document include choices made when an operating model was developed to evaluate alternative *SLA*s for the Pacific Coast Feeding Group (PCFG) for the eastern north Pacific gray whales. An example application of the model is provided.

INTRODUCTION
The workshop on the rangewide review of the population structure and status of North Pacific gray whales (IWC, 2014) developed several conceptual models for gray whales in the North Pacific. These hypotheses differed in terms of the number of stocks and how those stocks are divided into sub-stocks and how they are distributed across the North Pacific. The Workshop recommended that a framework based on an age- and sex-structured population dynamics model be developed to explore whether the conceptual models are consistent with the available data and whether the existing data are sufficient to enable most of the parameters of the model to be estimated.

This paper provides the mathematical specifications for a strawman sex- and age-structured model, outlines how this model could be used to implement one of the conceptual models developed by IWC (2014) [Fig. 1], and provides some preliminary results.

MODEL STRUCTURE
The model distinguishes 'stocks' and 'sub-stocks'. Stocks are demographically and genetically independent whereas sub-stocks are linked through dispersal of individuals[1], though perhaps at very low rates for some combinations of sub-stocks.

Each stock / sub-stock is found in a set of sub-areas, each of which may have catches (commercial, aboriginal or incidental), proportions of stocks / sub-stocks mixing[2] in those sub-areas, and indices of relative or absolute abundance. Catches may be specified to sets of months during the year if the various sub-stocks are not equally vulnerable to catches throughout the year.

[1] The term 'dispersal' is used here in the sense of 'effective dispersal', and refers to permanent movement of individuals among stocks. Such individuals become part of the population to which they move and contribute to future reproduction.

[2] Mixing is defined here as two stocks which overlap at some time on the feeding groups, but do not interbreed.

Basic Population Dynamics

The population dynamics are based on the standard age-structured model used by the IWC Scientific Committee and which has formed the basis for the evaluation of *SLA*s for the Eastern North Pacific gray whales, i.e.:

$$
\begin{aligned}
N_{t+1,0}^{m/f,i,j} &= 0.5B_{t+1}^{i,j} && a = 0 \\
N_{t+1,a}^{m/f,i,j} &= ((N_{t,a-1}^{m/f,i,j} - C_{t,a-1}^{m/f,i,j})\,S_{a-1} + I_{t,a-1}^{m/f,i,j})\tilde{S}_t^{i,j} && 1 \le a \le x-1 \\
N_{t+1,x}^{m/f,i,j} &= ((N_{t,x}^{m/f,i,j} - C_{t,x}^{m/f,i,j})S_x + (N_{t,x-1}^{m/f,i,j} - C_{t,x-1}^{m/f,i,j})\,S_{x-1} + I_{t,x}^{m/f,i,j} + I_{t,x-1}^{m/f,i,j})\,\tilde{S}_t^{i,j} && a = x
\end{aligned}
\quad (1.1)
$$

where $N_{t,a}^{m/f,i,f}$ is the number of males / females of age *a* in sub-stock *j* of stock *i* at the start of year *t*; $C_{t,a}^{m/f,i,f}$ is the catch of males / females of age *a* in sub-stock *j* of stock *i* during year *t* (whaling is assumed to take place in a pulse at the start of each year); S_a is the annual survival rate of animals of age *a* in the absence of catastrophic mortality events (assumed to be the same for males and females):

$$S_a = \begin{cases} S_0 & \text{if } a = 0 \\ S_{1+} & \text{if } 1 < a \end{cases} \quad (1.2)$$

S_0 is the calf survival rate for animals; S_{1+} is the survival rate for animals aged 1 and older; $\tilde{S}_t^{i,j}$ is the amount of catastrophic mortality (represented in the form of a survival rate) for sub-stock *j* of stock *i* during year *t* (catastrophic events are assumed to occur at the end of the year after mortality due to whaling and non-catastrophic natural causes and dispersal; in general $\tilde{S}_t^{i,j}$ =1, i.e. there is no catastrophic mortality); $B_{t+1}^{i,j}$ is the number of births to sub-stock *j* of stock *i* during year *t*; $I_{t,a}^{s,m/f}$ is the net dispersal of female/male animals of age *a* into sub-stock *j* of stock *i* during year *t*; and *x* is the maximum (lumped) age-class (all animals in this and the *x*-1 class are assumed to be recruited and to have reached the age of first parturition). *x* is taken to be 15[3].

Births and density-dependence

Density-dependence is assumed to be a function of numbers of animals ages 1 and older by feeding ground relative to the carrying capacity by feeding ground. The density-dependence component of sub-stock *j* of stock *i* is the sum of the density-dependence components by feeding group weighted by the proportion of animals from sub-stock *j* of stock *i* which are found on each feeding ground, i.e.:

$$F(i,j,t) = \sum_A \left(X^{A,i,j} (N_t^{1+,A} / K^{1+,A})^z \right) / \sum_A X^{A,i,j} \quad (2.1)$$

where z is the degree of compensation; N_t^{1+A} is the number of 1+ animals on feeding ground *A* at the start of year *t*:

$$N_t^{1+,A} = \sum_i \sum_j X^{A,i,j} \sum_{a=1}^{x} (N_{t,a}^{m,i,j} + N_{t,a}^{f,i,j}) \quad (2.2)$$

K_t^{1+A} is the carrying capacity for feeding ground *A*:

[3] The results would be identical to those reported here if x was set to the maximum of the age-at-recruitment and the age-at-maturity.

$$K^{1+,A} = \sum_i \sum_j X^{A,i,j} \sum_{a=1}^{x} (N_{-\infty,a}^{m,i,j} + N_{-\infty,a}^{f,i,j}) \tag{2.3}$$

$X^{A,i,j}$ is the proportion of animals of sub-stock *j* of stock *i* which is in feeding ground *A*.[4]

The number of births at the start of year *t* for sub-stock *j* of stock *i*, $B_t^{i,j}$, is given by:

$$B_t^{i,j} = b_t^{i,j}\, N_t^{f,i,j} \tag{2.4}$$

where $N_t^{f,i}$ is the number of mature females in sub-stock *j* of stock *i* at the start of year *t*:

$$N_t^{f,i,j} = \sum_{a=a_m}^{x} N_{t,a}^{f} \tag{2.5}$$

a_m is the age-at-maturity (the convention of referring to the mature population is used here, although this actually refers to animals that have reached the age of first parturition); $b_t^{i,j}$ is the probability of birth/calf survival for mature females:

$$b_t^{i,j} = \max(0, b_K\{1 + A^{i,j}(1 - F(I, j, t))\}) \tag{2.6}$$

b_K is the average number of live births per year per mature female at carrying capacity; and
$A^{i,j}$ is the resilience parameter for substock *j* of stock *i*.

Immigration (dispersal)
The numbers dispersing into sub-stock *j* of stock *i*, include contributions from pulse migration as well as diffusive dispersal:

$$\begin{aligned} I_{t,a}^{s,j,i} = & \sum_k \delta^{k,j,i} \tilde{N}_{t,a}^{s,i,k} - \sum_k \delta^{j,k,i} \tilde{N}_{t,a}^{s,i,j} + \\ & \sum_{k \neq j} \Omega_y^{k,j,i} \frac{\tilde{N}_{t,a}^{s,i,k}}{\sum_{a=1}^{x} (\tilde{N}_{t,a}^{m,i,k} + \tilde{N}_{t,a}^{f,i,k})} - \sum_{k \neq j} \Omega_y^{j,k,i} \frac{\tilde{N}_{t,a}^{s,i,j}}{\sum_{a=1}^{x} (\tilde{N}_{t,a}^{m,i,j} + \tilde{N}_{t,a}^{f,i,j})} - \end{aligned} \tag{3.1}$$

where $\delta^{k,j,i}$ is the rate of dispersal from sub-stock *k* to sub-stock *j* of stock *i*; $\Omega_y^{k,j,i}$ is the number of animals which disperse in year *y* from sub-stock *k* to sub-stock *j* of stock *i* in a pulse; and $\tilde{N}_{t,a}^{s,i,k} = (N_{t,a}^{s,i,k} - C_{t,a}^{s,i,k})\, S_a$.

Anthropogenic~~gonetic~~ removals
The catch by stock / sub-stock is generally determined by apportioning the catches by fleet[5], taking account of mixing (i.e. exposure to harvesting) matrices, according to:

$$C_{t,a}^{m/f,i,j} = \sum_k C_t^{m/f,k} \frac{\alpha_a^k X^{A_k,i,j} N_{t,a}^{m/f,i,j}}{\sum_{i,j,a} \alpha_a^k X^{A_k,i,j} N_{t,a}^{m/f,i,j}} \tag{4.1}$$

---

[4] It is usually the case that $\sum X^{A,i,j} = 1$. However, for the gray whales, this is not necessarily the case because catches can take place in the various sub-areas at different times. What is then important is the relative values of the $X^{A,i,j}$ among stocks and sub-stocks for a given feeding ground.

[5] A fleet is the combination of a fishery sector (commercial / aboriginal) and the sub-area in which the catch is taken.

where $C_t^{m/f,k}$ is the catch of males/females caught by fleet *k* during year *t*; A_k is the sub-area in which fleet *k* operates; and α_a^k is the relative vulnerability of animals of age *a* to harvest to the fleets which operate in sub-area *k*.

The incidental catches by sub-area are computed using the equation:

$$C_y^{\mathrm{I},A} = \begin{cases} \{1-\frac{0.5}{69}[1999-y]\}\bar{C}^{I.A} & \text{if } y \le 1999 \\ \bar{C}^{I,A} N_y^{1+,A} / N_{1999}^{1+,A} & \text{otherwise} \end{cases} \tag{4.2}$$

where $C_y^{\mathrm{I}/s,A}$ is the incidental catch of animals of sex *s* in sub-area *A* during year *y*; and $\bar{C}^{I.A}$ is the mean catch in sub-area *A* (see Table 1). The incidental catches are allocated to stock using the formula:

$$C_{t,a}^{I,m/f,i,j} = \sum_A C_t^{I,A} \frac{\tilde{\alpha}_a X^{A,i,j} N_{t,a}^{m/f,i,j}}{\sum_{i,j,a} \tilde{\alpha}_a X^{A,i,j} N_{t,a}^{m/f,i,j}} \tag{4.3}$$

where the selectivity pattern for incidental catches $\tilde{\alpha}_a$ is 1 for all ages (Weller *et al.*, 2008).

Initializing the parameter vector

The numbers at age in the pristine population are given by:

$$\begin{aligned} N_{-\infty,a}^{m/f,i,j} &= 0.5\, N_{-\infty,0}^{i,j} \prod_{a'=0}^{a-1} S_{a'} && \text{if } a < x \\ N_{-\infty,x}^{m/f,i,j} &= 0.5\, N_{-\infty,0}^{i,j} \prod_{a'=0}^{x-1} S_{a'} / (1-S_x) && \text{if } a = x \end{aligned} \tag{5.1}$$

The value for $N_{-\infty,0}^{i,j}$ is determined from the value for the pre-exploitation size of the 1+ component of sub-stock *j* of stock *i* using the equation:

$$N_{-\infty,0}^{m,i,j} = K^{1+,i,j} / \left(\sum_{a=1}^{x-1} \left(\prod_{a'=0}^{a-1} S_{a'} \right) + \frac{1}{1-S_x} \prod_{a'=0}^{x-1} S_{a'} \right) \tag{5.2}$$

where $K^{1+,i,j}$ is the carrying capacity (in terms of the 1+ population size size) for sub-stock *j* of stock *i*:

$$K_t^{1+,i,j} = \sum_{a=1}^{x} (N_{-\infty,a}^{m,i,j} + N_{-\infty,a}^{f,i,j}) \tag{5.3}$$

$N_{-\infty,a}^{m/f,i,j}$ is the number of animals of age *a* that would be in sub-stock *j* of stock *i* in the pristine population.

The model is based on the assumption that the age-structure at the start of year τ is stable rather than that the population was at its pre-exploitation equilibrium size at some much earlier year. The determination of the age-structure at the start of year τ involves specifying the effective 'rate of increase', γ, that applies to each age-class. There are two components contributing to γ, one relating to the overall population rate of increase (γ^+) and the other to the exploitation rate. Under the assumption of knife-edge recruitment to the fishery at age a_r, only the γ^+ component (assumed to be zero following Punt and Butterworth [2002]) applies to ages

a of a_r or less. The number of animals of age a at the start of year τ relative to the number of calves at that time, $N^*_{\tau,a}$, is therefore given by the equation:

$$N^*_{\tau,a} = \begin{cases} 1 & \text{if } a = 0 \\ N^*_{\tau,a-1}\, S_{a-1} & \text{if } a \le a_r \\ N^*_{\tau,a-1}\, S_{a-1}(1-\gamma) & \text{if } a_r < a < x \\ N^*_{\tau,x-1}\, S_{x-1}(1-\gamma)/(1-S_x(1-\gamma)) & \text{if } a = x \end{cases} \tag{5.4}$$

where B_τ is the number of calves in year τ and is derived directly from equations 2.1 and 2.6.

$$B_\tau = \left(1 - \left[1/(N^f_\tau b_K) - 1\right]/A\right)^{1/z} \frac{K^{1+}}{N^{1+,*}_\tau} \tag{5.5}$$

The effective rate of increase, γ, is selected so that if the population dynamics model is projected from year τ to a year Ψ, the size of the 1+ component of the population in a reference year Ψ equals a value, P_Ψ.

Likelihood function
Under the assumption that the estimates of abundance for a sub-area are log-normally distributed, the negative of the logarithm of the likelihood function is given by:

$$-\ell nL = \ell n\sqrt{\text{Det}[V]} + 0.5\sum_k (\ell\,\text{n}\,\underline{N}^{A,obs} - \ell\,\text{n}\,\underline{N}^A)[V^{-1}](\ell\,\text{n}\,\underline{N}^{A,obs} - \ell\,\text{n}\,\underline{N}^A)^T \tag{6.1}$$

where $N^{A,\text{obs}}_t$ is survey estimate of abundance for sub-area A during year t; and V is the sum of the variance-covariance matrix for the abundance estimates plus an additional variance term (assumed to be independent of year).

The data on the proportion of each stock in each sub-area is modelled under the assumption that the proportions are normally distributed, i.e.:

$$-\ell nL = \sum_i \sum_A \sum_t \tfrac{1}{2(\tau^{i,A}_t)^2}(p^{i,A}_t - p^{i,A,\text{obs}}_t)^2 \tag{6.2}$$

where $p^{i,A}_t$ is the model-estimate of the proportion of the animals in sub-area A which are from stock i; $p^{i,A,\text{obs}}_t$ is the observed proportion of animals in in sub-area A which are from stock I; and $\tau^{i,A}_t$ is the standard error of $p^{i,A,\text{obs}}_t$.

Quantification of uncertainty
Uncertainty can be quantified in various ways. For the purposes of the analyses of this report, the uncertainty of the model predictions for a scenario (choices for the stock structure hypothesis, MSYR, etc.) is quantified by bootstrapping. This involved generating pseudo abundance estimates from distributions with means given by the actual data and variance-covariance matrix V (with the values for the additional variance parameters set to those obtained by fitting the model to the actual estimates of abundance).

EXAMPLE APPLICATION
Stocks and spatial structure
The example application is based on the conceptual model of gray whales outlined in Fig. 1. There are two stocks ('Asian' and 'Eastern') for the example application, with the 'eastern' stock divided into three sub-stocks ('Sakhalin', 'North' and 'PCFG'). There are eight feeding

grounds (‘West of Kamchatka’, ‘Sakhalin’, ‘Kamchatka-East’, ‘Northern Bering Sea / South Chukchi’, ‘North Chukchi’, ‘Gulf of Alaska’, and ‘PCFG’), there are three migration corridors (Japan, Korea and California), and there are two wintering grounds (Asia and Mexico). The feeding grounds, migration corridors, and wintering grounds are the sub-areas for the model.

For this hypothesis, the ‘Northern Bering Sea / South Chukchi’ and ‘North Chukchi’ feeding grounds are combined into a single feeding ground (sub-area), denoted the ‘North’ feeding ground, while the Japanese and Korean migration corridors are also merged into a single ‘Japan/Korea/China’ migration corridor. Two of the feeding grounds ‘PCFG’ and ‘California’ are divided seasonally [Jun-Dec; Jan – May] because of differences in rates of incidental catch, combined with differences of the relative vulnerability of the various stocks and sub-stocks at this time. There are two fleets in the ‘North’ feeding ground to allow for historical commercial and aboriginal catches. An extra sub-area (Calif-3) is added to the model to enable it to be fitted to the estimates of absolute abundance under the assumption that all animals passing through California are subject to being counted with equal probability.

Parameterization

Catastrophic mortality is assumed to be zero (i.e., $\tilde{S}_t^{i,j}$ =1) except for the North sub-stock for 1999 and 2000 when it is assumed to be equal to the parameter $\tilde{S}$ (IWC, 2013). This assumption reflects the large number of dead gray whales observed stranded along the coasts of Oregon and Washington during 1999 and 2000 relative to the number stranded there in other years with data (Brownell *et al.*, 2007; Gulland *et al.*, 2005). The catastrophic mortality in 1999 and 2000 is assumed to have only impacted the North sub-stock because the abundance estimates for the PCFG and Sakhalin sub-stocks increased when the catastrophic mortality occurred, in contrast to those for the North sub-stock which declined substantially. Immigration occurs only between the North sub-stock and the PCFG sub-stock, and only animals aged 1+ immigrate. Allowance is also made for a pulse dispersal of 20 animals from the North sub-stock to the PCFG sub-stock in each of the years 1999 and 2000 (IWC, 2013).

The parameters of the population dynamics model are the carrying capacities of each stock, the proportion which each stock is at the start of the first year considered in the model (τ=1930), the intrinsic rate of growth of each stock, the survival rates for the North sub-stock in 1999 and 2000 (assumed to be the same), the dispersal rate between the North and PCFG sub-stocks, the relative vulnerability of PCFG as compared to other ~~whales~~sub-stocks in Southeast Alaska, the PCFG area in Dec-May (the migratory period)[6], and in California, and the additional variance parameters for each time-series of abundance estimates. There are in total 17 estimable parameters.

The value for the degree of compensation parameter is set to 2.39 (which corresponds approximately to MSYL occurring at 60% of carrying capacity) and MSYR is assumed to be 3.5%. For ease of parameterization, the numbers of animals dispersing from the ‘north’ and PCFG sub-stocks to the ‘Sakhalin’ sub-stock is assumed to be zero.

Two scenarios regarding the proportion of Sakhalin animals found in the Japan/Korea/China area are considered (0.2 and 0.1).

Data utilized

Table 3 (available as a spreadsheet) lists the historical catch data by sex, year, and area based on IWC (2011, 2013), Bradford (2003) and input from members of the Steering Group. Table 4 lists the abundance estimates for the Sakhalin, California and PCFG feeding grounds. The

[6] All PCFG sub-area catches during June-November are assumed to be from the PCFG sub-stock. See table 2 for the catch mixing matrices.

1998 estimate for the PCFG feeding ground is considered to be biased and is consequently ignored. Table 5 summarizes the mixing proportion data on which the analyses are based.

RESULTS AND DISCUSSION

Results of preliminary analyses

Figures 2 and 3 show the fits of the model to the abundance estimates. The model is able to capture the trends in abundance adequately when the mixing proportion of Sakhalin animals in the Japan/Korea/China migration corridor is assumed to be 0.2 (Fig. 3), but the fit to the abundance estimates for the PCFG feeding ground are misspecified when this mixing proportion is 0.1. The extent of additional variation (expressed as standard errors of logs) obtained by fitting the operating model to the actual data (the base model) is 0.054/0.052 (Sakhalin series), 0.088/0.081 (Southern California series), and < 0.02 (PCFG series) for the two choices for the mixing rates of Sakhalin animals in the Japan/Korea/China area. The model predicted proportions in the Japan/Korea/China area are 0.55 and 0.44 (0.2 mixing proportion for Sakhalin whales in the Japan/Korea/China area) and 0.68 and 0.31 (0.1 mixing proportion for Sakhalin whales in the Japan/Korea/China area) for observed proportions of 1 and 0 Sakhalin animals. The base model predictions of the proportion of PCFG whales in southeast Alaska, the PCFG sub-area (Dec-May), and California (June-Nov, Dec-May) is 0.57, 0.30, 0.27, and 0.19 respectively (0.2 mixing proportion) and 0.55, 0.27, 0.25 and 0.15 respectively (0.1 mixing proportion). These values match the data used for conditioning (0.57, 0.36, 0.30 and 0.09) adequately give the assumed standard deviation of 0.1 (Table 5).

The time-trajectories of abundance by stock are sometimes sensitive to the value of the mixing proportion of Sakhalin whales in the Japan-Korea area (Figs 4 and 5). Specifically, the Asian stock is a higher fraction of its initial size if the probability of the Sahkalin sub-stock being in Japan / Korea is 0.2. However, the fits to the Sakhalin abundance series is clearly mis-specified. This mis-specification can be addressed by increasing the MSY rate from 3.5%, but in the interests of simplicity, the results of this paper are based on a common MSY rate across stocks.

The stocks are estimated to be well below their (current) carrying capacities when the mixing proportion for Sakhalin whales in the Japan/Korea/China area is 0.2, with the Asian and Sakhalin stocks approximately 10% of their carrying capacities and the North and PCFG sub-stocks approximately half of theirs (Fig. 5). Note that the model does not have direct information on carrying capacity for the Sakhalin and North sub-stocks because neither of the associated abundance time-series provide strong evidence for a reduction in growth rate over time. The abundance data for the PCFG sub-area is stable. However, the model (which includes dispersal from the North to PCFG sub-stocks) suggests an increasing trend. In principle, model runs could be conducted in which the carrying capacity of the PCFG stock is set to approximately 200 1+ animals.

In contrast to the outcomes from the model in which the mixing proportion for Sakhalin whales in the Japan/Korea/China area is 0.2, setting the mixing rate to 0.1 leads to unrealistic estimates of the trend in abundance in the PCFG feeding ground. This may be due to convergence to a local minimum of the objective and hence requires further investigation.

Next steps

Several of the data inputs are preliminary. Specifically, it is necessary to finalize the catch series, update the survey estimates of abundance to include the variance covariance matrices for the abundance estimates for the Sakhalin feeding ground and the recent surveys off California. The mixing proportions should be updated to reflect ~~telemetry~~ photo-identification data and other catches of known stock animals off Asia. The underlying data on mixing should be reanalysed to provide appropriate values for standard errors.

Once the data have been finalized, allowance should be made for uncertainty regarding the mixing proportions when constructing the bootstrap data sets, and the model applied to all of the stock structure hypotheses. Finally, scenarios should be developed to examine the impact of anthropogenic impacts of gray whales across their range.

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Table 1

Average historical ~~western~~ ENP incidental catches 2008-2012 (J. Scordino, pers. commn).

Stratum	Average incidental catch
North	0.15
Southeast Alaska	0.70
PCFG [Dec – May]	1.10
PCFG [Jun – Nov]	1.55
California [Dec – May]	1.20
California [Jun – Nov]	3.65

Table 2

The catch mixing matrices for the example application. Allocation to sub-stocks is pre-specified, and depends for the PCFG sub-area on time of the year. The γs denote the estimable parameters of the catch mixing matrix. Note that the ‘Calif-3’ area is included so that the surveys cover all of the PCFG, Sakhalin and north stocks.

Stock / Sub-stock	Sub-area / season											
	Asia	Japan-Korea-China	Kamchatka-West	Sakhalin	Kamchatka-East	North	Southeast Alaska	PCFG (June – Nov)	PCFG (Dec– May)	California (June – Nov)	California (Dec – May)	Calif-3	Mexico
Western	1	1	1										
Eastern													
Sakhalin		0.1 /0.2[a]		1	1				1	1	1	1	1
North					1	1	1		1	1	1	1	1
PCFG							γ_1	1	γ_2	γ_3	γ_4	1	1

a – meant to capture the “occasional” -migration to Japan / Korea/China

Table 4a

Indices of 1+ abundance for the Sakhalin sub-area [From Cooke, to come] (J.G. Cooke, pers. comm.~~n~~)

Year	Estimate	CV
1995	64	0.041
1996	66.9	0.035
1997	72.9	0.024
1998	76.4	0.017
1999	84.4	0.011
2000	85.8	0.009
2001	91.4	0.006
2002	96.8	0.005
2003	104.3	0.005
2004	114	0.006
2005	119.2	0.006
2006	125.2	0.007
2007	126.8	0.008
2008	128.4	0.01
2009	128.9	0.011
2010	133.9	0.012
2011	137.8	0.013
2012	149.4	0.019

Table 4b

Estimates of absolute abundance (with associated standard errors) for the eastern North Pacific stock of gray whales based on shore counts (source: 1967/78-2006/07: Laake *et al*, 2012; 2006/07-2010/11: Durban *et al*, 2013).

Year	Estimate	CV	Year	Estimate	CV
1967/68	13426	0.094	1985/86	22921	0.081
1968/69	14548	0.080	1987/88	26916	0.058
1969/70	14553	0.083	1992/93	15762	0.067
1970/71	12771	0.081	1993/94	20103	0.055
1971/72	11079	0.092	1995/96	20944	0.061
1972/73	17365	0.079	1997/98	21135	0.068
1973/74	17375	0.082	2000/01	16369	0.061
1974/75	15290	0.084	2001/02	16033	0.069
1975/76	17564	0.086	2006/07	19126	0.071
1976/77	18377	0.080	2006/07	20750	0.060
1977/78	19538	0.088	2007/08	17820	0.054
1978/79	15384	0.080	2009/10	21210	0.046
1979/80	19763	0.083	2010/11	20990	0.044
1984/85	23499	0.089			

Table 4c

Estimates of absolute abundance (with associated CVs) for 41°-52°N (the PCFG sub-area) (source: J. Laake, pers. commn).

Year	Estimate	CV	Year	Estimate	CV
1998	126	0.086	2006	200	0.106
1999	147	0.102	2007	193	0.133
2000	149	0.101	2008	207	0.088
2001	181	0.077	2009	206	0.098
2002	198	0.064	2010	194	0.094
2003	210	0.086	2011	197	0.080
2004	218	0.078	2012	209	0.073
2005	218	0.120			

Table 5
Data on mixing proportions. The standard errors are assumed (Sources: Japan: Amanda Bradford; others: Jonathan Scordino)

Area	Year	Stock 1	Stock 2	Estimate (SD)
Japan	2007	Sakhalin	Asia	1 (0.1)
Japan	2012	Asia	Sakhalin	1 (0.1)
Southeast Alaska	2012	PCFG	North	0.57 (0.1)
PCFG (Dec-May)	2012	PCFG	North	0.36 (0.1)
California (Jun-Nov)	2012	PCFG	North	0.30 (0.1)
California (Dec-May)	2012	PCFG	North	0.09 (0.1)

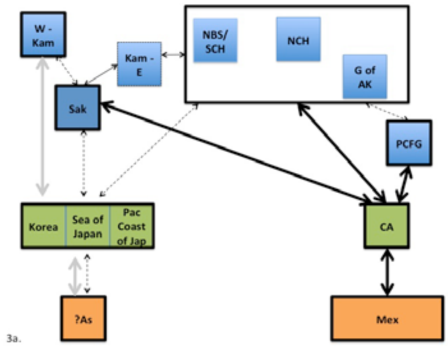

Figure 1. Conceptual overview of the stock-structure hypothesis being modelled (Model 3a of IWC [2014], "Two

breeding stocks (Asia and Mexico) may exist, although the Asian stock, which included whales that feed west of the Kamchatka Peninsula in the Okhotsk Sea and utilized migratory routes and wintering grounds in the WNP, may have been extirpated. The Mexico stock includes three feeding sub-stocks: PCFG, NBS/SCH-NCH-G of AK, and Sakhalin. The whales that feed off eastern Kamchatka are a mixed-stock aggregation including whales from both the Sakhalin and Northern feeding sub-stocks. Occasional movements of whales occur between 1) Sakhalin and the feeding region (W-Kam), migratory routes, and wintering grounds of the potentially extirpated Asian stock, 2) the Northern feeding area and the Asian migratory routes and wintering grounds, and 3) the PCFG and the Northern feeding region").

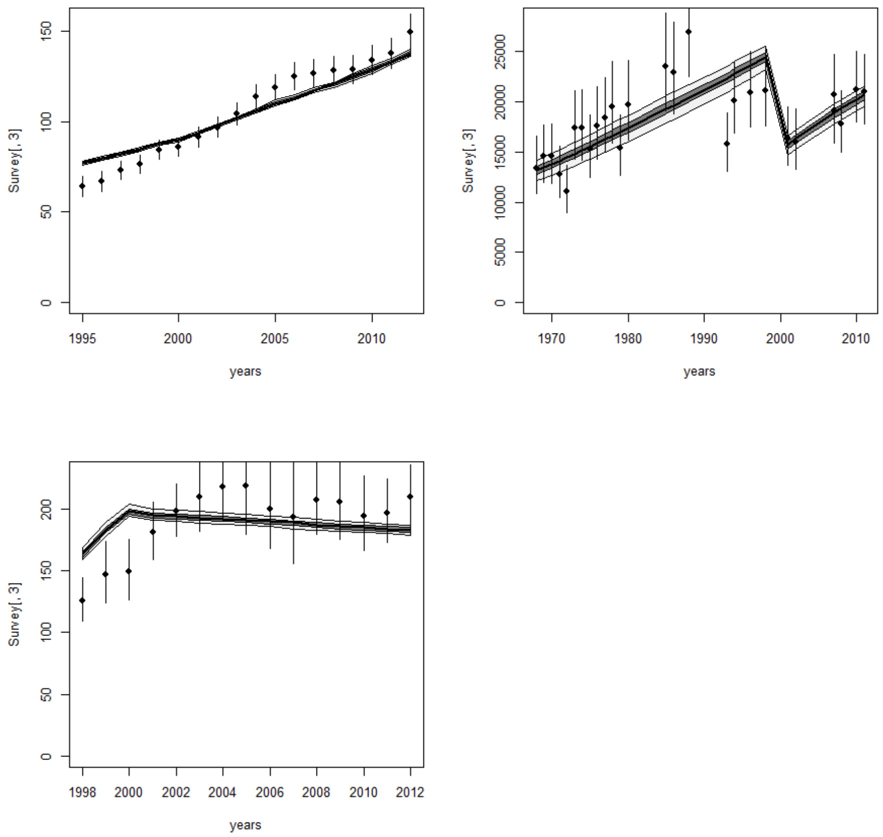

Figure 2. Fit of the population dynamics model to abundance estimate for the case in which the mixing fraction of Sakhalin animals in the Japan/Korea/China sub-area is assumed to be 0.1.

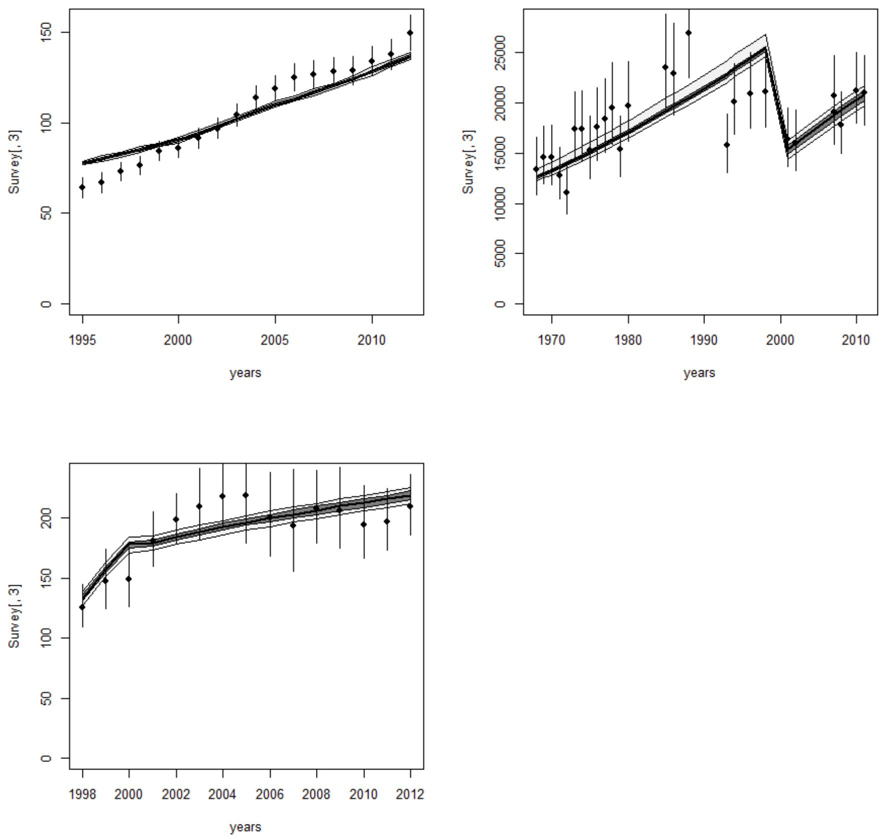

Figure 3. Fit of the population dynamics model to abundance estimate for the case in which the mixing fraction of Sakhalin animals in the Japan/Korea/China sub-area is assumed to be 0.2.

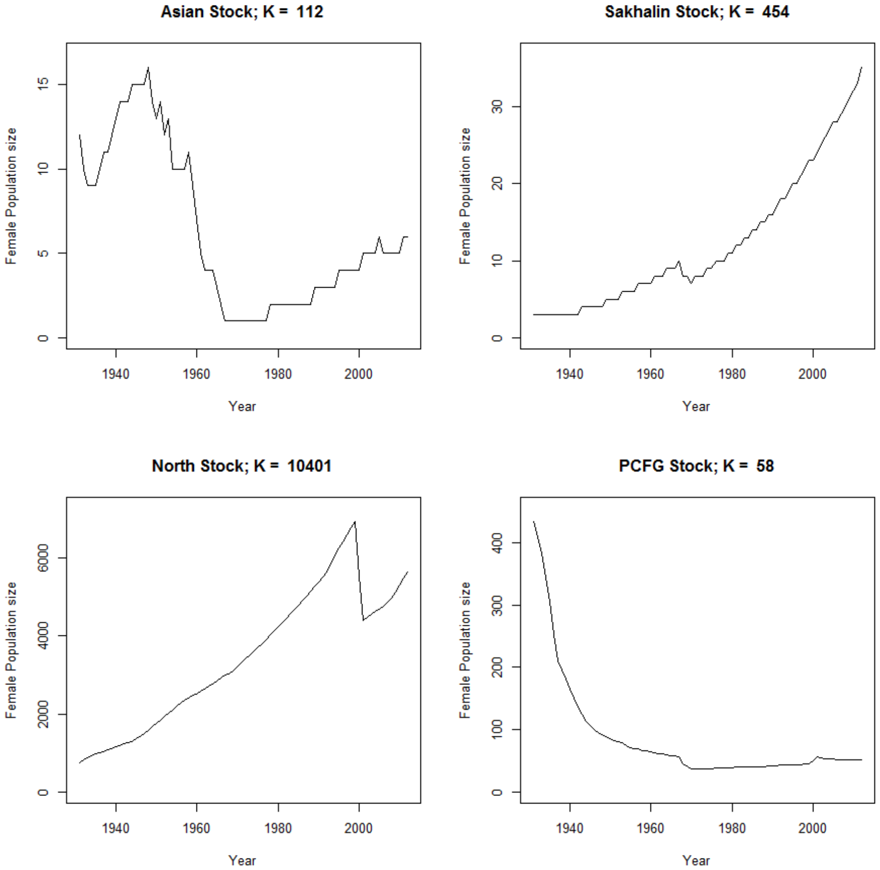

Figure 4. Time-trajectories of number by stock / sub-stock for the case in which the mixing fraction of Sakhalin animals in the Japan/Korea/China sub-area is assumed to be 0.1.

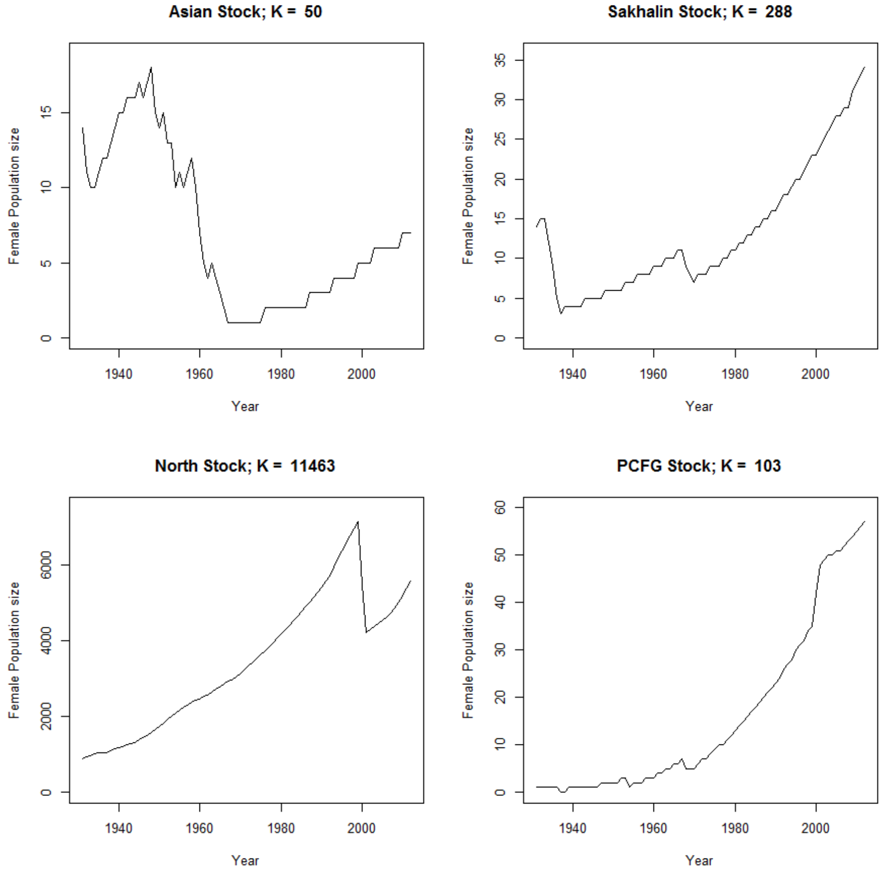

Figure 5. Time-trajectories of number by stock / sub-stock for the case in which the mixing fraction of Sakhalin animals in the Japan/Korea/China sub-area is assumed to be 0.2.

FISH and FISHERIES

Management strategy evaluation: best practices

André E Punt[1,2], Doug S Butterworth[3], Carryn L de Moor[3], José A A De Oliveira[4] & Malcolm Haddon[2]

[1]School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA, 98195, USA; [2]CSIRO Oceans and Atmosphere, GPO Box 1538, Hobart, TAS, 7001, Australia; [3]Marine Resource Assessment and Management Group (MARAM), Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch, 7701, South Africa; [4]CEFAS Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk, NR33 0HT, UK

Abstract

Management strategy evaluation (MSE) involves using simulation to compare the relative effectiveness for achieving management objectives of different combinations of data collection schemes, methods of analysis and subsequent processes leading to management actions. MSE can be used to identify a 'best' management strategy among a set of candidate strategies, or to determine how well an existing strategy performs. The ability of MSE to facilitate fisheries management achieving its aims depends on how well uncertainty is represented, and how effectively the results of simulations are summarized and presented to the decision-makers. Key challenges for effective use of MSE therefore include characterizing objectives and uncertainty, assigning plausibility ranks to the trials considered, and working with decision-makers to interpret and implement the results of the MSE. This paper explores how MSEs are conducted and characterizes current 'best practice' guidelines, while also indicating whether and how these best practices were applied to two case-studies: the Bering–Chukchi–Beaufort Seas bowhead whales (*Balaena mysticetus*; Balaenidae) and the northern subpopulation of Pacific sardine (*Sardinops sagax caerulea;* Clupeidae).

Keywords Fisheries management, management procedure, management strategy evaluation, simulation, stakeholders, uncertainty

Correspondence:
André E Punt, School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA 98195, USA
Tel.: +1 (206) 221-6319
Fax: +1 (206) 685-7471
E-mail: aepunt@uw.edu

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Introduction

Management strategies (also referred to as management procedures; Butterworth 2007, 2008a,b) are combinations of data collection schemes, the specific analyses applied to those data and the harvest control rules used to determine management actions based on the results of those analyses. Management strategy evaluation (MSE),[1] the evaluation of management strategies using simulation, is widely considered to be the most appropriate way to evaluate the trade-offs achieved by alternative management strategies and to assess the consequences of uncertainty for achieving management goals. Butterworth *et al.* (2010a) list three primary uses for MSE:

1. development of the management strategy for a particular fishery;
2. evaluation of generic management strategies; and
3. identification of management strategies that will not work and should therefore be eliminated from further consideration.

One specific use for MSE, particularly in the United States where the forms of the harvest control rules for federal fisheries management are constrained by the Magnusson–Stevens Act (MSA), is to quantify the impacts of uncertainty associated with management strategies adopted at present, and to identify the 'realizable' performance which can be achieved given the quality of the data available and the types of uncertainties which are inherent in the system being managed.

Butterworth (2007) contrasts MSE with the traditional approach to providing management advice, which involves conducting a 'best assessment' of the resource, evaluating uncertainty using confidence intervals and sensitivity tests, and providing a recommendation for a management action based on applying some harvest control rule or by conducting constant catch or constant fishing mortality projections. That paper explains how MSE overcomes many of the concerns with the traditional approach, including that the full range of uncertainty can be taken into account and that decision-makers consider longer term trade-offs among the management objectives, instead of focusing on short-term considerations only.

For the purposes of this paper, a MSE must address the fact that the data and models on which management strategies are based are subject to uncertainty. Consequently, analyses in which fishing mortality can be set and implemented exactly (e.g. Punt and Butterworth 1991) are not considered to be MSEs, even though such analyses may be useful in terms of understanding the dynamical properties of exploited ecosystems.

Management strategy evaluation has been used extensively to understand the expected behaviour of management strategies, but is increasingly being implemented to select management strategies for implementation in actual fisheries. The earliest use of MSE for such selection occurred in South Africa, where the control rules used to set total allowable catches (TACs) for the anchovy *Engraulis encrasicolus*, Engraulidae, and later the sardine *Sardinops sagax*, Clupeidae, fisheries were selected using what has since become known as MSE (Bergh and Butterworth 1987; Geromont *et al.* 1999; De Oliveira and Butterworth 2004). MSE has also been used in South Africa to select management strategies for the Cape hake *Merluccius paradoxus* and *M. capensis*, Merlucciidae (Rademeyer *et al.* 2008), rock lobster *Jasus lalandii* and *Palinurus gilchristi*, Palinuridae (Johnston and Butterworth 2005; Johnston *et al.* 2008) and most recently horse mackerel, *Trachurus trachurus capensis*, Carangidae (Furman and Butterworth 2012) fisheries. The use of management strategies that have been tested using simulation has been routine for the major fisheries in South Africa for some 20 years.

Management strategy evaluation has been used extensively by the International Whaling Commission (IWC) since the late 1980s to select management strategies to calculate potential catch limits for commercial whaling and determine actual strike limits for aboriginal subsistence whaling

[1]A term introduced into the fisheries lexicon by Smith (1994). To the extent possible, the nomenclature for MSE outlined by Rademeyer *et al.* (2007) is followed throughout.

(Punt and Donovan 2007). The use of MSE accelerated internationally following a 1998 ICES Symposium on Confronting Uncertainty in the Evaluation and Implementation of Fisheries-Management Systems, which included several papers illustrating the methods underlying MSE and then current applications (Butterworth and Punt 1999; Cooke 1999; Smith *et al.* 1999).

Management strategy evaluation has been used by the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) to select a management strategy for southern bluefin tuna *Thunnus maccoyii*, Scombridae (Kurota *et al.* 2010; Anonymous 2011). The Potential Biological Removals method, used to determine upper limits on anthropogenic removals of marine mammals in the USA, was also developed using MSE (Wade 1998). Similarly, MSE was used to evaluate a by-catch management control rule for seabirds (Tuck 2011). Outside of South Africa and the IWC, MSE has been applied most extensively in Australia where it has been used to compare and select management strategies for the Southern and Eastern Scalefish and Shark Fishery, SESSF (Punt *et al.* 2002; Wayte and Klaer 2010; Little *et al.* 2011), the Queensland spanner crab *Ranina ranina*, Raninidae fishery (Dichmont and Brown 2010), the Northern Prawn Fishery (Dichmont *et al.* 2008, 2013), the fishery for southern rock lobster *Jasus edwardsii*, Palinuridae off South Australia (Punt *et al.* 2012a) and the Tasmanian abalone fishery (Haddon and Helidoniotis 2013). The management strategies used to recommend catch limits for southern rock lobster off New Zealand have also been selected using MSE (Starr *et al.* 1997; Breen and Kim 2006).

Management strategy evaluation has been applied extensively to European fisheries to explore the performance of management strategies theoretically (Kell *et al.* 2005a,b, 2006), but few applications have resulted in strategies being formally implemented. The International Council for the Exploration of the Seas (ICES) provides a list of 18 management plans for North East Atlantic stocks that have been evaluated using MSE approaches since 2008 (ICES 2013). As an advisory body to the governments of ICES member countries and the European Commission, ICES bases its advice on these management plans if advice recipients have agreed that they can be used as a basis for that advice and provided the MSEs have shown them to fulfil ICES' precautionary criteria (ICES 2012). If this does not apply, ICES reverts to its own MSY framework, and if there is no basis for giving MSY-related advice, takes account of precautionary considerations (ICES 2012). The European Commission has its own advisory body, the Scientific, Technical and Economic Committee for Fisheries (STECF, established to advise on matters pertaining to the conservation and management of living aquatic resources) that performs impact assessments of proposed management plans, and may make use of MSEs for this purpose (STECF 2011a).

In North America, MSE has been applied to evaluate management strategies for the fishery for the northern subpopulation of Pacific sardine *Sardinops sagax caerulea*, Clupeidae, and the control rule used for this fishery from 1998 until 2012 was based on a MSE (PFMC 1998), as was the 2014 revision to this control rule (Hurtado-Ferro and Punt 2014). A revision to the management strategy adopted became necessary when the estimated relationship between recruitment success and environmental factors changed given new information. MSE has also been used to establish a management strategy for sablefish *Anoplopoma fimbria*, Anoplopomatidae off British Columbia (Cox and Kronlund 2008), for West Greenland halibut *Reinhardtius hippoglossoides*, Pleuronectidae (Butterworth and Rademeyer 2010; NAFO 2010) and for pollock *Pollachius virens*, Gadidae off eastern Canada (Rademeyer and Butterworth 2011).

Management strategy evaluation has recently been used to evaluate alternate management strategies for Tristan rock lobster (*Jasus tristani*) for three of the islands that form the Tristan da Cunha group of islands (Johnston and Butterworth 2013, 2014; Butterworth and Johnston 2014).

The focus for most previous MSEs has been single-species systems. However, MSE has also been used to evaluate management strategies to achieve multispecies or ecosystem objectives (Sainsbury *et al.* 2000; Fulton *et al.* 2007; Dichmont *et al.* 2008, 2013; Plagányi *et al.* 2013).

Management strategy evaluation is at the interface between science and policy. While it would be desirable to keep science and policy separate, there is a link. Decision-makers need to identify the desirable outcomes that any management strategy adopted should aim to achieve, while scientific analyses (the MSE) can inform the decision-makers on the feasible ranges of trade-offs. A well-structured MSE will utilize the links between policy and science, but ensure that a 'wall of science' remains whereby decision-makers do not decide scientific issues and scientists do not make policy decisions (Field *et al.* 2006).

While MSE is widely acknowledged to be the most appropriate way to compare management strategies, and the basic approach has been summarized in many publications, actual uses can differ markedly with regard to the likelihood that the resulting management strategy actually provides the best trade-off amongst the management objectives and is robust to uncertainty. Furthermore, it is well recognized that poorly conducted MSEs are likely to be less useful for management purposes than using the traditional best assessment approach coupled to essentially *ad hoc* advice (Rochet and Rice 2009; Butterworth *et al.* 2010b; Kraak *et al.* 2011). This paper therefore outlines the process of conducting MSEs and identifies a set of 'best practice' guidelines (Table 1). These proposed best practices for MSEs should assist in facilitating that MSEs are conducted in the most appropriate manner so that the resulting management strategies are best able to achieve their goals. The focus of the paper is on single-species applications of MSE, although applications that consider multispecies and ecosystem aspects are also considered. The extent to which these guidelines have been followed in practice is illustrated for two case-studies: the management strategy for the northern subpopulation of Pacific sardine and that for bowhead whales, *Balaena mysticetus* Balaenidae, in the Bering Sea, Chukchi Sea and Beaufort Sea.

MSE – the basics

The basic steps that need to be followed when conducting a MSE (Fig. 1) are as follows:

1. identification of the management objectives in concept and representation of these using quantitative performance statistics;
2. identification of a broad range of uncertainties (related to biology, the environment, the fishery and the management system) to which the management strategy should be robust;
3. development of a set of models (often referred to as 'operating models') which provide a mathematical representation of the system to be managed; an operating model must represent the biological components of the system to be managed, the fishery which operates on the modelled population, how data are collected from the managed system and how they relate to the modelled population (including the effect of measurement 'noise'); in addition, an implementation model is required that reflects how management regulations are applied in practice; note that more than a single operating model is nearly always required because of the need to cover the range of the ever-present uncertainties, which include the imprecision of the values of parameters estimated from fits to data, as well as structural uncertainties such as how many reproductively separate stocks of a species are present in the region considered;
4. selection of the parameters of the operating model(s) and quantifying parameter uncertainty (ideally by fitting or 'conditioning' the operating model(s) to data from the actual system under consideration);
5. identification of candidate management strategies which could realistically be implemented for the system;
6. simulation of the application of each management strategy for each operating model; and
7. summary and interpretation of the performance statistics; this may lead to refinement of the relative weighting of the management objectives as the simulation process develops and continues to provide more refined results to inform the quantitative trade-offs among competing goals.

The feedback loop between the management strategy and the operating model(s) is a fundamental aspect of MSE and is the particular feature, which distinguishes it from simple risk assessment where the implications of unchanging management regulations (e.g. constant TAC) are evaluated by use of projections. Simple risk assessment overestimates risk through failing to take account of management reactions to the information provided by future data.

Management strategy evaluation is not the same as conducting projections from a stock assessment, although a stock assessment may form the basis for the operating model(s) which are core to a MSE. Specifically, MSE takes feedback control into account, that is it takes account of the collection and use of future data on the status of the managed system. In addition, stock assessments usually involve selecting a single model structure and estimating the parameters of the model.

Table 1 Summary of the best practice guidelines.

Selection of objectives and performance metrics

- Involve decision-makers and stakeholders (e.g. using workshops) throughout the process to ensure the performance statistics capture the management objectives and are understandable.
- At a minimum, report statistics related to average catches, variation in catches and the impact on stock size.

Selection of uncertainties

- Consider a range of uncertainties, which is sufficiently broad that new information collected after the management strategy is implemented should generally reduce rather than increase this range.
- Include trials for each potential source of uncertainty (unless there is clear evidence that the source does not apply) and for the factors considered in Table 3.
- Consider the need for spatial structure, multiple stocks, predator-prey interactions and environmental drivers on system dynamics; modelling the last by imposing trends on the parameters of the operating model is often sufficient to understand its implications.
- Include predation effects using minimum realistic models and examine the potential for technical interactions amongst major fished species, especially in multispecies fisheries.
- Divide the trials into 'reference' and 'robustness' sets.
- Use Bayesian posterior distributions to capture the parameter uncertainty for each trial if possible.

Identification of candidate management strategies

- This should be the primary responsibility of the stakeholders/decision–makers, but with guidance from the analysts given the limitations of the management strategy evaluation (MSE). Care needs to be taken that the management strategy can be implemented in practice.
- Evaluate the entire management strategy. In cases in which the management strategy is complex, this may be impossible computationally, in which case a simplification of the assessment method is needed – the nature of the simplification should be based on simulation analyses.

Simulation of the application of the management strategy

- Check that operating model and management strategy are consistent with reality; projections into the future should generate quantities, such as past assessment errors and levels of variability in biomass and recruitment, on the same scales as those estimated to have occurred in the past.
- Conduct tests of the software, for example using 'perfect' data before conducting actual analyses.
- Base recommendations for management actions in management strategies only on data which would (with near certainty) actually be available.
- Document any assumptions regarding parameters assumed known when applying the management strategy.

Presentation of results and selection of a management strategy

- Develop a process, so that the decision-makers understand the results of the MSE and the range of trade-offs which are available to them.
- Use effective graphical summaries which are developed collaboratively with the stakeholders.
- Identify whether there are 'performance standards' which must be satisfied to eliminate some possible management strategies immediately and hence simplify the final decision process.
- Select a method for assigning a plausibility rank to each trial and take these ranks into account when making a final selection among candidate management strategies.

Other

- Include 'Exceptional Circumstances' provisions which specify the situations under which a management strategy's recommendations may be over-ridden.
- Include a schedule for when formal reviews of the implemented management strategy will take place.

Although an aim of a stock assessment is to quantify uncertainty, it is rarely possible to capture all the key sources of uncertainty within the confines of a stock assessment, in particular 'outcome uncertainty' (see below), and to carry uncertainty forward fully into the provision of management advice. MSE can also be used when it is not possible to apply standard methods of stock assessment, as is common in data-poor situations.

Although not the focus of the present paper, Marasco *et al.* (2007) observe that the results from a MSE may be used not only to choose amongst the candidate management strategies, but also to identify future research and monitoring goals. In addition, the results of a MSE can be used to evaluate how well existing monitoring and data analysis methods are able to reflect the true status of the system with reasonable accuracy (see e.g. Ful-

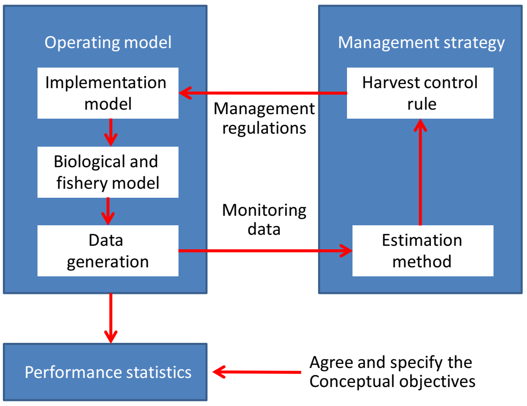

Figure 1 Conceptual overview of the management strategy evaluation modelling process.

ton *et al.* 2004; for an evaluation of ecosystem indicators). Marasco *et al.* (2007) also emphasize the need to continue to monitor the system following the implementation of a management strategy. Consistent with practice in, for example, the IWC and South Africa (Butterworth 2007; Punt and Donovan 2007), they stress the need to review and revise the MSE periodically, as consolidated outcomes from future monitoring and research become available.

Overview of the case-studies

Bering–Chukchi–Beaufort Seas bowhead whales

Bowhead whales in the Bering, Chukchi and Beaufort Seas are considered to be a single stock, separate from the stocks in the Okhotsk Sea, the Davis Strait and Hudson Bay, and off Spitsbergen. This stock, often referred to as the Bering–Chukchi–Beaufort (or BCB) Seas stock of bowhead whales, has been subject to hunting by aboriginal peoples off Alaska (USA) and Russia for centuries. In common with other stocks of bowhead whales, it was severely depleted by commercial whaling, which occurred between 1848 and 1914 in the case of the BCB stock. Commercial whaling on the BCB bowhead stock ceased once whaling there became economically non-viable, but aboriginal whaling continues at low levels.

Management of bowhead whales is challenging because individuals can live beyond 100 years (George *et al.* 1999). In addition, the location of the population and the fishery makes monitoring difficult (it involves ice platform sighting surveys of bowhead whales as they migrate through leads which open as the ice thaws). The aboriginal hunt of bowhead whales off Alaska and Russia is managed under the IWC. Management for aboriginal whaling is based on strike limits, which are the number of strikes of whales permitted within a season. Management advice is based on the number of strikes rather than numbers of whales landed because of the need to account for mortality when animals are struck but subsequently not landed ('lost').

Each country wishing to take whales for aboriginal subsistence purposes must provide the IWC with a 'Need Statement' which documents the number of annual strikes needed to satisfy the requirements of aboriginal peoples in terms of nutrition and culture. Management advice in the context of the BCB bowhead whales relates to whether the need requested can be satisfied without impacting the ability to achieve conservation-related management goals; this contrasts with commercial whaling, where the aim is to maximize the catch subject to the same constraint. The development of a management strategy for aboriginal subsistence whaling, and in particular for the BCB bowhead whales, commenced in 1995 after a management strategy for commercial whaling was adopted in 1994 (IWC 1994). A 'Strike Limit Algorithm' (SLA) was later adopted as the management strategy for the BCB bowhead whales in 2003 (IWC 2003). Prior to the use of the SLA, evaluation of whether the need requested was consistent with the IWC's conservation-related objective involved comparing the proposed need in terms of strikes with an estimate of a lower percentile (usually the lower 5th percentile) of a distribution for the replacement yield (the number of animals removed from the population each year which will keep the population at its current level; Givens *et al.* 1995).

The development of the SLA involved the IWC identifying management objectives for aboriginal subsistence whaling, obtaining a 'need envelope' from hunters and their scientific representatives (the range of possible maximum need levels by year over the next 100 years), developing operating models tailored to the dynamics of the BCB bowhead whale population, and simulating the application of candidate SLAs (equivalent to management strategies). The operating models for the BCB bowheads were case-specific, rather than generic as was the case for commercial whaling, because this was considered likely to lead to an improved ability to satisfy the management goals and because there are only a few aboriginal whaling fisheries. The development process was competitive, with several sets of 'developers' 'competing' to best satisfy the management goals. However, as it happened, the final selected SLA was none of these individual SLAs, but rather an average of the best two.

Northern subpopulation of Pacific sardine

The northern subpopulation of Pacific sardine is harvested off Mexico, the USA (including Alaska) and Canada. The population dynamics of Pacific sardine, in common with those of many small pelagic fish species, are characterized by large changes in abundance, driven primarily by environmental conditions. The long-term nature of these fluctuations has been confirmed for Pacific sardine using samples of fish scales from sediment cores in the Santa Barbara basin (Soutar and Isaacs 1969, 1974; Baumgartner *et al.* 1992). Sardine populations in the Santa Barbara basin are estimated to have peaked at intervals of approximately sixty years. The biomass and catch of Pacific sardine increased rapidly during the 1930s until the mid-1940s, and declined thereafter. The decline was likely due to a combination of environmental conditions leading to poor recruitments and very high fishing mortality rates.

The biomass of Pacific sardine began to rebuild during the 1980s, and by 1991 a directed fishery was re-established. The Pacific sardine fishery was managed by the State of California until 2000 when management authority was transferred to the Pacific Fishery Management Council (PFMC; Hill *et al.* 2011). Harvest Guidelines for Pacific sardine between 1998 and 2012 were set using a harvest control rule of the form (PFMC 1998):

$$\text{HG} = (\text{BIOMASS} - \text{CUT-OFF}) * \text{FRACTION} * \text{DISTRIBUTION}$$

where: HG (Harvest Guideline) is the allowable catch for each management year; BIOMASS is the estimate of the biomass of Pacific sardine aged 1 and older obtained from an age-structured stock assessment model; CUT-OFF is 150 000 mt and is the escapement threshold below which fishing is prohibited; FRACTION is a temperature-dependent exploitation fraction which ranges from 5 to 15%; and DISTRIBUTION is the average proportion of the coastwide biomass in USA waters, estimated at 0.87. In addition, there is a maximum allowable catch regardless of biomass such that HG ≤ MAXCAT, where MAXCAT is 200 000 mt. The purpose of CUT-OFF is to protect the stock when biomass is low. The purpose of FRACTION is to specify how much of the stock is available to the fishery when BIOMASS exceeds CUT-OFF. The DISTRIBUTION term recognizes that the stock ranges beyond USA waters and is therefore subject to foreign fisheries. In PFMC (1998), FRACTION was determined on the basis of a 3-year running average of the temperature at Scripps Pier, La Jolla, USA.

The overarching management plan for all coastal pelagic species (CPS) managed by the PFMC was modified in 2011 to be consistent with the 2006 reauthorization of the MSA. This involved formally introducing how the overfishing limit (OFL, the annual catch amount consistent with an estimate of the annual fishing mortality that corresponds to maximum sustainable yield) is calculated, as well as the acceptable biological catch (ABC, a harvest limit set below the OFL that incorporates a buffer against overfishing to take account of scientific uncertainty).

The specifications of the harvest control rule adopted in 1998 were determined using simulations in which the population dynamics were represented by a production model where productivity was related to an environmental variable (PFMC 1998). Results of assessments conducted after 1998 were analysed during a workshop in February 2013 (PFMC 2013) which suggested that the temperature at Scripps Pier no longer exhibited the same trends as most other measures of temperature for the offshore waters to the west of North America (McClatchie *et al.* 2010). Rather, the relationship between recruitment, spawning biomass and temperature was strongest when temperature was based on sea surface temperature obtained from CalCOFI samples (PFMC 2013).

The results from the February 2013 workshop formed the basis for developing a set of operating models for the northern subpopulation of Pacific sardine, as well as an initial set of candidate management strategies (PFMC 2013). The process of selecting the operating models and the candidate management strategies was iterative, involving presentations by the analysts to the PFMC as well as its Scientific and Statistical Committee, Coastal

Pelagic Species Advisory Panel and Coastal Pelagic Species Management Team. The PFMC took advice from these advisory bodies as well as from members of the public, including industry and environmental non-governmental organizations (ENGOs), and then directed the analysts. Hurtado-Ferro and Punt (2014) summarize the most recent MSE results, along with the specifications for the operating models and candidate management strategies.

Best practices for MSE

Establishing objectives and performance statistics

One of the main strengths of MSE is that the decision-makers clarify their objectives. Objectives for fisheries management can be categorized as either 'conceptual' ('strategic') or 'operational' ('tactical'). Conceptual objectives are generic, high-level policy goals. For example, the conceptual objectives for CPS off the USA west coast (i) promote efficiency and profitability in the fishery, including stability of the catch; (ii) achieve 'Optimum Yield' (OY); (iii) encourage cooperative international and interstate management of CPS; (iv) accommodate existing fishery sectors; (v) avoid discards; (vi) provide adequate forage for dependent species; (vii) prevent overfishing; (viii) acquire biological information and develop a long-term research programme; (ix) foster effective monitoring and enforcement; (x) use resources spent on management of CPS efficiently; and (xi) minimize gear conflicts (PFMC 2011). These goals are largely self-consistent, but this need not always be the case. For example, the conceptual objectives for aboriginal subsistence whaling (i) ensure that risks of extinction are not seriously increased by whaling; (ii) enable native people to hunt whales at levels appropriate to their cultural and nutritional requirements (i.e. satisfy their 'need'); and (iii) move populations towards and then maintain them at healthy levels. Objective (ii) may be in conflict with objectives (i) and (iii) for some populations.

To be included in a MSE, the conceptual objectives need to be converted into operational objectives (expressed in terms of the values of performance measures or performance statistics). This usually involves translating each conceptual objective into one or more operational objective(s) and performance statistic(s). For example, the conceptual objective of 'avoid overfishing' could be represented operationally as 'the annual probability that the stock drops below 20% of the unfished level should not exceed 5%'. However, some conceptual objectives may link to multiple operational objectives. For example, the conceptual objective 'achieve OY' could be quantified by the operational objectives 'maximize catch in biomass', 'minimize the interannual variation in catch' and 'maximize the economic rent to the fishing industry', amongst others.

The operating model(s) should be developed so that performance statistics can be calculated. For example, when there are explicit ecosystem and economic objectives, the operating model(s) may need to include a fleet dynamics model (Ulrich *et al.* 2007) or models of how fishing impacts ecosystem components other than the target species (Schweder *et al.* 1998), as well as related performance statistics.

It is inevitable that some of the objectives will be in conflict to some extent, and one aim of MSE is to highlight trade-offs among the objectives as quantified using performance statistics. For example, increased monitoring efforts may allow higher catches for the same level of risk (see Fig. 2), but the increased monitoring will come at a financial cost. The more common trade-offs are between risk to the resource and benefits to the fishery, and between average catch and variation in catch (the less variability in catch permitted, the lower the average catch needs to be able to accommodate catch reductions needed at times the resource might be at a low abundance). It is critical to ensure that the decision-makers are aware of these trade-offs. One way to achieve this is to use a utility function which balances the various factors in providing a single number. However, efforts to base MSEs on utility functions have generally been unsuccessful because decision-makers (and stakeholder groups) wish to see how well each candidate management strategy achieves each objective and how they trade off.

The difficulties associated with conflicting objectives become more challenging when management strategies are developed for fisheries which target multiple species, or when there are multiple stakeholder groups which fish using different gears or may have markedly different objectives (e.g. commercial and recreational sectors within a fishery). This is because what is seen as the 'optimal' state of the system will differ among stakeholders. Few management strategies that have been

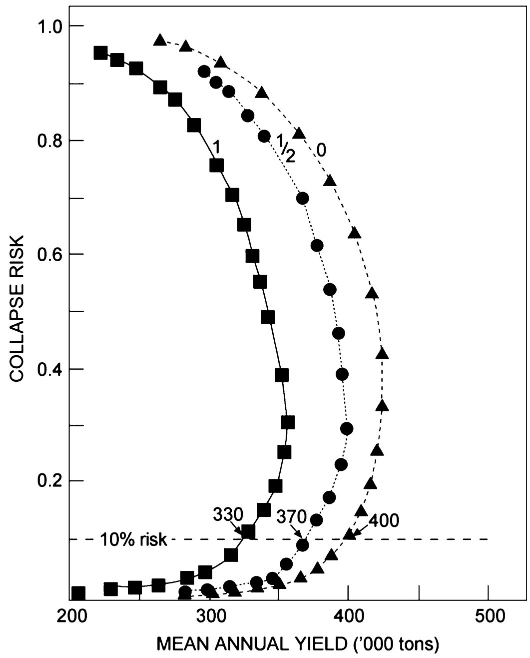

Figure 2 Relationship between risk and reward for South African anchovy ('collapse' is defined here as the spawning biomass falling below 10% of its average unexploited level, and risk reports the probability of that happening at least once during a 20-year period). Each line indicates a different level of survey precision (1: current precision; ½: double the survey effort; 0: perfect information; reproduced from Bergh and Butterworth 1987).

implemented have addressed the issue of between-species trade-offs. One notable exception is the South African fishery for anchovy and sardine. Here, there is a trade-off between anchovy and sardine catches because of an unavoidable by-catch of juvenile sardine with anchovy, which decreases the TAC possible for the more valuable adult sardine. This multiple species allocation problem was addressed over one period by allowing each company with rights to each of the two species to choose its preferred trade-off. First, the TACs that would follow under each company's desired trade-off were calculated; next quotas were allocated to that company which were computed by multiplying the TACs related to its trade-off by the proportional right to the combined (sardine and anchovy) fishery as a whole that it had been awarded; finally, the TACs themselves were calculated by summing the quotas awarded to each company for each species (De Oliveira 2003; Butterworth *et al.* 2012).

Best practice in terms of specifying objectives, particularly operational objectives, is through the use of inclusive workshops (Cox and Kronlund 2008; Mapstone *et al.* 2008; PFMC 2013). Workshop participants need to be representative of the decision-makers and other stakeholders, and efforts should be made to ensure that the decision-makers are fully aware of which decisions are theirs (weighting objectives, and selecting management strategies to be tested) and which decisions are primarily technical. Progress in such workshops may be facilitated by providing draft specifications that can be criticized, expanded upon or rejected outright.

The statistics used to evaluate the performance of alternative candidate management strategies should be chosen, so that they are easy for decision-makers and stakeholders to interpret (Francis and Shotton 1997; Peterman 2004). Butterworth and Punt (1999) comment that standard deviations or coefficients of variation of catch limits are difficult for many stakeholders to understand. Experience suggests that stakeholders find it much easier to relate to statistics such as the fraction of years in which the catch is less than some desirable level. Care should be taken to avoid having too many performance statistics. While it may seem desirable to have, for example, a number of performance statistics to quantify catch variation (IWC 1992), the final decision process is made considerably easier if the number of performance statistics is small, so that they can easily be summarized graphically. In any case, experience suggests that such catch variation statistics are often highly correlated with each other.

It is common to include performance statistics such as the probability of dropping below some threshold level [such as the minimum stock size threshold (MSST) defined in the USA MSA, or 20% of the estimated unfished biomass, B_0]. However, while dropping below MSST has implications in the USA (leading to the requirement for a rebuilding plan), the use of a metric such as the probability of dropping below a fixed fraction of B_0 can be criticized both because any such level is somewhat arbitrary, and because there is seldom evidence for threshold or depensatory effects. Nevertheless, in relation to answering questions of direct interest to decision-makers, such policy-related performance statistics may need to be included in the set reported. ICES (2013) notes that there are three ways to define the probability of dropping below a threshold: (i) the average probability (over simulations and years) of being below the threshold; (ii) the probability (over simulations) of dropping below the threshold at least once during each projection; and (iii) the maximum annual probability (over simulations) of being below the threshold over the projection period. Other ways to summarize these probabilities exist, including, for example, the probability in a given year. de Moor *et al.* (2011) comment that the probability of dropping below a threshold depends on the extent of process error, and define a performance statistic that evaluates risk in terms of the extent to which this probability increases with fishing, relative to its value in the absence of fishing.

A complicating factor with performance statistics that pertain to population size relative to B_0 or the MSY level is how these are to be defined in a changing environment and when there is time-varying predation (A'mar *et al.* 2009a,b, 2010). Usually, this problem has been resolved by replacing carrying capacity in these statistics by the population size which would have occurred had there been no catches (IWC 2003). However, for multispecies operating models, this can lead to counter-intuitive results where the unfished level is actually lower than the fished population size (Mori and Butterworth 2006).

Although most operational objectives relate to the fishery and the conservation of the species on which it depends, increasingly these objectives include ones pertaining to ecosystem impacts of fishing (Dichmont *et al.* 2008) and economic objectives (Dichmont *et al.* 2008; Anderson *et al.* 2010). Performance statistics can also relate to the management system itself. For example, in a MSE to evaluate management strategies for overfished USA west coast groundfish stocks, Punt and Ralston (2007) considered performance statistics such as when rebuilding was estimated to have occurred compared to how long this had been anticipated to take when the rebuilding plan was developed, and how often a rebuilding plan failed. This was because these were issues of interest to the decision-makers, which also related to the confidence stakeholders and the public have in the management system.

In the context of BCB bowheads, the conceptual objectives were selected by the IWC (i.e. the Commissioners). The operational objectives (and related performance statistics) were selected by the Scientific Committee of the IWC to reflect the intent of the conceptual objectives. These included statistics related to (i) the proportion of the nutritional and cultural need requested by aboriginal communities which could be satisfied, (ii) the delay in rebuilding to the population size corresponding to MSY caused by the mortality permitted and (iii) measures of the variation in the number of strikes permitted. No performance statistics specifically related to extinction risk were considered because none of the management strategies explored led to an appreciable risk of extinction – indeed the probability of extinction was zero for all management strategies and (plausible) simulations. The performance statistics related to the delay in rebuilding were hard to interpret, so that the final conservation-related statistics were based on simpler concepts such as the lowest ratio of population size to carrying capacity and the ratio of population size to carrying capacity after 100 years of simulated management.

The performance statistics for the Pacific sardine MSE were initially proposed during a workshop with stakeholders (PFMC 2013); these statistics were then refined based on input from the PFMC and its advisory bodies. The final set of performance statistics included conventional statistics related, for example, to average catches and variation in catches. However, the performance statistics also included quantities such as the proportion of times that the fishery was closed or its catch was <50 000 t, the average number of consecutive years the fishery was predicted to be closed, and the proportion of years that the biomass of animals aged 1 and older was <400 000 t. The last statistic was a proxy for indications of whether the biomass is sufficiently low that predators may be impacted.

Selection of uncertainties to consider and selection of operating model parameter values

Ideally, the range of uncertainties considered in a MSE should be sufficiently broad that new information collected after the management strategy is implemented should reduce rather than increase the range (Punt and Donovan 2007; IWC 2012a). However, in practice, it is seldom the case that it is possible to come close to incorporating all the pertinent uncertainties fully for any given situation, and choices are needed as to which uncertainties are the most consequential and reflect more plausible alternative hypotheses. Several attempts (Francis and Shotton 1997; Haddon 2011a) have been made to characterize sources of uncertainty. For the purposes of this paper, five sources of uncertainty are distinguished.

1. Process uncertainty: variation (usually assumed to be random, though sometimes incorporating autocorrelation) in parameters often considered fixed in stock assessments such as natural mortality, future recruitment about a stock–recruitment relationship and selectivity.
2. Parameter uncertainty: many operating models are fit to the data available, but the values estimated for the parameters of those operating models (e.g. fishery selectivity-at-age, the parameters of the stock–recruitment relationship and historical deviations in recruitment about the stock–recruitment relationship) are subject to error.
3. Model uncertainty: the form of relationships within an operating model will always be subject to uncertainty. The simplest type of model uncertainty involves, for example, whether the stock–recruitment relationship is Beverton–Holt or Ricker, whether a fixed value for a model parameter is correct, or whether fishery selectivity is asymptotic or dome-shaped. However, there are other more complicated types of model structure uncertainty such as how many stocks are present in the area modelled, the error structure of the data used for assessment purposes, the impact of future climate change on biological relationships such as the stock–recruitment function, and ecosystem impacts on biological and fishery processes.
4. Errors when conducting assessments, which inform the catch control rule that is being evaluated using the MSE: management advice for any system is based on uncertain data. Consequently, the data that inform catch control rules need to be generated in a manner which is as realistic as possible. Uncertainty arises when the model used for conducting assessments and providing management advice differs from the operating model, or the data are too noisy to estimate all key parameters reliably.
5. Outcome (or 'implementation') uncertainty: the impact of fishers and other players in the management system on the performance of management strategies has long been recognized (Rosenberg and Brault 1993; Rosenberg and Restrepo 1994). The most obvious form of this type of uncertainty is when catches are not the same as the TACs – typically more is taken or the decision-makers do not implement the TACs suggested by the management strategy. However, there are many other sources of outcome uncertainty, such as that associated with catch limits set for recreational fisheries and regulating discards. In some cases, this source of uncertainty has been found to dominate all the others (Dichmont *et al.* 2008; Fulton *et al.* 2011a).

In general, the evaluation of management strategies proceeds by first identifying the set of factors which are perceived to contribute the most to the uncertainty for the case in question. There will usually be factors for each of the five sources of uncertainty listed above. For example, factors could be 'the extent to which carrying capacity changes into the future', or 'the variation in realized catches about those intended'. Each factor will have a number of levels: for example, different rates of change in carrying capacity or variations in realized catch about the intended catch. Trials would then be constructed by selecting a level for each factor and thereby represent the range of uncertainty about a hypothesis to be considered in the evaluation. Best practice for a specific case involves explicitly addressing each of these uncertainties, or at least indicating how the uncertainties reflected were selected. Minimally, a MSE should consider (i) process uncertainty, in particular, variation in recruitment about the stock–recruitment relationship; (ii) parameter uncertainty relating to (a) productivity and (b) the overall size of the resource; and (iii) observation error in the data used when applying the management strategy. Which uncertainty is most important will be case-specific. For example, process uncertainty is unlikely to be very important for the management of large whale populations, whereas this uncertainty could be very consequential for a short-lived species such as Pacific sardine; the uncertainty factors considered in the MSEs for the two case-studies unsurprisingly differed markedly (Table 2).

Best practice is to divide MSE trials into a 'reference' (or 'base case') set of trials and a 'robustness' set of trials (Rademeyer *et al.* 2007). The reference trials are considered to reflect the most plausible hypotheses (see below for further comments on assigning plausibility to trials) and hence form the primary basis for identifying the 'best' management strategy, while the robustness trials are used to determine whether the management strategy behaves as intended in scenarios that are fairly unlikely, even though they are still plausible. While it is clearly desirable to conduct trials for all combinations for the levels for each factor (Kurota *et al.* 2010), this is often computationally impossible except when the management strategies being evaluated are fairly simple (Carruthers *et al.* 2014), and even then, conducting a MSE could be very computer-intensive depending on how many trials are run. Although partial factorial designs can be used to address this difficulty (Schweder *et al.* 1998), it is more common to select 'base' levels for each factor (in some cases multiple 'base levels'), and then to develop trials which involve varying each 'base' level in turn, perhaps also adding a few trials in which multiple factors are changed from their 'base' levels.

Table 2 Factors related to uncertainties considered in the simulation trials developed to test the management strategies for the Bering–Chukchi–Beaufort (BCB) Seas bowhead whales and the northern subpopulation of Pacific sardine.

BCB bowhead whales	Pacific sardine
Population dynamics	
• Inherent productivity	Extent of variation in recruitment
• Shape of the production function	Time-varying natural mortality
• Process error in calving rate	Time-varying productivity[1]
• Time trends in carrying capacity	Changes in selectivity spatially
• Time trends in productivity	Time-varying selectivity
• Occasional catastrophic mortality or recruitment events	Time-varying weight-at-age
• Time lags in the density dependence function	
• Alternative stock structure hypotheses[2]	
Data related	
• Survey frequency	Extent of auto-correlation in biomass estimates
• Average bias of survey estimates	Extent of variation in biomass estimates
• Trends in bias of survey estimates	Biomass estimates non-linearly related to true abundance
• Survey CV	
• Bias in reported catches	
Implementation related	
• Survey conducted to maximize strike limits	Only the USA follows the control rules

1All trials allowed for some variation in productivity due to environmental effects, but the manner in which productivity was related to the environment was varied in these trials.
2Conducted during the 2007 *Implementation Review* (International Whaling Commission 2008a,b, 2009, 2014).

Kraak *et al.* (2011) assert that the choice of sources of uncertainty included in MSE simulations often is quite arbitrary, and the uncertainties chosen do not necessarily reflect the key sources of uncertainty. They note that some MSEs conducted in Europe ignore spatial structure and whether egg production rather than spawning biomass drives recruitment. If these were indeed key uncertainties for the resources concerned, the scientists conducting those MSEs would clearly have been in error in ignoring them.

Best practice would involve trials based on at least a standard set of factors (Cooke 1999), so that the simulations extend over the set of uncertainties found to have had a large impact on the performance of management strategies for other systems (a list is given in Table 3). Most early operating models considered a single stock, ignored climate drivers of recruitment, growth and natural mortality, and treated the area being managed as a single homogeneous region. Each of these limitations can be overcome, particularly given the availability of sufficient computing resources. For example, although Butterworth and Punt (1999) commented that there were very few operating models which accounted for spatial structure when they conducted their review in 1998, subsequently Punt *et al.* (2005), IWC (2008a,b, 2009, 2014), Punt and Hobday (2009) and Carruthers *et al.* (2011) have all developed operating models which can, to some extent, account for spatial structure.

Climate and environmental variation is increasingly recognized as factors which often need to be included when evaluating management strategies. Two basic approaches have been adopted. The first is to include these factors in end-to-end models which represent entire ecosystems from physical processes to high trophic levels and fisheries, such as Atlantis (Fulton *et al.* 2011b) and Ecopath-with-Ecosim (Gaichas *et al.* 2012). The second is to relate environmental change to values of parameters empirically (Punt *et al.* 2014). Under the latter approach, environmental change can be

Table 3 List of factors, whose uncertainty commonly has a large impact on management strategy performance, which should be considered for inclusion in any management strategy evaluation.

Productivity • Form and parameters of the stock–recruitment relationship. • Presence of depensation. • Extent of variation and correlations in recruitment about the stock–recruitment relationship. • Occasional catastrophic mortality or recruitment events.	*Data-related issues* • CVs and effective samples sizes of data. • Changes in the relationship between catchability and abundance. • Changes in survey bias (fishery-independent data). • Survey and sampling frequency. • Ageing error. • Historical catch inaccuracy (bias).
Non-stationarity • Changes in the stock–recruitment relationship. • Time-varying natural mortality (potentially a multispecies operating model). • Time-varying carrying capacity (regime shift; linked to environmental variables or multispecies effects). • Time-varying growth and selectivity. *Other factors* • Spatial and stock structure. • Technical interactions. • Time-varying selectivity, movement and growth. • Initial stock size (unless it is estimated reliably when conditioning the operating model).	*Outcome (Implementation) uncertainty* • Decision-makers adjust or ignore management advice. • Realized catches differ from total allowable catches due to mis-reporting, black market catches, discards, etc.

modelled by linking environmental variables to the parameters that determine the dynamics of the population represented in the operating model (A'mar *et al.* 2009a; Ianelli *et al.* 2011; Punt 2011), or regime shift changes in parameters can be modelled (A'mar *et al.* 2009b; Wayte 2011; Szuwalski and Punt 2013). Most studies in which biological parameters are driven by environmental effects are conducted in circumstances where the relationships between the environment and the population dynamics are largely unknown (Hurtado-Ferro and Punt 2014). Most previous MSEs have allowed only one parameter of the operating model to exhibit time trends. However, it is possible to force a number of operating model parameters to do so. For example, Kell and Fromentin (2010) explored the performance of a VPA-based management strategy where both recruitment and migration varied as a function of the environment, while Punt *et al.* (2013) investigated the robustness of a management strategy for rock lobsters off Victoria, Australia, to time trends in natural mortality, catchability and growth.

Ecosystem effects, in particular biological and technological interactions, can be addressed within the context of end-to-end models such as Atlantis and Ecosim. However, most current investigations of the impacts of ecosystem effects on the performance of management strategies have been based on models of intermediate complexity for ecosystems (MICE; Punt and Butterworth 1995; Schweder *et al.* 1998; Plagányi 2007; A'mar *et al.* 2010; Howell *et al.* 2013), primarily because it is possible to parameterize these types of models by fitting them to monitoring data, although this renders the conclusions case-specific (Plagányi *et al.* 2014).

Technical interactions are probably easier to include in operating models given that there are usually direct data on catches and by-catches by fleet. Such interactions have been included in the MSEs conducted by De Oliveira and Butterworth (2004) for South African sardine and anchovy, by Dichmont *et al.* (2006a) for two prawn species off northern Australia, by Punt *et al.* (2005) for two shark species of southern Australia and by Kraak *et al.* (2008) for the flatfish complex in the North Sea. Dichmont *et al.* (2006a) and Kraak *et al.* (2008) model effort allocation based on economic incentives that lead to technical interactions among species.

How realistically the data are generated will directly impact the performance of any assessment method, and therefore also of any management strategies which depend on the results of the assessment. For example, most simulation studies generate age/length composition data from the survey or fishery catch in a way that matches the distributions assumed when fitting the assessment model (Bence *et al.* 1993; Sampson and Yin 1998; Radomski *et al.* 2005). However, this means that even very small sample sizes can appear to be extremely informative. In contrast, the residual patterns for actual stock assessments are often suggestive of both overdispersion and model misspecification. It is important to ensure that a number of plausible relationships between indices and true abundance are considered when assessments rely on fishery-dependent index data.

Best practice for parameter uncertainty for a given model structure is to sample parameters values from a Bayesian posterior distribution, or less ideally to use bootstrap samples or to sample parameter vectors from the asymptotic variance–covariance matrix for the parameters. Constructing Bayesian posterior distributions or developing bootstrap distributions for parameters can, however, be very intensive computationally.

Although the ideal is to evaluate management strategies using a trial structure which has been developed for a given stock or system, this may be impossible to achieve for data-poor situations. Nevertheless, it remains important to evaluate management strategies for data-poor situations, especially when the management strategies use proxies for measures of biomass; consequently, extensive testing of management strategies for data-poor situations has been undertaken, particularly in Australia (Haddon 2011b; Little *et al.* 2011; Plagányi *et al.* 2013, in press) and New Zealand (Bentley and Stokes 2009a,b). In these cases, there is a value in developing management strategies which can be applied generically. Naturally, generic management strategies would not be expected to perform as well as a management strategy that has been developed for a specific case (Butterworth and Punt 1999). When an evaluation of generic management strategies is to be undertaken, it is necessary to ensure that a broad range of species life histories are explored, along with a broad range of hypotheses regarding the quality of past and future data, and the state of the stock when the management strategy is first applied (Wiedenmann *et al.* 2013; Carruthers *et al.* 2014; Geromont and Butterworth in press-a). The values for the operating model parameters in this case would be selected based on generic considerations, and values for species which are characteristic of those to which the management strategy is to be applied.

Finally, it would be naive to believe that it is possible to identify all key uncertainties correctly, and it should not come as a surprise that some potential uncertainties not taken into account during the development of a management strategy turn out to be consequential. Kolody *et al.* (2008) drew attention to a key uncertainty (underestimation of historical catches) that was not initially considered during the development of a management strategy for southern bluefin tuna (*T. maccoyii*). They also questioned whether analyses of historical data, for example, as part of the process of conditioning the operating model(s) to data will capture the full extent of uncertainties. This problem should not imply that it is not worthwhile to conduct a MSE, but rather emphasizes that the earlier view that management strategies can be developed to run on 'autopilot' for a large number of years is likely flawed. Thus, the value of management strategies including 'Exceptional Circumstances' provisions and conducting regular *Implementation Reviews* (see final section) is high and justified, even if it entails additional work. Butterworth (2008a) emphasizes that the operating models considered in MSE analyses should remain 'broadly comparable' with the data. In practice, this means that use of, for example, strict model selection criteria to weight trials should be considered very carefully; in particular, use of, for example, AIC-weighting or the analytic hierarchy process (Merritt and Quinn 2000) should only be considered when there is confidence that the likelihood function is reliable (which is often not the case because the data inputs are not completely independent, as is usually assumed). Best practice in cases when the data used to parameterize the operating model are in conflict, for example when the various indices of abundance exhibit different trends, is to develop alternative operating models which represent each data set (Butterworth and Geromont 2001).

Identification of candidate management strategies which could realistically be considered for implementation

Ultimately, the management strategy chosen should reflect the policies developed by the decision-makers. Management strategies can be divided roughly into those that are model-based and those that are empirical, although some management strategies could be considered to be a mixture of the two types of strategies (Starr *et al.* 1997). Broadly, model-based management strategies usually involve two stages (see below), although some management strategies such as the IWC's Revised Management Procedure (IWC 1994) integrate the two stages to the point that it is impossible to distinguish them. For southern bluefin tuna, the model-based part of the management strategy is in effect a biologically plausible smoother of the two abundance indices used, with the actual harvest control rule having more in common with empirical harvest control rules than the more traditional model-based versions (Anonymous 2011).

The first stage in a model-based management strategy involves applying a stock assessment method (which may be much simpler than the methods used to develop the operating models that provide the basis for the MSE simulation testing process), and the second involves taking the results from that stock assessment model as the input for a harvest control rule. Several jurisdictions, including the USA and Australia, apply complex model-based management strategies, at least for their 'data rich' stocks. Despite the process being very intensive computationally, these types of management strategies have been evaluated using simulation (Dichmont *et al.* 2006b; A'mar *et al.* 2008, 2009a,b, 2010; Anonymous 2011; Fay *et al.* 2011; Punt *et al.* 2013). Model-based management strategies tend to lead to lower variation in terms of, for example, TACs than empirical approaches that do not constrain the estimated dynamics using population models (Butterworth and Punt 1999; Anonymous 2011), although this effect may be alleviated by imposing constraints on the extent of interannual change permitted in catch limits (see below).

In contrast to model-based management strategies, empirical management strategies do not utilize a population model to estimate biomass, fishing mortality or related quantities for use in harvest control rules. Rather, they set regulations such as TACs directly from monitoring data, usually after some data summary methods have been applied (e.g. CPUE standardization for catch and effort data). For example, the empirical harvest control rule used to recommend annual catch limits for the South African sardine involves setting catch limits as a constant proportion of the resource abundance estimated from the most recent hydro-acoustic survey. This rule is then subject to a number of constraints, or meta-rules, such as a maximum TAC and a maximum amount by which the TAC can decrease interannually. By removing this latter constraint during years of high TACs, the rule was designed to be flexible enough to allow the industry to take advantage of the occasional 'booms' that are a feature of this highly variable resource, without increasing the risk of the resource dropping to an undesirably low level (de Moor *et al.* 2011).

Rademeyer *et al.* (2007) remark that empirical management strategies are easier to test and are often easier to explain to decision-makers, but have the disadvantage that there might not be a clear basis for determining the target at which the resource will eventually equilibrate (Little *et al.* 2011). Examples of management strategies implemented which are empirical are those for hake, rock lobster, horse mackerel, anchovy and sardine off South Africa, for rock lobsters off South Australia and Tristan da Cunha, for West Greenland halibut and for pollock off eastern Canada. Most empirical management strategies base management decisions on trends in an index of abundance. However, there is a move towards 'target'-based rules, where TAC changes depend on the difference between the most recent level and the target for some abundance-related index (Little *et al.* 2011; Rademeyer and Butterworth 2011; Geromont and Butterworth in press-b), because the resultant catch limits tend to show less variability without impacting performance on other statistics such as average catch and risk to the resource. An example of an empirical 'target'-based rule is that used to recommend annual catch limits for the South African south coast rock lobster: the annual TAC is adjusted up or down from that recommended for the previous year according to whether the most recent measure of standardized CPUE is above or below a target value, with the extent of TAC adjustment proportional to the magnitude of the difference between the recent CPUE and the target value (Johnston *et al.* 2014). Management strategies can also be based on changes in metrics defined from age and size compositions (Butterworth *et al.* 2010b; Wayte and Klaer 2010; Fay *et al.* 2011).

Many management strategies impose constraints on how much catch limits can vary from 1 year to the next. For example, the management strategies for Australia's SESSF include 10 and 50% rules, which state that no change in TAC up or down will be larger than 50% of the current TAC; similarly, if a predicted change is <10% of the current TAC, then no change is made. In South Africa, both the hake and rock lobster management strategies include maximum TAC changes of either 5 or 10%, although these are over-ridden if appreciable declines in abundance become evident from the indices monitoring resource abundance. These minimum change rules have the advantage of smoothing out what might be noise from the management strategy output arising from noise in its data inputs.

Most of the management strategies considered in MSEs have been based on the conventional data used for stock assessments (e.g. catches, indices of abundance, age/length composition information). However, it is possible to develop management strategies, particularly for data-poor situations, using non-conventional data. For example, McGilliard *et al.* (2010) and Babcock and MacCall (2011) developed management strategies that use the ratio of the density inside and outside of marine protected areas to adjust limits on catch and effort in fished areas. Wilson *et al.* (2010) extended these approaches to use data on the proportion of old fish in the population. Christensen (1997) defined (and evaluated) a management strategy in which limits on effort are a function of the economic rent from the fishery, while Pomarede *et al.* (2010) evaluated one based on estimates of total mortality. The management control in most management strategies changes based on the data collected (feedback strategies), although some management strategies for data-poor situations are effectively non-feedback, setting management controls based, for example, on historical catch only. The performance of non-feedback strategies is, however, generally poor (Carruthers *et al.* 2014).

While the candidate management strategies which could be adopted should be identified by the decision-makers (or their advisers), best practice for MSE is also to evaluate additional management strategies to better understand the behaviour of the strategies identified by the stakeholders and decision-makers. In particular, it is a valuable exercise to apply variants of a management strategy in which the state of the stock is known exactly by the management strategy because this provides an upper limit to the 'value of information'. In addition, having results for 'reference' strategies, such as the strategy which maximizes average catch, can be useful for determining whether or not differences in performance statistics among management strategies are meaningful.

Most management strategies involve changes in the values of traditional management instruments such as catch limits, the total amount of effort or the length of the fishing season. However, MSE can also be used to evaluate novel management strategies such as that of Kai and Shirakihara (2005) that involves changing the size of a closed area based on the results of monitoring data.

It is essential that the management strategies being tested or compared are fully specified and can be implemented both for the operating models and in reality. Best practice is to simulate the management strategy exactly as it would be applied in reality, and this is commonly done when the management strategy is empirical (De Oliveira and Butterworth 2004; Little *et al.* 2011; Punt *et al.* 2012a; Carruthers *et al.* 2014), or the assessment method is not very demanding computationally (Kell and Fromentin 2009). It is becoming easier to evaluate complex management strategies given the increased availability of, for example, distributed computing including cloud computing. However, simulating very complicated management strategies such as those that involve fitting a statistical catch-at-age model can still require considerable computation (e.g. a single set of 100 simulations of 45 years to evaluate the actual management strategy for Gulf of Alaska walleye pollock took over 3 weeks on a fast desktop computer) and run the risk that fully automated fitting procedures may not find the global minimum that would be detected in the comprehensive searches typical of 'best assessment' approaches. Consequently, it is common to approximate application of a management strategy, for example by assuming that the estimates of biomass are log-normally distributed about the true biomass, perhaps with autocorrelated errors (DiNardo and Wetherall 1999; Hilborn *et al.* 2002; Anderson *et al.* 2010; Punt *et al.* 2012b).

However, ICES (2013) comments that it is generally not sufficient to simply add random noise to quantities derived from the operating model, and express concern that only 4 of the 18 MSEs which they reviewed had simulation tested the actual assessment. Failing to simulate application of the actual assessment method allows a broader set of hypotheses to be explored quickly, but the risk is that the actual error distribution associated with assessments does not match that assumed, and hence the values of the performance statistics are incorrect. In the extreme, the resultant relative ranking of management strategies may become incorrect. The justification for using an approximation to a management strategy may be examined by running a few simulations for the actual management strategy and the approximation, and comparing the results to ascertain whether the approximation is adequate. For example, ICES (2008) compared a 'full' and 'shortcut' MSE and found that the ranking of the performance of the harvest control rules evaluated changed when conducting a shortcut MSE compared to a full MSE (i.e. the best performing harvest control rule was different for the two evaluations).

The management strategy adopted for the BCB bowhead whales is based on averaging the strike limits from two SLAs (IWC 2003): (i) an empirical relationship between the strike limit and estimates of carrying capacity, the replacement yield predicted for the year for which a strike limit is needed, and the current stock size (Johnston and Butterworth 2000; Givens 2003); and (ii) a control rule based on the concept of adaptive Kalman filtering (a combination of Kalman filtering and Bayesian methodology; Dereksdóttir and Magnússon 2003). Both SLAs included ways to restrict interannual variation in strike limits, a factor considered very important during the selection process for a SLA. In particular, the component SLAs included a 'snap to need' feature which sets the strike limit equal to the need if the strike limit indicated by the algorithm is very close to the need.

The management strategy used for Pacific sardine is based on a set of control rules (Fig. 3) that are applied to an estimate of age 1+ biomass from a stock assessment model. The value for the FRACTION parameter may depend on the value of an environmental variable. The MSE for Pacific sardine (Hurtado-Ferro and Punt 2014) did not simulate application of the actual stock assessment process, but instead generated estimates of biomass directly from the operating model. Nevertheless, the extent of the errors

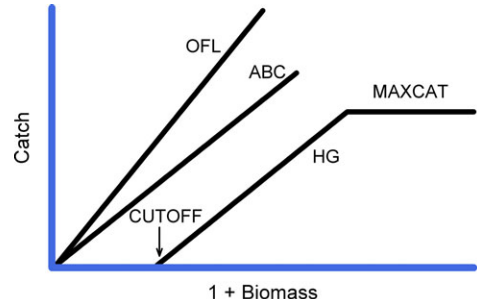

Figure 3 Harvest control rules applied to the northern subpopulation of Pacific sardine. The OFL is the overfishing level, which is based on the fishing mortality corresponding to maximum sustainable yield. The ABC is the acceptable biological catch, computed as the overfishing limit (OFL) reduced to account for scientific uncertainty. CUT-OFF determines the 1+ biomass at which the harvest guideline (HG) is zero, and MAXCAT is the maximum catch possible under the control rule.

associated with the biomass estimates for Pacific sardine was selected using a simulation evaluation of the actual stock assessment method (Hurtado-Ferro *et al.* 2014) in an attempt to ensure realism.

Simulation of application of each management strategy for each operating model

The actual process of linking the data generation phase of the operating model with the management strategy is generally straightforward, even if the process of conducting the simulations and summarizing the results can be very time-consuming. The difficult issues with MSE at this stage are primarily related to software development. There are several ways to minimize the chances of errors due to software coding, and use of these methods is best practice for MSE.

1. Base the operating model(s) and the management strategy on software that has been developed for broad application and has been tested extensively, such as Stock Synthesis (Methot and Wetzel 2013; Anderson *et al.* 2014; Maunder 2014), or use tools specifically developed to evaluate management strategies (Kell *et al.* 2007; Hillary 2009). However, in many instances, it is necessary to develop software for a specific case given the nature of the management strategy being evaluated and the hypotheses considered plausible – capturing the full range of uncertainty and of potentially

appropriate candidate management strategies should take priority over using available software.

2. Conduct simulations in which the system dynamics are deterministic, the operating model matches the estimation component of the management strategy, and the data are generated without error. In this situation, it should be possible for an analyst to heuristically predict the state of the system in the future fairly accurately (e.g. the stock should equilibrate at B_{MSY} if a strategy is based on a target fishing mortality of F_{MSY}, while if a strategy has a target level based on CPUE the stock should equilibrate at this level unless there are response-delay factors that induce oscillations) and compare this with where the MSE predicts the system will be. This provides a basic test to ensure that the coding of the operating model and of the management strategy is correct.
3. Conduct simulations in which the system dynamics are deterministic, the assessment model underlying the management strategy (if required) matches the operating model, and the data are generated with random error. Again, this provides a case where it is relatively straightforward to predict the results of the analyses.

The second and third of these steps also provide a way to eliminate poor management strategies from further consideration; it is virtually certain that a management strategy will not perform adequately in complex trials if it performs poorly when the data are not subject to error or there is no process error in the system.

The number of simulations for each trial (10 000 in the case of Pacific sardine and 100 in the case of the BCB bowheads) should be selected to ensure that the percentiles of the distributions on which performance statistics are based can be calculated with the precision required for the decisions to follow. The number to achieve a particular precision for probability-based statistics can be calculated taking into account that the simulations are independent (ICES 2013), and probability measures based on counts are therefore binomially distributed. Note that a very (perhaps prohibitively) large number of simulations may be needed if the decision-makers wish to draw conclusions based on very precise estimates of the lower fifth or first percentile of the distribution for some output from the operating model(s).

The number of years for which the operating model is projected will depend on the life history of the species under consideration. The number should be chosen, so that it is possible that the management strategy can impact the dynamics of the system and should cover 1–2 generations at minimum to allow for transients arising from response delays linked, for example, to the age at maturity. For example, the number of years for short-lived species such as sardine can be quite low while this number will be much higher for species such as bowhead whales.

It is essential, and hence best practice, that the management strategy bases recommendations for management actions only on data which would actually be available, and any assumptions regarding parameters assumed known when applying the management strategy need to be clearly documented (e.g. that natural mortality is assumed to be known exactly). One way to achieve this goal is to have separate segments of software for the operating model and for the management strategy, and to pass information (and management recommendations) between the operating model and management strategy using input and output files or their software equivalent.

The same set of random numbers should be used for all simulations for each trial, so that differences between candidate management strategies reflect the differences between the strategies themselves and not the consequences of different sets of observation and process errors.

Most management strategies assume that the data needed to apply them are always available (e.g. surveys are conducted at the expected frequency). However, this assumption might not be met in practice (e.g. a survey may not take place because of mechanical problems), and Butterworth (2008b) highlights that a management strategy should ideally also include specifications for how to provide management advice in circumstances in which anticipated data are not available. A related aspect is that the management strategy should ideally reward the provision of extra data and penalize the reverse situation. For example, the IWC's Revised Management Procedure reduces whale fishery catch limits to zero if new survey estimates do not become available within a specified time period (IWC 2012b).

Presentation of results and selection of a management strategy

Ultimately, the selection of a management strategy is not a scientific enterprise, but involves addressing trade-offs. This task lies primarily within the purview of decision-makers and policy. In principle, the selection of a management strategy could be automatic if a utility function was selected, which reflects the desired trade-offs amongst the objectives, and probabilities could be assigned to each alternative operating model configuration. However, this is rarely possible, and the authors know of no examples where a management strategy which has actually been implemented was selected this way.

There are almost always trade-offs among the management objectives. Consequently, it is desirable to provide results for a number of candidate strategies. Evaluation by the decision-makers of the trade-offs amongst the management objectives achieved by each candidate strategy may lead to a better understanding of what is possible, and even to changes to the relative ranking of management objectives. However, the results of management strategy simulations can be extensive and complicated, and the entire MSE process may be difficult for non-experts to comprehend. In South Africa, the details of the assumptions and sources of uncertainty were communicated, but statistics such as probability distributions were found hard to interpret (Cochrane *et al.* 1998). A better understanding of some of the trade-offs, particularly that between catch and catch variation, can be achieved by 'real-time gaming' of the MSE, which involves the decision-makers managing simulated populations where they are provided with the data which would actually be available on an annual basis. Walters (1994) provides an overview of the use of gaming to compare management options, including some best practices. Gaming has been used successfully in the South African fisheries (Butterworth *et al.* 1993). However, many MSE analyses are very computationally intensive, making real-time gaming impractical.

Stakeholders need to be involved in the decision process. However, more than that, they also need to be integrated within the entire MSE development process, including problem formulation, and even perhaps selecting the assumptions on which projections are based. This is, however, seldom easy and can be very time-consuming. Pastoors *et al.* (2007) describe an instance where stakeholders evaluated a MSE based on the extent to which hindcasts of the operating model could reproduce the observed dynamics of how TACs were set and whether the trends in stocks and catches proceeded 'logically'. Their advice was to present results relative to reference levels rather than in absolute terms, so as to reduce some of the concerns which stakeholders expressed.

As emphasized by Rademeyer *et al.* (2007), the basis for selecting a management strategy has to be clear to all stakeholders and should be made as simple as can be justified. Although much of the literature has focused on trade-offs among the objectives, some systems have fixed constraints. For example, the USA MSA effectively prohibits fishing mortality exceeding F_{MSY} for long periods, while adoption of a management strategy that would lead to high probabilities of decline of BCB bowhead whales would be considered unacceptable. Miller and Shelton (2010) identify an approach to selecting a management strategy based on 'satisficing', in which there are certain minimum standards for any candidate strategy, and only those candidates who satisfy these standards can be considered for possible adoption. Care should be taken not to require management strategies to meet performance statistic targets defined in terms of extreme tail probabilities, for example implementing a standard such as 'the probability of overfishing on an annual basis should not exceed 0.1%', because such probabilities are likely to be very poorly determined (Rochet and Rice 2009; Kraak *et al.* 2011). In cases in which the decision-makers require high certainty about a particular outcome, it is imperative that the analysts convey the likely level of precision possible from a MSE and that the major strength of a MSE lies in comparing the relative performance of alternative management strategies.

The first step in the process of selecting a management strategy should be explaining all of the options to the decision-makers, and placing the management strategies evaluated in the context of current management arrangements (Dowling *et al.* 2008). The value of effective graphical summaries cannot be over-emphasized. Some simple rules for constructing graphical summaries of results (see Figs 4 and 5 for examples) are to define 'best' performance for all operational objectives to be a high value for the associated performance statistics, and not to display too many performance statistics or management strategies on a single plot (contrast Figs 4 and 5 in this regard).

Perhaps most importantly, graphical approaches to summarizing performance statistics should be selected in collaboration with the decision-makers who need to understand and use them. For example, the axes in Fig. 5 were defined to report on the major areas of concern for stakeholders. 34 performance measures were identified by fishers, processors and local community, as well as given legislated fisheries and conservation objectives to across social, economic and ecological aspects (Fulton *et al.* 2014). For transparency, all of these measures were reported on, but it was not until the outcomes were aggregated and summarized around the major topic areas (using Fig 5 and other similar plots) that the relative performance and trade-offs between the objectives were clear. The axes represent natural groupings of the performance measures, but also highlight key concerns of the various stakeholders. Note that the industry and management efficiency axes used inverted performance scores, so that a larger score reflected better performance for all axes.

A key step in selecting a management strategy is dealing with the fact that not all of the trials reflect equally plausible hypotheses. This is partially addressed by assigning some trials to a reference set and the remaining trials to a robustness set (see above). However, other approaches are possible. For example, the IWC has adopted a set of guidelines for interpreting the results of trials to evaluate management strategies for commercial whaling. Specifically, trials are assigned to one of three categories ('high plausibility', 'medium plausibility' or 'low plausibility') by the Scientific Committee of the IWC (2012a). The required conservation performance of acceptable management strategies, expressed in terms of the values for performance statistics, is pre-specified for each

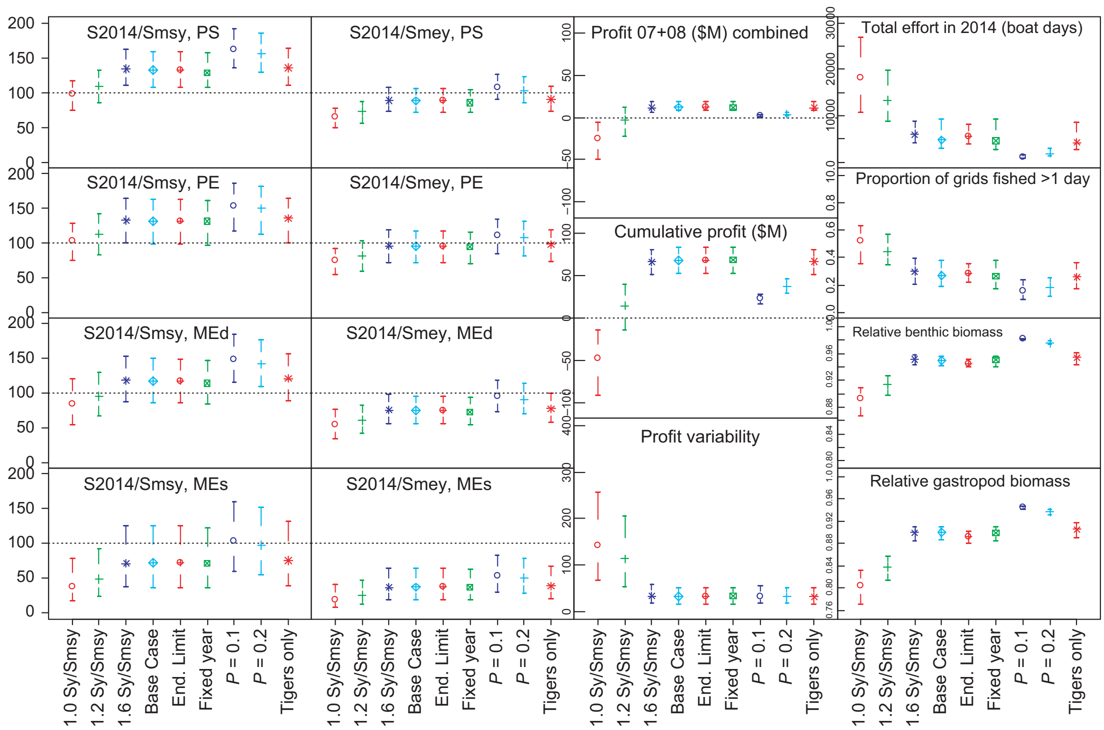

Figure 4 Biological, economic and ecosystem performance measures for a variety of management strategies for Australia's Northern Prawn Fishery (reproduced from Dichmont *et al.* 2008). The symbols indicate distribution medians, and the bars cover 95% of the simulation distributions. The performance statistics relate to spawning biomass relative to that at which MSY and maximum economic yield are achieved for four species (first two columns) and profit and its variability (third column). The right-most column shows the total effort in 2014, the proportion of grids fished for more than 1 day in 2014, the total benthic biomass relative to unfished levels, and the biomass of gastropods in 2014 relative to unfished levels. The management strategies differ in terms of the target biomass, the extent of precaution, and whether assessments for only two of the species form the basis for changes to effort limits.

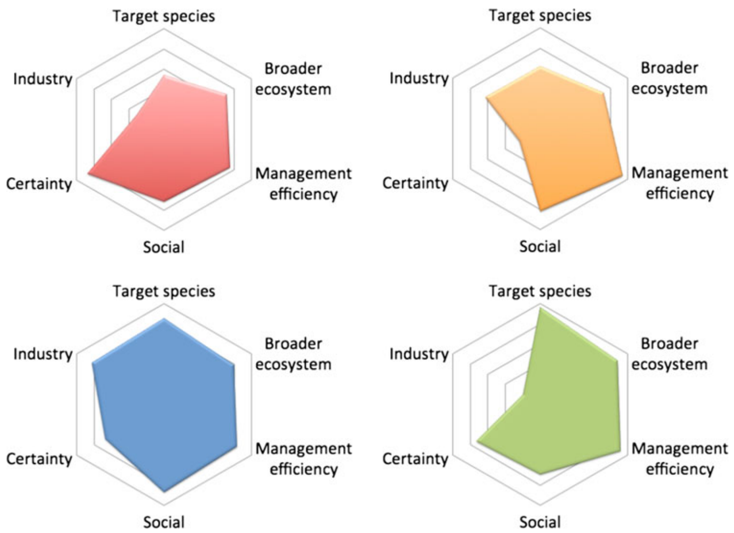

Figure 5 Example of plots which qualitatively compare four management strategies across six general areas of mean performance for a large multisector, multispecies fishery in southeastern Australia (E. Fulton, CSIRO, personal communication). A better result for a performance statistic is indicated by a vertex which is further from the centre of each hexagon.

category, which essentially (though not entirely – see IWC 2012a, for details) automates the process of selecting a 'best' management strategy. The assignment of plausibility for a trial is based on assigning a plausibility ranking to the level for each factor on which the trial is based ('high', 'medium', 'low' or 'no agreement'), with levels for which there is no agreement being treated as 'medium'. The ranking of a trial reflects the lowest rank assigned to each level of the factors on which it is based (thus to be categorized as a 'high' plausibility trial, the levels of all the factors included in the trial need to be considered to be of 'high' plausibility). Any trials considered to be 'low' plausibility are assigned a 'low' rank and ignored. This approach has been applied to select management strategies for the western North Pacific minke whales (IWC 2014), the western North Pacific Bryde's whales (IWC 2010) and the North Atlantic fin whales (IWC 2009).

In an effort to provide an improvement to simply selecting plausibility ranks based on expert judgement, Butterworth *et al.* (1996) proposed four sets of criteria with which plausibility ranks might be assessed:

1. how strong is the basis for the hypothesis in the data for the species or region under consideration?
2. how strong is the basis for the hypothesis in the data for a similar species or another region?
3. how strong is the basis for the hypothesis for any species? and
4. how strong or appropriate is the theoretical basis for the hypothesis?

Although this approach was presented to the Scientific Committee of the IWC, it was never adopted, and in general weights are almost always assigned based on expert judgement.

An alternative approach to addressing plausibility in selecting a management strategy is to assign weights to each trial and to compute integrated values for the performance statistics. However, this involves selection of quantitative weights upon which it is likely to be even more difficult to reach agreement than on assigning trials to categories of plausibility. Moreover, integrated performance statistics may obscure low plausibility trials for which performance is very poor (Rademeyer *et al.* 2007). Those authors also comment that stakeholders may benefit from being shown results of individual catch and population trajectories, as these tend to give a better impression of variation than statistics such as CVs and variances, which may be difficult for some stakeholders to understand.

Assignment of quantitative weights for plausibility becomes necessary if decision-makers wish to draw conclusions based on some percentile of the distribution of a performance statistic and the MSE is being conducted over a reference set of operating models. This was the case in the CCSBT, where the use of this set, rather than working only with a single reference case operation model, rendered consensus much more easily achieved in the Scientific Committee. Subsequently, the Commission requested its Scientific Committee to report results for reaching a target recovery level of 20% of the estimate unfished abundance by 2035 with 70% probability [see final agreed management strategy specifications reflected in CCSBT (2011)]. To provide such results, integration across the reference set became necessary.

While providing percentile results for a single operating model is a relatively objective process, as the statistical basis to take account of the associated stochastic effects is well established, extending to a reference set creates some difficulties. This is because the results will depend on the choice of which models are included in the set and how they are weighted, which is much less straightforward. Given that balance (between more optimistic and more pessimistic scenarios) is usually seen as a desired feature of a reference set of operating models, estimates of the medians of performance statistics would be expected to remain relatively robust and reliable. However, care should be taken in the interpretation of high and low percentiles of distributions for a reference set, as these will not be as firmly established as in the case of a single reference case operating model.

In the BCB bowhead case, the Chair of the group tasked with developing and testing alternative SLAs briefed the IWC as well as representatives of the hunting communities. In particular, as a key objective of the SLA was to satisfy the nutritional and cultural needs of aboriginal communities rather than to maximize catch, an important input to the analyses was the ‘Need Envelope’. This function was obtained through discussion with the hunters and their scientific representatives, and formed the basis for specifying performance statistics such as the fraction of total need over 100 years which could be satisfied.

In contrast to the bowhead case-study, the MSE for Pacific sardine was developed in the context of a USA Regional Fishery Management Council process. This allows for input by stakeholders, state and federal analysts, and the public during the development of management decisions. The structure of the MSE was initially developed during a workshop (PFMC 2013) which included biologists familiar with Pacific sardine and its relationship with the environment, modellers (including assessment biologists and ecosystem modellers), representatives of the advisory bodies of the PFMC, and stakeholders (conservation and industry). The MSE structure was then subjected to peer review through the PFMC’s Scientific and Statistical Committee on several occasions. Input from stakeholder groups included interpretation of the results of the simulations in the context of the objectives which each such group considered most important (Parrish 2014).

Did the case-studies follow ‘best practice’?

The two case-studies highlighted in this paper followed best practice to different extents. Both case-studies involved stakeholders and decision-makers at various points in the development and selection process, and included default performance statistics. The range of uncertainties was wider in the bowhead case-study, and there are some uncertainties which are likely important for Pacific sardine which were not explored (such as that the USA fishery operates at some times on the southern as well as the northern subpopulation). Such omissions were due to limited time being made available to conduct the MSE. In actual development and implementation, limited time frames are common and constitute a constraint on achieving best practice.

Neither of the case-studies explicitly considered predator-prey interactions as these were not seen as likely to have large impacts; the sardine case-study did however explore environmental impacts on recruitment, and both case-studies accounted for spatial structure to some extent. The bowhead case-study represented parameter uncertainty by sampling parameter vectors from a posterior distribution, whereas the sardine case-study explored this uncertainty through sensitivity testing.

The candidate management strategies for Pacific sardine were selected by the stakeholders and the decision-makers, whereas these were identified by the competing teams of ‘developers’ in the bowhead case. In contrast to the bowhead SLA, the actual management strategy for sardine was not simulated exactly because it was not the assessment itself (which is based on a statistical catch-at-age analysis) that was simulated. Rather, this assessment was approximated by true biomass from the operating model plus autocorrelated log-normal error. However, an attempt was made to assess the likely level of assessment error.

Both case-studies applied standard programming techniques to attempt to ensure that the code implementing the operating model(s) and management strategies was correct, but only in the sardine case were deterministic analyses undertaken. The code implementing the operating models for the bowhead case was developed by a member of the staff of the IWC and independently checked by one of us (AEP). Neither case-study conducted a thorough comparison of whether the operating model and management strategy produced results of projections consistent with reality through, for example, comparing variability in assessment outcomes with historical results, although some checks were carried out for sardine. Neither of the management strategies adopted included 'Exceptional Circumstances' provisions, although *Implementation Reviews* are mandated and have been conducted for the bowheads. The SLA for the BCB bowheads was subject to an *Implementation Review* in 2007 (IWC 2008a,b, 2009, 2014) and 2013 (IWC 2013). The 2007 *Implementation Review* focused on the possibility that the BCB stock may actually consist of two stocks as well as that different age and sex classes migrate differently. However, it did not lead to a change to the SLA developed for the BCB stock because the performance of this SLA was not markedly impacted by the multi-stock scenarios examined.

Both case-studies relied on graphical and tabular summaries, and both involved trying to educate the decision-makers on how to interpret the results from the MSE. Performance standards were adopted for interpreting the results of the trials for bowheads (IWC 2003), but the comparison of alternatives for Pacific sardine was based primarily on finding an acceptable trade-off among the performance statistics. The trials for the bowhead case were divided into 'reference' and 'robustness' trials, with most focus during selection given to the 'reference' set.

In summary, the application of MSE for bowheads followed the proposed best practice guidelines to the largest extent possible, while that for sardine took several short cuts, owing primarily to the need to complete the analyses in time for management decision-making.

Final comments

Management strategy evaluation arose from the desires to deal more systematically with the issue of uncertainties and to identify management strategies that are adaptive given the collection of new data. Although the benefits of active adaptive management strategies, that is management strategies which select management actions to increase 'contrast' and hence improve the information content of the available data, have long been known (Walters 1986), few jurisdictions have been able or willing to implement such strategies (Sainsbury *et al.* 1997 being a noteworthy exception, although in that case the 'experimental unit' was primarily a foreign fishery off Australia's northwest shelf). Consequently, MSE has in practice generally involved evaluation of passive adaptive management options, that is learning about the system dynamics through ongoing monitoring but without attempting to deliberately manipulate the system to learn more about it, although the strategy developed for the mid-water fishery for horse mackerel in South Africa is an exception to this (Furman and Butterworth 2012).

Management strategy evaluation has been applied most widely in relation to fisheries and cetacean conservation and management. However, it has also been applied to explore the performance of ballast-water management options (Dunstan and Bax 2008), and recently there have been calls for MSE to be applied to terrestrial systems, including in the development of conservation plans for threatened species (Milner-Gulland *et al.* 2010; Bunnefeld *et al.* 2011; Moore *et al.* 2013). Most fisheries applications have focused on single-species cases. However, MSE can be applied to identify management strategies to achieve ecosystem and multiuse objectives. The applications in this area remain few, in particular because of the computational requirements associated with fitting and projecting models such as Atlantis. However, one would expect that the number of these applications will increase rapidly as computational constraints become less of an issue.

Management strategy evaluation has generally been used to evaluate management strategies in terms of their ability to satisfy management goals, either generically or for a specific situation, with a view to possible formal adoption and implementation. However, an additional key reason for conducting a MSE is to identify when management strategies are likely to fail, and either to identify new data collection schemes to detect when failure might occur or to revise an existing management strategy appropriately. Finally, evaluation of the management strategies on which a fishery is based is part of several eco-certification systems, including that of the Marine Stewardship Council (MSC). In the case of Tristan da Cunha rock lobster, the MSE was conducted specifically to satisfy one of the performance indicators for MSC certification.

Smith *et al.* (1999) outline the roles for the various participants in the MSE development process, including those of decision-makers, industry, conservation agencies and groups, fishery scientists and MSE analysts. As noted above, the involvement of as many of these groups as possible enhances the likelihood that the results of the MSE will be considered credible and hence the strategy actually implemented throughout the period for which it is intended to apply. Although inclusion of stakeholders in the development of management strategies is emphasized by Smith *et al.* (1999) and in many other publications, the actual number of MSEs for which there is direct evidence that stakeholders were involved throughout the entire process is rare. ICES (2013) outlines the roles of stakeholders (and decision-makers) in the MSE process as it is typically applied in Europe. The MSE developed for Australia's SESSF was guided by a steering committee of stakeholders from all sectors of the fishing industry, an ENGO, decision-makers and representatives of two key funding agencies (Smith *et al.* 2007). In South Africa, the process is taken forward in the species-specific scientific working groups of the Fisheries Branch of the Government Department responsible; these groups include observers from both industry and ENGOs who participate actively.

The establishment of a management strategy is a critical part of effective management. However, it is only one part. There still needs to be a formal process for reviewing the appropriateness of a management strategy given information collected following adoption. In Europe, apart from performing impact assessments of proposed management plans, the European Commission's advisory body, STECF, also evaluates the performance of existing management plans in relation to their original objectives (STECF 2011b; Kraak *et al.* 2013). In South Africa, reviews of management strategies are planned for every 4 years, while reviews of the CCSBT management strategy are planned for every 9 years, with the latter commonly adjusting TACs only every 3 years (Butterworth 2008b). The IWC has established a formal process for the regular (usually 5-year) review of the basis for specific management strategies, termed *Implementation Reviews* (IWC 2012a, 2013; Punt and Donovan 2007).

A management strategy is tested for the set of hypotheses considered plausible when it was first developed. However, subsequent research could indicate that those hypotheses did not include the entire plausible range. Consequently, rules have been developed (IWC 2013) for when it is necessary to temporarily stop applying the management strategy and rely on *ad hoc* adjustments to management regulations or to initiate an *Implementation Review* before one is due. The management strategies for South African fish stocks include some formal 'Exceptional Circumstances' provisions (Butterworth 2008b), as do those for southern bluefin tuna, west Greenland halibut and east Canadian pollock, but most other management strategies do not. 'Exceptional Circumstances' are generally defined to apply when the future data fall outside of the range indicated for the projections considered in the MSE. The inclusion of such provisions should be considered a standard component of best practice.

We have identified 'best practices' for conducting MSE (Table 1). The 'best practices' should be followed as closely as possible, particularly when the intent is to use the MSE to develop a management strategy for a particular fishery. However, as we illustrate for the two case-studies, a MSE can be useful even if not all of the best practices are followed strictly. This is particularly the case when the aim of the MSE is to evaluate generic management strategies rather than to propose a management strategy for implementation to a specific stock. Most critical perhaps is that the primary aim of a MSE is to identify which uncertainties are most important in terms of achieving management objectives. What is the minimum that can be done for the process still to be considered as a MSE? We would propose this to be that a MSE *considers* all sources of influential uncertainty, even if they are not all represented in the operating models, *considers* all the management objectives, even if they cannot all be reflected in the operating models, and minimally allows for uncertainty in the information on which management advice is based.

Finally, the practice of MSE continues to develop, and so, just as management strategies should be adapted under changing circumstances, MSE best practice is expected to continue to become further articulated as more experience is gained.

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Developing management procedures that are robust to uncertainty: lessons from the International Whaling Commission

André E. Punt and Greg P. Donovan

Punt, A. E. and Donovan, G. P. 2007. Developing management procedures that are robust to uncertainty: lessons from the International Whaling Commission. – ICES Journal of Marine Science, 64: 603–612.

Traditionally, fisheries management advice has been based on stock assessments that considered merely the "best" set of assumptions while uncertainty arising only from observation and process error was quantified, if considered at all. Unfortunately, uncertainty attributable to lack of understanding of the true underlying system and to ineffective implementation may dominate the sources of error that must be accounted for if management is to be successful. The management procedure approach is advocated as the appropriate way to develop management advice for renewable resources. This approach, pioneered by the International Whaling Commission (IWC) Scientific Committee, takes politically agreed management objectives and incorporates all scientific aspects of management including data collection and analysis, development of robust harvest control laws or effort regulations, and monitoring. A primary feature is that uncertainty (including that arising from sources conventionally ignored) is taken into account explicitly through population simulations for a variety of scenarios. The nature of the management procedures developed for commercial and aboriginal subsistence whaling and the processes by which they have been developed is highlighted. We also identify lessons that have been learned from two decades of IWC experience and suggest how these can be applied to other fishery situations.

Keywords: baleen whales, error, management procedure, monitoring, stock assessment, uncertainty.

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A. E. Punt: School of Aquatic and Fishery Sciences, Box 355020, University of Washington, Seattle, WA 98195-5020, USA and CSIRO Marine and Atmospheric Research, GPO Box 1538, Hobart, Tasmania 7001, Australia. G. P. Donovan: International Whaling Commission, The Red House, 135 Station Road, Impington, Cambridge CB4 9NP, UK. Correspondence to A. E. Punt: tel: +1 206 2216319; fax: +1 206 6857471; e-mail: aepunt@u.washington.edu

Introduction

Management of renewable marine resources to the satisfaction of all is difficult, even if managers are provided with exact information on the status and likely future trends of the resources being exploited, because it is necessary to balance various, often conflicting, "resource orientated" and "user-orientated" management objectives (Hall and Donovan, 2002). Additionally, different sources of uncertainty complicate attempts to manage the resources. The sources of uncertainty can be classified broadly (Francis and Shotton, 1997) as: (i) observation error (arising from sampling and monitoring of resources); (ii) model structure error (arising from lack of knowledge of population dynamics processes); (iii) process error (arising from seemingly unpredictable natural variability in population parameters affecting abundance, particularly recruitment); and (iv) implementation error (arising from problems in enforcement of measures taken).

Management decisions are often based on scientific assessments of stock status and the predicted consequences of alternative management actions. Although the need for scientific advice when managing renewable resources is now widely accepted, one of the earliest examples of this requirement enshrined in an international convention is the International Convention for the Regulation of Whaling (IWC, 2005a), signed in 1946, which states that amendments to its regulations shall be "based on scientific findings" (Donovan, 1992). National legislation may also include such exhortations (Anon., 1996).

Historically, stock assessments have been based on only the "best" set of assumptions, irrespective of how good they may be. Scientific uncertainty, if considered at all, quantified only the uncertainty arising from observation and process error. In addition, assessments usually attempted to relate then current stock status to what now are termed "biological reference points". These can be catch-, biomass-, or fishing-mortality-based. Although catch-based reference points are now generally regarded as insufficiently precautionary (Larkin, 1977), the use of biomass- and fishing-mortality-based reference points remains widespread. For example, the Pacific Fishery Management Council (PFMC) defines a stock as overfished (and in need of a formal rebuilding plan) when stock biomass drops below 25% of the average value in an unfished state, and overfishing to be occurring when the rate of fishing mortality (F) exceeds F_{MSY} (F at which the maximum sustainable yield is achieved).

Reference points alone are not sufficient to provide a scientific basis for making management decisions, so harvest control rules (HCRs; see Figure 1 for an example) that use reference points are commonly applied. Unfortunately, although the use of HCRs

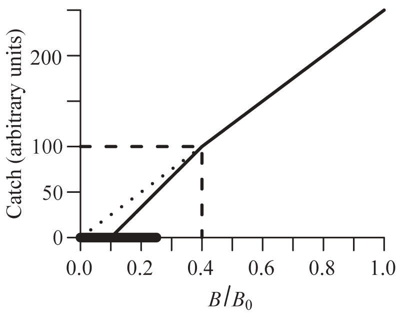

Figure 1. The harvest control rule (solid curve) used by the Pacific Fishery Management Council for stocks not designated as overfished (the solid bar indicates the range of stock sizes corresponding to being in an overfished state). Catch is reduced faster than linearly if a stock is assessed to be below the target biomass of 40% of the averaged unfished biomass ($0.4B_0$). Catch limits are not necessarily set to zero if a stock is depleted below $0.1B_0$; rather, a rebuilding plan is mandated to be developed for stocks depleted below $0.25B_0$.

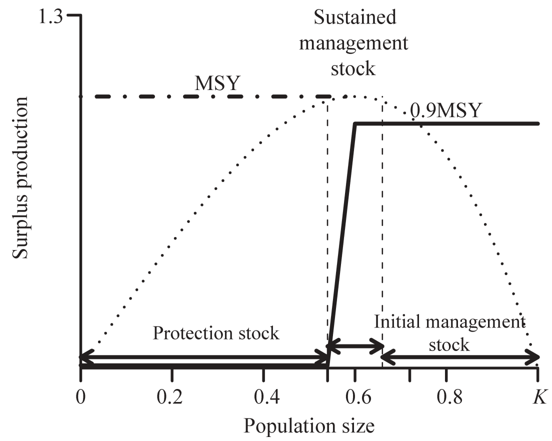

Figure 2. The catch control law for the NMP (solid lines) for the case in which MSYL is assumed to be $0.6K$.

provides a means of specifying scientific management advice in a more objective manner, uncertainty traditionally has not been explicitly accounted for in their application. The HCR in Figure 1 is fully specified when augmented with specifications related to how to conduct assessments and rebuilding analyses (Anon., 2005). The parameters required include the stock biomass in an unfished state (B_0), the current stock biomass ($B_{current}$), and F_{MSY}. Estimates of B_0 and $B_{current}$ are usually obtained by applying statistical catch-at-age analysis (e.g. Methot, 2006), and proxies for F_{MSY} are available, based on the relationship between spawning-biomass-per-recruit and F (Ralston, 2002). In 2005, this HCR could be applied to just 22 of the 80 species in the PFMC Groundfish Fishery Management Plan, i.e. insufficient information was available for all others. A further problem is that this HCR does not explicitly include a way to deal with uncertainty. Although scientists conducting assessments are encouraged to provide assessment scenarios that "bracket" uncertainty (Anon., 2006), there has been little consistency to date in how uncertainty has been bracketed for west coast groundfish, nor is there a formal way to use information from multiple alternative assessments when making management decisions.

Unfortunately, there is no guarantee that the management goals for a fishery will be satisfied even if (i) the HCR is fully-specified; (ii) data are available that, in principle, allow it to be applied; and (iii) some attempt is made to quantify uncertainty (Kirkwood, 1996). The only way to determine the effectiveness of a management process is to test it fully, using the simulation modelling approach pioneered by the Scientific Committee (SC) of the International Whaling Commission (IWC) when developing the Revised Management Procedure (RMP).

The IWC began using an HCR to provide formal management advice for commercial whaling in 1974, when it adopted what was termed the "New Management Procedure" (NMP; Figure 2). Problems with the NMP led to the development and adoption by the IWC of the "management procedure approach" (for a detailed account, see Hammond and Donovan, in press). Under this approach, management advice is based on a fully specified set of rules that have been tested in simulations of a wide variety of scenarios that specifically take uncertainty into account. The full procedure includes specifications for the data to be collected and how those data are to be used to provide management advice, in a manner that incorporates a feedback mechanism. Increasingly, there are examples of this approach being applied elsewhere (Kell *et al.*, 2006; Punt, 2006).

The problems with the NMP and the process of its replacement by the management procedure approach provide valuable lessons for other renewable resources. We review these problems (identifying the lessons learned), the process by which management procedures are evaluated by the SC, and how uncertainty is treated to ensure that the resulting management recommendations are sufficiently robust.

The New Management Procedure

The NMP was developed by Australian scientists as one response to calls for a moratorium on commercial whaling made at the United Nations conference on the environment and development, held in Stockholm in 1972 (Donovan, 1992, 1995). Although implicitly rather than explicitly expressed at the time, its two objectives were subsequently defined (IWC, 1981) as: (i) to ensure that the risks of extinction to individual stocks are not seriously increased by exploitation; and (ii) to maintain the status of whale stocks so as to make possible the highest continuing yield so far as the environment permits.

The conceptual basis for the NMP was the relationship between surplus production and population depletion (Allen, 1980). This relationship was assumed to be governed by a Pella–Tomlinson (1969) function, where the MSY level (MSYL) (the population size at which MSY is achieved) for whales was conventionally assumed to be 60% of the carrying capacity, K (Figure 2). Based on this, the NMP requires populations to be classified as either:

(i) Protection stocks–stocks depleted <0.9MSYL (the "protection level");

(ii) Sustained management stocks–stocks >0.9MSYL, but <1.2MSYL (a stock might also be classified in this category if it had been stable for "a considerable period" under a regime of constant catches);

(iii) Initial management stocks–stocks >1.2MSYL.

In addition, catch limits were constrained not to exceed the lower of 5% of the initial stock size and 0.9MSY.

The NMP was revolutionary for its time because it: (i) included a relatively high protection level (0.9MSYL, or 54% of the estimated unexploited level) at which catch limits were set to zero – although originally primarily justified for catch maximization rather than risk prevention (Butterworth and Best, 1994), many current management procedures still fail to include the concept of a protection level, or if they do, set the protection level considerably lower than 0.9MSYL; (ii) imposed a maximum catch limit that was less than the MSY estimate; (iii) aimed (even if implicitly) to leave stocks above (rather than at) MSYL; and (iv) appeared to take the decision-making process away from the politicians and to leave it with the scientists by "mechanizing" the provision of advice on catch limits.

Although seemingly well specified, the NMP definition is formally inconsistent because the constraint that catches cannot exceed 0.9MSY means that stocks will not be reduced to MSYL (de la Mare, 1986). In practice, however, this was one of the ways in which the NMP attempted to account for uncertainty by recognizing that determining whether a stock was at MSYL was difficult. A more serious problem was the lack of any formal (and agreed) basis to determine management units and to estimate the parameters needed to apply the NMP for each management unit, e.g. mortality, reproductive rates, and MSYL, with the required level of precision (Donovan, 1992). Although it is difficult to simulate the NMP decision-making process, de la Mare (1986) and IWC (1992a) evaluated the performance of one possible implementation using simulations and found it to behave poorly.

One consequence of these problems was that the SC was frequently unable to agree on catch limits when using the NMP. This was one of a complex set of reasons that the IWC introduced a moratorium on commercial whaling in 1982 to take effect in 1986 (e.g. Donovan, 1995). For example, in 1984, three species in four areas were considered in detail: sperm whales (*Physeter macrocephalus*) in the western North Pacific; Antarctic minke whales (*Balaenoptera bonaerensis*) in the southern hemisphere; common minke whales (*B. acutorostrata*) in the North Atlantic; and common minke whales in the North Pacific (IWC, 1985). However, the SC (i) was unable to provide estimates of initial and current population size for sperm whales in which it had confidence, and consequently did not provide advice on catch limits; (ii) was unable to agree on a classification for southern hemisphere minke whales (at that time, believed to have increased to above the initial carrying capacity in response to an expected surplus of krill resulting from the depletion of other large baleen whales, which made it impossible to be classified according to the NMP specifications), or on catch limits; (iii) could not classify either of the two stocks of minke whales in the northeastern Atlantic subject to commercial whaling (although ranges for catch limits were recommended despite dissenting views); and (iv) was able to classify only one of the two stocks of common minke whales in the North Pacific.

The Revised Management Procedure

Conceptual basis

The introduction of the moratorium led to the process of developing the RMP over a 6-y period (Hammond and Donovan, in press), which was finalized in 1994 with a written specification. The experience gained made it possible to develop a list of the steps needed to define and evaluate management procedures. Since then, these have been described extensively elsewhere (Kirkwood, 1996; Cooke, 1999; Sainsbury *et al.*, 2000; Donovan and Hammond, 2004; Kell *et al.*, 2006; Punt, 2006), but are summarized briefly here:

(i) qualitative specification and prioritization of the management objectives, as derived from legislation, legal decisions, and international standards and agreements;

(ii) quantification of the qualitative management objectives in the form of performance measures;

(iii) development and parameterization of a set of "operating models" that represent different plausible alternatives to the dynamics of the "true" resource and fishery being managed;

(iv) identification of candidate management procedures, including monitoring strategies;

(v) simulation of the future use of each candidate management procedure, involving for each time-step during the projection period: (a) generation of assessment data; (b) determination of the management action (i.e. assessment and application of some HCR); and (c) evaluation of the biological implications of the management action by removing the catch from the population as represented in the operating model;

(vi) summary of the performance of the candidate management procedures in terms of values for the performance measures; and

(vii) selection of the management procedure that best meets the specified objectives.

Most management procedures developed to date have focused on management using catch limits (e.g. Butterworth and Bergh, 1993; Geromont *et al.*, 1999; Punt and Smith, 1999), although some have been based on effort controls and forms of spatial management (e.g. Dichmont *et al.*, 2005). The major difference between these two types pertains to how management decisions are imposed (i.e. implementation error). For example, the performance of management systems based on catch limits can be affected by "highgrading" and "quota busting", while those based on effort regulations can be affected by "effort creep" and uncertainty in the relationship between fishing effort and fishing mortality. Key to the success of any evaluation of a management system based on a management procedure is the selection of the most important uncertainties to be reflected in the alternative operating models. These uncertainties should capture the major (but nevertheless plausible) factors that may affect the ability of each management procedure to satisfy the prescribed objectives.

Development

The development process of the RMP involved a series of workshops and discussion sessions during annual meetings of the SC. The initial focus was on developing a generic method for calculating safe catch limits that could be applied to any baleen whale population on its feeding grounds given perfect knowledge of stock structure (referred to as the "Catch Limit Algorithm", CLA). The CLA lies at the core of the RMP, which also includes

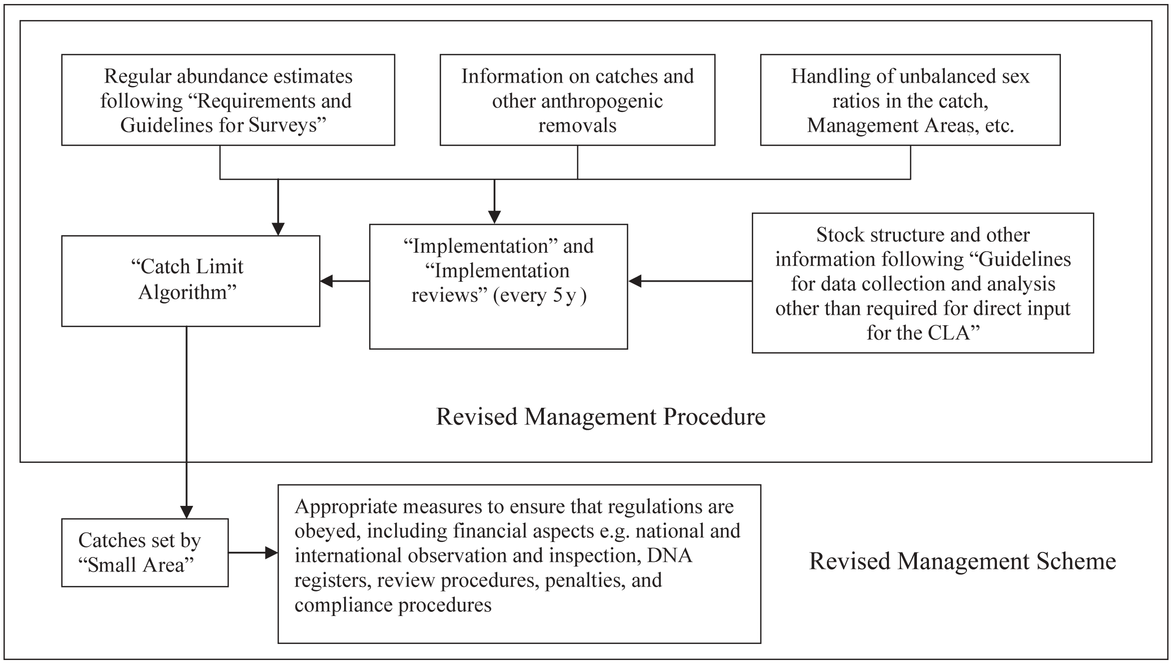

Figure 3. Schematic diagram of the management-procedure approach for commercial whaling (after Hammond and Donovan, in press) demonstrating the relationship between the CLA, the RMP, and the RMS.

rules on other scientific aspects of management, including multi-stock rules, and data and analysis requirements (Figure 3). Focus then shifted to developing ways of handling situations in which stock structure was uncertain. The approach chosen was to allow selection between a number of "variants". These variants are based on first setting catch limits for spatial/spatio-temporal strata that are small enough to ensure that whales of different stocks taken within each stratum will be taken in proportion to the abundances of those stocks (to avoid unintentionally taking whales out of proportion with their abundance in the area surveyed; IWC, 1999). Once these "Small Areas" have been determined, there are several ways (variants) in which catch limits may be combined to give a total limit for a wider area, depending, *inter alia*, on the available data for a particular species/region. Therefore, although the RMP is largely generic, it has case-specific aspects, because the choice between these multi-stock variants depends on further simulations (see the section "Implementation process" below).

The five CLAs developed by scientists from Australia, UK, South Africa, Iceland, and Japan initially differed quite markedly, e.g. in terms of the desired trade-off between risk and reward, whether population models were fitted to data on relative as well as absolute abundance indices, and whether relative abundance (catch per unit effort, cpue) data were used at all (Donovan, 1989; Hammond and Donovan, in press). However, the approaches converged over time. For example, it was rapidly agreed that there was little point in using cpue data because of disagreements regarding their reliability (IWC, 1989), and that future management procedures should be based on survey estimates of absolute abundance only.

This general approach of different teams developing candidate procedures has also been followed during the development phase of an Aboriginal Subsistence Whaling Management Procedure (AWMP), which eventually led to the adoption of "Strike Limit Algorithms" (SLAs) for the Bering–Chukchi–Beaufort Seas stock of bowhead whales (IWC, 2003a) and the eastern North Pacific stock of gray whales (IWC, 2005b). In the AWMP case, SLA development was pursued somewhat more cooperatively than had been the case for the RMP.

Discussion

Generic vs. case-specific approaches

An important difference between the AWMP and RMP is that the former followed a case-specific rather than a generic approach, the main reasons being that only a small number of aboriginal subsistence operations have been identified by the IWC and that it is unlikely that more will be accepted. In contrast, the number of potential commercial operations is substantially larger (in principle, all populations of all species of baleen whales could be subject to harvest), so that some standardization seemed desirable for reasons of efficiency. Furthermore, the management objectives for subsistence whaling differ from those for commercial whaling (e.g. rather than maximizing yield, the aim is to satisfy a pre-specified "need" in perpetuity, provided that certain conservation performance measures are met). Finally, aboriginal subsistence fisheries differ considerably in terms of the nature of the operations, the data available for assessment, and knowledge of stock structure. The adoption of a case-specific approach for data-rich operations (such as the bowhead and gray whale fisheries) accelerated the development of SLAs that met the management objectives. Had a generic management procedure robust to short time-series of abundance estimates and stock structure uncertainty been developed, the ability to satisfy subsistence needs for the data-rich aboriginal fisheries might well have been compromised.

The generic and the case-specific approaches have both advantages and disadvantages. For example, the amount of data available for individual species in finfish and invertebrate fisheries around the world ranges from extensive to almost nil, which would plead for case-specific approaches, because almost inevitably, generic procedures would have to be very conservative to achieve reasonable conservation performance in all cases. However, developing case-specific management procedures for all (or even the major) exploited stocks would be an immense undertaking that might be made lighter by first developing more generally applicable generic approaches. At the least, there may be value in developing generic management procedures that can be applied while case-specific procedures are being developed.

Implementation process

The RMP is considered final and has been adopted, but has not been used to set catch limits because the commercial whaling moratorium is still in place and no requests for advice on catch limits have been issued by the IWC. Before recommending that the RMP be applied to a species in a "region" (generally part of an ocean basin), simulation trials must be developed and run to capture the uncertainties deemed to be the most important for that stock complex/region. This process, referred to as an "Implementation" (in the IWC context, meaning that the SC notifies the Commission that it could produce information on catch limits if asked to do so), focuses primarily on uncertainties about stock structure, in particular temporal and spatial variation in the mixing of stocks in areas where whaling is to take place.

Many "Implementation Simulation Trials" (ISTs) may be required for specific cases if there are many alternative hypotheses related to stock structure, mixing, and other uncertainties such as the impact of bycatch of whales in fisheries. The process of designing, running, and interpreting ISTs can be onerous. For example, it took 12 y to complete the Implementation for western North Pacific minke whales (66 ISTs; IWC, 2003b). The reasons for this were that whaling occurs during migration (rather than on the feeding grounds, the situation for which the RMP had originally been designed) and that, because of the complex stock structure, new research conducted during the Implementation process led to a need to revise the hypotheses on which trials were based. The time required led to considerable frustration in the SC, and even to questions whether the RMP could be Implemented at all. Consequently, a rigorous set of requirements and guidelines was developed on how Implementations are to be conducted, so that the process could be completed within 2 y (Donovan and Hammond, 2004; IWC, 2005c). The guidelines also identify the information needed before an Implementation can commence (Figure 4). This information includes hypotheses about possible stock structure, specification of likely future removals (by both whaling and other anthropogenic causes), hypotheses about the size and spatial distribution of historical catches, and the abundance and migration data that will be used in the trials. The hypotheses identified during this "Pre-Implementation Assessment" should be sufficiently broad to prevent potential new information from leading to new hypotheses (but rather narrow or remove hypotheses). The guidelines also impose a temporal restriction on data that can be used. Data collected after a specified date can be used only when Implementations are reviewed.

The Implementation process focuses on developing ISTs to reflect plausible hypotheses and on assigning weights to each, based on perceived plausibility. The plausibility issue is one of the most difficult aspects to resolve and was a particular problem in the case of the western North Pacific common minke whale. Interpretation of the IST results (i.e. whether a particular variant performs adequately in terms of conservation objectives) is facilitated by a pre-specified set of rules. The first full application of the guidelines specified by IWC (2005c), from the Pre-Implementation Assessment through Implementation, is for western North Pacific Bryde's whales, and is scheduled for completion in 2007. North Atlantic fin whales have just completed the Pre-Implementation Assessment stage (IWC, 2007). The process used to develop and select management procedures is clearly far more formal at the IWC than that used to develop most fisheries management procedures. However, we believe that a process such as that adopted by the IWC would lead to a more rapid (and perhaps better documented) development and selection process.

Implementation Reviews

Although the simulation trials are based on 100-y projection periods (selected because of the slow dynamics of whales), the RMP and the AWMP include the requirement that "Implementation Reviews" be conducted every 5 y (IWC, 1999). North Atlantic common minke whales have already been through one review (IWC, 2004a). The aim of such reviews is to check that research conducted since the original Implementation does not reveal that hypotheses used in previous ISTs were not sufficiently broad to encompass reality or are no longer considered plausible. Basic changes to the RMP (as opposed to, for example, stock structure hypotheses in ISTs) are expected to arise rarely, and stringent conditions have been set on how proposed changes are reviewed (IWC, 1994, 2007).

Management procedures that have been implemented for finfish and invertebrate fisheries are generally revised irregularly (Punt, 2006), outside a formal structure and without formal requirements. An exception to this is the process established in South Africa (MCM, 2006).

Transparency

The taking of cetacean species for aboriginal and (particularly) commercial purposes remains a politically sensitive issue. Although the SC does not address issues regarding the politico-ethical acceptability of whaling (see Donovan, 1992), it is important that the process of developing and evaluating management procedures is wholly transparent. Transparency has been facilitated by having the chair of the group responsible for developing management procedures being considered both objective and independent (i.e. neither having expressed pro- or anti-whaling views nor being involved in developing one of the competing candidate management procedures). Transparency has also been achieved by having the computing manager at the IWC Secretariat responsible for coding (and testing) the operating models specified by the SC, validating the code for the CLA and SLAs, and conducting all calculations when recommendations on catch or strike limits are made. In contrast, such a clear separation of tasks is rarely the case for fisheries management. The development of a management procedure for southern bluefin tuna appears to be an exception (CCSBT, 2005a, 2005b).

Data collection and availability

The IWC has set standards for data collection. Specifically, a set of guidelines has been adopted for how surveys are to be conducted if the results are to be used in the RMP (IWC, 2005d). These guidelines also specify that catch limits will be reduced linearly to zero

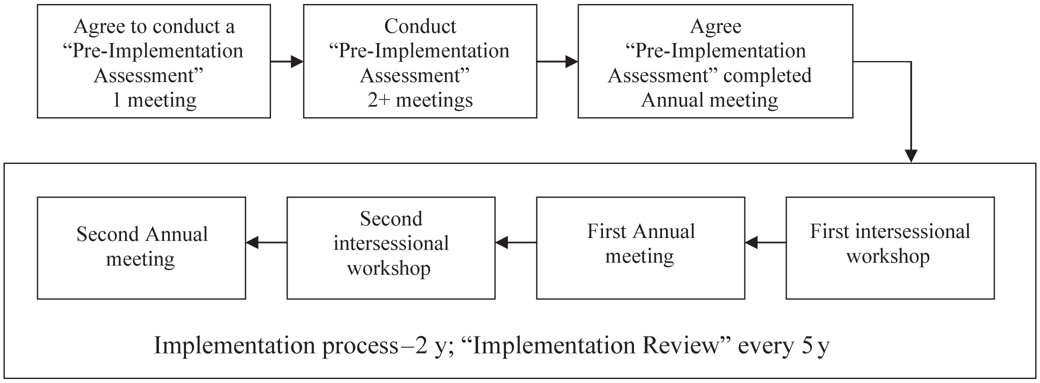

Figure 4. Conceptual overview of the procedure adopted by the IWC to facilitate implementation of the RMP (see IWC, 2005c).

over a period of 9–13 y after the last survey of an area (IWC, 1999). A data availability agreement (IWC, 2004a) specifies that all data used in the Implementation process must be freely available to members of the SC, although formal safeguards apply (e.g. with respect to publication rights). To date, no management procedure for a fish or invertebrate species has adopted such data collection standards or rules if the data required to apply the management procedure are not forthcoming.

Uncertainty factors considered

The uncertainties captured in simulation trials cover a number of factors. In general, the trials that capture uncertainty are divided into those considered most likely (the base-case or "evaluation" trials) and those considered less plausible, but for which performance should be adequate ("robustness" trials). The factors considered during the development of the CLA (Table 1) focused on those aspects considered most likely to affect performance. As expected, the factor having the greatest impact was the productivity of the resource. Therefore, the CLA was developed to perform adequately in the face of few data (only one estimate of absolute abundance when first applied) for stocks with perceived low productivity (an MSY that is only 1% of the number of mature animals at MSYL). Consequently, the resource is greatly underutilized when in fact productivity is higher. Other factors such as survey bias and temporal change in biological parameters also affected performance. Trials also included changes in carrying capacity and episodic events.

The uncertainties considered in developing SLAs for the Bering–Chukchi–Beaufort Seas stock of bowhead whales and the eastern North Pacific stock of gray whales (IWC, 2003b) were similar to those in Table 1, except that the impacts of demographic stochasticity, time-dependence in survey bias, and changes over time in the rate of natural mortality were also explored.

Stock structure

The multi-stock trials developed for specific Implementations have been much more complex than the single-stock trials used for developing the CLA and for the case-specific SLAs. For example, the trials developed for western North Pacific minke whales considered four major stock-structure assumptions based on an operating model that included 13 areas and a monthly time-step. The hypotheses underlying those assumptions were developed primarily from interpretations of genetic and length frequency data. The discussions of their relative plausibility were particularly fraught and led to the development of the guidelines referred to above (Donovan and Hammond, 2004; IWC, 2005e).

In fact, the major difference between the way management procedures have been evaluated for cetaceans and for fish and invertebrates is the focus on uncertainty in relation to stock structure. IWC (1992b, 1993, 1994) showed that a management procedure that performs adequately when stock structure is known can perform poorly when this is not the case. Specifically, conservation performance is poor when two stocks are assessed and managed as a unit, but catches are only taken (unintentionally) from one stock (Hall and Donovan, 2002). The lack of robustness to this type of uncertainty was the reason for the development of the multi-stock

Table 1. Factors and levels considered in the trials used to select the CLA (after IWC, 1992a). Underlined values denote those used to evaluate the candidate procedures, whereas the others were used to examine robustness.

Factor	Levels
Productivity	MSY rates of 1%; 4%; 7%; varying from 1% to 4%
Initial depletion, P_0	0.05, 0.3, 0.6, 0.99
Survey bias	0.5, 1, 1.5
Period of protection prior to management	Yes, No
Catches in error	No, half the true values
Age-at-maturity	7, 10
Episodic events	No, 50% of the population dies if an episodic event occurs at some specified frequency
MSYL	0.4*K*, 0.6*K*, 0.8*K*
Carrying capacity	Constant, increasing linearly over time, declining linearly over time
Survey intensity	Every fifth year, every tenth year

rules discussed above, and explains the need to conduct case-specific trials for any new Implementation of the RMP. An important new area of research being undertaken by the SC is the development of an individual-based simulation framework to investigate the performance of methods for analysing genetic data that may be used to inform stock-structure discussions in a management context (IWC, 2004b).

In reviewing how management procedures have been evaluated, Butterworth and Punt (1999) noted little progress in evaluating the impacts of spatial and stock structure on the performance of management procedures outside the IWC. More progress has been made on this front since then for shark populations off southern Australia (Punt *et al.*, 2005), groundfish species off southern Australia (Punt *et al.*, 2002), prawns off northern Australia (Dichmont *et al.*, 2005), and rock lobster off southern New Zealand (Bentley *et al.*, 2003). Plagányi *et al.* (2007) note that spatial structure will be considered when the management procedures for rock lobster, hake, sardine, and anchovy off South Africa are next revised.

Multispecies interactions

Interactions among species occur through bycatch, predation, or competition. Increasingly, such interactions are being explicitly included in operating models (Punt, 1993; Schweder *et al.*, 1998; Punt *et al.*, 2002; De Oliveira and Butterworth, 2004; Dichmont *et al.*, 2005; Plagányi and Butterworth, 2006). However, most focus has been on technical (i.e. bycatch) rather than biological (predation/competition) interactions. Adding biological interactions makes an operating model much more complicated, and requires more data to specify its parameters. The IWC has not attempted to build multispecies operating models, but rather has chosen to examine the impact of temporal changes in biological parameters that might be affected by biological interactions (such as carrying capacity, productivity, and natural mortality). Although it remains to be confirmed whether the implications of complicated biological interactions on the performance of management procedures can be captured adequately by varying parameter values of single-species operating models, the difficulties of predictive multispecies modelling approaches are well known, both in terms of assumptions and data requirements (e.g. IWC, 2004c).

Other features

The management procedures for commercial and aboriginal subsistence whaling share some common features, although their underlying objectives differ.

(i) The estimation methods that underlie the management procedures incorporate Bayesian aspects, by being based either on a conventional Bayesian assessment (Dereksdóttir and Magnússon, 2003, 2005), a Bayesian assessment that downweights the data to prevent large changes in stock status caused by noisy data (IWC, 1999), or on maximum-likelihood techniques with a penalty on deviations in parameter estimates from prior values (Johnston and Butterworth, 2004). The use of such methods is not related to philosophy, but rather to ensure that the parameters on which catch limits are based are set to conservative default values in the absence of informative data.

(ii) The RMP and Dereksdóttir–Magnússon SLAs account for parameter uncertainty by setting the catch limit based on a percentile of a posterior distribution <0.5. Consequently, increased uncertainty leads to lower catch limits.

(iii) The data used represent only a restricted subset of all data sources. For example, data on absolute abundance from surveys or (age-, sex-, and size-compositions of) catches, on relative abundance (e.g. from analyses of cpue data), and on fecundity rates exist for many whale stocks. However, only data on absolute abundance are used for setting catch limits, because other data sources can be subject to considerable uncertainty in interpretation. Hence, use of such data can lead to poorer performance than when they are ignored when the assumptions on which their use is predicated are wrong (e.g. that cpue is linearly proportional to abundance). Of course, ignoring additional data sources when they do provide useful information on status and trends may lead to some loss of yield (on average) for the same perceived risk to the resource. Although not used in the CLA, these data are used as part of the Implementation Review process to ensure that the parameter space of the uncertainty tested is still applicable.

(iv) All management procedures adopted involve fitting population dynamics models to data, because early work during RMP development suggested that model-based management procedures lead to less interannual variation in catch limits (IWC, 1992a). In contrast, many management procedures used in fisheries are based on changing catch limits in a direct relationship with the extent of changes in directly measurable quantities, such as cpue or survey estimates of abundance (De Oliveira and Butterworth, 2004; Breen *et al.*, 2006). One reason for this is that these more "empirical" approaches can be explained more easily to stakeholder groups. Although the need for simplicity is acknowledged by the IWC, stakeholder groups at the IWC generally have scientific advisors well versed in management procedures and their evaluation. In addition, particularly with respect to the AWMP development process, there has been a consistent effort to explain all stages of the process to the users and to consult with them on practical issues or design features (use of block quotas rather than annual quotas, carry-over provisions where catch limits are not reached in a particular year, etc.) (Donovan, 2006).

Given the recent adoption by the IWC of a formal structure to implement the RMP for a specific species and region and, in particular, the idea that there should be pre-specified standards of performance before the SC can recommend an Implementation, recognition of the value of research in reducing key uncertainties that lead to poor performance has increased. Specifically, IWC (2005c) allows for the use of a "research-conditional" option (Donovan and Hammond, 2004). Under strict conditions, this allows for temporary use of a variant that does not satisfy the pre-specified conservation performance standards, if this use is accompanied by an SC-approved research programme that should be able to determine whether or not the hypotheses on which performance is poor are indeed plausible. If the research fails to show within a specified time frame that the hypotheses are implausible, catch limits will be reduced to account for any catches above those that would have been set had a more conservative RMP variant been adopted that was robust to these hypotheses being true or not.

Available expertise and resources

The lack of people trained in the area of stock assessment and fisheries management is well recognized (Mace *et al.*, 2001). Unfortunately, the construction of alternative operating models that capture the key uncertainties requires considerable modelling experience. Consequently, efforts to develop appropriate management procedures are limited in many parts of the world more by an absence of suitable people than by financial resources. The lack of sufficient qualified personnel is one reason that the SC is reticent to conduct more than two Implementations at a time (IWC, 2005e), and why the Implementation process for North Atlantic fin whales will be delayed until after 2007 (both the western North Pacific Bryde's whale Implementation and a major bowhead whale Implementation Review are scheduled for completion in 2007).

Conclusions and lessons learned

The long development process of the management procedure approach within the SC of the IWC has been both painful and sometimes exhilarating. Nevertheless, the approach may well represent one of the most important recent advances in the management of renewable resources. The degree of rigour employed, particularly the explicit manner with which inevitable scientific uncertainty is dealt, is perhaps a by-product of the controversy surrounding whaling. In many respects, the framework is the first to have been specified for applying the precautionary principle to the management of renewable resources in a quantifiable manner (Garcia, 2000). Ironically though, the approach pioneered by the SC is not being used yet to manage commercial whaling, but is being applied to manage aboriginal subsistence fisheries as well as some commercial finfish and invertebrate fisheries (Hammond and Donovan, in press). In our opinion, the approach, despite the manifold difficulties that have been and will be encountered, represents the way forward to manage natural resources properly. The primary lessons learned may be summarized as follows.

(i) Management procedures should incorporate a degree of Bayesian philosophy; specifically the parameter values on which catch limits (or other regulations) are based should default to conservative values (e.g. a percentile <0.5 of their posterior distributions) until available data indicate otherwise. As a rule, if the point estimates of the parameters on which some management measure is based are identical for two stocks, the management measure taken should be less restrictive for the stock for which the information available is more precise. Including this feature in a management procedure encourages additional data collection.

(ii) Major gains may be made by having more than one team, each with a broad range of expertise, participating in the development process. Ensuring that the developers span a range of disciplines (biological, mathematical, and statistical) is likely to enhance the chances of the development of a management procedure that better satisfies the management objectives. Also, interaction among developers from different backgrounds, whether in a combative or collaborative environment, leads to innovative solutions. Close collaboration with representatives of all stakeholders and communication of the process to them will allow appropriate specification and quantification of the management objectives as well as the development of a procedure that is practical and carries a broad degree of support among users.

(iii) Management procedures should clearly specify their requirements for data and analysis, and include specific rules to handle situations in which the data needed to apply the management procedure are not available.

(iv) The time and effort required to develop sound management procedures should not be underestimated.

(v) Most non-IWC applications focus on the impact of observation and process error. However, structural error is likely to have a greater impact on performance, specifically with respect to spatial and stock structure.

(vi) A formal and well-specified process for evaluation is needed, particularly if the implementation is likely to be highly contentious. Of particular importance are a formal process for assigning weights to alternative simulation trials, a set of rules to determine when performance is considered adequate, and a "temporal science barrier"–a time limit after which new information will not be permitted to change how simulation trials are developed and performance is evaluated.

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SEASONAL GRAY WHALES IN THE PACIFIC NORTHWEST: AN ASSESSMENT OF OPTIMUM SUSTAINABLE POPULATION LEVEL FOR THE PACIFIC COAST FEEDING GROUP

André E. Punt[1]
and
Jeffrey E. Moore[2]

[1]School of Aquatic and Fishery Sciences
Box 355020
University of Washington
Seattle, WA 98195-5020

[2]Marine Mammal and Turtle Division
Southwest Fisheries Science Center
National Marine Fisheries Service, NOAA
8901 La Jolla Shores Dr.
La Jolla, CA 92037, USA

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André E. Punt[1]
and
Jeffrey E. Moore[2]

[1]School of Aquatic and Fishery Sciences
Box 355020
University of Washington
Seattle, WA 98195-5020

[2]Marine Mammal and Turtle Division
Southwest Fisheries Science Center
National Marine Fisheries Service, NOAA
8901 La Jolla Shores Dr.
La Jolla, CA 92037, USA

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Dr. Kathryn D. Sullivan, Acting Administrator
National Marine Fisheries Service
Samuel D. Rauch III, Assistant Administrator for Fisheries

Seasonal gray whales in the Pacific Northwest: An assessment of optimum sustainable population level for the Pacific Coast Feeding Group

Punt, André E.[1] and Moore, Jeffrey E.[2]

1 – School of Aquatic and Fishery Sciences, Box 355020, University of Washington, Seattle, WA 98195-5020
2 – Marine Mammal and Turtle Division, Southwest Fisheries Science Center, NOAA, 8901 La Jolla Shores Drive, La Jolla, CA 92037

Summary

A single population stock of gray whales referred to as the eastern North Pacific (ENP) stock is presently recognized in U.S. waters (Carretta *et al.* 2013). A small group of gray whales, known as the Pacific Coast Feeding Group, or PCFG spends the summer and autumn along the Pacific coast of North America, where they overlap with the Makah Tribe's Usual and Accustomed (U&A) fishing grounds off the coast of Washington. In 2005, the Makah requested that NOAA/NMFS waive the MMPA take moratorium and adopt regulations that would authorize the tribe to hunt ENP gray whales within their U&A. As part of its review of this proposed hunt, NMFS continues to evaluate information relevant to ENP stock structure and status, including the population dynamics of the PCFG. Assessing whether the PCFG is currently at Optimum Sustainable Population (OSP) (i.e., not depleted) was the objective of the analysis described in this report[1]. The assessment is based on modifications to an existing population dynamics model used by the International Whaling Commission (IWC) to conduct projections of gray whale abundance. The model is deterministic, age- and sex-structured, and consists of two groups (the 'north' group and the PCFG), which are assumed to be separate for purposes of the analysis, but with possible immigration between them. Parameter estimation is based on Bayesian methods. Thirteen variants of the model were run (models A – M); these differed with respect to how priors were specified and the number of parameters estimated. Ultimately it was not possible to draw a definitive conclusion as to whether the PCFG is within OSP. Across all 13 model variants, the estimated probability of the PCFG being above its Maximum Net Productivity Level (*MNPL*) and hence within OSP ranged from ≈ 0.35 on the low end (models F and G) to 0.83 (model M) and 0.88 (model K) on the high end. In the latter two models (K and M), bycatch mortality[2] was fixed at zero, which is not realistic. For the remaining 11 models, the probability was ≤ 0.70, which is fairly equivocal. This stems from the PCFG abundance time series being largely uninformative regarding population rate parameters since it is relatively flat (no information about growth rate or density-dependence), apart from the short period of growth explained by an atypical pulse immigration event. Given the limited available information, the apparent stability of the PCFG population size for the past decade has several possible explanations. One explanation is that the population is at or near its carrying capacity and thus above *MNPL* and within OSP. However, it is also possible, given different potential rates of intrinsic population growth, that the PCFG area could support more whales and that current numbers are regulated by a combination of bycatch mortality and emigration that offsets immigration and internal production (recruitment of calves born to known PCFG females). Obtaining better empirical estimates of bycatch mortality, net annual immigration rates, and reducing prior uncertainty in Maximum Sustainable Yield Rate (*MSYR)* and *MNPL* could potentially improve inference about the likelihood of the PCFG being within OSP.

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[1] This is a continuation of work first considered during the gray whale stock identification workshop described in Weller *et al*. (2013).

[2] "Bycatch mortality" refers to human-caused fisheries-related mortality (e.g., from entanglement in gear) as summarized in U.S. marine mammal stock assessment reports (e.g., Carretta *et al*. 2013).

Introduction

The National Marine Fisheries Service (NMFS) recognizes a single population stock of gray whales (*Eschrichtius robustus*) within U.S. waters, termed the Eastern North Pacific (ENP) stock (Carretta *et al.* 2013). This stock ranges from wintering areas in Baja California, Mexico, to summer/autumn feeding areas in the Bering, Beaufort, and Chukchi Seas. A relatively small number (100s) of these whales, referred to as the Pacific Coast Feeding Group (PCFG), spend the summer/autumn along the Pacific coast of North America, between Kodiak Island, Alaska, and northern California (Calambokidis *et al*. 2012). In 2010, the International Whaling Commission (IWC) Standing Working Group on Aboriginal Whaling Management Procedure noted that different names had been used to refer to gray whales feeding along the Pacific coast, and agreed to standardize the terminology referring to animals that spend the summer and autumn feeding in coastal waters of the Pacific coast of North America from California to southeast Alaska as the PCFG (IWC 2011). This definition was further refined for purposes of abundance estimation, limiting the geographic range to the area from northern California to northern British Columbia (from 41°N to 52°N), limiting the temporal range to the period from June 1 to November 30, and counting only those whales seen in more than one year within this geographic and temporal range (IWC 2012) for abundance estimation purposes. The IWC adopted this definition, but noted that "not all whales seen within the PCFG area at this time will be PCFG whales and some PCFG whales will be found outside of the PCFG area at various times during the year." (IWC 2012).

The range of the PCFG overlaps with the Makah Tribe's Usual and Accustomed (U&A) fishing grounds off the coast of Washington. In 2005, the Makah requested that NOAA/NMFS waive the U.S. Marine Mammal Protection Act (MMPA) take moratorium and adopt regulations that would authorize the tribe to hunt ENP gray whales within their U&A. As part of its review of this proposed hunt, NMFS continues to evaluate information relevant to ENP stock structure and status, including the population dynamics of the PCFG. This paper evaluates whether the PCFG is likely to be within its Optimum Sustainable Population level, or OSP. Under the MMPA, OSP means, "with respect to any population stock, the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element." Federal regulations implementing the MMPA describe OSP as a population size within a range that is at or above the level where the population's maximum net productivity occurs (termed the Maximum Net Productivity Level, or MNPL).[3] Populations below OSP are considered 'depleted' under the MMPA. Assessing whether the PCFG is currently within OSP (not depleted) was the objective of the analysis described in this report.

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[3] Regulations implementing the MMPA at 50 CFR 216.3 state that "Optimum sustainable population is a population size which falls within a range from the population level of a given species or stock which is the largest supportable within the ecosystem to the population level that results in maximum net productivity. Maximum net productivity is the greatest net annual increment in population numbers or biomass resulting from additions to the population due to reproduction and/or growth less losses due to natural mortality."

Methods

Population Model

The assessment of ENP gray whales is based on a population dynamics model with two groups, a 'north' group and the PCFG. These two groups are assumed to be separate for purposes of the analysis, but with possible immigration between them. The model considers four strata (north of 52^0N, south of 41^0N, PCFG area December – May, and PCFG area June – November) because the relative vulnerability of the two groups to whaling and bycatch mortality differs among these strata.

The parameters of the model are estimated using Bayesian methods. Unlike IWC (2013), the analysis allows for uncertainty in the amount of 'pulse' immigration from the north group to the PCFG in 1999 and 2000, uncertainty in the annual level of immigration from the north group to the PCFG, and in $MSYL_{1+}$ [4] and $MSYR_{1+}$ [5] (the subscript 1+ refers to animals 1-year old and older). In contrast, IWC (2013) conducted analyses for pre-specified values for the level of 'pulse' immigration, the annual level of immigration, and $MSYL_{1+}$ and $MSYR_{1+}$. Note that the terms *MSYL* and *MSYR* reflect IWC terminology; within an MMPA context MSYL is the same as MNPL.

The underlying population dynamics model is deterministic, age- and sex-structured, and based on a two-stock version of the Baleen II model (Punt, 1999). Reference to 'stock' or 'population' below means either the north group or the PCFG, noting that usage of the term 'stock' with the model descriptions refers generically to a population unit and does not imply a formally recognized stock as defined under the MMPA.

Basic dynamics

Equation 1 provides the underlying 1+ dynamics.

$$
\begin{aligned}
R^{s,m/f}_{t+1,a+1} &= (R^{s,m/f}_{t,a} + I^{s,m/f}_{t,a} - C^{s,m/f}_{t,a})\,\tilde{S}^s_t\,S^s_a + U^{s,m/f}_{t,a}\,\tilde{S}^s_t\,S^s_a\,\delta_{a+1} && 0 \le a \le x-2 \\
R^{s,m/f}_{t+1,x} &= (R^{s,m/f}_{t,x} + I^{s,m/f}_{t,x} - C^{s,m/f}_{t,x})\,\tilde{S}^s_t\,S^s_x + (R^{s,m/f}_{t,x-1} + I^{s,m/f}_{t,x-1} - C^{s,m/f}_{t,x-1})\,\tilde{S}^s_t S^s_{x-1} && (1) \\
U^{s,m/f}_{t+1,a+1} &= U^{s,m/f}_{t,a}\,\tilde{S}^s_t\,S^s_a\,(1-\delta_{a+1}) && 0 \le a \le x-2
\end{aligned}
$$

where $R^{s,m/f}_{t,a}$ is the number of recruited males/females of age *a* in stock *s* at the start of year *t*; $U^{s,m/f}_{t,a}$ is the number of unrecruited males/females of age *a* in stock *s* at the start of year *t*; $C^{s,m/f}_{t,a}$ is the catch of males/females of age *a* from stock *s* during year *t* (whaling and bycatch mortality is assumed to take place in a pulse at the start of each year); δ_a is the fraction of unrecruited animals of age *a*-1 which recruit at age *a* (assumed to be independent of sex, time, and stock); S^s_a is the annual survival rate of animals of stock *s* and age *a* in the absence of catastrophic mortality events (assumed to be the same for males and females):

$$
S^s_a = \begin{cases} S^s_0 & \text{if } a = 0 \\ S^s_{1+} & \text{if } 1 < a \end{cases} \qquad (2)
$$

[4] MSYL (Maximum Sustainable Yield Level) is the population size relative to carrying capacity at which surplus production is maximized; this is the same as MNPL under the MMPA.

[5] MSYR is the ratio of MSY to the population size at which MSY is achieved.

S_0^s is the calf survival rate for animals of stock *s*; S_{1+}^s is the survival rate for animals aged 1 and older for animals of stock *s*; $\tilde{S}_t^s$ is the amount of catastrophic mortality (represented in the form of a survival rate) for stock *s* during year *t* (catastrophic events are assumed to occur at the start of the year before mortality due to whaling, bycatch and natural causes; in general $\tilde{S}_t^s=1$, i.e. there is no catastrophic mortality); $I_{t,a}^{s,m/f}$ is the net migration of female/male animals of age *a* into stock *s* during year *t*; and *x* is the maximum (lumped) age-class (all animals in this and the *x*-1 class are assumed to be recruited and to have reached the age of first parturition). *x* is taken to be 15 for these trials.

Catastrophic mortality is assumed to be zero (i.e., $\tilde{S}_t^s=1$) except for the north group in 1999 and 2000 when it is assumed to be equal to the parameter $\tilde{S}$ (Punt and Wade, 2012). This assumption reflects the large number of dead ENP gray whales observed stranded along the coasts of Oregon and Washington during 1999 and 2000 relative to annual numbers stranding there historically (Gulland *et al*. 2005; Brownell *et al*. 2007). The mortality event is assumed to have only impacted the north group because the abundance estimates for the PCFG increased when the mortality event occurred, in contrast to those for the north group which declined substantially.

Immigration only occurs from the north group to the PCFG, and only animals aged 1+ immigrate. The annual number of animals immigrating is $I_t=\bar{I}\,N_t^{\text{north},1+}/20000$ where $\bar{I}$ is the hypothesized recent average number of individuals recruiting into the PCFG and 20000 is the approximate 1+ population size for the north group during those years (i.e., recent $N_t^{\text{north},1+}/20000\approx 1$ (Laake *et al*. 2012) and thus recent $I_t=\bar{I}$). The annual number of immigrants by age and sex is given by:

$$I_{t,a}^{s,m/f}=I_t\,\frac{(R_{t,a}^{\text{north},m/f}+U_{t,a}^{\text{north},m/f})}{N_t^{\text{north},1+}} \tag{3}$$

Emigration from the PCFG is modelled by implementing an extra survival rate, $\tilde{\tilde{S}}$ after 1930 (immigration or emigration are ignored when carrying capacity and the parameters which determine the productivity of the population are calculated). Owing to the different sizes of the two groups, emigrants from the PCFG are assumed to die rather than join the north group. The value of $\tilde{\tilde{S}}$ is set so that at carrying capacity immigration and emigration are balanced, i.e.:

$$\frac{\bar{I}\,K_{1+}^{\text{north}}}{20000}=K_{0+}^{\text{PCFG}}(1-\tilde{\tilde{S}}) \tag{4}$$

Births

The number of births to stock *s* at the start of year *t*+1, B_{t+1}^s, is given by:

$$B_{t+1}^s=b_{t+1}^s\,N_{t+1}^{s,f} \tag{5}$$

where $N_t^{s,f}$ is the number of mature females in stock *s* at the start of year *t*:

$$N_t^{s,f} = \sum_{a=a_m}^{x} (R_{t,a}^{s,f} + U_{t,a}^{s,f}) \qquad (6)$$

a_m is the age-at-maturity (the convention of referring to the mature population is used here, although this actually refers to animals that have reached the age of first parturition); b_{t+1}^s is the probability of birth/calf survival for mature females:

$$b_{t+1}^s = b_{-\infty}^s \{1 + A^s (1 - (N_{t+1}^{s,1+} / K^{s,1+})^{z^s})\} \qquad (6)$$

$b_{-\infty}^s$ is the average number of live births per year per mature female in the pristine (pre-exploitation) population for stock *s*; A^s is the resilience parameter for stock *s* (A^s determines how much birth rate can increase from $b_{-\infty}^s$ when resources are not limiting); z^s is the degree of compensation for stock *s* (determines the population size – relative to carrying capacity – at which MNPL occurs); and $N_t^{s,1+}$ and $K^{s,1+}$ are defined according to the equations:

$$N_t^{s,1+} = \sum_{a=1}^{x} (R_{t,a}^{s,\mathrm{f}} + U_{t,a}^{s,\mathrm{f}} + R_{t,a}^{s,\mathrm{m}} + U_{t,a}^{s,\mathrm{m}}) \qquad K^{s,1+} = \sum_{a=1}^{x} (R_{-\infty,a}^{s,\mathrm{f}} + U_{-\infty,a}^{s,\mathrm{f}} + R_{-\infty,a}^{s,\mathrm{m}} + U_{-\infty,a}^{s,\mathrm{m}}) \qquad (7)$$

The number of female births, $B_t^{s,f}$, is computed from the total number of the births during year *t* according to the equation:

$$B_t^{s,f} = 0.5 B_t^s \qquad (8)$$

The numbers of recruited/unrecruited calves is given by:

$$\begin{aligned} R_t^{s,f} &= \pi_0 B_t^{s,f} & R_t^{s,m} &= \pi_0 (B_t^s - B_t^{s,f}) \\ U_t^{s,f} &= (1-\pi_0) B_t^{s,f} & U_t^{s,m} &= (1-\pi_0)(B_t^s - B_t^{s,f}) \end{aligned} \qquad (9)$$

π_0 is the proportion of animals of age 0 which are recruited ($\pi_0 = 0$ for the analyses of this report).

Catches

The historical ($t < 2010$) catches by stratum (north, south, PCFG December – May, and PCFG June – November) are taken to be equal to the reported catches (IWC 2011; Table 1). The historical catches are allocated to the north group or PCFG in fixed proportions as follows:

(1) North area catches: all north animals;
(2) PCFG area catches in December – May: PCFG animals with probability ϕ_{PCFG} (base-case value 0.3, as determined by the photo-ID data; Calambokidis *et al*. 2012);
(3) PCFG area catches in June – November: all PCFG animals; and
(4) South area catches: PCFG animals with probability ϕ_{south} (base-case value 0.01, as determined by relative abundance).

The bycatch estimates by stratum for the historical period are computed using the equation (IWC 2013):

$$C_y^{\mathrm{I}/s} = 0.5\begin{cases}\left\{1-\frac{0.5}{69}[1999-y]\right\}\bar{C}^I & \text{if } y \le 1999 \\ \bar{C}^I N_y^{1+} / \bar{N}^{1+} & \text{otherwise}\end{cases} \tag{10}$$

where $C_y^{\mathrm{I}/s}$ is the bycatch of animals of sex s during year y; $\bar{C}^I$ is the mean catch in the stratum (see Table 2); and $\bar{N}^{1+}$ is the mean 1+ abundance (in the stratum concerned from 2000-2009). The catches from the PCFG and the north group are then allocated to age and size using the formula:

$$C_{t,a}^{s,m} = C_t^{s,m} R_{y,a}^{s,m} / \sum_{a"} R_{y,a"}^{s,m}; \qquad C_{t,a}^{s,\mathrm{f}} = C_t^{s,\mathrm{f}} R_{y,a}^{s,\mathrm{f}} / \sum_{a"} R_{y,a"}^{s,\mathrm{f}}; \tag{11}$$

Recruitment

The proportion of animals of age a that would be recruited if the population was pristine is a knife-edged function of age at age 0, i.e.:

$$\pi_a = \begin{cases} 0 & \text{if} \quad a = 0 \\ 1 & \text{otherwise}\end{cases} \tag{12}$$

The (expected) number of unrecruited animals of age a that survive to age a+1 is $U_{t,a}^{s,m/f}\ S_a$. The fraction of these that then recruit is:

$$\delta_{a+1} = \begin{cases}[\pi_{a+1} - \pi_a]/[1-\pi_a] & \text{if } 0 \le \alpha_a < 1 \\ 1 & \text{otherwise}\end{cases} \tag{13}$$

Maturity

Maturity is assumed to be a knife-edged function of age at age a_{m}.

Initialising the population vector

The numbers at age in the pristine population are given by:

$$\begin{aligned} R_{-\infty,a}^{s,\mathrm{m/f}} &= 0.5 \quad N_{-\infty,0}^{s} \quad \pi_a \prod_{a'=0}^{a-1} S_{a'}^{s} && \text{if} \quad 0 \le a < x \\ U_{-\infty,a}^{s,\mathrm{m/f}} &= 0.5 \quad N_{-\infty,0}^{s} \quad (1-\pi_a) \prod_{a'=0}^{a-1} S_{a'}^{s} && \text{if} \quad 0 \le a < x \\ R_{-\infty,x}^{s,\mathrm{m/f}} &= 0.5 \quad N_{-\infty,0}^{s} \quad \prod_{a'=0}^{x-1} \frac{S_{a'}^{s}}{(1-S_x)} && \text{if} \quad a = x \end{aligned} \tag{14}$$

where $R_{-\infty,a}^{s,\mathrm{m/f}}$ is the number of animals of stock s of age a that would be recruited in the pristine population; $U_{-\infty,a}^{s,\mathrm{m/f}}$ is the number of animals of stock s of age a that would be unrecruited in the pristine population; and $N_{-\infty,0}^{s}$ is the total number of animals of stock s of age 0 in the pristine population.

The value for $N^s_{-\infty,0}$ is determined from the value for the pre-exploitation size of the 1+ component of the population using the equation:

$$N^s_{-\infty,0} = K^{s,1+} / \left(\sum_{a=1}^{x-1} \prod_{a'=1}^{a-1} S^s_a + \frac{1}{1-S_x} \prod_{a'=0}^{x-1} S^s_{a'} \right) \tag{15}$$

It is not possible to make a simple density-dependent population dynamics model consistent with the abundance estimates for ENP gray whales (Reilly 1981; 1984; Cooke 1986; Lankester and Beddington 1986; Butterworth *et al.* 2002). This is why recent assessments of this stock (e.g. Punt and Wade 2012) have been based on starting population projections from a more recent year (denoted as τ) than that in which the first recorded catch occurred. The analyses are therefore based on the assumption that the age-structure at the start of τ = 1930 is stable rather than that the populations were at their pre-exploitation equilibrium sizes at the start of some much earlier year. The choice of 1930 for the first year of the simulation is motivated by the fact that the key assessment results are not sensitive to a choice for this year from 1930-1968 (Punt and Butterworth 2002; Punt and Wade 2012). The determination of the age-structure at the start of 1930 involves specifying the effective 'rate of increase', γ, that applies to each age-class. There are two components contributing to γ, one relating to the overall population rate of increase (γ^+) and the other to the exploitation rate. Under the assumption of knife-edge recruitment to the fishery at age 1, only the γ^+ component (assumed to be zero following Punt and Butterworth 2002) applies to ages *a* of age 0. The number of animals of age *a* at the start of τ=1930 relative to the number of calves at that time, $N^{s,*}_{\tau,a}$, is therefore given by the equation:

$$N^{s,*}_{\tau,a} = \begin{cases} 1 & \text{if } a=0 \\ N^{s,*}_{\tau,0} S^s_0 & \text{if } a \le 1 \\ N^{s,*}_{\tau,a-1} S^s_{a-1} (1-\gamma^+) & \text{if } 1<a<x \\ N^{s,*}_{\tau,x-1} S^s_{x-1} (1-\gamma^+) / (1-S^s_x (1-\gamma^+)) & \text{if } a=x \end{cases} \tag{16}$$

where B^s_τ is the number of calves in year τ (=1930) and is derived directly from equations 5 and 6 (for further details see Punt [1999]):

$$B^s_\tau = \left(1 - \left[1/(N^{s,f}_\tau b^s_{-\infty}) - 1\right] / A^s\right)^{1/z^s} \frac{K^{s,1+}}{N^{s,1+*}_\tau} \tag{17}$$

The effective rate of increase, γ^s, is selected so that if the population dynamics model is projected from 1930 to 1968, the size of the 1+ component of the population (both groups) in 1968 equals a pre-specified value, P^s_{1968}.

z and A

A^s, z^s and S^s_0, are obtained by solving the system of equations that relate $MSYL^s_{1+}$, $MSYR^s_{1+}$, S^s_0, S_{1+}, $f_{\max}$, a_m, A^s and z^s, where $f_{\max}$ is the maximum theoretical pregnancy rate (Punt 1999).

Parameter estimation

The method for estimating the parameters of the model (i.e. selecting 5,000 sets of equally likely values for the parameters $a_{\rm m}$, S_0^s, S_{1+}, $\tilde{S}$, $K_{1+}^{\rm north}$, $K_{1+}^{\rm PCFG}$, $A^{\rm north}$, $A^{\rm PCFG}$, $z^{\rm north}$, and $z^{\rm PCFG}$) is based on a Bayesian assessment (Punt and Butterworth 2002; Wade 2002; Punt and Wade 2012). The algorithm for conducting the Bayesian assessment is as follows:

(a) Draw values for the parameters S_{1+}, $f_{\rm max}$, $a_{\rm m}$, $K_{1+}^{\rm north}$, $K_{1+}^{\rm PCFG}$, $P_{1968}^{\rm north}$, $P_{1968}^{\rm PCFG}$, $\tilde{S}$, $MSYR_{1+}^s$, $MSYL_{1+}^s$, $CV_{add}^{\rm north}$ (the additional variance for the estimates of 1+ abundance at Carmel, California in 1968), $CV_{add}^{\rm PCFG}$ (the additional variance for the estimates of 1+ abundance from northern California to Southeast Alaska in 1968 – had such a survey taken place) from the priors (see Table 3 for the reference priors).

(b) Solve the system of equations that relate $MSYR_{1+}^s$, $MSYL_{1+}^s$, S_0^s, S_{1+}, $f_{\rm max}$, $a_{\rm m}$, A^s and z^s to find values for S_0^s, A^s and z^s.

(c) Calculate the likelihood of the projection for each area, given by[6]:

$$-\ell{\rm n}L = 0.5\ell{\rm n}\,|\,\mathbf{V}+\Omega\,| + 0.5\sum_i\sum_j(\ell{\rm n}N_i^{\rm obs} - \ell{\rm n}\hat{P}_i^{1+})[(\mathbf{V}+\Omega)^{-1}]_{i,j}(\ell{\rm n}N_j^{\rm obs} - \ell{\rm n}\hat{P}_j^{1+}) \qquad (18)$$

where $N_i^{\rm obs}$ is the $i^{\rm th}$ estimate of abundance[7] (Tables 4a, 4b), $\hat{P}_i^{1+}$ is the model-estimate corresponding to $N_i^{\rm obs}$, $\mathbf{V}$ is the variance-covariance matrix for the abundance estimates, and Ω is a diagonal matrix with elements given by $E(CV_{add,t}^2)$:

$$E(CV_{add,t}^2) = CV_{add}^2\,\frac{0.1+0.013P^*/\hat{P}_t}{0.1+0.013P^*/\hat{P}_{1968}} \qquad (19)$$

(d) Steps (a) – (c) are repeated a large number (typically 1,000,000) of times.

(e) 5,000 sets of parameters vectors are selected randomly from those generated using steps (a) – (c), assigning a probability of selecting a particular vector proportional to its likelihood. The number of times steps (a) – (c) are repeated is chosen to ensure that most of the 5,000 parameter vectors are unique.

The expected value for the estimate of abundance of the north area is taken to the total 1+ abundance (north group and PCFG combined) while the abundance estimates for the PCFG area are assumed to pertain to the PCFG only.

Model Scenarios

Thirteen models were run (Table 5). These included a reference model (Table 3) and 12 variants. These models do not represent a comprehensive set of options, but were used to

[6] This formulation assumes that the observed data relate to the medians of sampling distributions for the data. Alternative assumptions (such as that the observed data relate to the means of the sampling distributions) will be inconsequential given the extent of uncertainty associated with the estimates of abundance.

[7] The shore-based abundance estimate for year *y*/*y*+1 is assumed to pertain to abundance at the start of year *y*+1.

explore how the model behaved under certain conditions (e.g., parameter constraints) with respect to providing inference about the probability of the PCFG being within OSP.

Results and Discussion

Ultimately it was not possible to draw a definitive conclusion as to whether the PCFG is within OSP. Across all 13 model variants, the estimated probability of the population being above *MSYL* (i.e., *MNPL*), and hence within OSP ranged from ≈ 0.35 on the low end (models F and G) to 0.83 (model M) and 0.88 (model K) on the high end (see Table 6). In the latter two models (K and M), bycatch mortality was fixed at zero, which is not realistic. For the remaining 11 models, the probability was ≤ 0.70, which is fairly equivocal.

The time series of PCFG abundance estimates indicates that a rapid phase of population growth occurred between 1998 and 2001 associated with a pulsed immigration event (≈ 25 – 30 immigrants per year from the north group to the PCFG), followed by no substantial trend in abundance since then (Figure 1). A key reason for the inability to draw definitive conclusions about OSP is because it is unclear whether the stability of the PCFG over the last decade is best explained by it being at or near carrying capacity or whether it has been regulated at a lower level by some other processes.

Unfortunately, the time-series of abundance estimates for the PCFG is largely uninformative regarding population growth rate since it is relatively flat (no information about growth rate or density-dependence) apart from the short period of growth explained by an atypical immigration event. Consequently, estimates for population growth at *MNPL*, the value of *MNPL* itself (as a fraction of K), carrying capacity, and hence the current population depletion level (percentage of carrying capacity) for the PCFG were influenced strongly by the prior distributions. For example, the upper prior limit for K for the PCFG was 500 for models A – D, and the posterior median estimates for K ranged from 265 – 293 with upper 95% estimates close to 500, whereas, the upper prior limit was 1000 for models E – M, and the posterior median estimates for K ranged up to 441 with upper 95% estimates close to 800 or higher for most of these models (Table 6). Thus, in all of these models, the right tail of the posterior distribution for K was truncated to some extent by the upper bound for the prior for K (Figure 2), implying non-trivial (and sometimes substantial) probability that carrying capacity could be as high as the specified upper bound (and thus substantial probability that current population size is below *MNPL*).

Constraining both *MSYR* and *MNPL* for the PCFG to equal those of the north group (thus drawing on north group data to estimate some PCFG growth parameters; models J through M) did not substantially improve inference. For models J and L, the probability of the PCFG being within OSP was 0.44 and 0.52, respectively (Table 6). Models K and M included the additional constraint of fixing annual bycatch at zero, and model M also assumed zero annual immigration. The posterior distribution for carrying capacity was reasonably unconstrained by the prior (Figure 2) and the carrying capacity estimates were ≤ 250 animals (Table 6) for these two models (and also for model I, where *MNPL* and bycatch, but not *MSYR*, were constrained). Even so, the estimated probability of the population being within OSP was not definitive in these cases (probability = 0.83 and 0.88), and the assumptions of zero bycatch (models I, K, M) or full population closure (model M) are not justified for the PCFG (Weller *et al*. 2013), so these models do not represent realistic scenarios anyway. However, the estimates for these models provided the insight that bycatch mortality and movement between the north group and PCFG makes it difficult to estimate other population parameters, given the nature of the time series of abundance estimates (since parameters were not estimated well for other models that did not include the same constraints). Specifically, the only way for the model to mimic population stability when the population is assumed to be closed to bycatch or emigration is for the population to be at or near K (when K is estimated to be small), but many possible levels of K can explain the data when the population is allowed to be open (with some population losses due to bycatch and emigration).

In summary, the apparent stability of the PCFG population size for the past decade has multiple possible explanations given the limited available information. One explanation is that the population is at or near its carrying capacity and thus above *MNPL* and within OSP. However, it is also possible that the PCFG area could support more whales and that current numbers are regulated by a combination of emigration and bycatch mortality that offsets immigration and internal production (recruitment of calves born to known PCFG females). The PCFG would be expected at most to grow at around 6% per year (if it were well below *MNPL* and had the same intrinsic growth potential as the north group; Punt and Wade [2012]). It would grow at a slower rate if it is close to *MNPL* or has a lower growth rate potential than the larger north group (e.g., feeding in a less productive environment). Considering its small population size (around 200 animals), the PCFG therefore has the potential to increase at most by approximately 12 animals per year from births minus deaths, and the increase could be much smaller (e.g., just several animals per year). The PCFG can additionally grow due to immigration from the larger north group, but as modeled, immigration is offset by emigration to an extent that depends on the estimated abundance levels of the two groups relative to their respective carrying capacities. For example, if both groups are currently at the same fraction of K, PCFG immigration and emigration would be estimated to be equal. As a result, small losses from emigration and bycatch are sufficient to offset population gains from birth and immigration, especially if the PCFG has a relatively low intrinsic growth rate compared to the north group (e.g., as in models E through I; see Table 6). Moreover, bycatch mortality estimates in the models are likely underestimates of true bycatch mortality (Weller *et al.* 2013). If higher bycatch mortality rates were included in the analyses, this would decrease the estimated likelihood of the PCFG being within OSP, but true bycatch mortality rates are unknown with no good way at present of being approximated (thus we used the same values as in IWC analyses; Table 2).

Obtaining better empirical estimates of bycatch mortality, net annual immigration rates, and reducing prior uncertainty in *MSYR* and *MNPL* could potentially improve inference about the likelihood of the PCFG being within OSP.

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Table 1
Historical catches of ENP gray whales (IWC, 2011).

Year	South			PCFG Jun-Nov			PCFG Dec-May			North			Total		
	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total
1930	0	0	0	0	0	0	0	0	0	23	24	47	23	24	47
1931	0	0	0	0	0	0	0	0	0	5	5	10	5	5	10
1932	5	5	10	0	0	0	0	0	0	5	5	10	10	10	20
1933	30	30	60	0	0	0	0	0	0	8	7	15	38	37	75
1934	30	30	60	0	0	0	0	0	0	36	30	66	66	60	126
1935	55	55	110	0	0	0	0	0	0	16	28	44	71	83	154
1936	43	43	86	0	0	0	0	0	0	50	62	112	93	105	198
1937	0	0	0	0	0	0	0	0	0	12	12	24	12	12	24
1938	0	0	0	0	0	0	0	0	0	32	32	64	32	32	64
1939	0	0	0	0	0	0	0	0	0	19	20	39	19	20	39
1940	0	0	0	0	0	0	0	0	0	56	69	125	56	69	125
1941	0	0	0	0	0	0	0	0	0	38	39	77	38	39	77
1942	0	0	0	0	0	0	0	0	0	60	61	121	60	61	121
1943	0	0	0	0	0	0	0	0	0	59	60	119	59	60	119
1944	0	0	0	0	0	0	0	0	0	3	3	6	3	3	6
1945	0	0	0	0	0	0	0	0	0	25	33	58	25	33	58
1946	0	0	0	0	0	0	0	0	0	14	16	30	14	16	30
1947	0	0	0	0	0	0	0	0	0	11	20	31	11	20	31
1948	0	0	0	0	0	0	0	0	0	7	12	19	7	12	19
1949	0	0	0	0	0	0	0	0	0	10	16	26	10	16	26
1950	0	0	0	0	0	0	0	0	0	4	7	11	4	7	11
1951	0	0	0	0	0	0	1	0	1	5	8	13	6	8	14
1952	0	0	0	0	0	0	0	0	0	17	27	44	17	27	44
1953	0	0	0	0	0	0	6	4	10	15	23	38	21	27	48
1954	0	0	0	0	0	0	0	0	0	14	25	39	14	25	39
1955	0	0	0	0	0	0	0	0	0	22	37	59	22	37	59
1956	0	0	0	0	0	0	0	0	0	45	77	122	45	77	122
1957	0	0	0	0	0	0	0	0	0	36	60	96	36	60	96
1958	0	0	0	0	0	0	0	0	0	55	93	148	55	93	148
1959	1	1	2	0	0	0	0	0	0	73	121	194	74	122	196
1960	0	0	0	0	0	0	0	0	0	58	98	156	58	98	156
1961	0	0	0	0	0	0	0	0	0	77	131	208	77	131	208
1962	4	0	4	0	0	0	0	0	0	55	92	147	59	92	151
1963	0	0	0	0	0	0	0	0	0	68	112	180	68	112	180
1964	15	5	20	0	0	0	0	0	0	75	124	199	90	129	219
1965	0	0	0	0	0	0	0	0	0	71	110	181	71	110	181
1966	15	11	26	0	0	0	0	0	0	80	114	194	95	125	220
1967	52	73	125	0	0	0	0	0	0	109	140	249	161	213	374
1968	41	25	66	0	0	0	0	0	0	48	87	135	89	112	201
1969	39	35	74	0	0	0	0	0	0	50	90	140	89	125	214
1970	0	0	0	0	0	0	0	0	0	71	80	151	71	80	151
1971	0	0	0	0	0	0	0	0	0	57	96	153	57	96	153
1972	0	0	0	0	0	0	0	0	0	61	121	182	61	121	182
1973	0	0	0	0	0	0	0	0	0	97	81	178	97	81	178
1974	0	0	0	0	0	0	0	0	0	94	90	184	94	90	184
1975	0	0	0	0	0	0	0	0	0	58	113	171	58	113	171
1976	0	0	0	0	0	0	0	0	0	69	96	165	69	96	165
1977	0	0	0	0	0	0	0	0	0	87	100	187	87	100	187
1978	0	0	0	0	0	0	0	0	0	94	90	184	94	90	184
1979	0	0	0	0	0	0	0	0	0	58	125	183	58	125	183
1980	0	0	0	0	0	0	0	0	0	53	129	182	53	129	182
1981	0	0	0	0	0	0	0	0	0	36	100	136	36	100	136
1982	0	0	0	0	0	0	0	0	0	57	111	168	57	111	168
1983	0	0	0	0	0	0	0	0	0	46	125	171	46	125	171
1984	0	0	0	0	0	0	0	0	0	59	110	169	59	110	169
1985	0	0	0	0	0	0	0	0	0	54	116	170	54	116	170
1986	0	0	0	0	0	0	0	0	0	46	125	171	46	125	171
1987	0	0	0	0	0	0	0	0	0	48	111	159	48	111	159
1988	0	0	0	0	0	0	0	0	0	43	108	151	43	108	151
1989	0	0	0	0	0	0	0	0	0	61	119	180	61	119	180
1990	0	0	0	0	0	0	0	0	0	67	95	162	67	95	162

Year	South			PCFG Jun-Nov			PCFG Dec-May			North			Total		
	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total
1991	0	0	0	0	0	0	0	0	0	67	102	169	67	102	169
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	21	23	44	21	23	44
1995	0	0	0	0	0	0	0	0	0	48	44	92	48	44	92
1996	0	0	0	0	0	0	0	0	0	18	25	43	18	25	43
1997	0	0	0	0	0	0	0	0	0	48	31	79	48	31	79
1998	0	0	0	0	0	0	0	0	0	64	61	125	64	61	125
1999	0	0	0	0	0	0	0	1	1	69	54	123	69	55	124
2000	0	0	0	0	0	0	0	0	0	63	52	115	63	52	115
2001	0	0	0	0	0	0	0	0	0	62	50	112	62	50	112
2002	0	0	0	0	0	0	0	0	0	80	51	131	80	51	131
2003	0	0	0	0	0	0	0	0	0	71	57	128	71	57	128
2004	0	0	0	0	0	0	0	0	0	43	68	111	43	68	111
2005	0	0	0	0	0	0	0	0	0	49	75	124	49	75	124
2006	0	0	0	0	0	0	0	0	0	57	77	134	57	77	134
2007	0	0	0	0	1	1	0	0	0	50	81	131	50	82	132
2008	0	0	0	0	0	0	0	0	0	64	66	130	64	66	130
2009	0	0	0	0	0	0	0	0	0	59	57	116	59	57	116
2010	0	0	0	0	0	0	0	0	0	57	61	118	57	61	118

Table 2
Average estimated historical bycatches

Stratum	Average bycatch estimates
North	0[1]
PCFG [Dec – May]	2
PCFG [Jun – Nov]	1.4[2]
South	3.4

1 – obviously not actually zero, but will be small relative to population size
2 – includes southern whales during June – November as these whales are almost certainly PCFG animals

Table 3. The prior distributions for the ENP stock of gray whales, for the reference case scenario (case B in Table 5).

Parameter	**Prior distribution**
Maximum Sustainable Yield Rate, $MSYR_{1+}^{north}$	U[0.01,0.06]
$MSYR_{1+}^{PCFG}$	U[0.01,0.06]
Maximum Net Productivity Level, $MNPL^{north}$ (same as $MSYL_{1+}^{s}$)	0.6
$MNPL^{PCFG}$	0.6
Non-calf survival rate, S_{1+}	U[0.95, 0.99]
Age-at-maturity, a_m	U[6, 12]
K_{1+}^{north}	U[16,000, 70,000]
K_{1+}^{PCFG}	U[100, 500]
Maximum pregnancy rate, f_{max}	U[0.3, 0.6]
CV_{add}^{north}	U[0.1, 0.3]
CV_{add}^{PCFG}	U[0.05, 0.3]
1968 abundance, P_{1968}^{north}	U[8,000, 16,000]
1968 abundance, P_{1968}^{PCFG}	U[50, 300]
Catastrophic mortality, $\tilde{S}$	U[0.5,1.0]
Annual Immigration, $\overline{I}$	U[0,4]
Pulse Immigration, $I_{1999,2000}$	U[10, 50]

Table 4a Estimates of absolute abundance (with associated standard errors of the logs) for the ENP stock of gray whales based on shore counts (source: Laake *et al*. 2012).

Year	Estimate	CV	Year	Estimate	CV
1967/68	13426	0.094	1979/80	19763	0.083
1968/69	14548	0.080	1984/85	23499	0.089
1969/70	14553	0.083	1985/86	22921	0.081
1970/71	12771	0.081	1987/88	26916	0.058
1971/72	11079	0.092	1992/93	15762	0.067
1972/73	17365	0.079	1993/94	20103	0.055
1973/74	17375	0.082	1995/96	20944	0.061
1974/75	15290	0.084	1997/98	21135	0.068
1975/76	17564	0.086	2000/01	16369	0.061
1976/77	18377	0.080	2001/02	16033	0.069
1977/78	19538	0.088	2006/07	19126	0.071
1978/79	15384	0.080			

Table 4b Estimates of absolute abundance (with associated CVs) for gray whales in the PCFG area, 41^0-52^0N (source: Laake, 2013).

Year	Estimate	CV	Year	Estimate	CV
1998	101	0.062	2005	206	0.109
1999	135	0.089	2006	190	0.099
2000	141	0.093	2007	183	0.126
2001	172	0.073	2008	191	0.084
2002	189	0.048	2009	185	0.125
2003	200	0.082	2010	186	0.100
2004	206	0.072			

Table 5. Specifications for the scenarios

Case	Difference from case B
A	No Annual Immigration
B	Reference case (see Table 3)
C	$MSYL^{s}_{1+} \sim U[0.4, 0.8]$; no annual immigration $(\bar{I} = 0)$
D	$MSYL^{s}_{1+} \sim U[0.4, 0.8]$
E	$MSYL^{s}_{1+} \sim U[0.5, 0.85]$; $K^{PCFG}_{1+} \sim U[100,1000]$; $\bar{I} \sim U[0,6]$; $I_{1999,2000} \sim U[0,60]$
F	$MSYL^{s}_{1+} \sim U[0.5, 0.85]$; $K^{PCFG}_{1+} \sim U[100,1000]$; no annual immigration; $I_{1999,2000} \sim U[0,60]$
G	As for F except that MSYL for the two stocks constrained to be equal and $\bar{I} \sim U[0,6]$
H	As for F except that MSYL for the two stocks constrained to be equal
I	As for E, except MSYL for the two stocks constrained to be equal, there are no historical bycatches and no additional variance for PCFG abundance estimates
J	As for E except MSYL and MSYR for the two stocks constrained to be equal
K	As for J, but there are no historical bycatches
L	As for J, but there is no additional variance for PCFG abundance estimates
M	As for J, but there are no historical bycatches and no annual immigration

Table 6. Summaries of the posterior distributions for selected parameters from all model scenarios (Table 5). P(N>MNPL) is probability that the 1+ population size is above the Max Net Productivity Level and thus the population is within OSP (for the north group and the PCFG). For other parameters, the posterior median and 95% credible intervals are presented. MSYR is the population growth rate at MNPL, which is estimated in terms of a proportion of abundance at MNPL.

Run	P(N>MNPL) North	P(N>MNPL) PCFG		MSYR North	MSYR PCFG	MNPL North	MNPL PCFG	K North	K PCFG
A	0.771	0.7016	5%	0.019	0.011	0.6	0.6	20895	179
			50%	0.038	0.022	0.6	0.6	25384	265
			95%	0.055	0.045	0.6	0.6	57578	465
B	0.753	0.6418	5%	0.019	0.011	0.6	0.6	20997	194
			50%	0.037	0.022	0.6	0.6	25676	292
			95%	0.056	0.043	0.6	0.6	58693	472
C	0.847	0.659	5%	0.021	0.011	0.531	0.467	19514	183
			50%	0.042	0.021	0.702	0.612	22714	285
			95%	0.056	0.045	0.791	0.778	54866	475
D	0.836	0.643	5%	0.02	0.011	0.53	0.458	19596	191
			50%	0.042	0.02	0.701	0.612	22652	293
			95%	0.056	0.042	0.792	0.775	55224	476
E	0.8184	0.3962	5%	0.021	0.011	0.545	0.515	19447	196
			50%	0.041	0.017	0.704	0.651	22596	376
			95%	0.056	0.039	0.809	0.795	57869	920
F	0.849	0.3546	5%	0.021	0.011	0.554	0.517	19451	188
			50%	0.042	0.019	0.716	0.653	22502	439
			95%	0.056	0.039	0.811	0.8	52813	940
G	0.7988	0.3474	5%	0.02	0.011	0.543	0.543	19544	195
			50%	0.041	0.018	0.687	0.687	23164	398
			95%	0.056	0.039	0.791	0.791	58187	923
H	0.839	0.4178	5%	0.02	0.011	0.549	0.549	19622	188
			50%	0.042	0.018	0.7	0.7	22674	441
			95%	0.056	0.041	0.797	0.797	54808	927
I	0.756	0.6634	5%	0.02	0.01	0.532	0.532	19732	168
			50%	0.039	0.015	0.672	0.672	23466	250
			95%	0.056	0.033	0.778	0.778	61570	805
J	0.3386	0.4354	5%	0.017	0.017	0.515	0.515	21315	191
			50%	0.024	0.024	0.63	0.63	40607	346
			95%	0.043	0.043	0.771	0.771	47154	839
K	0.3594	0.8798	5%	0.016	0.016	0.515	0.515	20912	132
			50%	0.023	0.023	0.631	0.631	42624	241
			95%	0.049	0.049	0.762	0.762	67563	643
L	0.399	0.5168	5%	0.017	0.017	0.517	0.517	20760	193
			50%	0.025	0.025	0.647	0.647	37928	312
			95%	0.046	0.046	0.787	0.787	66508	791
M	0.5958	0.8262	5%	0.017	0.017	0.519	0.519	20112	122
			50%	0.03	0.03	0.651	0.651	27641	195
			95%	0.051	0.051	0.771	0.771	64866	772

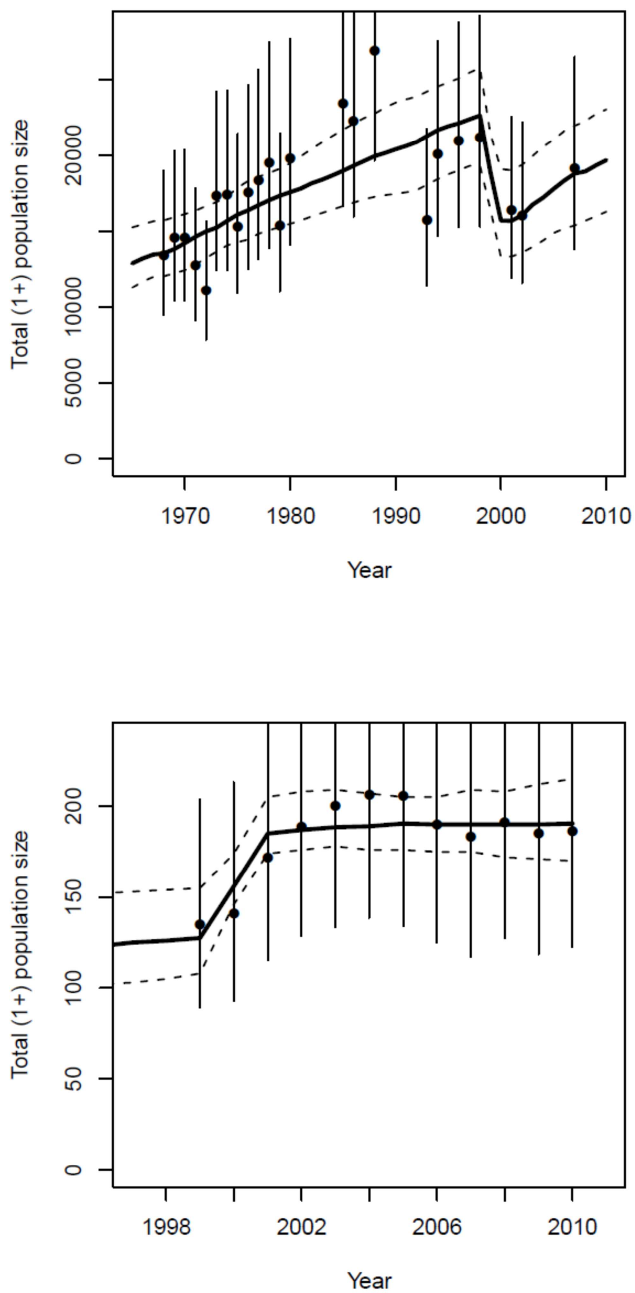

Figure 1. Abundance estimates for the north group (top) and PCFG (bottom) from the reference model (model B). Points and error bars represent actual estimates (Calambokidis *et al*, 2012). Solid line represents posterior median estimates (dotted lines represent 90% credible intervals). Estimates from all models (A – M) are similar.

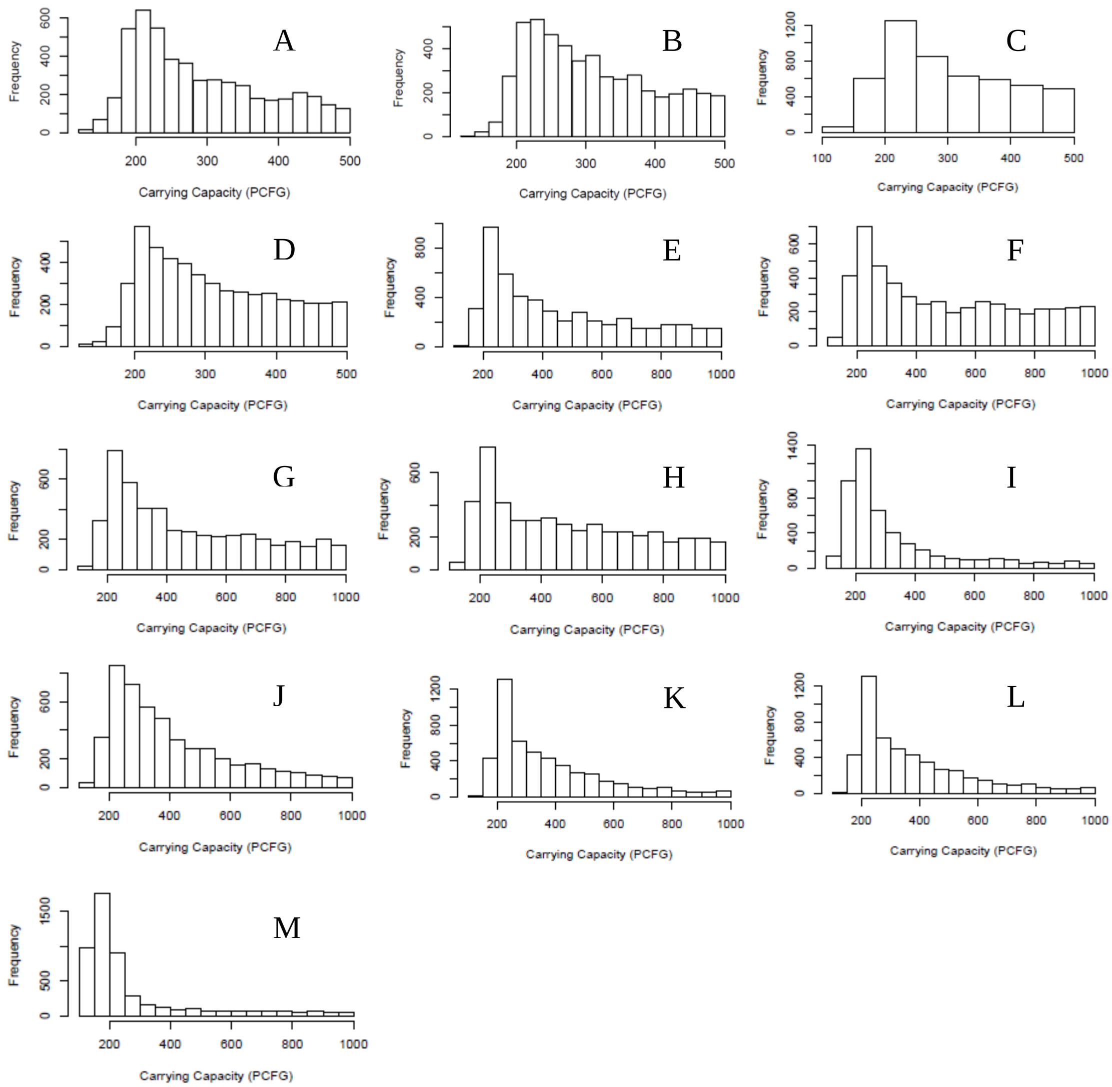

Figure 2. Posterior distributions for carrying capacity for the PCFG, for model scenarios A through M.

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NOAA Technical Memorandum NMFS-AFSC-207

Population Status of the Eastern North Pacific Stock of Gray Whales in 2009

by
A. E. Punt and P. R. Wade

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Alaska Fisheries Science Center

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by
A. E. Punt[1] and P. R. Wade[2]

[1] School of Aquatic and Fishery Sciences
University of Washington
Box 355020
Seattle, WA 98195-5020

[2] National Marine Mammal Laboratory
Alaska Fisheries Science Center
7600 Sand Point Way NE
Seattle, WA 98115-6489
www.afsc.noaa.gov

U.S. DEPARTMENT OF COMMERCE
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February 2010

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ABSTRACT

An age- and sex-structured population dynamics model is fitted using Bayesian methods to data on the catches and abundance estimates for the eastern North Pacific (ENP) stock of gray whales (*Eschrictius robustus*). The prior distributions used for these analyses incorporate revised estimates of abundance for ENP gray whales and account explicitly for the drop in abundance caused by the 1999-2000 mortality event. A series of analyses are conducted to evaluate the sensitivity of the results to different assumptions. The baseline analysis estimates the ENP gray whale population to be above the maximum net productivity level (MNPL), because the posterior mean for the ratio of 2009 abundance to MNPL, termed the optimal sustainable population ratio, is 1.29 (with a posterior median of 1.37 and a 90% probability interval of 0.68-1.51), indicating the population is estimated to be well above MNPL. The baseline analysis estimates a probability of 0.884 that the population is above its MNPL, which means there is a 0.884 probability that it is at its optimum sustainable population size as defined by the U.S. Marine Mammal Protection Act. These results are consistent across all the model runs. The baseline model also estimates the 2009 ENP gray whale population size (posterior mean of 21,911) to be at 85% of its carrying capacity (posterior mean of 25,808), and this is also consistent across all the model runs.

CONTENTS

INTRODUCTION

The eastern North Pacific (ENP) gray whale (*Eschrichtius robustus*) population has been hunted extensively by both commercial and aboriginal whalers. Indigenous peoples of both North America and Russia have hunted gray whales in some locations for centuries and possibly for 2,000 years or more (Krupnik 1984, O'Leary 1984). The winter breeding grounds of the ENP gray whale (lagoons and adjacent ocean areas in Baja California, Mexico) were discovered by Yankee whalers in the early 19th century, and two commercial whaling vessels first hunted gray whales (in Magdalena Bay) in the winter of 1845-46 (Henderson 1984). This began a period of intense hunting with large catches of ENP gray whales by Yankee whalers from 1846 until 1873 which decimated the population. Whaling ships and shore-based whalers continued to catch gray whales for the next two decades which drove the population to apparent commercial extinction by 1893. In the 20th century, modern commercial pelagic whaling of ENP gray whales began in 1910 and ended in 1946 when gray whales received full protection under the International Convention for the Regulation of Whaling (Reeves 1984). Aboriginal catches of ENP gray whales along the Chukotka Peninsula of Russia have continued since 1946 until the present. Gray whales were listed as endangered under the U.S. Endangered Species Act in 1973 and after increasing substantially in population size, they were removed from the endangered species list in 1994.

From 1846 to 1900 recorded commercial kills numbered nearly 9,000 gray whales, and it is roughly estimated that about 6,000 gray whales were killed by aboriginal hunters during this same period, for a total of more than 15,500 whales caught (Table 1). Since 1900, about 11,500 additional ENP gray whales have been killed by commercial and aboriginal whalers for a total since 1846 of more than 27,000 whales caught (Table 1). The magnitude of the catches, particularly for the period of high exploitation during the 1800s, gives some information on the likely pre-exploitation population size. For example, Jones et al. (1984) state that "most whaling historians and biologists believe the pre-exploitation stock size was between 15,000 and 24,000 animals".

ENP gray whales migrate along the west coast of North America, and the National Marine Fisheries Service (NMFS) has taken advantage of this nearshore migration pattern to conduct shore-based counts of the population in central California during December-February from 1967-68 to 2006-07. These survey data have been used to estimate the abundance of the ENP gray whale stock over the survey period (Reilly 1981; Buckland et al. 1993; Laake et al. 1994; Hobbs et al. 2004; Rugh et al. 2005, 2008a).

The resulting sequence of abundance estimates has also been used to estimate the population's growth rate (Buckland et al. 1993, Buckland and Breiwick 2002), as well as its status relative to the maximum net productivity level (MNPL)[1] and carrying capacity (*K*) (Reilly 1981, Lankester and Beddington 1986, Cooke 1986, Wade 2002, Punt and Butterworth 2002). However, attempts to model the gray whale population from 1846 until the present, accounting for the catch record, assuming that the stock was at its carrying capacity in 1846 (has and this has not changed) has run into difficulties because the catch history cannot be reconciled with a population that increased at the observed rate from 1967-68 to 1979-80 (Reilly 1981, Cooke 1986, Lankester and Beddington 1986). The explanation for this is simple; if one assumes a relatively low maximum growth rate, the ENP gray whales would not have been able to increase between 1967-68 and 1979-80 because of the catches during that time, and if one assumes a high maximum growth rate, the population would not be increasing then because it would have already returned to carrying capacity. Butterworth et al. (2002) investigated the inability to fit a standard population dynamics model to the data for the ENP gray whales extensively and concluded that the catch history and the observed rate of increase could be reconciled in one of three different ways, which were not mutually exclusive: a) a 2.5× increase in *K* between 1846 and 1988, b) a 1.7× increase or more in the commercial catch between 1846 and 1900, and c) a 3× increase or more in aboriginal catch levels prior to 1846 compared to what was previously assumed (Butterworth et al. 2002).

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[1]The maximum net productivity level is described in the National Marine Fisheries Service's definition of "optimum sustainable population" (OSP) (50 CFR 216.3) as the abundance level that results in the greatest net annual increment in population numbers or biomass resulting from additions to the population due to reproduction and/or growth less losses due to natural mortality. Under the U.S. Marine Mammal Protection Act, populations above MNPL are considered to be at OSP; populations below MNPL can be designated as 'depleted' and are afforded a greater level of protection.

Given these difficulties, recent gray whale population assessments have been conducted by modeling the population since 1930 or later, rather than trying to model the population since 1846 (e.g., Punt and Butterworth 2002, Wade 2002). These analyses differed from the earlier assessments by not assuming the population size in 1846 was *K*. Instead, *K* is essentially estimated by the recent trend in abundance, where a growing population implies that *K* has likely not yet been reached, and a roughly stable population implies the population is at or near *K*. Based on abundance surveys through 1995-96, point estimates of *K* from these analyses ranged from 24,000 to 32,000, but these estimates were relatively imprecise because they had broad confidence intervals (Wade 2002, Punt and Butterworth 2002). In particular, the results did not exclude the possibility that *K* could be much larger than this range. However, these analyses did suggest that the population was likely close to *K* and at or above its MNPL. For example, Wade (2002) estimated a probability of 0.72 the population was above MNPL in 1996. Punt and Butterworth (2002) also conducted analyses projecting the population from the year 1600 under various assumptions that historic commercial and aboriginal catches were underestimated (as in Butterworth et al. (2002)). Those analyses resulted in point estimates of *K* that ranged between 15,000 and 19,000. In those analyses, it was estimated the population was at a very high fraction of *K* in 1996 and had a very high probability of being above MNPL.

Recently, Rugh et al. (2008b) evaluated the accuracy of various components of the shore-based survey method, with a focus on pod size estimation. They found that the correction factors that had been used to compensate for bias in pod size estimates were calculated differently for different sets of years. In particular, the correction factors estimated by Laake et al. (1994) were substantially larger than those estimated by Reilly (1981). Also, the estimates for the surveys prior to 1987 in the trend analysis were scaled based on the abundance estimate from 1987-88. This meant that the first 16 abundance estimates used one set of correction factors, and the more recent 7 abundance estimates used different (and larger) correction factors which would influence the estimated trend and population trajectory. In addition, there were other subtle differences in the analysis methods used for the sequence of abundance estimates. Thus, a re-evaluation of the analysis techniques and a reanalysis of the abundance estimates were warranted to apply a more uniform approach throughout the years. Laake et al. (2009) derived a better, more consistent, approach to abundance estimation, and incorporated it into an analysis to re-estimate abundance for all 23 shore-based surveys. These new revised abundance estimates led to this re-assessment of the ENP gray whale population.

Here, we re-assess the population of ENP gray whales by fitting an age- and sex-structured population model to these revised abundance estimates, using similar methods as those used by Wade (2002) and Punt and Butterworth (2002). Note also that we use recent abundance estimates from 1997-98, 2000-01, 2001-02, and 2006-07 that were not available in previous assessments. As in Punt and Butterworth (2002), we also perform sensitivity tests to various assumptions or modeling decisions.

These analyses also incorporate new information about the biology of the ENP gray whales developed in recent studies. In particular, it is now recognized that the population experienced an unusual mortality event in 1999 and 2000. An unusually high number of gray whales were stranded along the west coast of North America in those years (Moore et al. 2001, Gulland et al. 2005). Over 60% of the dead whales were adults, and more adults and subadults stranded in 1999 and 2000 relative to the years prior to the mortality event (1996-98), when calf strandings were more common. Many of the stranded whales were emaciated, and aerial photogrammetry documented that migrating gray whales were skinnier in girth in 1999 relative to previous years (Perryman and Lynn 2002, W. Perryman, Southwest Fisheries Science Center, SWFSC, pers. comm.). In addition, calf production in 1999 and 2000 was less than one third of that in the previous years (1996-98). In 2001 and 2002, strandings of gray whales along the coast decreased to levels that were below their pre-1999 level (Gulland et al. 2005), and average calf production in 2002-2004 returned to the level seen in pre-1999 years (Table 2). A Working Group on Marine Mammal Unusual Mortality Events (Gulland et al. 2005) concluded that the emaciated condition of many of the stranded whales supported the idea that starvation could have been a significant contributing factor to the higher number of strandings in 1999 and 2000. Perryman et al. (2002) found a significant positive correlation between an index of the amount of ice-free area in gray whale feeding areas in the Bering Sea and their estimates of calf production for the following spring for the years 1994 to 2000; the suggested mechanism is that longer periods of time in open water provides greater feeding opportunities for gray whales. Whether or not heavy ice cover was ultimately the mechanism that caused the 1999-2000 event, it is clear that ENP gray whales were substantially affected in those years; whales were on average skinnier, they had a lower survival rate (particularly of adults), and calf production was dramatically lower. Given that this event may have affected the status of the ENP gray whale population relative to *K*, we specified an additional model parameter ("catastrophic mortality") that allowed for lower survival in the years 1999 and 2000 to investigate this effect.

METHODS

Available Data

A variety of data sources are available to assess the status of the ENP stock of gray whales. These data sources are used when developing the prior distributions for the parameters of the population dynamics model, when pre-specifying the values for some of the parameters of this model, and when constructing the likelihood function. Table 1 lists the time series of removals. It should be noted that the catches for the years prior to 1930 are subject to considerable uncertainty, and evaluating these catches remains an active area of research. However, the uncertainty associated with these early catches is inconsequential for this report because the population projections do not start before 1930.

The key source of information on the abundance of the ENP gray whales is based on data collected from the southbound surveys that have been conducted since 1967-68 near Carmel, California (Laake et al. 2009; Table 2). Information on trends in calf numbers are also available from surveys of calves during the northbound migration (Perryman et al. 2002, W. Perryman, pers. comm., Table 2). The calf abundance data are not included in the baseline analyses, but are considered in one of the tests of sensitivity.

Analysis Methods

The Population Dynamics Model

The analyses use an age- and sex-structured population dynamics model which assumes that all whaling takes place at the start of the year, and that all animals are 'recruited' to the hunted population by age 5 (i.e., hunting only occurs on animals age 5 and older) (Punt 1999, Punt and Butterworth 2002). The dynamics of the population are assumed to be governed by the equations:

$$N^s_{t+1,a} = \begin{cases} 0.5 \ P^{\mathrm{M}}_{t+1} \ f_{t+1} & \text{if } a = 0 \\ N^s_{t,a-1}(1-F^s_{t,a-1})\, S_{a-1}\tilde{S}_y & \text{if } 1 \le a \le x-1 \\ N^s_{t,x}(1-F^s_{t,x})\, S_x\tilde{S}_y + N^s_{t,x-1}(1-F^s_{t,x-1})\, S_{x-1}\tilde{S}_y & \text{if } a = x \end{cases} \quad , \qquad (1)$$

where $N^s_{t,a}$ is the number of animals of age a and sex s (m / f) at the start of year t,

S_a is the annual survival rate of animals of age a in the absence of catastrophic mortality events (assumed to be the same for males and females),

$\tilde{S}_y$ is the amount of catastrophic mortality (represented in the form of a survival rate) during year y (catastrophic events are assumed to occur at the start of the year before mortality due to whaling and natural causes),

$F^s_{t,a}$ is the exploitation rate on animals of sex s and age a during year t,

P^{M}_t is the number of females that have reached the age at first parturition by the start of year t,

$$P^{\mathrm{M}}_t = \sum_{a=a_m+1}^{x} N^{\mathrm{f}}_{t,a} \quad , \qquad (2)$$

a_m is the age-of-maturity,

f_t is pregnancy rate (number of calves of both sexes per ‘mature’ female) during year t (note that Equation (1) assumes an equal male : female sex ratio at birth), and

x is the maximum age class, which for convenience is lumped across older age classes (i.e., individuals stay in this age class until they die).

Density dependence on fecundity can be modeled by writing the pregnancy rate, f_t, as follows:

$$f_t = \max\left(f_{eq}\left[1 + A\left\{1 - \left(\tilde{S}_{t-2}P^{1+}_{t-2} / K^{1+}\right)^z\right\}\right], 0\right) \quad , \qquad (3)$$

where f_{eq} is the pregnancy rate at the pre-exploitation equilibrium, $f(F=0)$[2]:

$$f(F) = 2\left\{ \sum_{a=a_m+1}^{x} \tilde{N}_a^{\mathrm{f}}(F) \right\}^{-1} \quad , \qquad (4)$$

A is the resilience parameter:

$$A = \frac{f_{\max} - f_{eq}}{f_{eq}} \quad , \qquad (5)$$

$f_{\max}$ is the maximum (theoretical) pregnancy rate,

z is the degree of compensation,

P_t^{1+} is number of animals aged 1 and older at the start of year *t*:

$$P_t^{1+} = \sum_s \sum_{a=1}^{x} N_{t,a}^s \quad , \qquad (6)$$

K^{1+} is the (current) pre-exploitation equilibrium size (carrying capacity) in terms of animals aged 1 and older,

$\tilde{N}_a^s(F)$ is the number of animals of sex *s* and age *a* when the exploitation rate is fixed at *F*, expressed as a fraction of the number of calves of the same sex *s* (see Appendix 1 of Punt (1999) for details).

Note that although these equations are written formally as if only the pregnancy rate component of 'fecundity' as defined here is density-dependent, exactly the same equations follow if some or all of this dependence occurs in the infant survival rate (Punt 1999). Catastrophic mortality is assumed to occur before density-dependence because many of the deaths in 1999 and 2000 occurred before mating was likely to have occurred. Note that non-catastrophic natural mortality does not appear in Equation 3 because it cancels out. The time-lag in Equation 3 is specified to

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[2] The pregnancy rate at the pre-exploitation equilibrium can be considered to be the equilibrium pregnancy rate when the exploitation rate, *F*, is fixed at zero.

match the reproductive cycle of gray whales; mature female gray whales mate and become pregnant in early winter, have a gestation period of slightly longer than one year, and give birth at the start of the next year (on average in January) (Rice and Wolman 1971, Shelden et al. 2004). Their body condition at the end of the summer feeding season will help determine their probability of becoming pregnant the following winter and producing a calf a year later. Therefore, the density-dependent effect on calf production is assumed to be determined by the population size during the feeding season two time-steps prior (approximately 1.5 years earlier).

Following past assessments of the ENP stock of gray whales (e.g., Butterworth et al. 2002, Punt and Butterworth 2002, Punt et al. 2004), the catch (by sex) is assumed to be taken uniformly from the animals aged 5 and older, that is,

$$F_{t,a}^{s} = C_{t}^{s} / \sum_{a=5}^{x} N_{t,a}^{s} \quad . \tag{7}$$

The population is assumed to have had a stable age-structure at the start of the projection period (year t_{INIT}).

$$N_{t_{\text{INIT}},a}^{s} = N_{t_{\text{INIT}}}^{\text{Tot}} \tilde{N}_{a}^{s}(F_{\text{INIT}}) / \sum_{s'} \sum_{a'=0}^{x} \tilde{N}_{a'}^{s'}(F_{\text{INIT}}) \quad , \tag{8}$$

where $N_{t_{INIT}}^{\text{Tot}}$ is the size of the total (0+) component of the population at the start of year t_{INIT}. The value of F_{INIT} is selected numerically so that:

$$N_{t_{\text{INIT}}}^{\text{Tot}} = 0.5\, N_{0}(F_{\text{INIT}}) \sum_{s} \sum_{a=0}^{x} \tilde{N}_{a}^{s}(F_{\text{INIT}}) \quad , \tag{9}$$

where $N_{0}(F_{\text{INIT}})$ is the number of calves (of both sexes) at the start of the year when $F = F_{\text{INIT}}$:

$$N_{0}(F_{\text{INIT}}) = \left(1 - \frac{1}{A}\left[\frac{f(F_{\text{INIT}})}{f_{\text{eq}}} - 1\right]\right)^{1/z} \frac{K^{1+}}{\tilde{P}^{1+}(F_{\text{INIT}})} \quad , \tag{10}$$

$\tilde{P}^{1+}(F)$	is the size of the 1+ component of the population as a function of F, expressed as a fraction of the number of calves (of both sexes).

Parameter Estimation

Catastrophic mortality is assumed to be zero (i.e., $\tilde{S}_y = 1$) except for 1999 and 2000 when it is assumed to be equal to a parameter $\tilde{S}$. This assumption reflects the large number of dead ENP gray whales observed stranded along the coasts of Oregon and Washington during 1999 and 2000 relative to numbers stranding there annually historically (Gulland et al. 2005, Brownell et al. 2007).

The parameters of the population dynamics model are a_m; $\tilde{S}$; K^{1+}; the 1+ population size at the start of 1968, P^{1+}_{1968} [3]; $MSYL^{1+}$ (the maximum sustainable yield level for the 1+ population, which is the population size at which maximum sustainable yield (MSY) is achieved when hunting takes place uniformly on animals aged 1 and older); $MSYR^{1+}$ (the ratio of MSY to $MSYL^{1+}$); f_{max}; and the non-calf survival rate, S_{1+}. The analysis does not incorporate a prior distribution for the survival rate of calves (S_0) explicitly. Instead, following Wade (2002), an implicit prior distribution for this parameter is calculated from the priors for the five parameters a_m, f_{max}, S_{1+}, $MSYR^{1+}$ and $MSYL^{1+}$. For any specific draw from the prior distributions for these five parameters, the value for S_0 is selected so that the relationships imposed by the population model among the six parameters are satisfied. If the resulting value for S_0 is less than zero or greater than that of S_{1+}, the values for S_{1+}, a_m, f_{max}, $MSYR^{1+}$ and $MSYL^{1+}$ are drawn again[4]. Thus, the prior for S_0 is forced to conform to the intuitive notion that the survival rate of calves must be lower than that for older animals (and must be larger than zero) (Caughley 1966).

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[3] The 1968 population size is taken to be a measure of initial abundance so that the analyses based on different starting years are comparable in terms of their prior specifications.

[4] The implications of different treatments of how to handle situations in which the calculated value for S_0 is outside of plausible bounds is examined by Brandon et al. (2007).

Under the assumption that the logarithms of the estimates of abundance based on the southbound surveys are normally distributed, the contribution of these estimates to the negative of the logarithm of the likelihood function (ignoring constants independent of the model parameters) is

$$-\ell nL = 0.5\ell n\,|\mathbf{V}+\Omega| + 0.5\sum_i \sum_j (\ell nN_i^{obs} - \ell n\hat{P}_i^{1+})[(\mathbf{V}+\Omega)^{-1}]_{i,j}(\ell nN_j^{obs} - \ell n\hat{P}_j^{1+}) \ , \qquad (11)$$

where N_i^{obs} is the i[th] estimate of abundance[5],

$\hat{P}_i$ is the model-estimate corresponding to N_i^{obs},

$\mathbf{V}$ is the variance-covariance matrix for the abundance estimates, and

Ω is a diagonal matrix with elements CV_{add}^2 (this matrix captures sources of uncertainty not captured elsewhere; termed "additional variance" in Wade (2002)).

A Bayesian approach is used to estimate the 'free' parameters of the model based on the prior distributions in Table 3 and the sampling/importance resampling (SIR) algorithm (Rubin 1988).

(a) Draw values for the parameters S_{1+}, a_m, f_{max}, MSYR^{1+}, MSYL^{1+}, K^{1+}, P_{1968}^{1+}, $\tilde{S}$, and CV_{add} from the priors in Table 3.
(b) Solve the system of equations that relate S_0, S_{1+}, a_m, f_{max}, MSYR^{1+}, MSYL^{1+}, A and z (Punt 1999, Eqs. 18-21) to find values for S_0, A, and z, and find the population size in year t_{INIT} and the population rate of increase in this year, so that, if the population is projected from year t_{INIT} to 1968, the total (1+) population size in 1968 equals the generated value for P_{1968}^{1+}.
(c) Compute the likelihood for the projection (see Equation 11).
(d) Repeat steps (a)-(c) a very large number (typically 5 million) of times.
(e) Select 5,000 parameter vectors randomly from those generated using steps (a)-(d), assigning a probability of selecting a particular vector proportional to its likelihood

[5] The abundance estimate for year *y*/*y*+1 is assumed to pertain to abundance at the start of year *y*+1.

The above formulation implies that the year for which a prior on abundance is specified (1968) is not necessarily the same as the first year of the population projection (t_{INIT} , baseline value 1930). Starting the population projection before the first year for which data on abundance are available allows most of the impact of any transient population dynamics caused by the assumption of a stable age-structure to be eliminated. Therefore, the model population should mimic the real population more closely by allowing the sex- and age-selectivity of the catches to correctly influence the sex- and age-distribution of the population once the trajectory reaches years where it is compared to the data (i.e., 1967-68 and beyond).

Output Statistics

The results are summarized by the posterior medians, means and 90% credibility intervals for $MSYR^{1+}$, $MSYL^{1+}$, S_{1+}, S_0, $\tilde{S}$, and K^{1+} and the following management-related quantities:

(a) P^{1+}_{2009} / K^{1+} – the *depletion level*, or the number of 1+ animals at the start of 2009, expressed as a percentage of that corresponding to the equilibrium level;

(b) $P^{1+}_{2009} / MSYL^{1+}$ - the *OSP ratio*, the number of 1+ animals at the start of 2009, expressed as a percentage of that at which *MSY* is achieved; and

(c) $\lambda_{\max}$ – the maximum rate of increase (given a stable age-structure and the assumption of no maximum age; Breiwick et al. 1984)

P^{1+}_{2009} / K^{1+} is termed the *depletion level* because it provides a measure of how depleted the population is relative to the carrying capacity ("*K*"), as the equilibrium level in a density-dependent model is equivalent to carrying capacity. $P^{1+}_{2009} / MSYL^{1+}$ is referred to as the *OSP ratio* because it provides a measure of whether the population is above MNPL ($MSYL^{1+}$ is essentially equivalent to MNPL) and therefore at OSP (e.g, Gerrodette and DeMaster 1990). Because the model is age-structured and includes human removals it is parameterized in terms of $MSYL^{1+}$. $MSYL^{0+}$, which is the population level at which MSY occurs when hunting takes place uniformly on animals aged 0 and older, is exactly equivalent to MNPL. The difference between $MSYL^{1+}$ and $MSYL^{0+}$ is small in a long-lived animal with a relatively slow population growth rate. In the case of the ENP gray whale assessment model, $MSYL^{1+}$ has been found to be nearly equivalent to MNPL (Punt, unpublished data), so we consider $MSYL^{1+}$ to be equivalent to MNPL here for the calculation of the output statistic *OSP ratio*. Populations at OSP will have a value of 1.0 or higher for *OSP ratio*. Note that $\lambda_{\max}$ can be equated to r_{max} (e.g., as in Wade (1998)) through the equation $r_{max} = \lambda_{\max} - 1.0$.

Sensitivity Tests

Our baseline assessment includes the baseline estimates of 1+ abundance (Table 2) and allows for a catastrophic mortality event in 1999-2000. The sensitivity of the results of the analyses is explored to:

(a) Vary the first year considered in the population projection (1940, 1950 and 1960);
(b) Replace the estimates of abundance for the southbound migration by the values used in the previous assessment (Table 2, "Unrevised estimates");
(c) Replace the abundance estimates with the "Lo" and "Hi" series (Table 2)[6];
(d) Ignore the catastrophic event in 1999-2000 (abbreviation "No event");
(e) Base the analysis on the generalized logistic equation (see Appendix for details) (abbreviation "Gen Logist")[7];
(f) Split the abundance series after 1987-88 (abbreviation "Split series"), where the first abundance series is treated as a relative index of abundance scaled to absolute abundance through a constant of proportionality, and the second series is treated as an absolute index of abundance; and
(g) Include the calf counts at Point Piedras Blancas, California (Perryman et al. 2002, Perryman, pers. comm.) in the analysis (abbreviation "With calf counts").

For the last sensitivity test, the contribution of the data on calf counts to the negative of the logarithm of the likelihood function (ignoring constants independent of the model parameters) is

[6] The sequence of gray whale abundance estimates depends in part on the estimates of observer detection probability that were measured with the double observer data. Assessment of matches amongst the pods detected by the observers depends on the weighting parameters for distance and time measurements (Laake et al. 2009). The weighting parameters used for the baseline abundance estimates were selected such that 95% of the observations of the same pod would be correctly matched. Sensitivity is explored to matching weighting parameters that gave a 98% and 90% (Table A2; Laake et al. 2009).
[7] The sensitivity test is provided because the generalized logistic model has been the basis for some previous management advice for this stock (e.g., Wade 2002).

based on the assumption that the calf counts are relative indices of the total number of calves and are subject to both modeled and unmodeled sources of uncertainty; that is,

$$-\ell n L = 0.5\sum_i \ell n(\sigma_i^2 + CV_{\text{add-2}}^2) + 0.5\sum_i \frac{(\ell n C_i^{\text{obs}} - \ell n(q(N_{i,0}^{\text{m}} + N_{i,0}^{\text{f}})))^2}{\sigma_i^2 + CV_{\text{add-2}}^2} \quad , \qquad (12)$$

where C_i^{obs} is the observed number of calves during year *i*,

q is the constant of proportionality between the calf counts and model estimates of the number of calves,

σ_i is the standard deviation of the logarithm of C_i^{obs}, and

$CV_{\text{add-2}}^2$ is the additional variance associated with the calf counts.

Prior Distributions

The prior distributions (Table 3) are generally based on those used in recent International Whaling Commission (IWC) assessments of ENP gray whales. The prior distributions for S_{1+}, K^{1+}, $\tilde{S}$, CV_{add}, $CV_{\text{add-2}}$, and $\ell n q$ were selected to be uniform over a sufficiently wide range so that there is effectively no posterior probability outside of that range.

The prior for the age-at-maturity differs from that used in previous assessments, Uniform[5,9], based on the review by Bradford et al. (unpublished manuscript)[8] who could find no basis for that range in the literature. They concluded that the most relevant data set for age-at-maturity was that of Rice and Wolman (1971), corrected by Rice (1990) for the underestimation of whale ages by one year in the original study, resulting in a median age of 9, and lower and upper bounds of 6 and 12. Bradford et al. (unpublished manuscript) note that the only observation of the age-at-first-reproduction (AFR) in ENP gray whales (a known whale observed with a calf for the first time) was 7 years for a whale first seen as a calf in a lagoon in Mexico. In the western Pacific population of gray whales, there have been observations of AFR of 7 and 11 years for the

[8] Bradford, A.L., D.W. Weller, A.R. Lang, A.M. Burdin, and R.L. Brownell, Jr. Unpublished manuscript. Comparing age at first reproduction information from western gray whale to age at sexual maturity estimates of eastern gray whales. School of Aquatic and Fishery Sciences, Box 355020, University of Washington, Seattle.

only two whales whose first calving has been documented to date (Bradford et al. unpublished manuscript). The prior for the maximum birth rate, $f_{max,}$ was set equal to the prior selected for recent assessments (Wade 2002, Punt and Butterworth 2002). This prior implies a minimum possible calving interval between 1.67 and 3.33 years.

The prior for the population size (in terms of animals aged 1 and older) in 1968 differs from that used in previous assessments. Rather than combining a uniform prior on 1968 population size with the abundance estimate for 1968 to create an informative prior for P_{1968}^{1+} as was the case in previous assessments, this assessment assumes a broad uniform prior for 1968 population size, and includes all of the estimates of abundance in the likelihood function. This is because the previous approach cannot be applied because all of the estimates of abundance are correlated (Laake et al. 2009).

The prior for MSYR is bounded below by the minimum possible value and above by a value which is above those supported by the data. This prior is broader than those considered in previous assessments because those assessments assigned a prior to MSYR when this parameter is expressed in terms of removals of mature animals only. The prior for $MSYL^{1+}$ has been assumed to be uniform from 0.4 to 0.8. The central value for this prior reflects the common assumption when conducting IWC assessments of whale stocks that maximum productivity occurs at about 60% of carrying capacity. The upper and lower bounds reflect values commonly used to bound MSYL for whale stocks (e.g., those used in the tests that evaluated the IWC's catch limit algorithm).

RESULTS

The baseline assessment estimates that ENP gray whales increased substantially from 1930 until 1999 when a substantial reduction in population size from close to carrying capacity (in terms of median parameter estimates) occurred (Fig. 1). This reduction was associated with an estimated decline in non-calf survival from 0.982 to 0.847 (posterior means, where $0.981 \times 0.863 = 0.847$) in each of 1999 and 2000. The population is estimated to have been increasing since 2000. The model fits the data well, although, as in previous IWC assessments, the analyses suggest that the coefficients of variation for the abundance estimates are underestimated (by 14% median estimate). The baseline assessment estimates that this stock is currently well above MSYL^{1+} (posterior mean for $P_{2009}^{1+} / MSYL^{1+}$ of 1.29) (Table 4). The probability that the stock is currently greater than MSYL^{1+} is 0.884.

The probability that the stock is currently above MSYL^{1+} is less for the baseline analysis and for the analysis in which the original abundance estimates are used ("Unrevised estimates" in Table 4) than in some earlier assessments. The reasons for this are explored using the analyses in which no allowance is made for survival having dropped in 1999-2000 ("No Event" and "Unrevised, No event" in Table 4, see also Fig. 2) because the previous assessments did not explicitly account for the mortality event. This comparison suggests that allowing for the possibility of a catastrophic mortality event in 1999-2000 has reduced the ability to constrain the upper bound for carrying capacity because the lower 5% limit for $P_{2009}^{1+} / MSYL^{1+}$ is notably higher for the analyses which ignore this event (Table 4). Bayes factors comparing the analyses which include a 1999-2000 catastrophic mortality event and those which do not provide support for estimating a parameter for the 1999-2000 event; for example, in the baseline analysis the ln(Bayes factor) value is 3.00 compared to the "No event" model, which is interpreted as strong but not definitive support (Kass and Raftery 1995) for including the catastrophic mortality parameter in the model.

The results are insensitive to changing the first year of the analysis (Table 4, Fig. 3). The key management-related results are also not sensitive to splitting the series in 1987-88, using the calf count estimates and using the "Lo" and "Hi" abundance estimates (Fig. 4). The results for the generalized logistic model are most comparable with the two "No event" analyses because no account is taken of a catastrophic mortality event in 1999-2000 when fitting the generalized logistic model (Appendix). While not entirely comparable, the qualitative conclusions from the generalized logistic model are identical to those from the age-structured model.

Figure 5 shows the posterior distributions for the parameters for the baseline analysis. These posteriors show that the data update the priors for MSYR^{1+} and MSYL^{1+} to a substantial extent. The posterior MSYL^{1+} emphasizes higher values for MSYL^{1+}, which is not unexpected given that the rate of increase for the ENP gray whales is assessed to have been high until just before this population (almost) reached its current carrying capacity. The posteriors for the age-at-maturity, maximum fecundity, and adult survival place greatest support on low, high, and high values, respectively. This is consistent with the fairly high growth rates and values for $MSYR^{1+}$. The posterior for the survival multiplier is also updated substantially, with both high (close to 1) and low values (below 0.7) assigned low posterior probability.

The maximum rate of increase, λ_{max}, is well-defined in all of the analyses. The posterior mean estimates of this quantity range from 1.057 to 1.068 and are fairly precisely determined (Table 4).

DISCUSSION

The sensitivity tests were designed to examine the effect of various assumptions on the assessment results and to examine the effect of changes in the methods that have occurred, particularly in the abundance estimation. Overall, the results are consistent across most of the sensitivity tests with some exceptions. In particular, the baseline model fit to the unrevised abundance estimates had relatively different results from the other analyses. Leaving aside that analysis for the moment, the posterior medians for the parameters of interest were relatively consistent. Across all the other analyses, posterior means for K^{1+} ranged from 21,146 to 27,716, for the *depletion level* ranged from 0.76 to 0.96, and for the *OSP ratio* ranged from 1.22 to 1.54. Therefore, as in previous assessments, the ENP gray whale population is estimated to be above $MSYL^{1+}$ and approaching or close to *K*. The estimates of *depletion level* and *OSP ratio* in Wade (2002) and in Punt and Butterworth (2002) are very similar to the results presented here, though the current estimates of *K* are lower. The results in Wade and Perryman (2002) and Brandon (2009), which were the only previous assessments to use abundance estimates from the 1997-98 and subsequent surveys, gave higher and more precise estimates for *depletion level* and *OSP ratio* than estimated here; however, in common with previous assessments, those results are superseded by this new assessment because it uses the revised abundance estimates of Laake et al. (2009).

The posterior means for the life history parameters were very consistent as well, with the posterior means for λ_{max} ranging from 1.057 to 1.068, non-calf survival ranging from 0.972 to 0.983, and calf survival ranging from 0.706 to 0.730. The parameter $MSYL^{1+}$ was updated to strongly emphasize higher values in the baseline analysis. As discussed above, $MSYL^{1+}$ is nearly equivalent to MNPL. There are theoretical arguments for why MNPL should be relatively higher in marine mammals than, say, marine fishes (Eberhardt and Siniff 1977, Fowler 1981, Taylor and DeMaster 1993), but, in general, there has not been empirical data of sufficient quantity and quality to estimate this parameter well in marine mammals (Goodman 1988, Ragen 1995, Gerrodette and DeMaster 1990). Empirical evidence that is available for large, long-lived mammals has shown convex nonlinear density-dependence in life history parameters such as age-specific birth and mortality rates (Fowler et al. 1980; Fowler 1987, 1994), which suggest MNPL > 0.5*K*. A relatively long time-series of abundance estimates has documented the recovery of harbor seal (*Phoca vitulina*) populations in Washington state, and Jeffries et al. (2003) estimated MNPL to be greater than 0.5*K* for these populations. In the ENP gray whale analysis here, values from 0.40 to 0.54 for $MSYL^{1+}$ have low probability in the posterior distribution (Fig. 5, Table 4) which is consistent with the conclusions of Taylor and Gerrodette (1993) that MNPL was likely to be greater than 0.5*K*. Thus, the posterior distribution for $MSYL^{1+}$ estimated here suggests that the ENP gray whale population experienced a decrease in population growth only when it was relatively close to K^{1+}.

The results did not vary much for a large number of the sensitivity tests, providing assurance that the assumptions made for the baseline analysis did not have a substantial influence on the results. Changing the initial year from which the model was projected had little effect on the results, which is similar to the results seen in Punt and Butterworth (2002) for initial years ranging from 1930 to 1968, as used here. The results for the 'Lo' and 'Hi' series of abundance estimates are very similar to the baseline results, suggesting that that those assumptions made in calculating the abundance estimates do not have a strong influence on the results of the assessment. Additionally, splitting the abundance time series in 1987-88 did not have a substantial effect. This is particularly reassuring, because some changes in the field methods happened at that time, notably the use of a second independent observer during that and subsequent surveys (Laake et al. 2009). The generalized logistic model provided similar results to the 'No-event' analysis, with some small differences. This was similar to results seen in Wade (2002), where the quantitative values for some parameters were somewhat different for the generalized logistic, although the qualitative results are nearly identical in this case. That the quantitative results differ between the generalized logistic and the baseline analyses is to be expected because the analysis based on the generalized logistic did not account for the dynamics of sex- and age-structure, and also ignored time-lags in the dynamics.

The baseline analysis fits the abundance data better than in the 'No-event' analysis because it includes the catastrophic mortality event in 1999-2000 (Figs. 1, 2). Furthermore, the Bayes factor confirms that there is strong, but not definitive, evidence supporting the use of a model including the catastrophic mortality. The model estimates that 15.3% of the non-calf population died in each of the years with catastrophic mortality, compared to about 2% in a normal year. In that 2-year period, the model estimates the population fell from being at 99% of K^{1+} in 1998 to 83% in 1999 and 71% in 2000, before increasing back up to 91% by 2009. In contrast, the 'No-event' analysis estimates the population had reached a level very close to K^{1+} by ~1995 and has remained there since, which clearly does not fit with the evidence regarding the biological effects on the population in 1999 and 2000. In the baseline analysis the estimate of the number of whales that died in 1999 and 2000 was 3,303 (90% interval 1,235-7,988) and 2,835 (90% interval 1,162-6,389), respectively, for a combined total for the two years of 6,138 (90% interval 2,398-14,377). In comparison, the 'No-event' analysis estimates that the number of whales that died in 1999 was 587, and in 2000 it was 447. Comparing the number of strandings (from Mexico to Alaska) reported in Gulland et al. (2005) in the years around the mortality event to these estimates of total deaths from the baseline model indicates that only 3.9-13.0% of all ENP gray whales that die in a given year end up stranding and being reported.

The baseline analysis is more conservative regarding status relative to K^{1+} than the 'No-event' analysis. On the other hand, it can be argued that the 'No-event' analysis provides a more accurate estimation of current average K^{1+}. In other words, the baseline analysis does a better job of modeling the actual time-course of the population by including the mortality event, but it might provide an overestimate of the average recent K^{1+} by essentially considering high abundance estimates to be near K^{1+}, but lower abundance estimates to be lower than K^{1+}. The different interpretations hinge on whether K^{1+} is viewed as relatively fixed, with the 1999-2000 mortality event considered to be unrelated to density-dependence (and therefore K^{1+}), or whether K^{1+} is viewed as something that can vary from year to year, with the 1999-2000 years viewed as an event when K^{1+} itself was low. As populations increase in density, the impact of density-independent factors on population dynamics probably become more pronounced (Durant et al.

2005, Wilcox and Eldred 2003). The actual carrying capacity of the environment, in terms of prey available for the ENP gray whale population, is likely to vary from year to year to a greater or lesser extent due to oceanographic conditions affecting primarily benthic production. In terms of the model, the parameter K^{1+} that is being estimated is interpreted as the average carrying capacity in recent years. In the baseline analysis, the estimated K^{1+} is approximately (though not exactly) the average recent K^{1+} for the years before the mortality event, whereas in the 'No-event' analysis, the estimate of average recent K^{1+} includes all the recent years, including 1999-2000, and is lower. This is clear from the results, where the baseline estimate of K^{1+} is 25,808 (90% interval 19,752- 49,639), whereas the 'No-event' estimate of K^{1+} is substantially lower, 21,640 (90% interval 18,301-25,762). Further work that could be conducted would be to model K^{1+} with a distribution defined by two parameters, a mean and a variance, to explicitly allow K^{1+} to vary from one year to the next. If such a model included density-dependence in survival, the 1999-2000 event could be modeled as a substantial decline in K^{1+} in those years rather than as a single event affecting mortality. Such an analysis would provide an estimate of average recent K^{1+} that included the low recent years, 1999-2000.

The analysis using the original unrevised estimates is not a sensitivity test in the usual sense. Those results are provided simply to aid in interpretation of the results of the other analyses relative to past results using the unrevised estimates. For example, no previous analyses other than Brandon (2009) had used the 2006-07 abundance estimate, so this sensitivity test provides a comparison in which both analyses use that estimate. In the 'No-event' model, the analyses using the original and revised abundance estimates are nearly identical for estimates of *depletion level* and *OSP ratio*. *K* was estimated to be higher in the analysis that used the original abundance estimates, but even though *K* is lower using the revised abundance estimates, overall the entire time-series is shifted such that the estimates of status relative to *K* are unchanged.

In contrast, in the baseline model, the original abundance estimates give a fairly different result from any other analysis. From the discussion of how correction factors for the abundance estimates were calculated in different years in Laake et al. (2009), it is clear that the revised abundance estimates should be more accurate, and there were shifts of certain sequences of abundance estimates relative to one another that influence the results. For example, the three estimates from 1993-94 to 1997-98 are the three highest estimates in the original time-series, whereas the three estimates from 1984-85 to 1987-88 are the three highest estimates in the revised time-series. This has an effect on the baseline analysis results because the model is trying to fit the drop in abundance that occurred after the 1997-98 abundance estimate. That drop is substantially larger in the unrevised data set than it is in the revised data set, and therefore the results for the baseline model differ somewhat between the revised and unrevised data sets.

The only previous assessment that modeled the 1999-2000 mortality event was that of Brandon (2009), whose point estimates of total natural mortality in those years ranged from 1,300 to 5,200, depending upon a variety of assumptions he explored, lower than the 6,138 estimated here in the baseline model. The difference presumably arises because Brandon (2009) modeled mortality as a function of a sea-ice index for the Bering Sea, following the relationship found between calf production and sea-ice (Perryman et al. 2002). This constrains the dynamics of the mortality in Brandon (2009) to reflect the dynamics of the index to some extent. In contrast, the 1999-2000 mortality was unconstrained in the baseline analysis here and is essentially estimated by what value fit the drop in abundance estimates best. Brandon (2009) noted this difficulty in his analysis, stating it was not possible in his analysis to fit the strandings data for the 1999-2000 mortality event without allowing for some additional process error in the survival rates during those years.

λ_{max} is estimated to be 1.062 (90% interval 1.032-1.088) in the baseline analysis. This is similar to, but a little lower than, the estimate from Wade (2002) of 1.072 (90% interval 1.039-1.126) and the estimates from Wade and Perryman (2002). The posterior for λ_{max} from the 'No-event' analysis is very similar to this, as is that from the 'No-event' analysis using the unrevised abundance estimates, indicating the lower estimates of λ_{max} seen here are not due entirely to the revision of the abundance estimates but are instead partly due to the additional four abundance estimates used here (1997-98 to 2006-07) that were not available at the time the Wade (2002) analysis was conducted. To get an estimate of λ_{max} of 1.062, the posterior distribution favored a low age-of-maturity, a high maximum fecundity, and a high adult survival. λ_{max} appears to be well-defined, as the posterior medians from most of the sensitivity tests are very similar. It should be noted that these are theoretical estimates of the population growth rate at a very low population size, based upon the density-dependent assumptions of the population model; the

ENP gray whale has not been observed to actually grow this rapidly because the population was estimated to be approaching *K* by the time its growth rate was monitored; consequently, the observed population growth rate was less than its theoretical maximum.

The small and endangered western North Pacific population of gray whales has been estimated to have an annual population increase that is between 2.5% and 3.2% per year, but there is concern that this growth rate is low because of possible Allee effects and from ongoing human-caused mortality (Bradford et al. 2008). Best (1993) summarized the growth rates of eight severely depleted baleen whale populations (other than gray whales) and the values ranged from 3.1% to 14.4%. Some of these estimates were not very precise, and Zerbini et al. (in press) has pointed out that the higher rates are implausible given life-history constraints for (at least) humpback whales (*Megaptera novaeangliae*). In more recent studies of other species, a number of estimates of trend have been similar to the estimates of $\lambda_{\max}$ reported here. In a simulation study based on empirical estimates of life history parameters for humpback whales, Zerbini et al. (in press) estimated maximum rates of increase of 7.5%/year (95% CI = 5.1-9.8%) using one approach and 8.7%/year (95% CI = 6.1-11.0%) using a second approach. Calambokidis et al. (2008) calculated point estimates of 4.9% to 6.7% for the North Pacific humpback whale population using data from a recently completed North Pacific study of humpback whale abundance. Zerbini et al. (2006) used line transect data from sequential surveys to estimate an annual rate of increase for humpback whales in shelf waters of the northern Gulf of Alaska from 1987 to 2003 of 6.6% per year (95% CI: 5.2-8.6%), and for fin whales of 4.8% (95% CI 4.1-5.4%). On the other hand, Mizroch et al. (2004) estimated a rate of increase for North Pacific humpback whales in Hawaii using mark-recapture methods for the years 1980-1996 of 10% per year, but the confidence limits were wide (95% C.I. of 3-16%). Other unpublished estimates are available spanning essentially a similar range as originally reported by Best (1993) (i.e., see IWC SC/61/REP6). In summary, the estimates of $\lambda_{\max}$ reported here are similar to trend estimates seen in other species, but there are also lower and higher values that have been recorded.

As noted above, one of the primary management goals of the U.S. Marine Mammal Protection Act is to maintain populations at OSP, which is considered to be a level above their MNPL. The baseline analysis described here estimates the ENP gray whale population to be at a level above their MNPL (i.e., MSYL^{1+}) because the posterior mean for the *OSP ratio* is 1.29 (with a posterior median of 1.37 and a 90% interval of 0.68-1.51), meaning the population is estimated to be at 129% of MNPL. The baseline model estimates a probability of 0.884 that the population is above MNPL (i.e., the probability that the value of the *OSP ratio* is >1.0). These results are consistent across all our model runs. The baseline model also estimates the ENP gray whale population to be close to *K*, and this is also consistent across all the other model runs.

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Table 1a. -- Historical (pre-1944) aboriginal catches from the Eastern North Pacific stock of gray whales (C. Allison, IWC Secretariat, pers. commn.).

Years	Annual kill
1600-1675	182
1676-1750	183
1751-1840	197.5
1841-1846	193.5
1847-1850	192.5
1851-1860	187
1861-1875	111
1876-1880	110
1881-1890	108
1891-1900	62
1901-1904	61
1905-1915	57
1916-1928	52
1929-1930	47
1931-1939	10
1940-1943	20

Table 1b. -- Commercial and recent aboriginal (post-1943) catches from the Eastern North Pacific stock of gray whales (C. Allison, IWC Secretariat, pers. commn).

Year	Male	Female	Year	Male	Female	Year	Male	Female	Year	Male	Female
1846	23	45	1889	7	13	1932	3	7	1975	58	113
1847	23	45	1890	7	13	1933	36	69	1976	69	96
1848	23	45	1891	7	13	1934	64	92	1977	86	101
1849	23	45	1892	7	13	1935	48	96	1978	94	90
1850	23	45	1893	0	0	1936	74	114	1979	57	126
1851	23	45	1894	0	0	1937	5	9	1980	53	129
1852	23	45	1895	0	0	1938	18	36	1981	36	100
1853	23	45	1896	0	0	1939	10	19	1982	56	112
1854	23	45	1897	0	0	1940	39	66	1983	46	125
1855	162	324	1898	0	0	1941	19	38	1984	59	110
1856	162	324	1899	0	0	1942	34	67	1985	55	115
1857	162	324	1900	0	0	1943	33	66	1986	46	125
1858	162	324	1901	0	0	1944	0	0	1987	47	112
1859	162	324	1902	0	0	1945	10	20	1988	43	108
1860	162	324	1903	0	0	1946	7	15	1989	61	119
1861	162	324	1904	0	0	1947	0	1	1990	67	95
1862	162	324	1905	0	0	1948	6	13	1991	69	100
1863	162	324	1906	0	0	1949	9	17	1992	0	0
1864	162	324	1907	0	0	1950	4	7	1993	0	0
1865	162	324	1908	0	0	1951	5	9	1994	21	23
1866	79	159	1909	0	0	1952	15	29	1995	48	44
1867	79	159	1910	0	1	1953	19	29	1996	18	25
1868	79	159	1911	0	1	1954	13	26	1997	48	31
1869	79	159	1912	0	0	1955	20	39	1998	64	61
1870	79	159	1913	0	1	1956	41	81	1999	69	55
1871	79	159	1914	6	13	1957	32	64	2000	63	52
1872	79	159	1915	0	0	1958	49	99	2001	62	50
1873	79	159	1916	0	0	1959	66	130	2002	80	51
1874	79	159	1917	0	0	1960	52	104	2003	71	57
1875	17	33	1918	0	0	1961	69	139	2004	43	68
1876	17	33	1919	0	0	1962	53	98	2005	49	75
1877	17	33	1920	1	1	1963	60	120	2006	57	77
1878	17	33	1921	13	25	1964	81	138	2007	50	82
1879	21	42	1922	6	4	1965	71	110	2008	64	66
1880	17	34	1923	0	0	1966	100	120			
1881	17	33	1924	1	0	1967	151	223			
1882	17	33	1925	70	64	1968	92	109			
1883	19	39	1926	25	17	1969	93	121			
1884	23	45	1927	7	25	1970	70	81			
1885	21	41	1928	4	8	1971	62	91			
1886	17	33	1929	0	3	1972	66	116			
1887	7	13	1930	0	0	1973	98	80			
1888	7	13	1931	0	0	1974	94	90			

Table 2. -- Baseline estimates of 1+ abundance (and associated standard errors of the logs) from southbound surveys (Laake et al. 2009), the estimates of 1+ abundance used in previous assessments, two alternative series of abundance estimates, and estimates of calf numbers from northbound surveys (W. Perryman, SWFSC, pers. commn).

1+ abundance					Calf counts		
	Laake et al. (2009)		Unrevised estimates				
Year	Estimate	CV	Estimate	CV	Year	Estimate	SE
1967/68	13426	0.094	13776	0.078	1994	945	68.2
1968/69	14548	0.080	12869	0.055	1995	619	67.2
1969/70	14553	0.083	13431	0.056	1996	1146	70.7
1970/71	12771	0.081	11416	0.052	1997	1431	82.0
1971/72	11079	0.092	10406	0.059	1998	1388	92.0
1972/73	17365	0.079	16098	0.052	1999	427	41.1
1973/74	17375	0.082	15960	0.055	2000	279	34.8
1974/75	15290	0.084	13812	0.056	2001	256	28.6
1975/76	17564	0.086	15481	0.060	2002	842	78.6
1976/77	18377	0.080	16317	0.050	2003	774	73.6
1977/78	19538	0.088	17996	0.069	2004	1528	96.0
1978/79	15384	0.080	13971	0.054	2005	945	86.9
1979/80	19763	0.083	17447	0.056	2006	1020	103.3
1984/85	23499	0.089	22862	0.060	2007	404	51.2
1985/86	22921	0.081	21444	0.052	2008	553	53.0
1987/88	26916	0.058	22250	0.050	2009	312	41.9
1992/93	15762	0.067	18844	0.063			
1993/94	20103	0.055	24638	0.060			
1995/96	20944	0.061	24065	0.058			
1997/98	21135	0.068	29758	0.105			
2000/01	16369	0.061	19448	0.097			
2001/02	16033	0.069	18178	0.098			
2006/07	19126	0.071	20110	0.088			

Table 2. -- Continued.

	1 + abundance			
	Lo series		Hi series	
Year	Estimate	SE	Estimate	SE
1967/68	12961	0.094	14298	0.095
1968/69	14043	0.080	15493	0.081
1969/70	14049	0.082	15498	0.084
1970/71	12328	0.081	13601	0.082
1971/72	10695	0.092	11799	0.093
1972/73	16763	0.079	18493	0.080
1973/74	16772	0.081	18503	0.083
1974/75	14760	0.084	16283	0.085
1975/76	16955	0.086	18705	0.087
1976/77	17739	0.079	19570	0.081
1977/78	18860	0.088	20806	0.089
1978/79	14850	0.080	16383	0.081
1979/80	19077	0.082	21046	0.083
1984/85	22684	0.089	25025	0.090
1985/86	22126	0.081	24409	0.082
1987/88	25661	0.057	28692	0.056
1992/93	14785	0.065	17879	0.072
1993/94	19468	0.057	21124	0.056
1995/96	20636	0.063	22314	0.063
1997/98	20426	0.063	22378	0.065
2000/01	16051	0.063	17145	0.062
2001/02	15162	0.066	16883	0.067
2006/07	18775	0.071	20129	0.072

Table 3. -- The parameters and their assumed prior distributions.

Parameter	Prior distribution
Non-calf survival rate, S_{1+}	U[0.950, 0.999] [a]
Age-at-maturity, a_m	U[6,12][b]
Maximum birth rate, f_{max}	U[0.3, 0.6][a]
Carrying capacity, K^{1+}	U[10 000, 70 000] [c]
Population size in 1968, P^{1+}_{1968}	U[5 000, 20 000][c]
Maximum Sustainable Yield Level, $MSYL^{1+}$	U[0.4, 0.8][a]
Maximum Sustainable Yield Rate, $MSYR^{1+}$	U[0, 0.1][a]
Extra mortality, $\tilde{S}$	U[0.2, 1.0][c]
Additional variance, 1+ abundance estimates, CV_{add}	U[0, 0.35][a,c]
Additional variance, calf counts, CV_{add-2}	U[0.2, 0.8][c,d]
Constant of proportionality, ℓnq	U[-∞, ∞][d,e]

a. Equal to the prior distribution used in the most recent assessments (Punt et al. 2004).

b. Bradford et al. (unpublished manuscript).

c. Preliminary analyses provided no evidence of posterior support for values outside this range.

d. Not used in the baseline analysis.

e. The non-informative prior for a scale parameter (Butterworth and Punt 1996).

Table 4. -- Posterior distributions for the key model outputs (posterior mean, posterior median [in square parenthesis], and posterior 90% intervals) for the baseline analysis and the sensitivity tests.

	Baseline	t_{INIT} =1940	t_{INIT} =1950	t_{INIT} =1960	Unrevised Estimates	No Event	Gen Logist	With calf counts
K^{1+}	25808 [22756]	25450 [22506]	24681 [22282]	24396 [222047]	41046 [37889]	21640 [20683]	21146 [20668]	27716 [24194]
	(19752 49639)	(19537 49109)	(19454 43887)	(19212 43307)	(24214 66564)	(18301 25762)	(18229 24292)	(20387 51775)
MSYR^{1+}	0.046 [0.048]	0.047 [0.048]	0.049 [0.049]	0.048 [0.049]	0.035 [0.034]	0.052 [0.053]	0.065 [0.066]	0.040 [0.040]
	(0.022 0.064)	(0.022 0.067)	(0.024 0.068)	(0.024 0.070)	(0.025 0.050)	(0.026 0.068)	(0.034 0.096)	(0.022 0.057)
MSYL^{1+}	0.656 [0.669]	0.664 [0.677]	0.677 [0.689]	0.691 [0.702]	0.611 [0.611]	0.672 [0.684]	0.630 [0.640]	0.632 [0.638]
	(0.532 0.725)	(0.535 0.741	(0.541 0.762)	(0.545 0.786)	(0.506 0.706)	(0.577 0.730)	(0.441 0.786)	(0.514 0.725)
P^{1+}_{2009} / K^{1+}	0.849 [0.919]	0.865 [0.933]	0.885 [0.946]	0.899 [0.959]	0.615 [0.598]	0.956 [0.977]	0.964 [0.976]	0.775 [0.816]
	(0.393 1.006)	(0.403 1.016)	(0.451 1.022)	(0.453 1.043)	(0.334 0.948)	(0.872 0.987)	(0.922 0.989)	(0.372 0.984)
P^{1+}_{2009} / $MSYL^{1+}$	1.288 [1.366]	1.295 [1.362]	1.302 [1.355]	1.296 [1.343]	1.002 [0.992]	1.423 [1.424]	1.541 [1.515]	1.217 [1.284]
	(0.681 1.508)	(0.701 1.522)	(0.775 1.516)	(0.786 1.513)	(0.580 1.459)	(1.303 1.583)	(1.252 2.091)	(0.681 1.494)
λ_{max}	1.062 [1.063]	1.063 [1.063]	1.063 [1.062]	1.062 [1.060]	1.054 [1.052]	1.068 [1.069]	0.107 [0.088]	1.057 [1.057]
	(1.032 1.088)	(1.033 1.094)	(1.035 1.094)	(1.035 1.092)	(1.036 1.081)	(1.038 1.091)	(0.042 0.242)*	(1.033 1.080)
S_{1+}	0.981 [0.982]	0.981 [0.982]	0.980 [0.982]	0.980 [0.982]	0.978 [0.980]	0.983 [0.985]	N/A	0.972 [0.972]
	(0.957 0.997)	(0.957 0.997)	(0.957 0.997)	(0.957 0.997)	(0.956 0.997)	(0.960 0.998)		(0.954 0.993)
S_0	0.711 [0.732]	0.716 [0.734]	0.713 [0.727]	0.706 [0.720]	0.662 [0.666]	0.730 [0.747]	N/A	0.722 [0.751]
	(0.423 0.950)	(0.426 0.949)	(0.426 0.952)	(0.425 0.949)	(0.400 0.926)	(0.437 0.955)		(0.428 0.943)
$\tilde{S}$	0.863 [0.865]	0.866 [0.867]	0.868 [0.870]	0.870 [0.870]	0.814 [0.809]	1	N/A	0.847[0.840]
	(0.772 0.951)	(0.778 0.951)	(0.779 0.960)	(0.781 0.961)	(0.725 0.915)			(0.749 0.949)

* r rather λ_{max} .

Table 4. -- Continued.

	Baseline	Split series	Lo series	Hi series	Unrevised No event	Calf counts No event
K^{1+}	25808 [22756] (19752 49639)	274891 [22870] (19640 55929)	25826 [22030] (19129 52878)	26902 [24181] (21043 48118)	24162 [23044] (20946 29554)	21501 [20887] (18439 24793)
$MSYR^{1+}$	0.046 [0.048] (0.022 0.064)	0.046 [0.047] (0.024 0.062)	0.046 [0.048] (0.021 0.064)	0.046 [0.048] (0.023 0.063)	0.047 [0.048] (0.032 0.061)	0.049 [0.050] (0.028 0.065)
$MSYL^{1+}$	0.656 [0.669] (0.532 0.725)	0.648 [0.663] (0.529 0.721)	0.654 [0.670] (0.520 0.725)	0.654 [0.664] (0.537 0.725)	0.663 [0.673] (0.568 0.722)	0.668 [0.676] (0.577 0.733)
P_{2009}^{1+} / K^{1+}	0.849 [0.919] (0.393 1.006)	0.819 [0.908] (0.358 1.003)	0.837 [0.917] (0.355 1.008)	0.855 [0.913] (0.428 1.005)	0.957 [0.975] (0.881 0.985)	0.958 [0.974] (0.906 0.984)
$P_{2009}^{1+} / MSYL^{1+}$	1.288 [1.366] (0.681 1.508)	1.253 [1.357] (0.642 1.502)	1.270 [1.361] (0.632 1.504)	1.301 [1.366] (0.748 1.512)	1.446 [1.442] (1.344 1.608)	1.438 [1.436] (1.314 1.607)
λ_{max}	1.062 [1.063] (1.032 1.088)	1.063 [1.064] (1.037 1.088)	1.062 [1.063] (1.032 1.088)	1.063 [1.064] (1.034 1.089)	1.063 [1.062] (1.043 1.087)	1.065 [1.065] (1.037 1.090)
S_{1+}	0.981 [0.982] (0.957 0.997)	0.981 [0.982] (0.957 0.997)	0.980 [0.982] (0.957 0.997)	0.981 [0.982] (0.957 0.998)	0.982 [0.984] (0.959 0.997)	0.980 [0.982] (0.958 0.997)
S_0	0.711 [0.732] (0.423 0.950)	0.711 [0.729] (0.420 0.949)	0.710 [0.728] (0.420 0.949)	0.708 [0.725] (0.425 0.949)	0.705 [0.716] (0.420 0.950)	0.720 [0.732] (0.426 0.954)
$\tilde{S}$	0.863 [0.865] (0.772 0.951)	0.860 [0.862] (0.763 0.958)	0.862 [0.862] (0.775 0.950)	0.855 [0.857] (0.772 0.939)	1	1

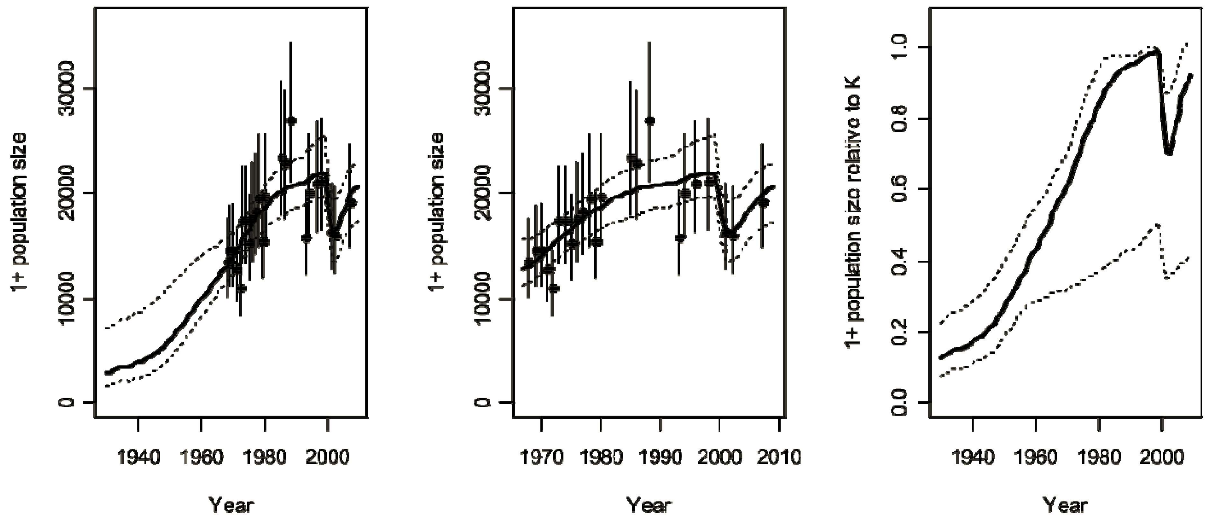

Figure 1. -- Posterior distributions (medians and 90% credibility intervals) for the time-trajectories of 1+ population size (left panels) and 1+ population size expressed relative to (current) carrying capacity (right panel) for the baseline analysis.

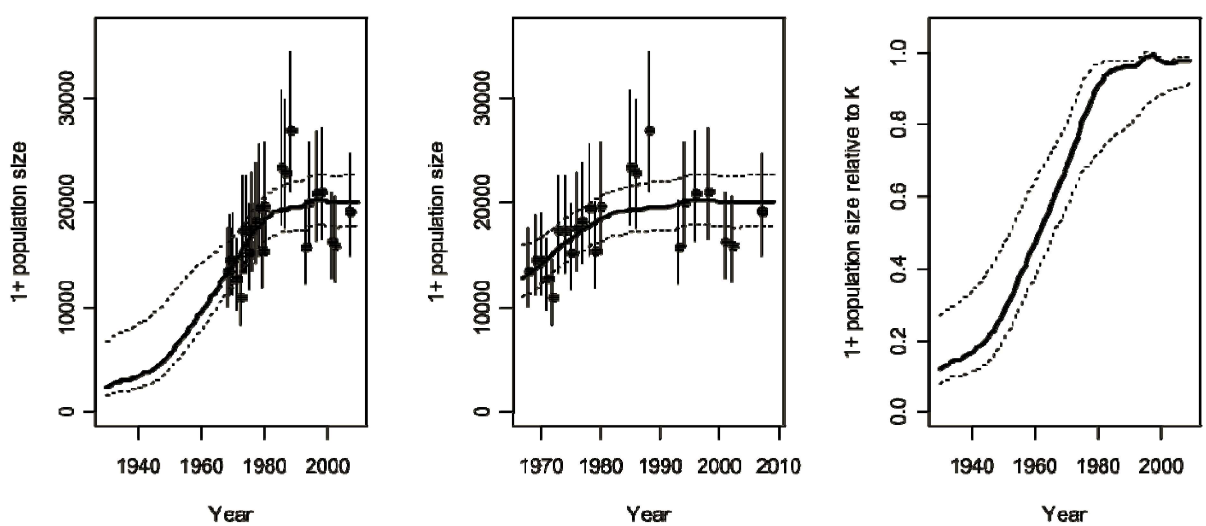

Figure 2. -- Posterior distributions (medians and 90% credibility intervals) for the time-trajectories of 1+ population size (left panels) and 1+ population size expressed relative to (current) carrying capacity (right panel) for the "No event" analysis.

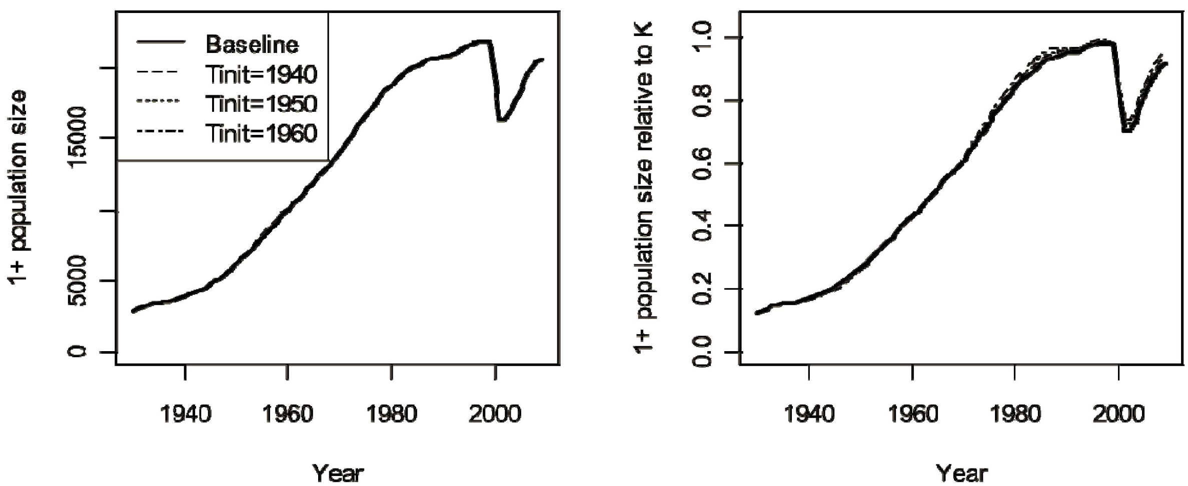

Figure 3. -- Posterior median time-trajectories of 1+ population size (left panel) and 1+ population size expressed relative to (current) carrying capacity (right panel) for the baseline analysis and the sensitivity tests which vary the value for t_{INIT}.

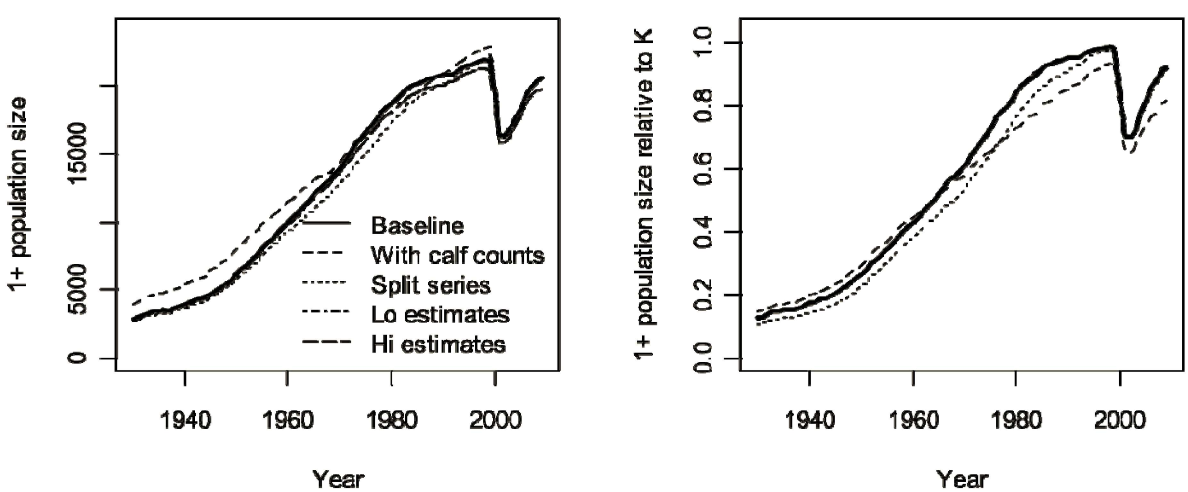

Figure 4. -- Posterior median time-trajectories of 1+ population size (left panel) and 1+ population size expressed relative to (current) carrying capacity (right panel) for the baseline analysis and a subset of the sensitivity tests.

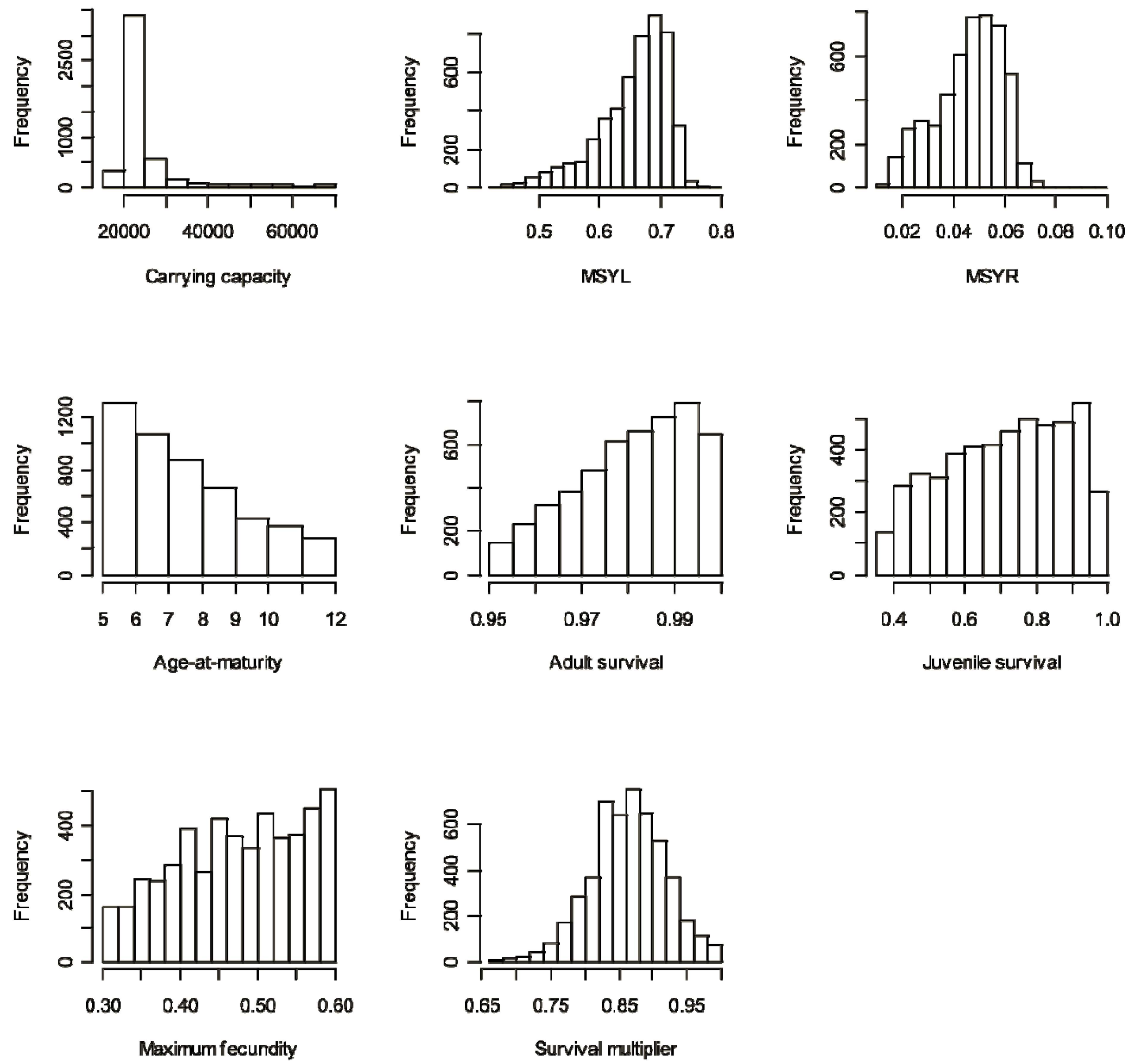

Figure 5. -- Posterior distributions for the parameters of the baseline analysis.

APPENDIX

Analyses Based on the Generalized Logistic Equation

The dynamics of the population are assumed to be governed by the generalized logistic model:

$$N_{y+1} = N_y + rN_y(1-(N_y / K)^z) - C_y \quad , \qquad \text{(App.1)}$$

where N_y is the number of animals at the start of year *y*,

- r is the intrinsic rate of growth,
- z is the extent of compensation,
- K is the (current) carrying capacity, and
- C_y is the catch (in numbers) during year *y*.

The parameters of Equation 1 are *r*, *z*, *K*, and N_{1968} while the data available to estimate these parameters are the estimates of abundance and their associated variance-covariance matrix. The analysis based on the same likelihood function (Eq. 11 of the main text) and priors as the baseline analysis using the age- and sex-structured model.

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Population status of the eastern North Pacific stock of gray whales in 2009

ANDRE E. PUNT[+] AND PAUL R. WADE*

Contact e-mail: aepunt@u.washington.edu

ABSTRACT

An age- and sex-structured population dynamics model is fitted using Bayesian methods to data on the catches and abundance estimates for the Eastern North Pacific (ENP) stock of gray whales. The prior distributions used for these analyses incorporate revised estimates of abundance for ENP gray whales and account explicitly for the drop in abundance caused by the 1999–2000 mortality event. A series of analyses are conducted to evaluate the sensitivity of the results to different assumptions. The model fits the available data adequately, but, as in previous assessments, the measures of uncertainty associated with the survey-based abundance estimates are found to be negatively biased. The data support the inclusion of the 1999–2000 mortality event in the model, and accounting for this event leads to greater uncertainty regarding the current status of the resource. The baseline analysis estimates the ENP gray whale population to be above the maximum sustainable yield level (MSYL) with high probability (0.884). The posterior mean for the ratio of 2009 (1+) abundance to MSYL is 1.29 (with a posterior median of 1.37 and a 90% probability interval of 0.68–1.51). These results are consistent across all the model runs conducted. The baseline model also estimates the 2009 ENP gray whale population size (posterior mean of 20,366) to be at 85% of its carrying capacity (posterior mean of 25,808), and this is also consistent across all the model runs. The baseline model estimate of the maximum rate of increase, λ_{max}, is 1.062 which, while high, is nevertheless within the range of estimates obtained for other baleen whales.

KEYWORDS: ASESSMENT; GRAY WHALES; WHALING – ABORIGINAL

INTRODUCTION

The eastern North Pacific (ENP) gray whale (*Eschrichtius robustus*) population has been hunted extensively by both commercial and aboriginal whalers. Indigenous peoples of both North America and Russia have hunted gray whales in some locations for centuries and possibly for 2000 years or more (Krupnik, 1984; O'Leary, 1984). The winter breeding grounds of the ENP gray whale (lagoons and adjacent ocean areas in Baja California, Mexico) were discovered by Yankee whalers in the early 19th century, and two commercial whaling vessels first hunted gray whales (in Magdalena Bay) in the winter of 1845–46 (Henderson, 1984). This began a period of intense hunting with large catches of ENP gray whales by Yankee whalers from 1846 until 1873 which decimated the population. Whaling ships and shore-based whalers continued to catch gray whales for the next two decades which drove the population to apparent commercial extinction by 1893. In the 20th century, modern commercial pelagic whaling of ENP gray whales began in 1910 and ended in 1946 when gray whales received full protection under the International Convention for the Regulation of Whaling (Reeves, 1984). Aboriginal catches of ENP gray whales along the Chukotka Peninsula of Russia have continued since 1946 until the present.

From 1846 to 1900 recorded commercial kills numbered nearly 9,000 gray whales, and it is roughly estimated that about 6,500 gray whales were killed by aboriginal hunters during this same period, for a total of more than 15,500 whales caught (Table 1). Since 1900, about 11,500 additional ENP gray whales have been killed by commercial and aboriginal whalers for a total since 1846 of more than 27,000 whales caught (Table 1). The magnitude of the catches, particularly for the period of high exploitation during the 1800s, gives some information on the likely pre-exploitation population size. For example, Jones *et al.* (1984) state that 'most whaling historians and biologists believe the pre-exploitation stock size was between 15,000 and 24,000 animals'.

ENP gray whales migrate along the west coast of North America, and the US National Marine Fisheries Service (NMFS) has taken advantage of this nearshore migration pattern to conduct shore-based counts of the population in central California during December–February from 1967–68 to 2006–07. These survey data have been used to estimate the abundance of the ENP gray whale stock over the survey period (Buckland *et al.*, 1993; Hobbs *et al.*, 2004; Laake *et al.*, 1994; Reilly, 1981; Rugh *et al.*, 2008a; 2005). The resulting sequence of abundance estimates has also been used to estimate the population's growth rate (Buckland and Breiwick, 2002; Buckland *et al.*, 1993), as well as its status relative to the maximum sustainable yield level (MSYL)[1] and carrying capacity (*K*) (Cooke, 1986; Lankester and Beddington, 1986; Punt and Butterworth, 2002; Reilly, 1981; Wade, 2002). However, attempts to model the gray whale population from 1846 until the present, accounting for the catch record and assuming that the stock was at its carrying capacity in 1846, have run into difficulties because the catch history cannot be reconciled with a population that increased at the observed rate from 1967/68 to 1979/80 (Cooke, 1986; Lankester and Beddington, 1986; Reilly, 1981). The

[1] MSYL expressed in terms of 1+ component of the population.

[+] *School of Aquatic and Fishery Sciences, University of Washington, Box 355020, Seattle, WA 98195-5020, USA.*
* *National Marine Mammal Laboratory, Alaska Fisheries Science Center, 7600 Sand Point Way, NE Seattle, WA 98115-6489, USA.*

Table 1a

Historical (pre-1944) aboriginal catches from the eastern North Pacific stock of gray whales (C. Allison, IWC Secretariat, pers. comm.).

Years	Annual kill
1600–1675	182
1676–1750	183
1751–1840	197.5
1841–1846	193.5
1847–1850	192.5
1851–1860	187
1861–1875	111
1876–1880	110
1881–1890	108
1891–1900	62
1901–1904	61
1905–1915	57
1916–1928	52
1929–1930	47
1931–1939	10
1940–1943	20

explanation for this is simple; if one assumes a relatively low maximum growth rate, the ENP gray whales would not have been able to increase between 1967/68 and 1979/80 because of the catches during that time, and if one assumes a high maximum growth rate, the population would not be increasing then because it would have already returned to carrying capacity. Butterworth *et al.* (2002) investigated the inability to fit a standard population dynamics model to the data for the ENP gray whales extensively and concluded that the catch history and the observed rate of increase could be reconciled in one of three different ways, which were not mutually exclusive: (1) a 2.5X increase in *K* between 1846 and 1988, (2) a 1.7X increase or more in the commercial catch between 1846 and 1900, and (3) a 3X increase or more in aboriginal catch levels prior to 1846 compared to what was previously assumed (Butterworth *et al.*, 2002).

Given these difficulties, recent gray whale assessments have been conducted by modelling the population since 1930 or later, rather than trying to model the population since 1846 (e.g. Punt and Butterworth, 2002; Wade, 2002). These analyses differed from the earlier assessments by not assuming that the population size in 1846 was *K*. Instead, *K* is essentially estimated by the recent trend in abundance, where a growing population implies that *K* has likely not yet been reached, and a roughly stable population implies the population is at or near *K*. Based on abundance surveys through 1995–96, point estimates of *K* from these analyses ranged from 24,000 to 32,000, but these estimates were relatively imprecise because they had broad probability intervals (Punt and Butterworth, 2002; Wade, 2002). In particular, the results did not exclude the possibility that *K* could be much larger than this range. However, these analyses did suggest that the population was probably close to *K* and at or above its MSYL. For example, Wade (2002) estimated a probability of 0.72 that the population was above $MSYL^{1+}$ in 1996. Punt and Butterworth (2002) also conducted analyses projecting the population from the year 1600 under various assumptions that historic commercial and aboriginal catches were underestimated (as in Butterworth *et al.*, 2002). Those analyses resulted in point estimates of *K* that ranged between 15,000 and 19,000. In those analyses, it was estimated the population was at a very high fraction of *K* in 1996 and had a very high probability of being above $MSYL^{1+}$.

Recently, Rugh *et al*. (2008b) evaluated the accuracy of various components of the shore-based survey method, with a focus on pod size estimation. They found that the correction factors that had been used to compensate for bias in pod size estimates were calculated differently for different sets of years. In particular, the correction factors estimated by Laake *et al*. (1994) were substantially larger than those estimated by Reilly (1981). Also, the estimates for the surveys prior to 1987 in the trend analysis were scaled based on the abundance estimate from 1987–88. This meant that the first 16 abundance estimates used one set of correction factors, and the more recent 7 abundance estimates used different (and larger) correction factors which would influence the estimated trend and population trajectory. In addition, there were other subtle differences in the analysis methods used for the sequence of abundance estimates. Thus, a revaluation of the analysis techniques and of the abundance estimates was warranted to apply a more uniform approach throughout the years. Laake *et al.* (In press) derived a better, more consistent, approach to abundance estimation, and incorporated it into an analysis to re-estimate abundance for all 23 shore-based surveys. These new revised abundance estimates led to the present re-assessment of the ENP gray whale population.

The population is assessed by fitting an age- and sex-structured population model to these revised abundance estimates, using methods similar to those of Wade (2002) and Punt and Butterworth (2002); recent abundance estimates from 1997/98, 2000/01, 2001/02, and 2006/07 that were not available in previous assessments are also used. As in Punt and Butterworth (2002), sensitivity tests are performed to examine various assumptions or modelling decisions.

The analyses also incorporate new information about the biology of the ENP gray whales from recent studies. In particular, it is now recognised that the population experienced an unusual mortality event in 1999 and 2000. An unusually high number of gray whales were stranded along the west coast of North America in those years (Gulland *et al.*, 2005; Moore *et al.*, 2001). Over 60% of the dead whales were adults, and more adults and subadults stranded in 1999 and 2000 relative to the years prior to the mortality event (1996–98), when calf strandings were more common. Many of the stranded whales were emaciated, and aerial photogrammetry documented that migrating gray whales were skinnier in girth in 1999 relative to previous years (Perryman and Lynn, 2002; W. Perryman, SWFSC, pers. comm.). In addition, calf production in 1999 and 2000 was less than one third of that in the previous years (1996–98). In 2001 and 2002, strandings of gray whales along the coast decreased to levels that were below their pre-1999 level (Gulland *et al.*, 2005) and average calf production in 2002–2004 returned to the level seen in pre-1999 years (Table 2). A US Working Group on Marine Mammal Unusual Mortality Events (Gulland *et al.*, 2005) concluded that the emaciated condition of many of the stranded whales supported the idea that starvation could have been a significant contributing factor to the higher number of strandings in 1999 and 2000. Perryman *et al.* (2002) found a

Table 1b
Commercial and recent aboriginal (post-1943) catches from the eastern North Pacific stock of gray whales (C. Allison, IWC Secretariat, pers. comm.).

Year	Male	Female	Year	Male	Female	Year	Male	Female	Year	Male	Female
1846	23	45	1889	7	13	1932	3	7	1975	58	113
1847	23	45	1890	7	13	1933	36	69	1976	69	96
1848	23	45	1891	7	13	1934	64	92	1977	86	101
1849	23	45	1892	7	13	1935	48	96	1978	94	90
1850	23	45	1893	0	0	1936	74	114	1979	57	126
1851	23	45	1894	0	0	1937	5	9	1980	53	129
1852	23	45	1895	0	0	1938	18	36	1981	36	100
1853	23	45	1896	0	0	1939	10	19	1982	56	112
1854	23	45	1897	0	0	1940	39	66	1983	46	125
1855	162	324	1898	0	0	1941	19	38	1984	59	110
1856	162	324	1899	0	0	1942	34	67	1985	55	115
1857	162	324	1900	0	0	1943	33	66	1986	46	125
1858	162	324	1901	0	0	1944	0	0	1987	47	112
1859	162	324	1902	0	0	1945	10	20	1988	43	108
1860	162	324	1903	0	0	1946	7	15	1989	61	119
1861	162	324	1904	0	0	1947	0	1	1990	67	95
1862	162	324	1905	0	0	1948	6	13	1991	69	100
1863	162	324	1906	0	0	1949	9	17	1992	0	0
1864	162	324	1907	0	0	1950	4	7	1993	0	0
1865	162	324	1908	0	0	1951	5	9	1994	21	23
1866	79	159	1909	0	0	1952	15	29	1995	48	44
1867	79	159	1910	0	1	1953	19	29	1996	18	25
1868	79	159	1911	0	1	1954	13	26	1997	48	31
1869	79	159	1912	0	0	1955	20	39	1998	64	61
1870	79	159	1913	0	1	1956	41	81	1999	69	55
1871	79	159	1914	6	13	1957	32	64	2000	63	52
1872	79	159	1915	0	0	1958	49	99	2001	62	50
1873	79	159	1916	0	0	1959	66	130	2002	80	51
1874	79	159	1917	0	0	1960	52	104	2003	71	57
1875	17	33	1918	0	0	1961	69	139	2004	43	68
1876	17	33	1919	0	0	1962	53	98	2005	49	75
1877	17	33	1920	1	1	1963	60	120	2006	57	77
1878	17	33	1921	13	25	1964	81	138	2007	50	82
1879	21	42	1922	6	4	1965	71	110	2008	64	66
1880	17	34	1923	0	0	1966	100	120			
1881	17	33	1924	1	0	1967	151	223			
1882	17	33	1925	70	64	1968	92	109			
1883	19	39	1926	25	17	1969	93	121			
1884	23	45	1927	7	25	1970	70	81			
1885	21	41	1928	4	8	1971	62	91			
1886	17	33	1929	0	3	1972	66	116			
1887	7	13	1930	0	0	1973	98	80			
1888	7	13	1931	0	0	1974	94	90			

significant positive correlation between an index of the amount of ice-free area in gray whale feeding areas in the Bering Sea and their estimates of calf production for the following spring for the years 1994 to 2000; the suggested mechanism is that longer periods of time in open water provides greater feeding opportunities for gray whales. Whether or not heavy ice cover was ultimately the mechanism that caused the 1999–2000 event, it is clear that ENP gray whales were substantially affected in those years; whales were on average skinnier, they had a lower survival rate (particularly of adults) and calf production was dramatically lower. Given that this event may have affected the status of the ENP gray whale population relative to *K*, an additional model parameter ('catastrophic mortality') has been specified in the model that allowed for lower survival in the years 1999 and 2000 to investigate this effect.

METHODS

Available data

A variety of data sources are available to assess the status of the ENP stock of gray whales. These data sources are used when developing the prior distributions for the parameters of the population dynamics model, when pre-specifying the values for some of the parameters of this model, and when constructing the likelihood function. Table 1 lists the time-series of removals. It should be noted that the catches for the years prior to 1930 are subject to considerable uncertainty, and evaluating these catches remains an active area of research. However, the uncertainty associated with these early catches is inconsequential for this paper because the population projections do not start before 1930.

The key source of information on the abundance of the ENP gray whales is data collected from the southbound surveys that have been conducted since 1967/68 near Carmel, California (Laake *et al.*, In press; Table 2). Information on trends in calf numbers are also available from surveys of calves during the northbound migration (Perryman *et al.*, 2002; W. Perryman, pers. comm.; Table 2). The calf abundance data are not included in the baseline analyses, but are considered in one of the tests of sensitivity.

Analysis methods

The population dynamics model

An age- and sex-structured population dynamics model is used that assumes that all whaling takes place at the start of

Table 2

Baseline estimates of 1+ abundance (and associated standard errors of the logs) from southbound surveys (Laake *et al.*, In press), the estimates of 1+ abundance used in previous assessments, two alternative series of abundance estimates ('Hi' and 'Lo', see footnote 7 for details), and estimates of calf numbers from northbound surveys (W. Perryman, SWFSC, pers. comm.).

	1+ abundance								1+ abundance			
	Laake *et al.* (In press)		Unrevised estimates			Calf counts			Lo series		Hi series	
Year	Estimate	CV	Estimate	CV	Year	Estimate	SE	Year	Estimate	SE	Estimate	SE
1967/68	13,426	0.094	13,776	0.078	1994	945	68.2	1967/68	12,961	0.094	14,298	0.095
1968/69	14,548	0.080	12,869	0.055	1995	619	67.2	1968/69	14,043	0.080	15,493	0.081
1969/70	14,553	0.083	13,431	0.056	1996	1,146	70.7	1969/70	14,049	0.082	15,498	0.084
1970/71	12,771	0.081	11,416	0.052	1997	1,431	82.0	1970/71	12,328	0.081	13,601	0.082
1971/72	11,079	0.092	10,406	0.059	1998	1,388	92.0	1971/72	10,695	0.092	11,799	0.093
1972/73	17,365	0.079	16,098	0.052	1999	427	41.1	1972/73	16,763	0.079	18,493	0.080
1973/74	17,375	0.082	15,960	0.055	2000	279	34.8	1973/74	16,772	0.081	18,503	0.083
1974/75	15,290	0.084	13,812	0.056	2001	256	28.6	1974/75	14,760	0.084	16,283	0.085
1975/76	17,564	0.086	15,481	0.060	2002	842	78.6	1975/76	16,955	0.086	18,705	0.087
1976/77	18,377	0.080	16,317	0.050	2003	774	73.6	1976/77	17,739	0.079	19,570	0.081
1977/78	19,538	0.088	17,996	0.069	2004	1,528	96.0	1977/78	18,860	0.088	20,806	0.089
1978/79	15,384	0.080	13,971	0.054	2005	945	86.9	1978/79	14,850	0.080	16,383	0.081
1979/80	19,763	0.083	17,447	0.056	2006	1,020	103.3	1979/80	19,077	0.082	21,046	0.083
1984/85	23,499	0.089	22,862	0.060	2007	404	51.2	1984/85	22,684	0.089	25,025	0.090
1985/86	22,921	0.081	21,444	0.052	2008	553	53.0	1985/86	22,126	0.081	24,409	0.082
1987/88	26,916	0.058	22,250	0.050	2009	312	41.9	1987/88	25,661	0.057	28,692	0.056
1992/93	15,762	0.067	18,844	0.063				1992/93	14,785	0.065	17,879	0.072
1993/94	20,103	0.055	24,638	0.060				1993/94	19,468	0.057	21,124	0.056
1995/96	20,944	0.061	24,065	0.058				1995/96	20,636	0.063	22,314	0.063
1997/98	21,135	0.068	29,758	0.105				1997/98	20,426	0.063	22,378	0.065
2000/01	16,369	0.061	19,448	0.097				2000/01	16,051	0.063	17,145	0.062
2001/02	16,033	0.069	18,178	0.098				2001/02	15,162	0.066	16,883	0.067
2006/07	19,126	0.071	20,110	0.088				2006/07	18,775	0.071	20,129	0.072

the year, and that all animals are 'recruited' to the hunted population by age 5 (i.e. hunting only occurs on animals age 5 and older) (Punt, 1999; Punt and Butterworth, 2002). The dynamics of the population are assumed to be governed by the equations:

$$N^s_{t+1,a} = \begin{cases} 0.5P^M_{t+1}f_{t+1} & \text{if } a=0 \\ N^s_{t,a-1}(1-F^s_{t,a-1})S_{a-1}\tilde{S}_t & \text{if } 1 \le a \le x-1 \\ N^s_{t,x}(1-F^s_{t,x})S_x\tilde{S}_t + N^s_{t,x-1}(1-F^s_{t,x-1})S_{x-1}\tilde{S} & \text{if } a=x \end{cases} \quad (1)$$

where

$N^s_{t,a}$ is the number of animals of age a and sex s (m/f) at the start of year t,

S_a is the annual survival rate of animals of age a in the absence of catastrophic mortality events (assumed to be the same for males and females),

$\tilde{S}_t$ is the amount of catastrophic mortality (represented in the form of a survival rate) during year t (catastrophic events are assumed to occur at the start of the year before mortality due to whaling and natural causes; in general $\tilde{S}_t=1$, i.e. there is no catastrophic mortality),

$F^s_{t,a}$ is the exploitation rate on animals of sex s and age a during year t,

P^M_t is the number of females that have reached the age at first parturition by the start of year t,

$$P^M_t = \sum_{a=a_m+1}^{x} N^f_{t,a} \quad (2)$$

a_m is the age-of-maturity,

f_t is pregnancy rate (number of calves of both sexes per 'mature' female) during year t (note that Equation (1) assumes an equal male : female sex ratio at birth), and

x is the maximum age-class, which for convenience is lumped across older age-classes (i.e. individuals stay in this age-class until they die).

Density dependence on fecundity can be modelled by writing the pregnancy rate, f_t, as follows:

$$f_t = \max\left(f_{eq}\left[1+A\left\{1-\left(\bar{S}_{t-2}P^{1+}_{t-2}/K^{1+}\right)^z\right\}\right],0\right). \quad (3)$$

Where f_{eq} is the pregnancy rate at the pre-exploitation equilibrium, $f(F=0)$[2]:

$$f(F) = 2\left\{\sum_{a=a_m+1}^{x}\tilde{N}^f_a(F)\right\}^{-1} \quad (4)$$

A is the resilience parameter:

$$A = \frac{f_{\max}-f_{eq}}{f_{eq}} \quad (5)$$

f_{max} is the maximum (theoretical) pregnancy rate,

z is the degree of compensation,

P^{1+}_t is number of animals aged 1 and older at the start of year t:

$$P^{1+}_t = \sum_s\sum_{a=1}^{x} N^s_{t,a} \quad (6)$$

K^{1+} is the (current) pre-exploitation equilibrium size (carrying capacity) in terms of animals aged 1 and older, and

$\tilde{N}^s_a(F)$ is the number of animals of sex s and age a when the exploitation rate is fixed at F, expressed as a fraction of the

[2]The pregnancy rate at the pre-exploitation equilibrium can be considered to be the equilibrium pregnancy rate when the exploitation rate, F, is fixed at zero.

number of calves of the same sex s (see appendix 1 of Punt (1999) for details).

Although these equations are written formally as if only the pregnancy rate component of 'fecundity' as defined here is density-dependent, exactly the same equations follow if some or all of this dependence occurs in the infant survival rate (Punt, 1999). Catastrophic mortality is assumed to occur before density-dependence because many of the deaths in 1999 and 2000 occurred before mating was likely to have occurred. Non-catastrophic natural mortality does not appear in Equation 3 because it cancels out. The time-lag in Equation 3 is specified to match the reproductive cycle of gray whales; mature female gray whales mate and become pregnant in early winter, have a gestation period of slightly longer than one year, and give birth at the start of the next year (on average in January) (Rice and Wolman, 1971; Shelden *et al.*, 2004). Their body condition at the end of the summer feeding season will help determine their probability of becoming pregnant the following winter and producing a calf a year later. Therefore, the density-dependent effect on calf production is assumed to be determined by the population size during the feeding season two time-steps prior (approximately 1.5 years earlier).

Following past assessments of the ENP stock of gray whales (e.g. Butterworth *et al.*, 2002; Punt *et al.*, 2004; Punt and Butterworth, 2002), the catch (by sex) is assumed to be taken uniformly from the animals aged five and older, that is:

$$F^s_{t,a} = C^s_t / \sum_{a=5}^{x} N^s_{t,a} \quad (7)$$

Where C^s_t is the catch of animals of sex s during year t.

The population is assumed to have had a stable age-structure at the start of the projection period (year t_{INIT}).

$$N^s_{t_{INIT},a} = N^{Tot}_{t_{INIT}} \tilde{N}^s_a(F_{INIT}) / \sum_{s'} \sum_{a'=0}^{x} \tilde{N}^{s'}_{a'}(F_{INIT}) \quad (8)$$

Where $N^{Tot}_{t_{INIT}}$ is the size of the total (0+) component of the population at the start of year t_{INIT}. The value of F_{INIT} is selected numerically so that:

$$N^{Tot}_{t_{INIT},a} = 0.5 N_0(F_{INIT}) / \sum_{s} \sum_{a=0}^{x} N^s_a(F_{INIT}) \quad (9)$$

Where $N_0(F_{INIT})$ is the number of calves (of both sexes) at the start of the year when $F = F_{INIT}$:

$$N_0(F_{INIT}) = \left(1 - \frac{1}{A}\left[\frac{f(F_{INIT})}{f_{eq}} - 1\right]\right)^{1/z} \frac{K^{1+}}{\tilde{P}^{1+}(F_{INIT})} \quad (10)$$

$\tilde{P}^{1+}(F)$ is the size of the 1+ component of the population as a function of F, expressed as a fraction of the number of calves (of both sexes).

Parameter estimation

Catastrophic mortality is assumed to be zero (i.e. $\tilde{S}_y = 1$) except for 1999 and 2000 when it is assumed to be equal to a parameter $\tilde{S}$. This assumption reflects the large number of dead whales observed stranded along the coasts of Oregon and Washington during 1999 and 2000 relative to numbers stranding there annually historically (Brownell *et al.*, 2007; Gulland *et al.*, 2005).

The parameters of the population dynamics model are a_m; $\tilde{S}$; K^{1+}; the 1+ population size at the start of 1968, P^{1+}_{1968} [3]; $MSYL^{1+}$ (the maximum sustained yield level for the 1+ population, which is the population size at which maximum sustained yield (MSY) is achieved when hunting takes place uniformly on animals aged 1 and older, relative to K^{1+}); $MSYR^{1+}$ (the ratio of MSY to $MSYL^{1+}$); f_{max}; and the non-calf survival rate, S_{1+}. The analysis does not incorporate a prior distribution for the survival rate of calves (S_0) explicitly. Instead, following Wade (2002), an implicit prior distribution for this parameter is calculated from the priors for the five parameters a_m, f_{max} , S_{1+}, $MSYR^{1+}$ and $MSYL^{1+}$. For any specific draw from the prior distributions for these five parameters, the value for S_0 is selected so that the relationships imposed by the population model among the six parameters are satisfied. If the resulting value for S_0 is less than zero or greater than that of S_{1+}, the values for S_{1+}, a_m, f_{max}, $MSYR^{1+}$ and $MSYL^{1+}$ are drawn again[4]. Thus, the prior for S_0 is forced to conform to the intuitive notion that the survival rate of calves must be lower than that for older animals and must be larger than zero (Caughley, 1966).

Under the assumption that the logarithms of the estimates of abundance based on the southbound surveys are normally distributed, the contribution of these estimates to the negative of the logarithm of the likelihood function (ignoring constants independent of the model parameters) is:

$$-\ell nL = 0.5\ell n\left|V + \Omega\right| + 0.5\sum_i \sum_j (\ell n N^{obs}_i - \ell n \hat{P}^{1+}_i)[V + \Omega)^{-1}]_{i,j} (\ell n N^{obs}_j - \ell n \hat{P}^{1+}_j), \quad (11)$$

Where N^{obs}_i is the i^{th} estimate of abundance[5],

$\hat{P}_i$ is the model-estimate corresponding to N^{obs}_i,

V is the variance-covariance matrix for the abundance estimates, and

Ω is a diagonal matrix with elements CV^2_{add} (this matrix captures sources of uncertainty not captured elsewhere; termed 'additional variance' in Wade (2002)).

A Bayesian approach is used to estimate the 'free' parameters of the model based on the prior distributions in Table 3 and the sampling/importance resampling (SIR) algorithm (Rubin, 1988).

(a) Draw values for the parameters S_{1+}, a_m, f_{max}, $MSYR^{1+}$, $MSYL^{1+}$, K^{1+}, P^{1+}_{1968}, $\tilde{S}$, and CV_{add} from the priors in Table 3.

(b) Solve the system of equations that relate S_0, S_{1+}, a_m, f_{max}, $MSYR^{1+}$, $MSYL^{1+}$, A and z (Punt, 1999; Eqs. 18–21) to find values for S_0, A, and z, and find the population size in year t_{INIT} and the population rate of increase in this year, so that, if the population is projected from year t_{INIT}

[3]The 1968 population size is taken to be a measure of initial abundance so that the analyses based on different starting years are comparable in terms of their prior specifications.

[4]The implications of different treatments of how to handle situations in which the calculated value for S_0 is outside of plausible bounds is examined by Brandon *et al.* (2007) .

[5]The abundance estimate for year y/y+1 is assumed to pertain to abundance at the start of year y+1.

to 1968, the total (1+) population size in 1968 equals the generated value for P^{1+}_{1968}.

(c) Compute the likelihood for the projection (see Equation 11).

(d) Repeat steps (a)–(c) a very large number (typically 5 million) of times.

(e) Select 5,000 parameter vectors randomly from those generated using steps (a)–(d), assigning a probability of selecting a particular vector proportional to its likelihood

The above formulation implies that the year for which a prior on abundance is specified (1968) is not necessarily the same as the first year of the population projection (t_{INIT}, baseline value 1930). Starting the population projection before the first year for which data on abundance are available allows most of the impact of any transient population dynamics caused by the assumption of a stable age-structure to be eliminated. Therefore, the model population should mimic the real population more closely by allowing the sex- and age-selectivity of the catches to correctly influence the sex- and age-distribution of the population once the trajectory reaches years where it is compared to the data (i.e. 1967/68 and beyond).

Table 3
The parameters and their assumed prior distributions.

Parameter	Prior distribution
Non-calf survival rate, S_{1+}	U[0.950, 0.999][a]
Age-at-maturity, a_m	U[6,12][b]
Maximum pregnancy rate, f_{max}	U[0.3, 0.6][a]
Carrying capacity, K^{1+}	U[10,000, 70,000][c]
Population size in 1968, P^{1+}_{1968}	U[5,000, 20,000][c]
Maximum Sustainable Yield Level, $MSYL^{1+}$	U[0.4, 0.8][a]
Maximum Sustainable Yield Rate, $MSYR^{1+}$	U[0, 0.1][a]
Catastrophic mortality, $\tilde{S}$	U[0.2, 1.0][c]
Additional variance, 1+ abundance estimates, CV_{add}	U[0, 0.35][a,c]
Additional variance, calf counts, CV_{add-2}	U[0.2, 0.8][c,d]
Constant of proportionality, ℓnq	U[$-\infty$, ∞][d,e]

[a]Equal to the prior distribution used in the most recent assessments (Punt *et al*., 2004); [b]Bradford *et al*. (2010); [c]preliminary analyses provided no evidence of posterior support for values outside this range; [d]not used in the baseline analysis; [e]the non-informative prior for a scale parameter (Butterworth and Punt, 1996).

Output statistics

The results are summarised by the posterior medians, means and 90% credibility intervals for $MSYR^{1+}$, $MSYL^{1+}$, S_{1+}, S_0, $\tilde{S}$, and K^{1+} and the following management-related quantities:

(a) P^{1+}_{2009} is the number of 1+ animals at the start of 2009;

(b) P^{1+}_{2009} / K^{1+} is the depletion level, or the number of 1+ animals at the start of 2009, expressed as a percentage of that corresponding to the equilibrium level;

(c) $P^{1+}_{2009} / MSYL^{1+}$ is the MSYL *ratio*, the number of 1+ animals at the start of 2009, expressed as a percentage of that at which MSY is achieved; and

(d) λ_{max} is the maximum rate of increase (given a stable age-structure and the assumption of no maximum age; Breiwick *et al*., 1984)

P^{1+}_{2009} / K^{1+} is termed the *depletion level* because it provides a measure of how depleted the population is relative to the carrying capacity, as the equilibrium level in a density-dependent model is equivalent to carrying capacity. $P^{1+}_{2009} / MSYL^{1+}$ is referred to as the MSYL *ratio* because it provides a measure of whether the population is above $MSYL^{1+}$ Note that λ_{max} can be equated to r_{max} (e.g. as in Wade, 1998) through the equation $r_{max} = \lambda_{max} - 1.0$.

Sensitivity tests

Our baseline assessment includes the baseline estimates of 1+ abundance (Table 2) and allows for a catastrophic mortality event in 1999–2000. The sensitivity of the results of the analyses is explored to:

(a) varying the first year considered in the population projection (1940, 1950 and 1960);

(b) replacing the estimates of abundance for the southbound migration by the values used in the previous assessment (Table 2, 'Unrevised estimates');

(c) replacing the abundance estimates with the 'Lo' and 'Hi' series (Table 2)[6] ;

(d) ignoring the catastrophic event in 1999–2000 (abbreviation 'No event');

(e) basing the analysis on the generalised logistic equation (see Appendix 1 for details; abbreviation 'Gen Logist')[7];

(f) splitting the abundance series after 1987/88 (abbreviation 'Split series'), where the first abundance series is treated as a relative index of abundance scaled to absolute abundance through a constant of proportionality, and the second series is treated as an absolute index of abundance; and

(g) including the calf counts at Point Piedras Blancas, California (Perryman *et al*., 2002; Perryman, pers. comm.) in the analysis (abbreviation 'With calf counts').

For the last sensitivity test, the contribution of the data on calf counts to the negative of the logarithm of the likelihood function (ignoring constants independent of the model parameters) is based on the assumption that the calf counts are relative indices of the total number of calves and are subject to both modelled and unmodelled sources of uncertainty:

$$-\ell nL = 0.5\sum_i \ell n(\sigma_i^2 + CV_{add-2}^2) + 0.5\sum_i \frac{(\ell nA_i^{obs} - \ell n(q(N_{i,0}^m + N_{i,0}^f)))^2}{\sigma_i^2 + CV_{add-2}^2} \qquad (12)$$

[6]The sequence of gray whale abundance estimates depends in part on the estimates of observer detection probability that were measured with the double observer data. Assessment of matches amongst the pods detected by the observers depends on the weighting parameters for distance and time measurements (Laake *et al*., In press). The weighting parameters used for the baseline abundance estimates were selected such that 95% of the observations of the same pod would be correctly matched. Sensitivity is explored to matching weighting parameters that gave 98% and 90% (table A2; Laake *et al*., In press).

[7]This sensitivity test is provided because the generalised logistic model has been the basis for some previous management advice for this stock (for example, Wade, 2002).

where

A_i^{obs} is the estimate of the number of calves during year i based on the surveys at Point Piedras Blancas;

q is the constant of proportionality between the calf counts and model estimates of the number of calves;

σ_i is the standard error of the logarithm of C_i^{obs} ; and

CV_{add-2}^2 is the additional variance associated with the calf counts.

Prior distributions

The prior distributions (Table 3) are generally based on those used in recent International Whaling Commission (IWC) assessments of ENP gray whales. The prior distributions for S_{1+}, K^{1+}, $\tilde{S}$, CV_{add}, CV_{add-2}, and ℓnq were selected to be uniform over a sufficiently wide range so that there is effectively no posterior probability outside of that range.

The prior for the age-at-maturity differs from that used in previous assessments, Uniform[5,9], based on the review by Bradford *et al.* (2010) who could find no basis for that range in the literature. They concluded that the most relevant data set for age-at-maturity was that of Rice and Wolman (1971), corrected by Rice (1990) for the underestimation of whale ages by one year in the original study, resulting in a median age of 9, and lower and upper bounds of 6 and 12. Bradford *et al.* (2010) note that the only observation of the age-at-first-reproduction (AFR) in ENP gray whales (a known whale observed with a calf for the first time) was 7 years for a whale first seen as a calf in a lagoon in Mexico. In the western Pacific population of gray whales, there have been observations of AFR of 7 and 11 years for the only two whales whose first calving has been documented to date (Bradford *et al.*, unpublished ms). The prior for the maximum pregnancy rate, f_{max}, was set equal to the prior selected for recent assessments (Punt and Butterworth, 2002; Wade, 2002). This prior implies a minimum possible calving interval between 1.67 and 3.33 years.

The prior for the population size (in terms of animals aged 1 and older) in 1968 differs from that used in previous assessments. Rather than combining a uniform prior on 1968 population size with the abundance estimate for 1968 to create an informative prior for P_{1968}^{1+} as was the case in previous assessments, this assessment assumes a broad uniform prior for 1968 population size, and includes all of the estimates of abundance in the likelihood function. This is because the previous approach cannot be applied because all of the estimates of abundance are correlated (Laake *et al.*, In press).

The prior for $MSYR^{1+}$ is bounded below by the minimum possible value and above by a value which is above those supported by the data. This prior is broader than those considered in previous assessments because those assessments assigned a prior to $MSYR^{1+}$ when this parameter is expressed in terms of removals of mature animals only. The prior for $MSYL^{1+}$ has been assumed to be uniform from 0.4 to 0.8. The central value for this prior reflects the common assumption when conducting IWC assessments of whale stocks that maximum productivity occurs at about 60% of carrying capacity. The upper and lower bounds reflect values commonly used to bound MSYL for whale stocks (e.g. those used in the tests that evaluated the IWC's catch limit algorithm).

RESULTS

The baseline assessment estimates that ENP gray whales increased substantially from 1930 until 1999 when a substantial reduction in population size from close to carrying capacity (in terms of median parameter estimates) occurred (Fig. 1). This reduction was associated with an estimated decline in non-calf survival from 0.982 to 0.847 (posterior means, where 0.981 × 0.863 = 0.847) in each of 1999 and 2000. The population is estimated to have been

Table 4

Posterior distributions for the key model outputs (posterior mean, posterior median [in square parenthesis], and posterior 90% intervals) for the baseline analysis and the sensitivity tests.

	Baseline	t_{INIT}=1940	t_{INIT}=1950	t_{INIT} =1960	Unrevised estimates	No event	Gen logist	With calf counts
K^{1+}	25,808 [22,756]	25,450 [22,506]	24,681 [22,282]	24,396 [22,047]	41,046 [37,889]	21,640 [20,683]	21,146 [20,668]	27,716 [24,194]
	(19,752 49,639)	(19,537 49,109)	(19,454 43,887)	(19,212 43,307)	(24,214 66,564)	(18,301 25,762)	(18,229 24,292)	(20,387 51,775)
$MSYR^{1+}$	0.046 [0.048]	0.047 [0.048]	0.049 [0.049]	0.048 [0.049]	0.035 [0.034]	0.052 [0.053]	0.065 [0.066]	0.040 [0.040]
	(0.022 0.064)	(0.022 0.067)	(0.024 0.068)	(0.024 0.070)	(0.025 0.050)	(0.026 0.068)	(0.034 0.096)	(0.022 0.057)
$MSYL^{1+}$	0.656 [0.669]	0.664 [0.677]	0.677 [0.689]	0.691 [0.702]	0.611 [0.611]	0.672 [0.684]	0.630 [0.640]	0.632 [0.638]
	(0.532 0.725)	(0.535 0.741	(0.541 0.762)	(0.545 0.786)	(0.506 0.706)	(0.577 0.730)	(0.441 0.786)	(0.514 0.725)
P_{2009}^{1+} / K^{1+}	0.849 [0.919]	0.865 [0.933]	0.885 [0.946]	0.899 [0.959]	0.615 [0.598]	0.956 [0.977]	0.964 [0.976]	0.775 [0.816]
	(0.393 1.006)	(0.403 1.016)	(0.451 1.022)	(0.453 1.043)	(0.334 0.948)	(0.872 0.987)	(0.922 0.989)	(0.372 0.984)
$P_{2009}^{1+} / MYSL^{1+}$	1.288 [1.366]	1.295 [1.362]	1.302 [1.355]	1.296 [1.343]	1.002 [0.992]	1.423 [1.424]	1.541 [1.515]	1.217 [1.284]
	(0.681 1.508)	(0.701 1.522)	(0.775 1.516)	(0.786 1.513)	(0.580 1.459)	(1.303 1.583)	(1.252 2.091)	(0.681 1.494)
P_{2009}^{1+}	20,366 [20,447]	20,489 [20,511]	20,583 [20,648]	20,678 [20,705]	22,773 [22,701]	20,247 [20,127]	20,213 [20,090]	19,892 [19,863]
	(17,515 23,127)	(19,628 23,274)	(17,726 23,247)	(17,856 23,497)	(19,910 25,865)	(17,726 22,993)	(17,827 22,910)	(16,872 22,723)
λ_{max}	1.062 [1.063]	1.063 [1.063]	1.063 [1.062]	1.062 [1.060]	1.054 [1.052]	1.068 [1.069]	0.107 [0.088]	1.057 [1.057]
	(1.032 1.088)	(1.033 1.094)	(1.035 1.094)	(1.035 1.092)	(1.036 1.081)	(1.038 1.091)	(0.042 0.242)*	(1.033 1.080)
S_{1+}	0.981 [0.982]	0.981 [0.982]	0.980 [0.982]	0.980 [0.982]	0.978 [0.980]	0.983 [0.985]	N/A	0.972 [0.972]
	(0.957 0.997)	(0.957 0.997)	(0.957 0.997)	(0.957 0.997)	(0.956 0.997)	(0.960 0.998)		(0.954 0.993)
S_0	0.711 [0.732]	0.716 [0.734]	0.713 [0.727]	0.706 [0.720]	0.662 [0.666]	0.730 [0.747]	N/A	0.722 [0.751]
	(0.423 0.950)	(0.426 0.949)	(0.426 0.952)	(0.425 0.949)	(0.400 0.926)	(0.437 0.955)		(0.428 0.943)
$\tilde{S}$	0.863 [0.865]	0.866 [0.867]	0.868 [0.870]	0.870 [0.870]	0.814 [0.809]	1	N/A	0.847[0.840]
	(0.772 0.951)	(0.778 0.951)	(0.779 0.960)	(0.781 0.961)	(0.725 0.915)			(0.749 0.949)

*r rather λ_{max}.

Cont.

Table 4 (continued).

	Baseline	Split series	Lo series	Hi series	Unrevised no event	Calf counts no event
K^{1+}	25,808 [22,756] (19,752 49,639)	27,489 [22,870] (19,640 55,929)	25,826 [22,030] (19,129 52,878)	26,902 [24,181] (21,043 48,118)	24,162 [23,044] (20,946 29,554)	21,501 [20,887] (18,439 24,793)
MSYR^{1+}	0.046 [0.048] (0.022 0.064)	0.046 [0.047] (0.024 0.062)	0.046 [0.048] (0.021 0.064)	0.046 [0.048] (0.023 0.063)	0.047 [0.048] (0.032 0.061)	0.049 [0.050] (0.028 0.065)
MSYL^{1+}	0.656 [0.669] (0.532 0.725)	0.648 [0.663] (0.529 0.721)	0.654 [0.670] (0.520 0.725)	0.654 [0.664] (0.537 0.725)	0.663 [0.673] (0.568 0.722)	0.668 [0.676] (0.577 0.733)
P^{1+}_{2009} / K^{1+}	0.849 [0.919] (0.393 1.006)	0.819 [0.908] (0.358 1.003)	0.837 [0.917] (0.355 1.008)	0.855 [0.913] (0.428 1.005)	0.957 [0.975] (0.881 0.985)	0.958 [0.974] (0.906 0.984)
P^{1+}_{2009} / $MYSL^{1+}$	1.288 [1.366] (0.681 1.508)	1.253 [1.357] (0.642 1.502)	1.270 [1.361] (0.632 1.504)	1.301 [1.366] (0.748 1.512)	1.446 [1.442] (1.344 1.608)	1.438 [1.436] (1.314 1.607)
P^{1+}_{2009}	20,366 [20,447] (17,515 23,127)	20,380 [20,372] (17,708 23,139)	19,752 [19,817] (16,925 22,432)	21,654 [21,594] (18,607 24,683)	22,781 [22,456] (20,432 26,047)	20,337 [20,283] (17,912 23,050)
λ_{max}	1.062 [1.063] (1.032 1.088)	1.063 [1.064] (1.037 1.088)	1.062 [1.063] (1.032 1.088)	1.063 [1.064] (1.034 1.089)	1.063 [1.062] (1.043 1.087)	1.065 [1.065] (1.037 1.090)
S_{1+}	0.981 [0.982] (0.957 0.997)	0.981 [0.982] (0.957 0.997)	0.980 [0.982] (0.957 0.997)	0.981 [0.982] (0.957 0.998)	0.982 [0.984] (0.959 0.997)	0.980 [0.982] (0.958 0.997)
S_0	0.711 [0.732] (0.423 0.950)	0.711 [0.729] (0.420 0.949)	0.710 [0.728] (0.420 0.949)	0.708 [0.725] (0.425 0.949)	0.705 [0.716] (0.420 0.950)	0.720 [0.732] (0.426 0.954)
$\tilde{S}$	0.863 [0.865] (0.772 0.951)	0.860 [0.862] (0.763 0.958)	0.862 [0.862] (0.775 0.950)	0.855 [0.857] (0.772 0.939)	1	1

increasing since 2000. The model fits the data well, although, as in previous IWC assessments, the analyses suggest that the coefficients of variation for the abundance estimates are underestimated (by 14% median estimate). The baseline assessment estimates that this stock is currently well above MSYL^{1+} (posterior mean for P^{1+}_{2009} / MSYL^{1+} of 1.29) (Table 4). The posterior probability that the stock is currently greater than MSYL^{1+} is 0.884.

The posterior probability that the stock is currently above MSYL^{1+} is less for the baseline analysis and for the analysis in which the original abundance estimates are used ('Unrevised estimates' in Table 4) than in some earlier assessments. The reasons for this are explored using the analyses in which no allowance is made for survival having dropped in 1999–2000 ('No Event' and 'Unrevised, No event' in Table 4, see also Fig. 2) because the previous assessments did not explicitly account for the mortality event. This comparison suggests that allowing for the possibility of a catastrophic mortality event in 1999–2000 has reduced the ability to constrain the upper bound for carrying capacity because the lower 5% limit for P^{1+}_{2009} / MSYL^{1+} is notably higher for the analyses which ignore this event (Table 4). Bayes factors comparing the analyses which include a 1999–2000 catastrophic mortality event and those which do not provide support for estimating a parameter for the 1999/2000 event. For example, in the baseline analysis the *ln* (Bayes factor) value is 3.00 compared to the 'No event' model. This is interpreted as strong, but not definitive, support (Kass and Raftery, 1995) for including the catastrophic mortality parameter in the model.

The results are insensitive to changing the first year of the analysis (Table 4, Fig. 3). The key management-related results are also not sensitive to splitting the series in 1987–88, using the calf count estimates and using the 'Lo' and 'Hi' abundance estimates (Fig. 4). The results for the generalised logistic model are most comparable with the two 'No event' analyses because no account is taken of a catastrophic mortality event in 1999–2000 when fitting the generalised logistic model (see Appendix 1). While not entirely comparable, the qualitative conclusions from the generalised logistic model are identical to those from the age-structured model.

Fig. 5 shows the posterior distributions for the parameters for the baseline analysis. These posteriors show that the data update the priors for MSYR^{1+} and MSYL^{1+} to a substantial extent. The posterior for MSYL^{1+} emphasises higher values for MSYL^{1+}, which is not unexpected given that the rate of

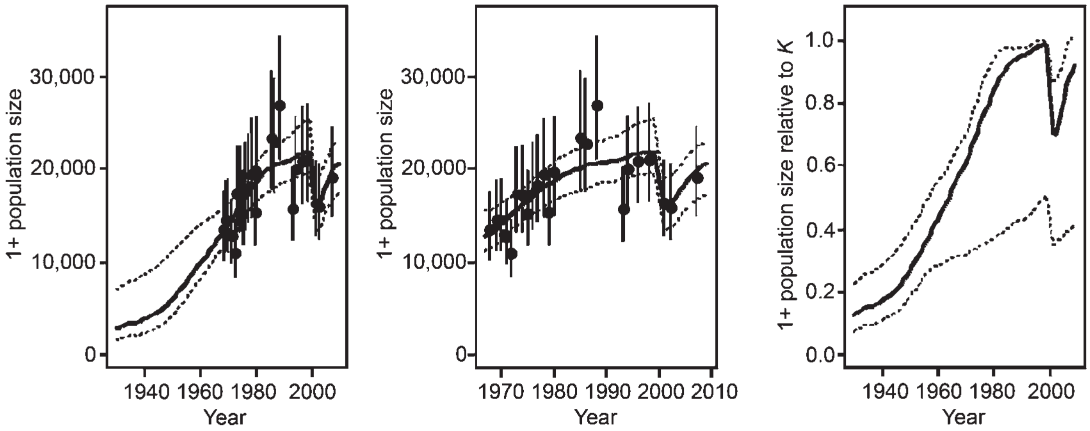

Fig. 1. Posterior distributions (medians and 90% credibility intervals) for the time-trajectories of 1+ population size (left and centre panels) and 1+ population size expressed relative to (current) carrying capacity (right panel) for the baseline analysis.

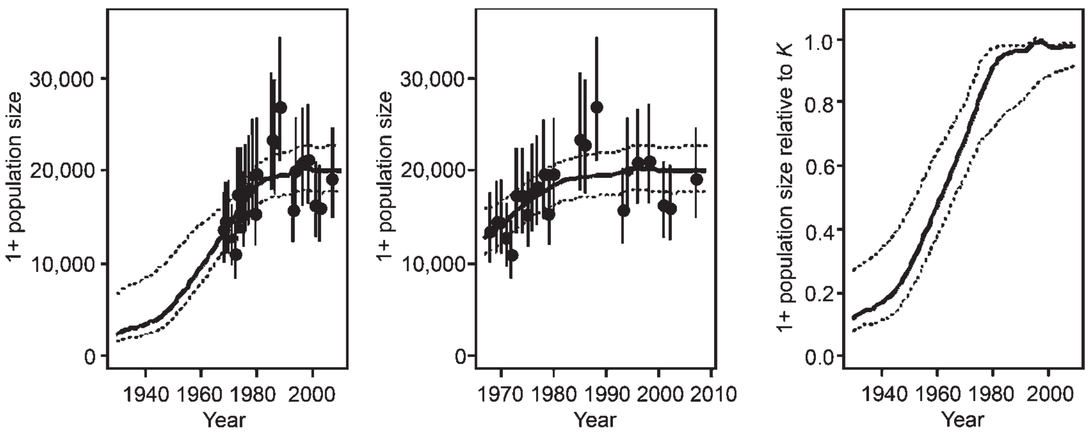

Fig. 2. Posterior distributions (medians and 90% credibility intervals) for the time-trajectories of 1+ population size (left and centre panels) and 1+ population size expressed relative to (current) carrying capacity (right panel) for the 'No Event' analysis.

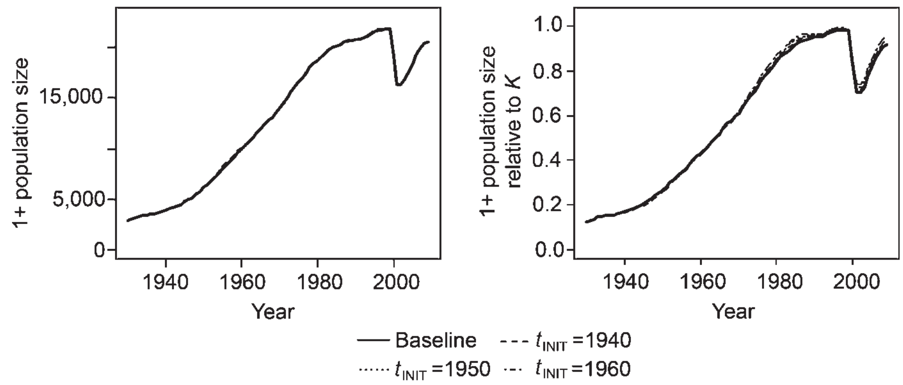

Fig. 3. Posterior median time-trajectories of 1+ population size (left panel) and 1+ population size expressed relative to (current) carrying capacity (right panel) for the baseline analysis and the sensitivity tests which vary the value for t_{INIT}.

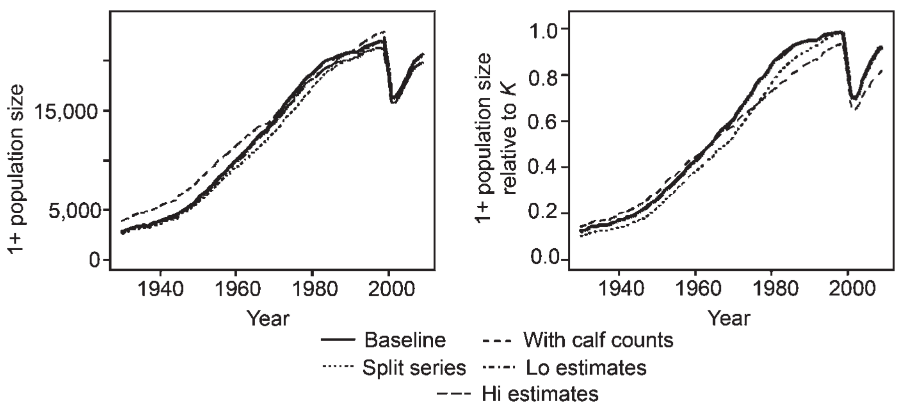

Fig. 4. Posterior median time-trajectories of 1+ population size (left panel) and 1+ population size expressed relative to (current) carrying capacity (right panel) for the baseline analysis and a subset of the sensitivity tests.

increase for the ENP gray whales is assessed to have been high until just before this population (almost) reached its current carrying capacity. The posteriors for the age-at-maturity, maximum fecundity, and adult survival place greatest support on low, high, and high values, respectively. This is consistent with the fairly high growth rates and values for $MSYR^{1+}$. The posterior for the survival multiplier is also updated substantially, with both high (close to 1) and low values (below 0.7) assigned low posterior probability. Sensitivity tests in which the bounds for the priors were widened (results not shown) did not lead to outcomes which differed noticeably from the baseline assessments.

The maximum rate of increase, λ_{max}, is well-defined in all of the analyses. The posterior mean estimates of this quantity range from 1.057 to 1.068 and are fairly precisely determined (Table 4).

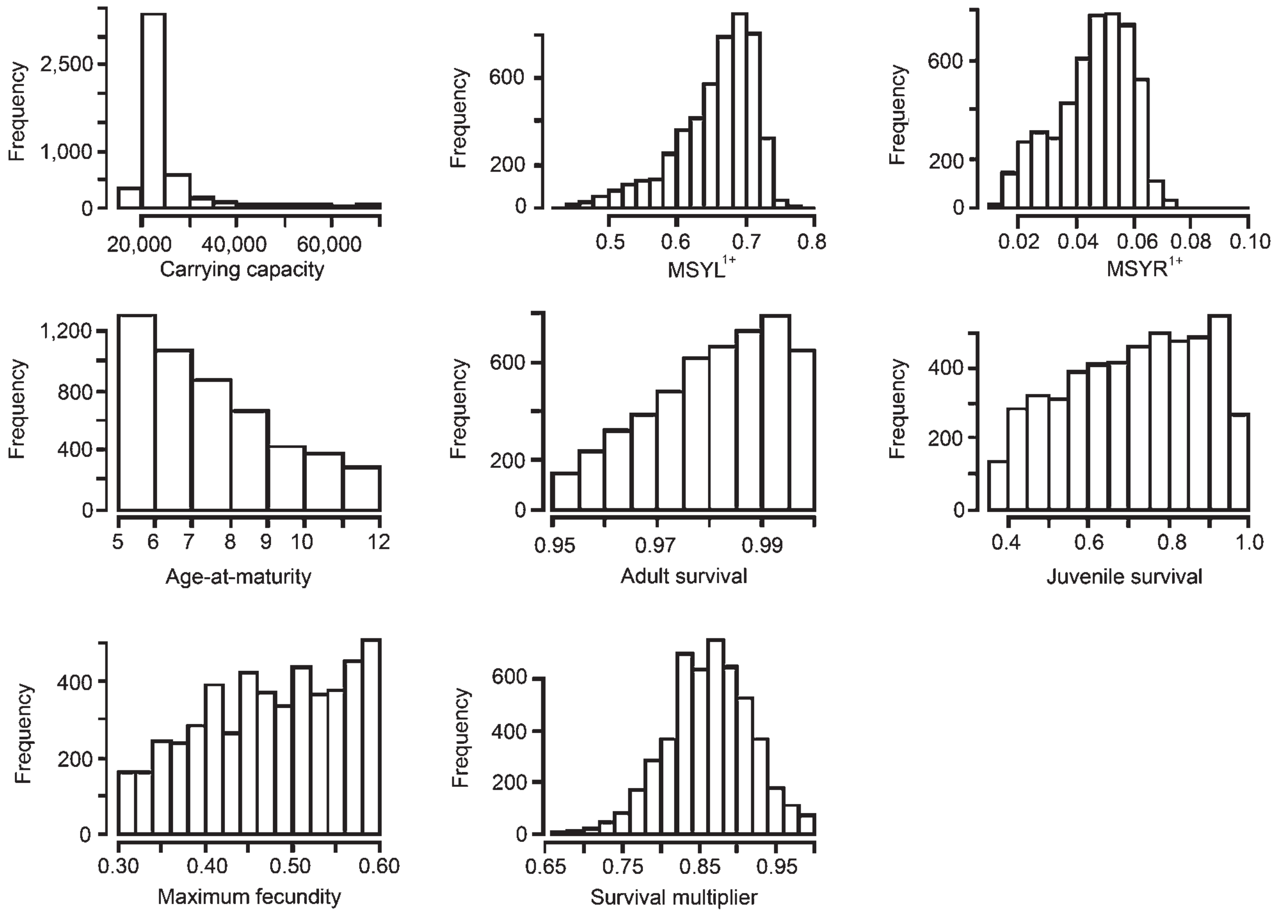

Fig. 5. Posterior distributions for the parameters of the baseline analysis.

DISCUSSION

The sensitivity tests were designed to examine the effect of various assumptions on the assessment results and to examine the effect of changes in the methods that have occurred, particularly related to abundance estimation. Overall, the results are consistent across most of the sensitivity tests with some exceptions. In particular, the baseline model fit to the unrevised abundance estimates had relatively different results from the other analyses. Leaving aside that analysis for the moment, the posterior medians for the parameters of interest were relatively consistent. Across all the other analyses, posterior means for K^{1+} ranged from 21,146 to 27,716, for the *depletion level* ranged from 0.76 to 0.96, and for the *MSYL ratio* ranged from 1.22 to 1.54. Therefore, as in previous assessments, the ENP gray whale population is estimated to be above $MSYL^{1+}$ and approaching or close to *K*. The estimates of *depletion level* and *MSYL ratio* in Wade (2002) and in Punt and Butterworth (2002) are very similar to the results presented here, although our current estimates of *K* are lower. The results in Wade and Perryman (2002) and Brandon (2009), which were the only previous assessments to use abundance estimates from the 1997/98 and subsequent surveys, gave higher and more precise estimates for *depletion level* and *MSYL ratio* than estimated here. However, in common with previous assessments, those results are superseded by this new assessment because it uses the revised abundance estimates of Laake *et al.* (In press).

The posterior means for the life history parameters were very consistent as well, with the posterior means for λ_{max} ranging from 1.057 to 1.068, non-calf survival ranging from 0.972 to 0.983, and calf survival ranging from 0.706 to 0.730. The parameter $MSYL^{1+}$ was updated to strongly emphasise higher values in the baseline analysis. There are theoretical arguments for why MSYL should be relatively higher in marine mammals than, say, marine fishes (Eberhardt and Siniff, 1977; Fowler, 1981; Taylor and DeMaster, 1993), but, in general, there has not been empirical data of sufficient quantity and quality to estimate this parameter well for marine mammals (Gerrodette and DeMaster, 1990; Goodman, 1988; Ragen, 1995). Empirical evidence that is available for large, long-lived mammals has shown convex nonlinear density-dependence in life history parameters such as age-specific birth and mortality rates (Fowler, 1987; 1994; Fowler *et al.*, 1980), which suggest MSYL > 0.5*K*. A relatively long time-series of abundance estimates has documented the recovery of harbour seal (*Phoca vitulina*) populations in Washington state, and Jeffries *et al*. (2003) estimated MSYL to be greater than 0.5*K* for these populations. In the ENP gray whale analysis here, values from 0.40 to 0.54 for $MSYL^{1+}$ have low probability in the posterior distribution (Fig. 5, Table 4) which is consistent with the conclusions of Taylor and Gerrodette (1993) that MSYL was likely to be greater than 0.5*K*. Thus, the posterior distribution for $MSYL^{1+}$ estimated here (posterior means for the baseline analysis of 0.656, range of posterior means 0.611– 0.691), suggests that the ENP gray whale population experienced a decrease in population growth only when it was relatively close to K^{1+}.

The results did not vary much for a large number of the sensitivity tests, providing assurance that the assumptions made for the baseline analysis did not have a substantial influence on the results. Changing the initial year from which the model was projected had little effect on the results, which is similar to the results seen in Punt and Butterworth (2002) for initial years ranging from 1930 to 1968, as used here. The results for the 'Lo' and 'Hi' series of abundance estimates are very similar to the baseline results, suggesting that assumptions made in calculating the abundance estimates do not have a strong influence on the results of the assessment. Additionally, splitting the abundance time series in 1987/88 did not have a substantial effect. This is particularly reassuring, because some changes in the field methods happened at that time, notably the use of a second independent observer during that and subsequent surveys (Laake *et al.*, In press). The generalised logistic model provided similar results to the 'No-event' analysis, with some small differences. This was similar to results seen in Wade (2002), where the quantitative values for some parameters were somewhat different for the generalised logistic, although the qualitative results are nearly identical in this case. That the quantitative results differ between the generalised logistic and our baseline analyses is to be expected because the analysis based on the generalised logistic did not account for the dynamics of sex- and age-structure, and also ignored time-lags in the dynamics.

The baseline analysis fits the abundance data better than in the 'No-event' analysis because it includes the catastrophic mortality event in 1999–2000 (Figs 1 and 2). Furthermore, the Bayes factor confirms that there is strong, but not definitive, evidence supporting the use of a model including the catastrophic mortality. The model estimates that 15.3% of the non-calf population died in each of the years with catastrophic mortality, compared to about 2% in a normal year. In that 2-year period, the model estimates of the population size relative to K^{1+} fell from being at 99% of K^{1+} in 1998 to 83% in 1999 and 71% in 2000, before increasing back up to 91% by 2009. In contrast, the 'No-event' analysis estimates the population had reached a level very close to K^{1+} by ~1995 and has remained there since, which clearly does not match the evidence regarding the biological effects on the population in 1999 and 2000. In the baseline analysis, the estimate of the number of whales that died in 1999 and 2000 was 3,303 (90% interval 1,235–7,988) and 2,835 (90% interval 1,162–6,389), respectively, for a combined total for the two years of 6,138 (90% interval 2,398–14,377). In comparison, the 'No-event' analysis estimates that the number of whales that died in 1999 was 587 and in 2000 it was 447. Comparing the number of strandings (from Mexico to Alaska) reported in Gulland *et al.* (2005) in the years around the mortality event to these estimates of total deaths from the baseline model indicates that only 3.9–13.0% of all ENP gray whales that die in a given year end up stranding and being reported.

The baseline analysis is more conservative regarding status relative to K^{1+} than the 'No-event' analysis. On the other hand, it can be argued that the 'No-event' analysis provides a more accurate estimation of current average K^{1+}. In other words, the baseline analysis does a better job of modelling the actual time-course of the population by including the mortality event, but it might provide an overestimate of the average recent K^{1+} by essentially considering high abundance estimates to be near K^{1+}, but lower abundance estimates to be lower than K^{1+}. The different interpretations hinge on whether K^{1+} is viewed as relatively fixed, with the 1999–2000 mortality event considered to be unrelated to density-dependence (and therefore K^{1+}), or whether K^{1+} is viewed as something that can vary from year to year, with the 1999–2000 years viewed as an event when K^{1+} itself was low. As populations increase in density, the impact of density-independent factors on population dynamics probably becomes more pronounced (Durant *et al.*, 2005; Wilcox and Eldred, 2003). The actual carrying capacity of the environment, in terms of prey available for the ENP gray whale population, is likely to vary from year to year to a greater or lesser extent due to oceanographic conditions affecting primarily benthic production. In terms of the model, the parameter K^{1+} that is being estimated is interpreted as the average carrying capacity in recent years. In the baseline analysis, the estimated K^{1+} is approximately (though not exactly) the average recent K^{1+} for the years before 1999–2000, whereas in the 'No-event' analysis, the estimate of average recent K^{1+} includes all the recent years, including 1999–2000, and is lower. This is clear from the results, where the baseline estimate of K^{1+} is 25,808 (90% interval 19,752–49,639), whereas the 'No-event' estimate of K^{1+} is substantially lower, 21,640 (90% interval 18,301–25,762).

The analysis using the original unrevised estimates is not a sensitivity test in the usual sense. Those results are provided simply to aid in interpretation of the results of the other analyses relative to past results using the unrevised estimates. For example, no previous analyses other than Brandon (2009) had used the 2006/07 abundance estimate, so this sensitivity test provides a comparison in which both analyses use that estimate. In the 'No-event' model, the analyses using the original and revised abundance estimates are nearly identical for estimates of *depletion level* and *MSYL ratio*. K^{1+} was estimated to be higher in the analysis that used the original abundance estimates, but even though K^{1+} is lower using the revised abundance estimates, overall the entire time-series is shifted such that the estimates of status relative to K^{1+} are unchanged.

In contrast, in the baseline model, the original abundance estimates give a fairly different result from any other analysis. From the discussion of how correction factors for the abundance estimates were calculated in different years in Laake *et al.* (In press), it is clear that the revised abundance estimates should be more accurate, and there were shifts of certain sequences of abundance estimates relative to one another that influence the results. For example, the three estimates from 1993/94 to 1997/98 are the three highest estimates in the original time-series, whereas the three estimates from 1984/85 to 1987/88 are the three highest estimates in the revised time-series. This has an effect on the baseline analysis results because the model is trying to fit the drop in abundance that occurred after the 1997/98 abundance estimate. That drop is substantially larger in the unrevised data set than it is in the revised data set, and therefore the results for the baseline model differ somewhat between the revised and unrevised data sets.

The only previous assessment that modelled the 1999–2000 mortality event was that of Brandon (2009), whose point estimates of total natural mortality in those years ranged from 1,300 to 5,200, depending upon a variety of assumptions he explored, lower than the 6,138 estimated here in the baseline model. The difference presumably arises because Brandon (2009) modelled mortality as a function of a sea-ice index for the Bering Sea, following the relationship found between calf production and sea-ice (Perryman *et al.*, 2002). This constrains the dynamics of the mortality in Brandon (2009) to reflect the dynamics of the index to some extent. In contrast, the 1999–2000 mortality was unconstrained in the baseline analysis here and is essentially estimated by what value fit the drop in abundance estimates best. Brandon (2009) noted this difficulty in his analysis, stating it was not possible in his analysis to fit the strandings data for the 1999–2000 mortality event without allowing for some additional process error in the survival rates during those years.

λ_{max} is estimated to be 1.062 (90% interval 1.032–1.088) in the baseline analysis. This is similar to, but a little lower than, the estimate from Wade (2002) of 1.072 (90% interval 1.039–1.126) and the estimates from Wade and Perryman (2002). The posterior for λ_{max} from the 'No-event' analysis is very similar to this, as is that from the 'No-event' analysis using the unrevised abundance estimates, indicating the lower estimates of λ_{max} seen here are not due entirely to the revision of the abundance estimates but are instead partly due to the additional four abundance estimates used here (1997/98 to 2006/07) that were not available at the time the Wade (2002) analysis was conducted. To get an estimate of λ_{max} of 1.062, the posterior distribution favoured a low age-of-maturity, a high maximum fecundity, and a high adult survival. λ_{max} appears to be well-defined, as the posterior medians from most of the sensitivity tests are very similar. It should be noted that these are theoretical estimates of the population growth rate at a very low population size, based upon the density-dependent assumptions of the population model; the ENP gray whale has not been observed to actually grow this rapidly because the population was estimated to be approaching *K* by the time its growth rate was monitored; consequently, the observed population growth rate was less than its theoretical maximum.

The small and endangered western North Pacific population of gray whales has been estimated to have an annual population increase that is between 2.5% and 3.2% per year, but there is concern that this growth rate is low because of possible Allee effects and from ongoing human-caused mortality (Bradford *et al.*, 2008). Best (1993) summarised the growth rates of eight severely depleted baleen whale populations (other than gray whales) and the values ranged from 3.1% to 14.4%. Some of these estimates were not very precise, and Zerbini *et al*. (2010) suggested that the higher rates are implausible given life-history constraints for (at least) humpback whales (*Megaptera novaeangliae*). In more recent studies of other species, a number of estimates of trend have been similar to the estimates of λ_{max} reported here. In a simulation study based on empirical estimates of life history parameters for humpback whales, Zerbini *et al.* (2010) estimated maximum rates of increase of 7.5%/year (95% CI 5.1–9.8%) using one approach and 8.7%/year (95% CI 6.1–11.0%) using a second approach. Calambokidis *et al*. (2008) calculated point estimates of 4.9% to 6.7% for the North Pacific humpback whale population using data from a recently completed North Pacific study of humpback whale abundance. Zerbini *et al.* (2006) used line transect data from sequential surveys to estimate an annual rate of increase for humpback whales in shelf waters of the northern Gulf of Alaska from 1987 to 2003 of 6.6% per year (95% CI 5.2–8.6%), and for fin whales of 4.8% (95% CI 4.1–5.4%). On the other hand, Mizroch *et al*. (2004) estimated a rate of increase for North Pacific humpback whales in Hawaii using mark-recapture methods for the years 1980–1996 of 10% per year, but the confidence limits were wide (95% CI 3–16%). Other unpublished estimates are available spanning essentially a similar range as originally reported by Best (1993) (i.e. see IWC, 2010)). In summary, the estimates of λ_{max} reported here are similar to trend estimates seen in other species, but there are also lower and higher values that have been recorded.

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Appendix 1

ANALYSES BASED ON THE GENERALISED LOGISTIC EQUATION

The dynamics of the population are assumed to be governed by the generalized logistic model:

$$N_{y+1} = N_y + rN_y(1-(N_y/K)^z) - C_y \qquad \text{(App.1)}$$

where N_y is the number of animals at the start of year y;

r is the intrinsic rate of growth;

z is the extent of compensation;

K is the (current) carrying capacity; and

C_y is the catch (in numbers) during year y.

The parameters of Equation (App.1) are r, z, and K while the data available to estimate these parameters are the estimates of abundance and their associated variance-covariance matrix. The analysis is based on the same likelihood function (Eqn (11) of the main text) and priors as the baseline analysis using the age- and sex-structured model.

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Original Article

Conserving and recovering vulnerable marine species: a comprehensive evaluation of the US approach for marine mammals

André E. Punt[1]*, Paula Moreno[2], John R. Brandon[3], and Michael A. Mathews[4]

[1]University of Washington, School of Aquatic and Fishery Sciences, Seattle, WA 98195, USA
[2]University of Southern Mississippi, Gulf Coast Research Laboratory, MS 39564, USA
[3]Independent Consultant, Pacifica, CA, USA
[4]Independent Consultant, Bryan, TX, USA

*Corresponding author: tel: +1 206 221 6319; e-mail: aepunt@uw.edu

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Human-caused mortality due primarily to bycatch in fisheries is considered a major threat to some long-lived, slow-growing, and otherwise vulnerable marine species. Under many jurisdictions these species are designated as “protected”, and fisheries are subject to a management system that includes monitoring and assessment of bycatch impacts relative to management objectives. The US management system for marine mammals is one of the most sophisticated in the world, with a limit on human-caused mortality computed using the potential biological removal (PBR), formula. Fisheries are categorized according to their impact relative to PBR, and take reduction teams established to develop take reduction plans (TRPs) when bycatch exceeds PBR. The default values of the parameters of the PBR formula were selected in the late 1990s using management strategy evaluation (MSE), but the system, in particular the classification of fisheries, has yet to be evaluated in its entirety. A MSE framework is developed that includes the PBR formula, as well as the processes for evaluating whether a stock is “strategic”, assigning fisheries to categories, and implementing TRPs. The level of error associated with fisheries classification was found not to impact the ability to achieve the conservation objective established for a stock under the US Marine Mammal Protection Act (i.e. maintain or recover the stock to/at optimum sustainable population). However, this ability is highly dependent on the life history and absolute abundance of the species being managed, as well as on the premise that bycatch is reduced if bycatch is estimated to exceed the PBR. The probability of correctly classifying fisheries depends on both the coefficient of variations (CVs) of the estimates of bycatch and the marine mammal stock’s abundance because classification depends on the ratio of the estimate of bycatch by fishery-type to the stock’s PBR, and the precision of the former depends on the bycatch CV and the latter on the abundance estimate CV. Moreover, the probability of correctly classifying a fishery decreases for smaller populations, particularly when a fishery has low to moderate impact.

Keywords: bycatch, conservation, fishery management, management strategy evaluation, marine mammals, MMPA, PBR, simulation

Introduction

Human-caused mortality due primarily to bycatch in fisheries is considered a major threat to some long-lived slow-growing marine species, including several stocks of marine mammals (e.g. Read *et al.*, 2006; Reeves *et al.*, 2013). Species subject to incidental mortality are often consequently designated as “protected”, and the fisheries that are the source of incidental mortality managed to reduce impacts. The “potential biological removal (PBR) approach”, which involves the calculation of a limit on human-caused mortality, is written into the 1994 amendments to the US Marine Mammal Protection Act (MMPA, originally enacted in 1972), and has been considered for several other long-lived species worldwide subject to incidental mortality. Examples include: marine mammals in Canada (e.g. Hammill and Stenson, 2007;

Stenson *et al.*, 2012) and the United Kingdom (Butler *et al.*, 2008); pilot whales (*Globicephala macrorhynchus*) in Japan (Kanaji *et al.*, 2011); dugongs (*Dugong dugon*) in the Torres Strait, between Australia and Papua New Guinea (Marsh *et al.*, 2004); and sea-birds (Dillingham and Fletcher, 2011), sea-lions (*Phocarctos hookeri;* Maunder *et al.*, 2000), seabirds (Richard and Abraham, 2013), and Hector's dolphins (*Cephalorhynchus hectori*) in New Zealand (Slooten and Dawson, 2008; Slooten, 2013).

The PBR is calculated by applying a harvest control rule (or in this context a removal control rule) that is the product of three parameters: (i) a minimum estimate of abundance that "provides reasonable assurance that the stock size is equal to or greater than the estimate" (N_{MIN}); (ii) one-half of the maximum intrinsic rate of population growth (0.50 R_{MAX}); and (iii) a recovery factor (F_R) between 0.1 and 1.0 (Wade, 1998), i.e.:

$$\text{PBR} = N_{MIN} 0.50\, R_{MAX} F_R \quad (1)$$

Within the United States, the default values of parameters of the PBR formula are $R_{MAX} = 0.04$ for cetaceans and 0.12 for pinnipeds, N_{MIN} = the lower 20th percentile of the (log-normal) distribution for recent abundance estimates, and F_R selected depending on the status of the stock (Wade, 1998). These default values were selected by Wade (1998) using a management strategy evaluation (MSE) approach (Punt *et al.*, 2016) to achieve a primary goal of the MMPA, which is to allow stocks of marine mammals to be maintained at or above their optimum sustainable population (OSP) level (MMPA, 1972). To capture uncertainty associated with management of marine mammal (and other protected) species subject to incidental mortality, the MSE considered scenarios related to productivity, the value for maximum net productivity level (MNPL), the proxy for OSP, the precision and bias with which estimates of abundance are obtained, and how close estimated incidental catches are to the PBR (Wade, 1998).

Although the PBR approach has been the subject of substantial simulation testing (e.g. Wade, 1998; Taylor *et al.*, 2000; Brandon *et al.*, 2017), those simulation studies made assumptions that do not fully capture the actual manner in which human-caused mortality of marine mammals is managed with respect to commercial fisheries in the United States and likely other jurisdictions where fishery interactions with protected species are managed.

Areas were the earlier simulation tests do not mimic the actual US management system include that removals of marine mammals were assumed to be normally distributed about the PBR. In addition, the PBR formula is only one part of the management system. Specifically, the US management system also involves determining whether a stock is "strategic", classifying fisheries based on the magnitude of the mortality and serious injury (MSI) they cause relative to PBR; establishing take reduction teams (TRTs) if thresholds are exceeded, and implementing take reduction plans (TRPs) for those fisheries (Figure 1). Importantly, for the US system, only stocks that are assessed to be strategic and fisheries assessed to have frequent or occasional interactions need to be managed (although restrictions can and have also been placed on fisheries with a low chance of interactions). A full evaluation of the management system that accounts for the common sources of uncertainty associated with making these assessments (whether a stock is strategic and classifying fisheries) is needed since management measures to limit incidental mortality of marine species focus to a large extent on limiting bycatch in fisheries. Systems for management marine mammal bycatch elsewhere in the world (such as that used in New Zealand to manage the impact of the fishery for squid on Hooker's sea lions) are similar to that the US system, but there is no formal process for assessing species to be strategic and classifying fisheries in terms of their impacts on Hooker's sea lions.

This article develops a MSE framework that mimics the US system for managing marine mammal–fishery interactions, to the extent that it is possible to represent this system within a set of rules that can be simulated. It then examines the implications, in terms of achieving the primary goal of maintaining stocks at/above their OSP size, of various uncertainties not considered by Wade (1998), Taylor *et al.* (2000), and Brandon *et al.* (2017),

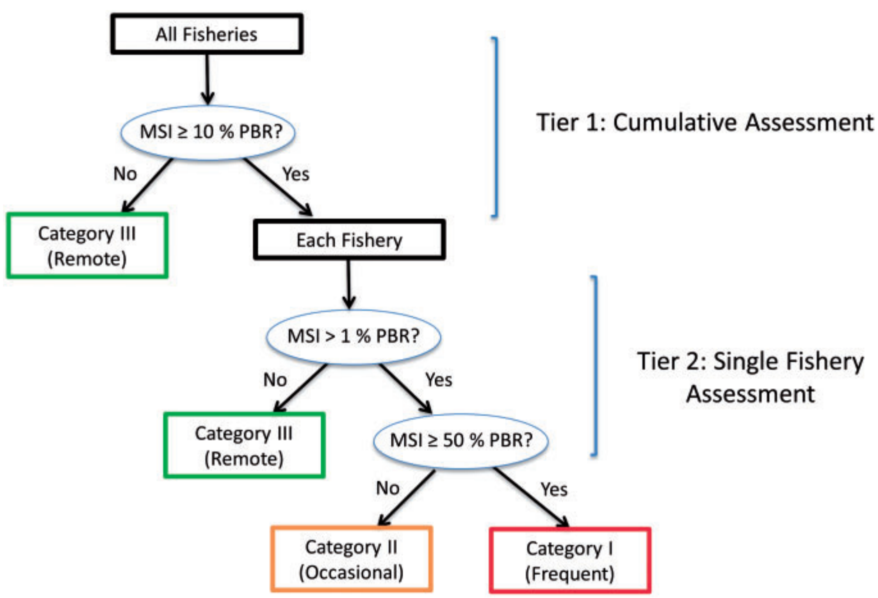

Figure 1. Process followed to develop Take Reduction Plans and establish bycatch reduction goals. MSI = Mortality and Serious Injury; ESA = Endangered Species Act. This study addresses the strategic stock i.e. where the stock is depleted.

in particular the impact of demographic stochasticity, which is likely pertinent for several cetacean stocks as they are of sizes at which demographic uncertainty may be influential. This article then explores the performance of the management system when there are multiple fisheries and different levels of monitoring of abundance and incidental mortality.

The analyses evaluate (i) the probability of mis-classifying a stock as non-strategic and hence the conservation implications of failing to trigger management actions, and (ii) the probability of incorrectly classifying fisheries given uncertainty in estimates of removals and abundance. The use of these performance metrics therefore extends the analyses of Wade and DeMaster (1999) who explored the probability of mis-classifying stocks as strategic. The analyses consider a variety of scenarios to explore the effects of uncertainty. In particular, the analyses consider scenarios that vary the frequency and precision with which estimates of abundance become available as this may have an impact on the ability to correctly identify a stock as strategic and classify fisheries. It also includes scenarios that vary the precision of estimates of bycatch among fisheries, which will also influence the ability to correctly identify a stock as strategic, as well as the ability to correctly identify the fisheries that are likely to be having the largest impacts on the stock. Simulations were performed under two constraints: (i) once a stock is designated strategic it remains strategic throughout the simulation and (ii) classification of fisheries is performed every 5 years.

Methods

Overview of MSE

MSE is the use of simulation to assess the performance of management strategies (combinations of data collection schemes, methods for analysing the data collected, and harvest/removal control rules). MSE has been used extensively to evaluate management strategies for fish, invertebrate and marine mammal stocks (Punt and Donovan, 2007; Punt *et al.*, 2016) and has also been recommended for application in terrestrial situations (e.g. Bunnefeld *et al.*, 2011). It involves the development of an "operating model" that represents the system being managed and how the system is monitored. In this case, the operating model includes the marine mammal stock, the fisheries that cause incidental mortality, and how monitoring occurs for abundance and incidental mortality (Figure 2). Several versions of the operating model are created to allow various sources of uncertainty to be represented. The second major component of an MSE is the management strategy. In the case of the US marine mammal management system, the management strategy includes the PBR formula as well as the rules for determining if a stock is strategic, classifying fisheries in terms of their impact on marine mammal stocks and recommended management measures. The overall steps of an MSE are: (i) develop the operating model; (ii) specify the sources and range of uncertainties to be considered and thereby the "simulation experiments" to be undertaken; (iii) define performance metrics that quantify the management objectives; (iv) select the candidate management strategies; (v) conduct projections; and (vi) summarize the results (Punt *et al.*, 2016).

A MSE for the US marine management system

The PBR applies to all sources of incidental human-caused MSI experienced by stocks of marine mammals. Consequently, human-caused "mortality" in the MSE is understood to encompass both outright deaths and serious injuries, i.e. MSI. For the purposes of this article, only MSI due to fisheries is modelled.

Biological component of the operating model

The biological component of the operating model is an age- and sex-structured population dynamics model that operates on integers (Equation T1.1), where the numbers of births and deaths are binomial random variables. The number of calves produced each year depends on the number of females that have reached the age of first parturition (Equation T1.4) and a birth rate that is density-dependent, with the extent of density-dependence a function of the abundance of animals aged 1 and older relative to carrying capacity (Equation T1.5) (Table 1).

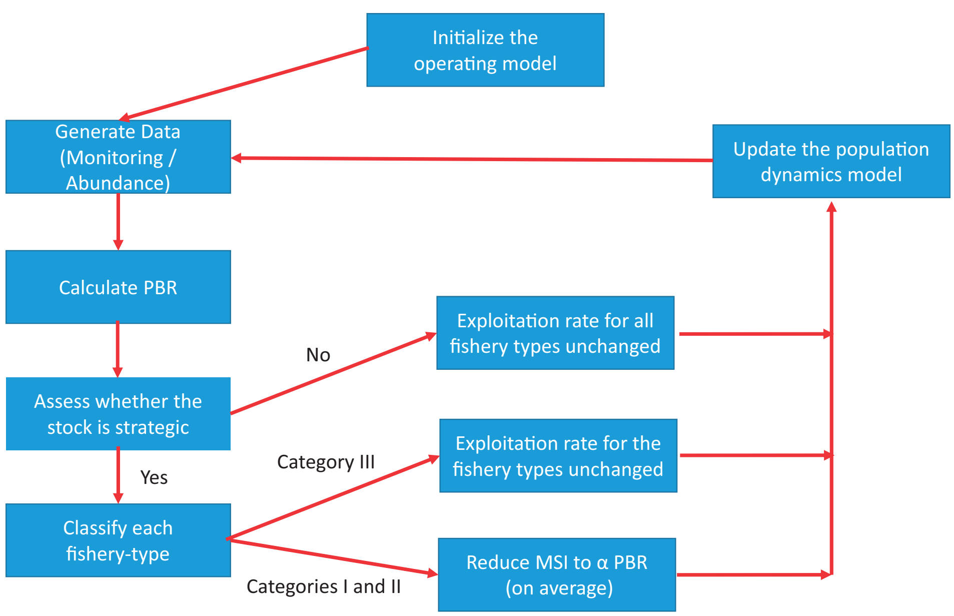

Figure 2. Overview of the steps for the MSE.

Table 1. The population dynamic equations underlying the operating model.

Equation No	Equation	Description
Population dynamics		
T1.1	$N^s_{t+1,a} = \begin{cases} B(C_{t+1}, 0.5) & \text{if } a = 0 \\ B\left(N^s_{t,a-1} - M^s_{t,a-1}, S_{a-1}\right) & \text{if } 1 \le a < x \\ B\left(N^s_{t,x-1} - M^s_{t,x-1}, S_{x-1}\right) + B\left(N^s_{t,x} - M^s_{t,x}, S_x\right) & \text{if } a = x \end{cases}$	Basic population dynamics
T1.2	$B(z,p)$	Binomial distribution with parameters *z* and *p*
T1.3	$C_t = B(P_t, b_t)$	Calf production
T1.4	$P_t = \sum_{a=a_p}^{x} N^{fem}_{t,a}$	Breeding females
T1.5	$b_t = b_{eq}\max\left\{0, 1 + \left(b_{max}/b_{eq} - 1\right)\left[1 - \left(N^{1+}_t/K^{1+}\right)^{\theta}\right]\right\}$	Density-dependent birth rate
T1.6	$N^{1+}_t = \sum_s \sum_{a=1}^{x} N^s_{t,a}$	Number of animals aged 1 and older
T1.7	$M^s_{t,a} = \sum_{f=1}^{N_f} M^{s,f}_{t,a}$	Human-caused mortality by sex and age
T1.8	$M^{s,f}_{t,a} = B\left(N^s_{t,a} - \sum_{f'=1}^{f-1} M^{s,f'}_{t,a}, \phi^{s,f}_s \tilde{F}^f_t\right)$	Human-caused mortality by sex, age, and fishery-type
T1.9	$\tilde{F}^f_t = F^f_t / \left(1 - \sum_{f'=1}^{f-1} F^{f'}_t\right)$	Effective removal rate by fishery-type
Data generation		
T1.10	$\hat{N}_t = \beta N^{1+}_t e^{\epsilon_y - \sigma^2/2}\ \epsilon_y \sim N(0;\sigma^2)$	Estimates of abundance

Table 2 provides the definitions for the symbols.

Table 2. The symbols included in the specification of the operating model.

Symbol	Description
C_t	Number of calves at the start of year *t*
F^f_t	Unconditional removal rate for fully-vulnerable animals during year *t* (i.e. the probability of a fully-vulnerable animal being removed during year *t* by fishery-type *f*)
$\tilde{F}^f_t$	Removal rate for fully vulnerable animals that have survived fishery-types 1, 2,. . ., *f*–1
K^{1+}	Carrying capacity in terms of the number of animals aged 1 and older
$\hat{M}_t$	Estimate of the mortality during year *t*
$\hat{M}^f_t$	Estimate of the mortality by fishery-type *f* during year *t*
$M^s_{t,a}$	Human-caused mortality of sex *s* and age *a* during year *t*
$M^{s,f}_{t,a}$	Human-caused mortality of sex *s* and age *a* by fishery-type *f* during year *t*
N^f	Number of fishery-types
$\hat{N}_t$	Estimate of the number 1+ animals at the start of year *t*
$N^s_{t,a}$	Number of animals of age *a* and sex *s* (m/fem), at the start of year *t*
N^{1+}_t	Number of animals aged 1 and older at the start of year *t*
P_t	Number of females that have reached the age of first parturition (a_p) at the start of year *t*
S_a	Survival rate for animals of age *a*
a_p	Age-at-first parturition
b_t	Birth rate during year *t*
b_{eq}	Birth rate when the population is at carrying capacity; $b_{eq} = (\sum_{a=a_p}^{s} \tilde{N}^{fem}_a)^{-1}$
b_{max}	Birth rate in the limit of zero population size
x	Plus-group age (values for the population dynamics parameters, including human-caused mortality rates, are the same from age *x* onwards)
β	Extent of bias in the abundance estimate
$\phi^{s,f}_a$	Relative vulnerability of animals of age *a* and sex *s* to fishery-type *f*
θ	Shape parameter, which determines where MNPL occurs relative to carrying capacity
σ	The standard error of the observation errors, i.e. $\sigma^2 = \ell n(1 + CV^2_N)$, where CV_N is the coefficient of variation about the true abundance
χ	Relative 1+ population size at the start of the projection period

The number of animals by age and sex in the unfished state (years −500 or −30) are computed based on a pre-specified value for the number of 1+ animals and the relative numbers by age in the unfished state. The age and sex structure at the start of the first year that the management system is applied (year 0) is computed by projecting the population forward to year 0 under a constant probability of being bycaught and solving for this probability, $\bar{F}^f$ (i.e. $F^f_t = \bar{F}^f$) so that the number of 1+ animals at the start of the first year relative to K^{1+} (the carrying capacity in terms of 1+ animals) equals a pre-specified value, χ.

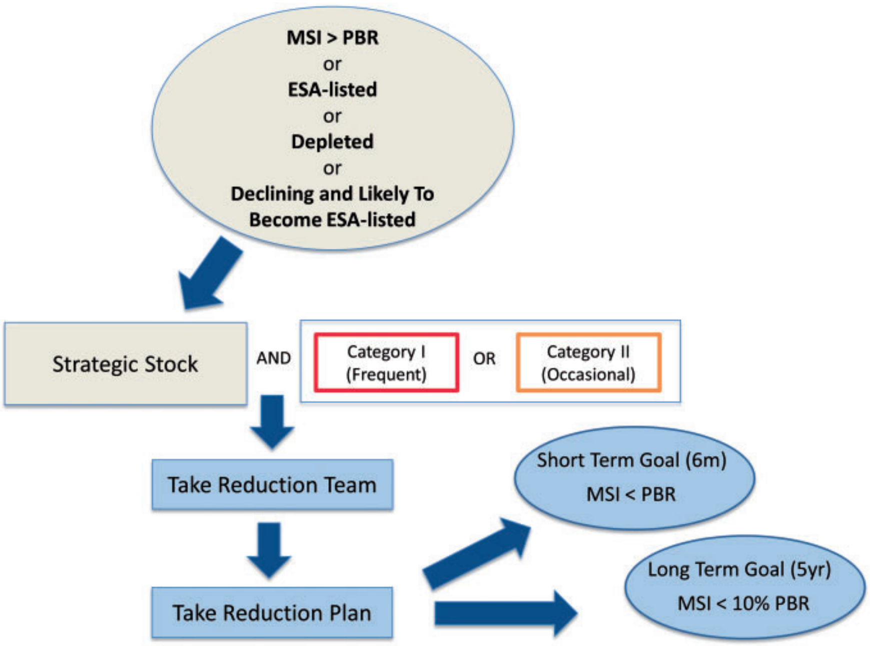

Figure 3. Decision tree for classification of fisheries based on percent of PBR removed annually. MSI = Mortality and Serious Injury. Simulations are performed for the Tier 2 step in 5-year steps.

The operating model assumes that there are several (N_f) fishery-types (i.e. fishing fleets using similar fishing practices in terms of bycatch risk to marine mammal stocks), each of which can potentially lead to mortality or serious injury. Human-caused mortality (Equation T1.7) is hence the sum over fishery-types of the mortality by fishery-type. The fishery-types are assumed to be sequential for computational ease, i.e. bycatch in fishery-type 1 occurs first, followed by bycatch in fishery-type 2, etc (Equation T1.8). The operating model allows vulnerability to differ between sex and age-classes. The fully vulnerable removal rates (i.e. the removal rate for animals for which vulnerability is highest) in Equation T1.8 are set so that the unconditional removal rate for fully vulnerable animals is achieved (Equation T1.9).

The operating model is parameterized for three species of cetaceans, representing baleen whales (the humpback whale *Megaptera novaeangliae*; and the bowhead whale *Balaena mysticetus*) and toothed whales (bottlenose dolphin *Tursiops truncatus*). These species were selected because the goal of the paper was to focus on cetaceans, since this group accounts for the majority of US marine mammal stocks. We include species from baleen and toothed whales to cover a range of life-history types with adequate information available for the parameters required. Also, the species selected have US stocks of high management priority (i.e. strategic stocks managed under the PBR framework) and stocks that are subject to fisheries mortality identified as a threat in the NMFS Stock Assessment Reports. A "generic" marine mammal is included to allow for comparisons with the analyses conducted by Wade (1998).

Data generation

The sampling error for the estimates of estimates of abundance is assumed to be log-normal (Equation T1.10). Estimates of abundance are assumed to become available every fourth year starting in year 9 for the bulk of the analyses. The true bycatch in year t is $M_t = \sum_f \sum_s \sum_a M^{s,f}_{t,a}$. The bycatch used when applying the management system is an estimate based on observing some pre-specified fraction of trips. The estimated bycatch during year t by fishery-type f, $\hat{M}^f_t$, is generated by first generating the observed bycatch (i.e. the bycatch observed if a proportion r^f of hauls/trips is observed) and dividing the resulting value by r^f. Bycatch is assumed to be clumped so the observed bycatch is assumed to be beta-binomial distributed where the actual proportion of bycatch observed, r^f_t is beta distributed with mean r^f and a pre-specified coefficient of variation (CV), and $\hat{M}^f_t$ is then generated from $B(M^f_t, r^f_t)$ where $M^f_t = \sum_s \sum_a M^{s,f}_{t,a}$.

The PBR and classification of fisheries are updated every 5 years based on the estimates of MSI and abundance available at that time. To mimic the actual management system, it is assumed that it takes 2 years to process and analyse bycatch data prior to their use in management (i.e. the bycatch data used when determining management actions for year 0 are for years -2, -3, etc), while this delay is 3 years for the estimates of abundance.

The management strategy

The management strategy being evaluated involves four steps; (i) calculation of the PBR; (i) determination of whether the stock is strategic; (iii) classifying each fishery-type to a Category (I, II, or III); and (iv) implementation of management actions to reduce bycatch rates (if this is warranted given the results of steps a, b, and c) (Figures 2 and 3).

The PBR formula

The PBR formula (Equation 1) depends on three inputs. The minimum abundance estimate (N_{MIN}) is calculated given the assumption of log-normal sampling error:

$$N_{\min} = N' \exp\left(-z\sqrt{\ln(1 + CV(N')^2)}\right) \qquad (2)$$

where $N^{'}$ is the most recent estimate of 1+ abundance, while R_{MAX} depends on whether the species is a cetacean or a pinniped (Wade, 1998). Barlow *et al.* (1995), Wade (1998), and Brandon *et al.* (2017) outline how the default values for z and F_R are calculated using the results of simulated application of the PBR approach. The value of z is set to 0.842 (corresponding to N_{MIN} being the lower 20th percentile of the distribution for the estimate of abundance) following Wade (1998). The default values for F_R may vary between 0.1 and 1, where endangered stocks are assigned a value of 0.1 and threatened, depleted or stocks of unknown status are assigned a value of 0.5. F_R is set to 1 for the bulk of the analyses of this article. Sensitivity to the expected ratio of the bycatch to the PBR (which is equivalent to F_R) is also explored through the scenarios in which management effectiveness (α) is varied (see below).

Assessing if a stock is strategic

In the United States, a stock can be designated as "strategic" if it is listed or likely to become listed under the US Endangered Species Act (ESA), if it is "depleted" (defined under the MMPA as a stock that is below OSP), or if (estimated) MSI exceeds PBR. It is beyond the scope of this article to model how species are listed, or likely to become listed, under the ESA so this aspect of the management system is ignored. Assessing whether a stock is "depleted" involves conducting a regression of log-abundance on year, then calculating the reduction in abundance over the period between the first abundance estimate and the present year, and assessing whether the resulting reduction is >0.5. This procedure mimics the rule of thumb that is used by the NMFS to assess whether a stock is "depleted" (NMFS, 2016). Evaluating whether MSI is greater than PBR involves computing the average of estimates of human-caused mortality over the 5 years prior to the year when the PBR is updated, and comparing that with the PBR for the current year (NMFS, 2016). A stock is designated as strategic if the average bycatch (MSI) exceeds PBR. This evaluation is conducted every 5 years.

Assignment of fisheries to categories

The primary task of the team charged with reducing bycatch is to develop a plan that identifies ways to reduce MSI below PBR within 6 months and to reduce MSI below 10% of PBR within 5 years [i.e. zero mortality rate goal (ZMRG)] taking into consideration the feasibility of proposed measures (costs to the fishing industry, available gear technology, etc.) and existing fishery management plans. Fishery-types are assigned to Categories (Category I: Frequent; Category II: Occasional; Category III: Remote) depending on the (estimated) amount of fisheries bycatch (or MSI) by fishery-type relative to PBR (Figure 3). Each fishery is categorized using the average of the MSI for the most recent 5 years. This fisheries classification is conducted every 5 years, which is a simplification of the actual procedure used to classify fisheries. The 5-year interval was selected to coincide with the timeframe established for the ZMRG (i.e. long-term goal to reduce bycatch).

Implementation of management actions

The impact of the management system on the stock's rate of recovery to MNPL depends on whether the stock is strategic, how each fishery-type is classified, and the extent to which management measures (mandatory or voluntary) to reduce bycatch are implemented. The actual removal rate, F_t^f (Equation T1.9), is beta distributed about its expected value with pre-specified CV, CV^f while the value of the expected removal rate for fleet f depends on the fishery classifications.

(i) The expected removal rate for all fishery-types remains unchanged from that for the previous year if the stock is not yet assessed to be strategic.

(ii) If the stock is strategic, the expected removal rates for fishery-types assigned to Category I or Category II are reduced to a factor (α) multiplied by the ratio of the PBR to the number of available animals, reflecting that the fishery-types should be managed to allow for recovery, i.e. the expected removal rate for fully-vulnerable animals for fishery-type f is given by $\alpha\,\Omega^f\, PBR_t / \sum_s \sum_a \phi_a^{s,f} N_{t,a}^s$ where $\phi_a^{s,f}$ is the relative vulnerability of animals of sex s and age a to fishery-type f, and Ω^f is the proportion of total mortality due to fishery-type f, which is determined by the scenario under consideration. The value of α relates to the extent to which recovery is enhanced, with $\alpha = 0.1$ representing the goal that MSI is reduced to <10% of PBR within 5 years [the zero mortality rate goal (ZMRG)]. The default value for α is 1 following Wade (1998), but sensitivity is explored to alternative values (0.1, 0.5, and 2).

Operating model parameterization

The parameters that define the population dynamics model are: carrying capacity (K^{1+}), age at first parturition (a_p), the survival rates for ages 0 and 1+, maximum birth rate (b_{max}), the parameter that determines the ratio of MNPL to carrying capacity θ, and initial depletion (χ) (Tables 3 and 4). The value for b_{max} is computed based on a pre-specified value for the maximum rate of increase λ_{max}, which is assumed to be 1.04 for most simulations for consistency with the analyses of Wade (1998), while the value of θ is computed from the value for MNPL (Punt, 1999). MNPL is thought to occur between 50 and 85% of carrying capacity for marine mammals (e.g. Taylor and DeMaster, 1993), with the base value for the simulations set to 0.5 following Wade (1998).

The parameter values for the "generic" marine mammal match the assumptions made by Wade (1998) during the development of the PBR formula. Wade's (1998) analyses used a production model as the operating model, but that does not actually represent a life history typical of any marine mammal—this case is included to allow comparison with previous work. To this end (i.e. for comparability with Wade, 1998) initial depletion is assumed to be $0.3K^{1+}$ for most scenarios. The FORTRAN code for the MSE model is available from: https://github.com/PBR-FullMSE.

Scenarios

Table 4 lists the values for the factors considered in the simulations. The range for the bycatch and abundance estimate CVs capture those used in the simulation studies by Wade (1998) and Brandon *et al.* (2017). These factors are used to develop four simulation experiments (Table 5).

(i) Experiment no. 1. Previous evaluations of the performance of the PBR approach ignored demographic stochasticity. This experiment involves conducting projections for the case of a single fishery-type for five levels of carrying capacity, K^{1+} (with lower population sizes leading to greater extents of demographic stochasticity through the assumed

Table 3. The values for the biological and fishery parameters of the operating model.

Parameter	Humpback whale	Bottlenose dolphin	Bowhead whale	Generic[a]
Age-at-first parturition, a_p	11 years (Zerbini *et al.*, 2010)	7 years[b]	18 years (IWC, 2016)	1 year
Calf survival, S_0	0.90 (Zerbini *et al.*, 2010)	0.5 (Wells *et al.*, 2005)	0.944 (IWC, 2016)	0.90
Adult survival, S_a $(a > 0)$	0.95 (Zerbini *et al.*, 2010)	0.951 (Speakman *et al.*, 2010)	0.990 (IWC, 2016)	0.95
Selectivity	Age 1+	Age 1+	Age 1+	Age 1+
Plus group age	Age 15	Age 10	Age 25	Age 5
Baseline Maximum rate of increase, λ_{max}[c]	1.04	1.04	1.04	1.04

[a]Parameters selected to mimic the production model of Wade (1998).

[b]Value selected given the wide range of values reported in the literature (e.g. Stolen and Barlow, 2003; Wells, 2003; Fruet *et al.*, 2015 and a review by Vollmer and Rosel, 2013).

[c]Analyses are also conducted in which λ_{max} is set the values estimated for the Eastern Pacific humpback stock (1.064; Calambokidis and Barlow, 2004), and the Bering-Chukchi-Beaufort Seas stock of bowhead whales (1.03; Brandon and Wade, 2006), and as well as the value for a bottlenose dolphin with an age-at-maturity of 7 (1.035 Reilly and Barlow, 1986).

Table 4. Factors considered in the analyses. The values in bold are the reference values [i.e. values in the studies by Wade (1998) and Brandon *et al.* (2017)].

Factor	Levels			
Population dynamic-related				
Species-types	Humpback, bowhead, Bottlenose dolphin; generic			
Carrying capacity, K^{1+}	1000, 10000, 100000, 1000000, 10000000			
Initial depletion, χ	0.1, **0.3**, 0.45			
Maximum rate of increase, λ_{max}	**1.04,** 1.02			
MNPL	0.4, **0.5**, 0.6			
Recovery factor, F_R	1.0			
Fishery structure and impact				
Number of fishery-types	**1**, **3**			
Scenarios regarding allocation of MSI to fishery-type, Ω^f		Fishery-type		
	Scenario	1	2	3
	A	0.7	0.25	0.05
	B	0.4	0.4	0.2
	C	0.33	0.33	0.33
	D	0.5	0.49	0.01
	E	0.9	0.05	0.05
Monitoring				
Number of pre-management abundance estimates	**3**, 5, 7			
Frequency with which abundance estimates become available	2, **4**, 8 years			
Abundance estimate CV	0.1, **0.2**, 0.4, 0.6, 0.8			
Abundance estimate bias, β	**1**, 2			
Expected proportion of hauls/trips covered	**0.3**			
Bycatch estimate CV	0.1, **0.3**, 0.5, 0.7, 0.9			
Management effectiveness				
E(Bycatch / PBR), α	0.1, 0.5, **1.0**, 2.0			
CV of fishing mortality, CV^f	**0.3**			

binomial birth–death process); and biological parameters either based on the three species concerned or generic parameters that match the assumptions underlying the production function on which the simulations conducted by Wade (1998) were based. The PBR is computed setting N_{MIN} to the lower 20th percentile of the sampling distribution for the most recent estimate of abundance, R_{MAX} to 0.04, and F_R to 1. In addition to the latter default values, simulations were conducted with λ_{max} set to values representative of the species under consideration (Table 3) and F_R to 0.5, 0.2 and 0.1. The MSI starts in year 500 so the population is in quasi-equilibrium by year 0 and the stock is always assumed to be strategic so these simulations are as comparable with those of Wade (1998) and Brandon *et al.* (2017) as possible.

(ii) Experiment no. 2. This experiment extends the previous evaluation of sensitivity to parameters of the operating model conducted by Wade (1998) and Brandon *et al.* (2017) by considering three fishery-types (scenario A) and also including sensitivity to the frequency with which estimates of abundance become available, precision and bias of abundance estimates, life history parameters, the precision of the estimates of bycatch and the extent of management effectiveness. For ease of interpretation this experiment involves changing only one aspect of a reference scenario (Table 3) in turn for simulations based on the life history parameters for the four species-types and for the lowest and highest carrying capacity levels. MSI starts in year 30 for these simulations and the managed stock is always assumed to be strategic.

Table 5. The scenarios considered in the analyses.

	Experiment			
Factor	**1**	**2**	**3**	**4**
Population dynamic-related				
Species	**All**	Humpback and dolphin	Humpback and dolphin	Humpback and dolphin
Carrying capacity	**All**	**10 000 000; 1000**	**10 000 000; 1000**	10 000 000
Initial depletion	0.3	0.3	0.3	**All**
λ_{max}	1.04	**1.02, 1.04**	1.04	1.04
MNPL	0.5	**0.4, 0.5, 0.6**	0.5	0.5
Recovery Factor (F_R)	**1**	**1**	**1**	**1**
Fishery structure and impact				
First year with MSI	−500	−30	−30	−30
Number of fishery-types	1	3	3	3
Allocation scenarios	N/A	A	**A-E**	A
Monitoring				
Number of pre-management abundance estimates	3	3	3	**3, 5, 7**
Frequency with which abundance estimates become available	4	**2, 4, 8**	4	4
Abundance estimate CV	0.2	**0.2, 0.8**	**All**	**0.2, 0.8**
Abundance estimate bias, β	1	**1, 2**	1	1
Bycatch CV	0.3	**0.3, 0.9**	**All**	0.3
Management effectiveness				
E(Bycatch/PBR), α	1.0	**All**	1.0	1.0
Cases	24	96	500	12

Each experiment consisted of 1000 simulations over 100 years. The entries in bold are varied in the experiment. For definitions of "All", see Table 1.

(iii) Experiment no. 3. This experiment explores how well it is possible to detect whether a stock is strategic and to assign a fishery-type to the correct Category (I, II, or III) as a function of precision of the estimates of bycatch and absolute abundance, and how the precision of abundance estimates and bycatch impacts the ability to rebuild stocks to OSP and maintain them there. This experiment is based on the life history parameters for the humpback whale and the bottlenose dolphin. MSI starts in year 30 for these simulations, and analyses are conducted for the lowest and highest carrying capacity levels. MSI is caused by three fishery-types and five scenarios regarding the relative impact of the fishery-types are explored. Unlike experiments 1 and 2, the rules for assessing whether a stock is strategic and classifying fisheries are applied. The value of α was set to 1 for this experiment to ease the interpretation of the probability of over- and under-classification error.

(iv) Experiment no. 4. This experiment explores the ability of the monitoring system to correctly detect whether a stock is strategic and classify fisheries as a function of the number of estimates of abundance before the management system is first applied and the abundance estimate CV, as well as for different levels of initial depletion of the stock (stock size relative to unfished stock size). This experiment is based on the life history parameters for the humpback whale and the bottlenose dolphin. MSI starts in year -30 for these simulations, and results are conducted for the lowest and highest carrying capacity levels. The fishery-types follow scenario A.

Each scenario involves 1000 replicates of a 100-year projection period. This number of replicates is sufficient to enable differences among scenarios to be detected.

Results

Experiment 1

Figure 4a plots the probability that the number of age-1+ animals exceeds MNPL ($0.5K^{1+}$) at the end of the 100-year projection period (henceforth denoted P-MNPL) as a function of K^{1+} and Figure 4b shows the lower 5th percentile of the ratio of the final 1+ numbers to K^{1+} (N_{fin}/K) when there is one fishery-type and the recovery factor, F_R, is set to 1. Results are shown in Figure 4a and b for the four species-types. The expectation would be that P-MNPL would be 0.95 and the lower fifth percentile of N_{fin}/K would be 0.5 (dashed lines in Figure 4a and b). This is indeed almost the case for the "generic" marine mammal when K^{1+} equals the largest three values considered (i.e. $K^{1+} \geq$ 100 000, which corresponds to initial population size > 30 000). However, P-MNPL < 0.95 and $N_{fin}/K < 0.5$ for lower values for K^{1+} for the "generic" marine mammal and for all values for K^{1+} for the other species-types. P-MNPL $\geq$ 0.95 decreases with reductions in K^{1+}, i.e. smaller initial population size for the "generic" marine mammal and increases for the other three species-types. This can be attributed to the effects of demographic uncertainty, which means that the distribution for population size at the end of the projection is wider for lower values of K^{1+} (illustrated for the humpback whale in Figure 4e and f). A consequence of this additional variation is that the probability of being above 0.5 K is higher for cases in which the median value for final population size is less than 0.5 K (Figure 4e) and vice versa (Figure 4f).

The production functions (production above replacement vs. relative abundance) for the four species-types are the same (Figure 5, left panel), but the removal rate at which MNPL is achieved is lower for the humpback whale, the bottlenose dolphin and (particularly) the bowhead whale, with the MNPL removal rate for the bowhead whale being 0.75 of that for the "generic" marine mammal. The four species-groups have very similar rates of natural mortality and identical assumed maximum rates of increase. However, they differ in terms of age-at-maturity, suggesting that the reason for the difference in the removal rate at which production is greatest relates to age-structure effects, with higher ages-at-maturity corresponding to lower values for this removal rate. The lesser productivity for animals with a higher

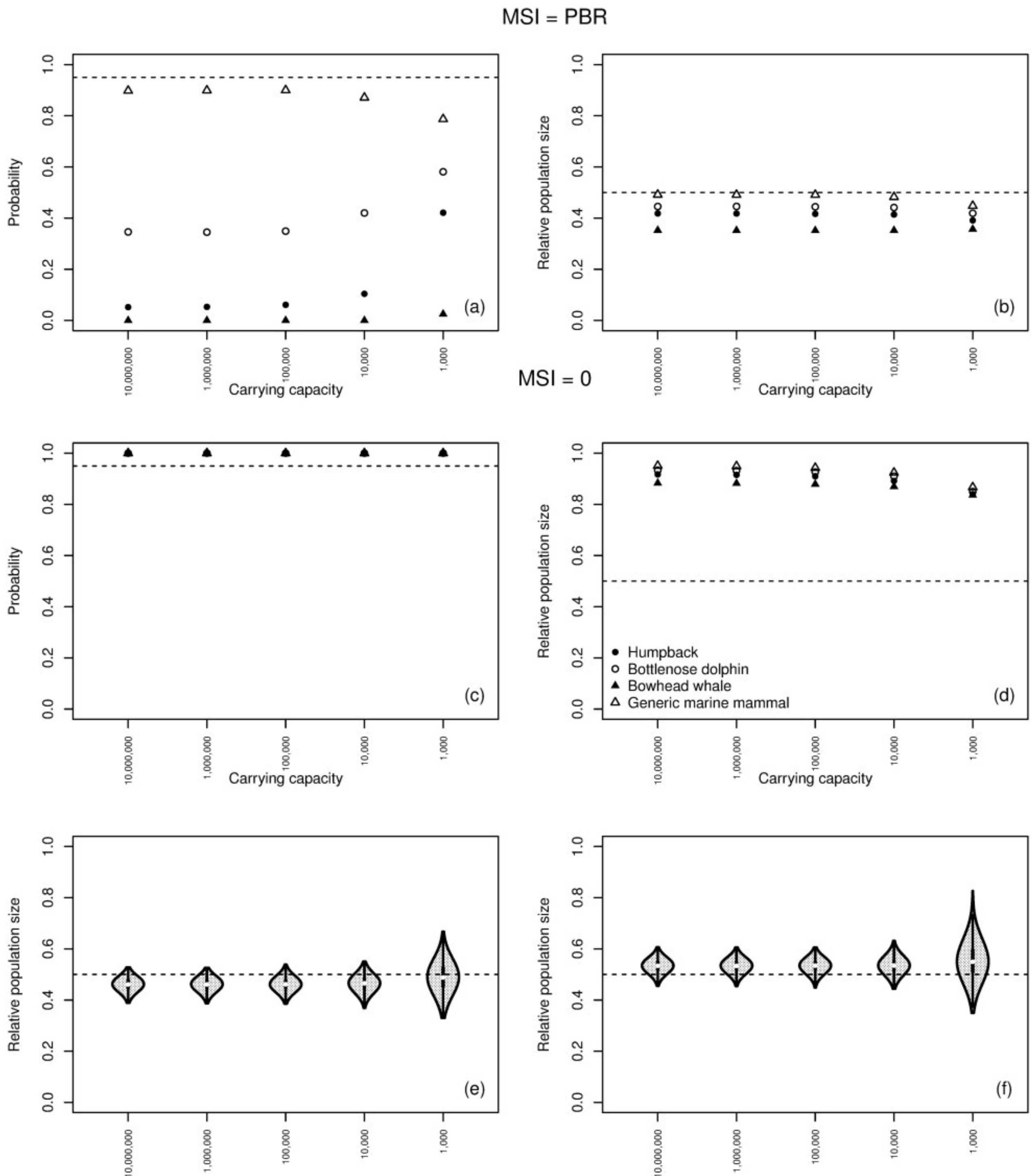

Figure 4. Results for experiment #1. Performance statistics consist of the probability that the number of 1+ animals exceeds MNPL (a, c) and the lower 5th percentile of the ratio of final 1+ population size to carrying capacity (b,d) when expected MSI is equal to PBR (a,b) and when it is assumed to be zero (c,d). The lower panels show the distributions of final 1+ population size relative to carrying capacity for $K^{1+} = 10{,}000{,}000$ (e) and $K^{1+} = 1{,}000$ (f) for the humpback whale when expected MSI is equal to PBR. Dashed lines represent MNPL.

age-at-maturity is also evident in the final size under zero future bycatch (Figure 4c and d). Thus, the lesser ability to achieve the MMPA goal of recovering (or maintaining) stocks to (at) OSP for the humpback, bowhead whales and the bottlenose dolphin compared with the "generic" marine mammal results from the adoption of more realistic biological parameters.

Experiment 2

Experiment 2 examines the impact of various factors [including those considered by Wade (1998) and Brandon *et al.* (2017)] on the recovery of the stock for each of the four species-types as indicated by the lower fifth percentile of final abundance (Figure 6, left column) and probability of exceeding MNPL after 100 years

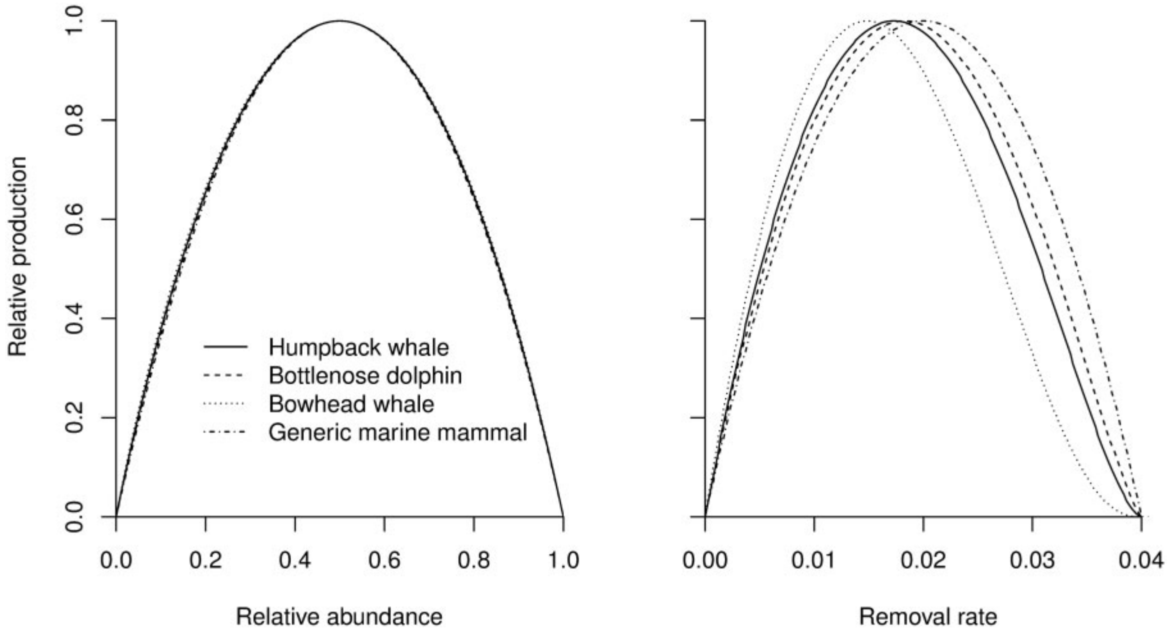

Figure 5. Production (expressed relative to the production at MNPL) versus the ratio of 1+ abundance to carrying capacity for the four species-types (left panel) and production relative to removal rate on 1+ animals (right panel) for these species-types.

(Figure 6, right column). The base case results for this experiment differ from those for Experiment 1 because the historical MSI occurs over 30 rather than 500 years and there are three fishery-types rather than only one. The qualitative impact of the various factors considered matches that of earlier studies (e.g. Wade, 1998; Brandon *et al*., 2017), with lower productivity (λ_{mac}), lower MNPL, a higher abundance estimate CV, positively biased estimates of abundance, and lower management effectiveness leading to lesser lower fifth percentiles of final abundance (and hence P-MNPL), while higher MNPL, and greater management effectiveness leading to the opposite effect (Figure 6 for carrying capacity = 10 000 000; Supplementary Figure S1 for carrying capacity = 1000). Outcomes are particularly sensitive to changes in MNPL and the precision of the estimates of abundance. Most of these changes are expected, noting that in terms of conservation performance, increased management effectiveness (i.e. changing α from 1 to 0.1) is quantitatively equivalent to a scenario where α is held constant and a more conservative value for the recovery factor, F_R is assumed. The results are largely unchanged by the frequency with which estimates of abundance become available, a common observation for these types of management systems (e.g. IWC, 2015) and by the CV of bycatch. However, it should be noted that the effect of frequency with which estimates of abundance become available is being evaluated by computing N_{MIN} based only on the most recent abundance estimate.

The results in Figures 4 and 6 are very similar even though Figure 6 is based on a more realistic situation. As before, there are quite marked differences in results among species-types, with the values for P-MNPL again being highest for the "generic" marine mammal (Figure 6d) and lowest for the bowhead whale (Figure 6c).

Experiment 3

Figure 7 summarizes the results of Experiment 3 in terms of the relationship between population size relative to carrying capacity after 100 years and P-MNPL (columns 1 and 2) and the CVs for the estimates of bycatch and of abundance, as well as the risk of not identifying a stock as strategic when it is (column 3), and the probability of misclassifying a fishery-type to a higher or lower category (under- and over- classification error, columns 4–6) for the humpback whale when carrying capacity is 10, 000, 000 and the fishery impacts follow Scenario A (Table 4). Over-classification would, for example, be assigning a fishery that should be in Category II to Category I, while under-classification error would, for example, be assigning a fishery that should be in Category II to Category III. Over-classification error could lead to unnecessary restrictions on a fishery while under-classification error could lead to a reduction in the rate of recovery of a depleted population.

Bycatch in the model is stochastic which implies, for example, that even though fishery-type 1 constitutes 70% of the bycatch in expectation, variation in bycatch about its expected value may lead to bycatch for this fishery-type being <50% of PBR, i.e. a fishery-type that is in expectation in Category I will at some points in time be in Category II given variation in bycatch. Over-classification in this case in then classifying fishery-type 1 to be in Category I when bycatch during the last 5 years is less than half of the PBR.

The lower fifth percentile of the number of 1+ animals relative to carrying capacity declines as the CV for abundance increases, reflecting again that higher abundance estimate CVs lead to broader distributions for final population size. One consequence of this is that the probability of being above MNPL is larger (but never reaches 0.95) for higher abundance estimate CVs. P-MNPL is largely independent of the CV for the estimates of bycatch, except when the abundance estimate CV is 0.6 and higher (Figure 7, lower two rows). In most cases, it is possible to detect that a stock is strategic when it is in fact at 30% of carrying capacity because MSI is often well in excess of PBR in this case, although there is some chance of requiring a few years to identify that a stock is strategic in this situation when the abundance estimate CV is high (column 3 of the bottom row of Figure 7).

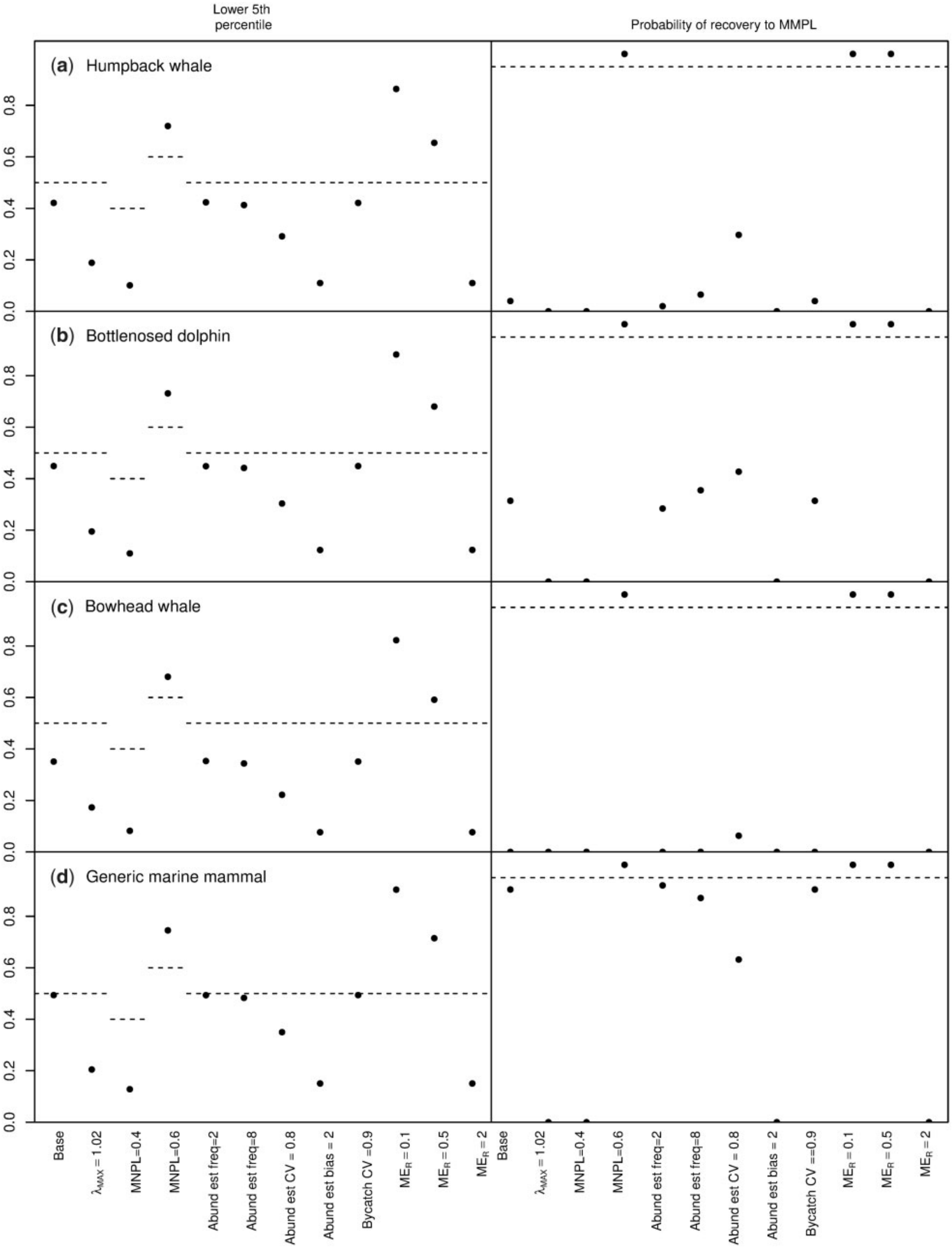

Figure 6. Summary of the results of Experiment #2. The performance statistics for each analysis are: the lower 5th percentile of the relative abundance after 100 years (column 1), the probability that the number of 1+ animals exceeds MNPL after 100 years (column 2). The results in this figure are based on the fishery-types given by Scenario A and carrying capacity equals its largest value $K = 10{,}000{,}0000$. ME denotes management effectiveness (E(Bycatch / PBR), α). Dashed lines are values for MNPL.

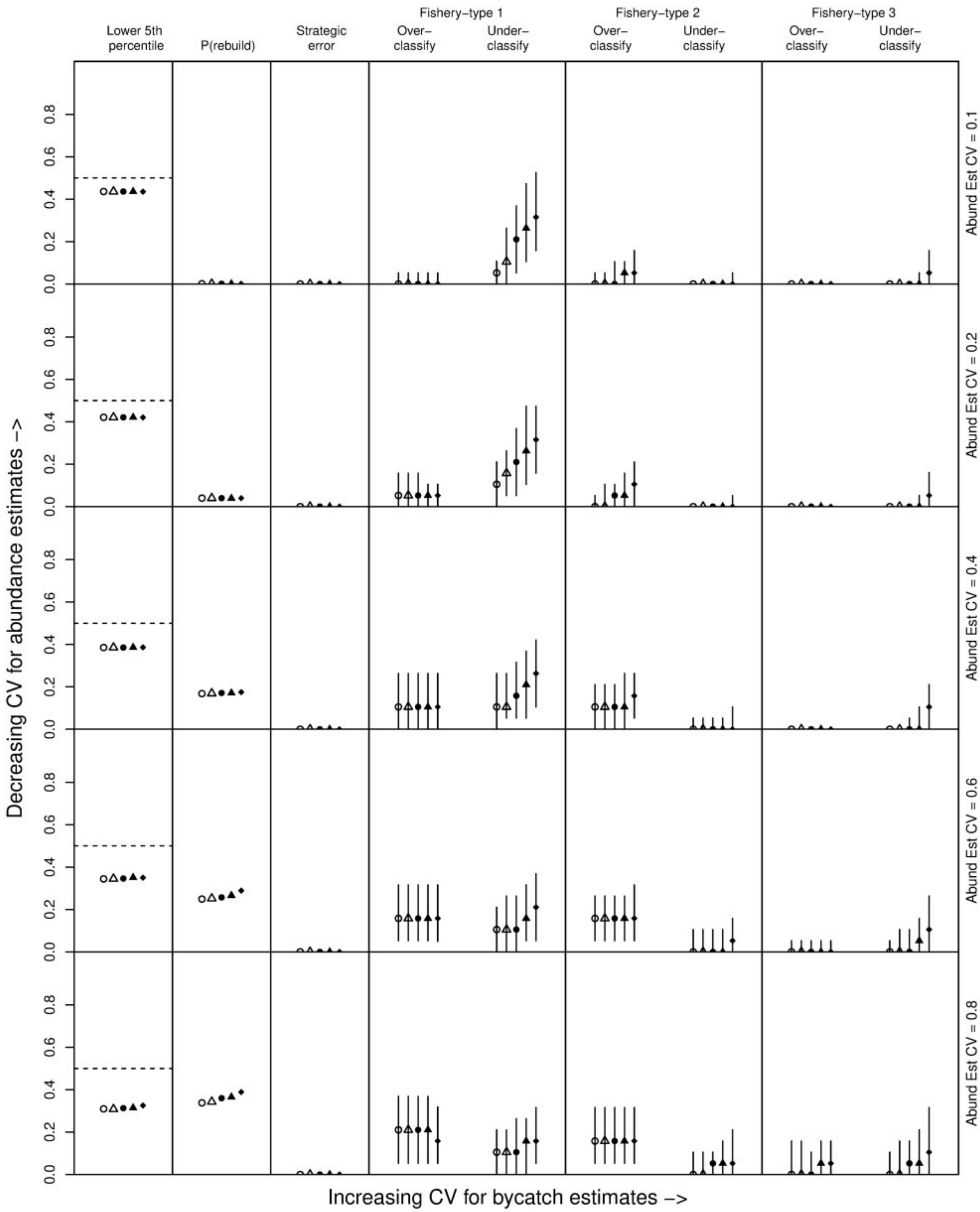

Figure 7. Summary of the results of Experiment #3. The performance statistics for each analysis are: the lower 5th percentile of the relative abundance after 100 years (column 1), the probability that the number of 1+ animals exceeds MNPL after 100 years (column 2), the probability (across years within a simulation) that the stock is identified to be strategic (median and 95% intervals across simulations; column 3), the probability across years within a simulation (median and 95% intervals over simulations) that fishery-types 1, 2 and 3 are assigned to a higher or lower fishery classification than they should be (columns 4-6). The results in this figure pertain to the humpback whale when the relative impact of each of the fishery-types is given by Scenario A and carrying capacity equals its largest value. The rows show results for increasing levels of CV for the abundance estimates and the results within each row pertain to increasing values (left to right) for the CV of the bycatch estimates (CV values are 0.1, 0.3, 0.5, 0.7 and 0.9).

The probability of correctly classifying a fishery-type as Categories I, II, or III depends on its true classification and on its bycatch magnitude, i.e. it is easier to classify a fishery-type when that fishery-type constitutes a high proportion of MSI than when the proportion is close to a threshold level such as 0.5—contrast the rates of classification error for Scenario A with those for Scenario D (Supplementary Figure S2c), where the rate of over-classification error remains high for all levels of abundance estimate CV. The probability of over-classifying a fishery-type (i.e. assigning a fishery that should be in Category III to Category II or a fishery that should be in Category II to Category I) increases with increasing CVs for the estimates of abundance. This is most evident for fishery-type 1 in Figure 7. However, there is relatively little impact of the bycatch CV on the probability of over-classifying fisheries. The probability of under-classifying fisheries is more complex than the probability of over-classification as this probability depends on the impact of fishery-type (contrast the results for fishery-type 1 with that for fishery-type 3 in Figure 7). In addition, there is an interaction between the CV for the estimates of abundance and that for the estimates of bycatch, with the effect of the CV for bycatch being less marked when the CV of abundance is higher (i.e. lower precision for abundance estimates).

The results are not qualitatively sensitive to the allocation of MSI to fishery-type, but the absolute level of classification error varies (as expected) with this allocation. The lowest levels of classification error occur for Scenario E (Supplementary Figure S2d) although the pattern of classification error is the same as for Scenario A. The former result occurs because the allocations of MSI by fishery-type are respectively the highest and (close to) lowest, making classification easier. The results for the bottlenose dolphin (Supplementary Figure S3) are qualitatively similar to those for the humpback whale, except that less recovery occurs for the bottlenose dolphin.

The results in terms of final population size, probability of recovery, and fishery classification error rates are sensitive to the magnitude of carrying capacity (contrast Figures 7 and 8; Supplementary Figures S2–S5). In general, the probability of incorrectly classifying a fishery is much higher for a smaller population, and particularly when the magnitude of the fishery impact is fairly small (e.g. 5 and 25% for fishery-types 3 and 2). This is because smaller populations lead to lower MSI in absolute terms.

Experiment 4

This experiment explores the impact of the number of estimates of abundance prior to first application of the management system, the CV of the estimates of abundance and the initial depletion when the management system is first applied. There is very little impact of having additional estimates of abundance on any of the performance metrics, primarily because although the probability of identifying a stock as strategic (Figure 9, column 3) uses all of the abundance estimates to estimate whether it is depleted to less than half of carrying capacity, the PBR is based only on the most recent estimate of abundance. Although the probability of over-classifying fishery-types with moderate to high bycatch fractions (columns 5 and 4, respectively) increases with the CV of abundance estimates (i.e. abundance estimates with lower precision), over-classification of fisheries with small bycatch fractions (column 6) and under-classification of fisheries are not much influenced by the CV of abundance estimates. There is only a weak interaction between the CV of abundance estimates and number of historical estimates of abundance (the exception being the probability of incorrectly classifying fishery-type 3, Figure 9, column 6). The most marked effect in Figure 9 is the impact of the initial depletion on the probability of recovery to MNPL and the lower fifth percentile of the relative abundance after 100 years of applying the management system, with high initial depletions leading to higher values for the two performance statistics. However, this pattern is to be expected given that changing initial depletion changes the time to recovery all things being equal. There is a slight increase in the number of years to detect a stock is strategic (MSI > PBR), with increasing values for initial depletion, but this number is always low and little impacted by the number of estimates of abundance before the management system is first implemented (Figure 9, column 3). In contrast to Experiment 3, the probability of recovery is generally higher for bottlenose dolphins. Lower abundance estimate CVs lead to lower probabilities of recovery, except for bottlenose dolphins when initial depletion = 0.45 (Figure 9, second column).

Discussion

The management system for regulating marine mammal–fishery interactions is more formal than in most other jurisdictions. The system developed in the US in response to the requirements of the MMPA consists of the PBR formula, the approach used to assess whether a stock is strategic, the process of classifying fisheries in terms of their impact relative to PBR, and when warranted the TRTs and hence any TRPs. The MMPA also contains provisions that fisheries that export fish and fish products from other countries into the United States must have regulations for incidental marine mammal mortality limits that meet the MMPA standards (Williams *et al.*, 2016). The PBR formula, which is central to the management system, was developed using MSE by Wade (1998), with a key goal being that stocks that are depleted to 30% of their carrying capacity be recovered to the population size corresponding to maximum production, MNPL, within 100 years with 95% probability. However, the simulations conducted by Wade (1998) were based on an operating model that did not include age-structure and hence did not account for the time-lags caused by age-structure. Also, Wade's analysis ignored the fact that the relationship between the maximum rate of increase and the rate of increase as the population approaches MNPL depends on vital rates. Most previous attempts to apply the PBR approach to species other than marine mammals have also not considered the impact of demographic factors on the ability to achieve recovery and conservation goals.

The previous MSE was restricted to a single part of the management system: the PBR formula, ignoring feedbacks with components applied to reduce MSI in fisheries. This limits the ability of managers to evaluate some of the trade-offs of improving the precision of abundance and/or bycatch estimates. Furthermore, previous MSEs could not evaluate the ability to correctly classify fisheries. Thus, this MSE more fully informs managers as to which conditions are more likely to result in insufficient or unnecessary regulation of fisheries (due to incorrect under- or over-classification) and which strategies might be more successful, i.e. achieve stock conservation goals while minimizing unnecessary adverse impacts to fisheries, as directed by the MMPA.

Impact of the MSE being based only on the PBR formula

The results for Experiment 1 are based on a scenario in which the stock is always considered to be strategic and there is only one

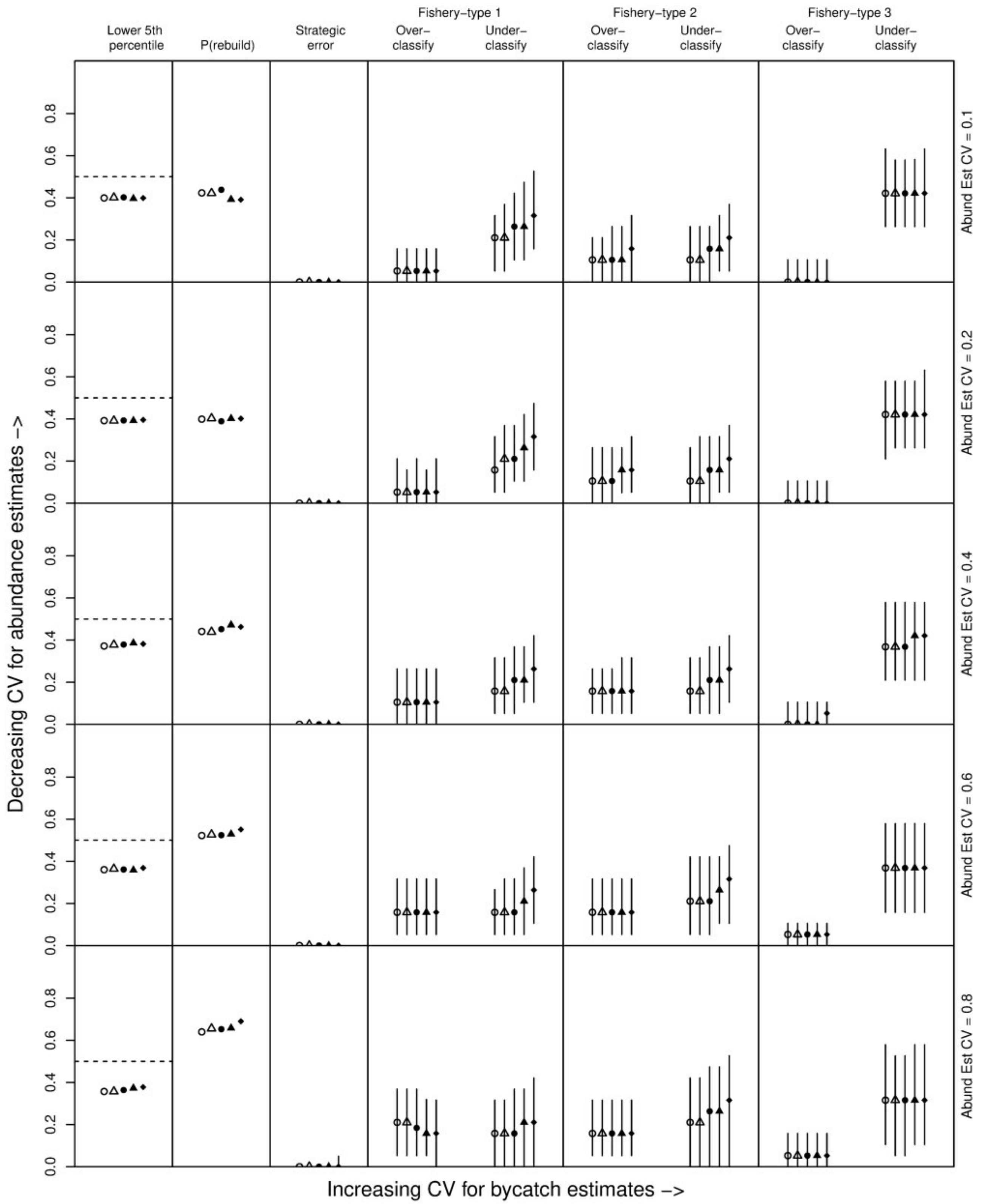

Figure 8. As for Figure 7, except that carrying capacity is 1,000 instead of 10,000,000, i.e. initial abundance is 300 instead of 3,000,000.

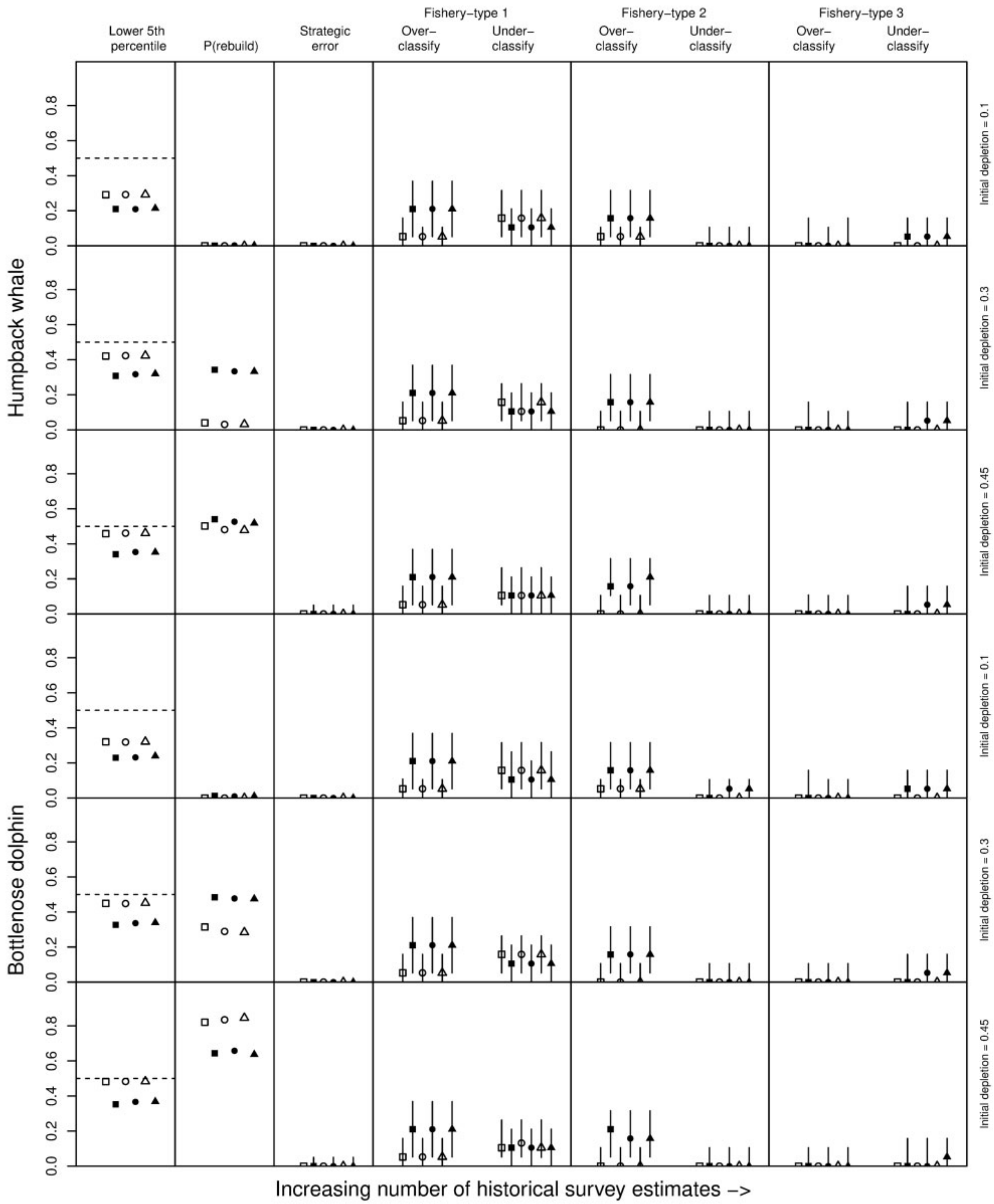

Figure 9. Summary of the results of Experiment #4 consisting of 1,000 simulations over 100 years for humpback whales and bottlenose dolphins. The performance statistics for each analysis are: the lower 5th percentile of the relative abundance after 100 years (column 1), the probability that the number of 1+ animals exceeds MNPL after 100 years (column 2), the probability (across years within a simulation) that the stock is incorrectly identified as not to being strategic (median and 95% intervals across simulations; column 3), the probability across years within a simulation (median and 95% intervals over simulations) that fishery-types 1, 2 and 3 are incorrectly assigned to a higher (under-classified) or lower (over-classified) fishery category than they should be (columns 4-6). The results in this figure are when the relative impact of each of the fishery-types is given by Scenario A (0.7, 0.25, 0.05), carrying capacity equals its largest value (10,000,000) and initial depletion (i.e. fraction of the initial population remaining) varies between 0.1 and 0.45 (rows). The results within each row pertain to different values for the number of estimates of abundance (square = 3, circle = 5, triangle = 7) and the CV of the estimate of abundance (open symbols = 0.2 vs closed symbols = 0.8). Additional details for Experiment #4 in listed in Table 5.

fishery-type, whereas Experiment 3 considered multiple fishery-types and accounted for errors caused by not identifying a stock as strategic and incorrectly classifying and hence managing fishery-types. The results of Experiment 3 are very similar to those of Experiment 1 even though the population is not stable in the first year. This suggests that ignoring assessing whether a stock is strategic and classifying fishery-types as was the case in the simulations conducted by Wade (1998), Taylor *et al.* (2000), and Brandon *et al.* (2017) is largely inconsequential compared with the effects of the values of the parameters of the PBR formula. This is because the probability of not identifying a stock that is depleted to 30% of the unfished level as strategic is very low (Figures 6–8), and the probability of classifying a fishery that should be in Categories I or II to III is likely very low.

Impact of population demographics

The results of Experiment 1 show that the ability to satisfy the management goals is highly dependent on the biological characteristics of the species being managed. The results for the "generic" marine mammal with essentially infinite population size are very similar to those obtained by Wade (1998) using an operating model in which there are no time-lags (Figure 4). However, allowing for more realistic population dynamics (parameterizing the operating model to represent a humpback whale, a bowhead whale or a bottlenose dolphin) leads to lower rates of increase under this management strategy (Figure 4) and hence lower probabilities of recovery to MPNL within 100 years if λ_{max}=1.04. The probability of recovery also depends on the size of the population. This is because the impact of demographic uncertainty is inconsequential for very large populations, but can be consequential for small populations (~300 1+ individuals for a stock with a carrying capacity of 1000 initially depleted to 30%). The increased variation in population size leads to higher probabilities of recovery for species with low age-at-maturity and vice versa for species with higher ages-at-maturity.

The actual values for λ_{max} are likely to differ from 1.04. Supplementary Figure S6 shows distributions for final population size after 100 years for humpback whales, bottlenose dolphins, and bowhead whales when λ_{max} is set to the values in the footnote to Table 3. As expected, the probability of recovery is very sensitive to λ_{max}, with humpbacks (upper panels) predicted to recover with high probability irrespective of the magnitude of carrying capacity and the value for the recovery factor F_R. In contrast, the impacts of demographic parameters are exacerbated when $\lambda_{max} <$ 1.04 (Supplementary Figure S6, centre and lower panels). Setting F_R to 0.5 or lower increases the probability of recovery to 0.5 *K* to 0.95 or higher, except for when K^{1+}=1000 for bottlenose dolphins.

Figure 10 explores the impact of demographic effects further by showing deterministic time-trajectories of population size under zero catch for populations with natural survival rates of 0.95 and different values for the age-at-maturity when the population age-structure for each population was in equilibrium in year 0. The year in which the number of 1+ animals reaches MNPL (half of carrying capacity) ranges from 23 (age-at-maturity = 1) to 28 (age-at-maturity = 16), illustrating how time-lags in population dynamics impact recovery rates (and hence the values for performance metrics in the MSE). These results suggest that the results of the Wade (1998) analysis will be more valid for marine species with lower ages-at-maturity such as seabirds and pinnipeds.

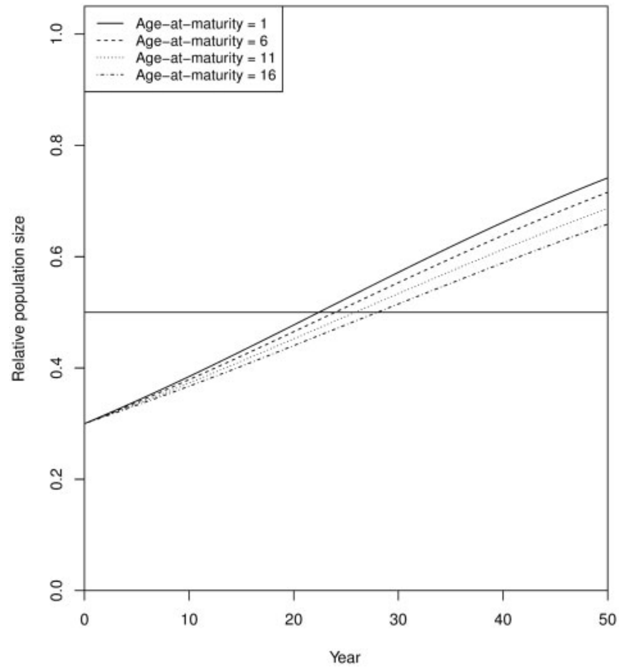

Figure 10. Sensitivity of the time-trajectory of future population size under zero future bycatch to the assumed age-at-maturity. The horizontal line indicates MNPL.

The negative consequences of these two effects on the ability to achieve the performance goals can be overcome by adopting a lower value than one for the recovery factor, F_R that is part of the PBR formula (see, e.g. Supplementary Figure S7). The majority of US cetacean stocks have a recovery factor below one: 100% of the Atlantic/Gulf of Mexico stocks, 97% of the Pacific stocks, and 80% of the stocks in the Alaska region (Carretta *et al.*, 2017; Hayes *et al.*, 2017; Muto, *et al.*, 2017). The results suggest a need to either develop parameters of the PBR by species, i.e. to conduct species-specific MSE analyses, or more practically, to develop parameterizations of the PBR formula for groups of species/stocks that fall into broad categories related to demographics and population size. At present, the value of F_R is linked to perceived stock status—a lower value for F_R for more depleted populations (and higher uncertainty regarding stock status), but this does not account for the fact that the time to recovery also depends on the size of the population in absolute terms.

The results for humpbacks in this paper are less optimistic than those in Brandon *et al.* (2017). Both this paper and Brandon *et al.* (2017) parameterized the density-dependence function in terms of b_{max} and θ. The value for b_{max} was set so that λ_{max} equalled its pre-specified value in both papers. However, Brandon *et al.* (2017) set θ directly to the values for θ in the age-aggregated model used by Wade (1998) whereas this paper set θ to achieve the same value for MNPL as used by Wade (1998). The relationship between θ and MNPL depends on age-structure effects (Punt, 1999), which leads to different model outcomes given differences in the parameterization.

Ability to classify fisheries

The ability to correctly classify fisheries into Categories I–III is strongly related to the proportion of bycatch of the fishery and is more often influenced by the precision of abundance than by the precision of bycatch estimates. Generally, over-classification errors are high when the proportion of bycatch in a fishery-type is moderately high (30–50%) regardless of the precision of abundance and bycatch estimates. However, as the proportion of bycatch in the fishery becomes very high (70–90%), the over-classification errors become more pronounced as the precision of abundance estimates decreases ($CV \geq 0.4$). The starkest contrast between over- and under- classification errors occurs when the level of bycatch of a fishery-type ranges from 20 to 30%. In this case, the under-classification error is low, contrasting with a large over-classification error. There are a few cases, particularly when the precision of abundance estimates is high, where classification errors increase as the precision of bycatch estimates decreases, revealing an interaction between precision of abundance and bycatch estimates. This suggests that improving the precision of bycatch estimates becomes more relevant once a threshold on the precision of abundance estimates is reached.

Despite the errors in classifying fisheries, they tend to be assigning a fishery that is in Categories II to I and vice versa. However, fisheries in Categories I and II are all managed to reduce MSI to PBR and ideally towards the ZMRG. There was a negligible probability of classifying fishery-types in Categories I or II to III (severe under-classification error). The possibility of severe over-classification error (a Category III fishery-type assigned to Categories I or II) is only explored in detail in Scenario D, with the error probability high, particularly for high bycatch CV (Supplementary Figures S2c, S4c, S3d, and S5d, column 6).

Sensitivity analyses

The performance of the management system is as expected when the parameters of the operating model are varied. Of greatest note is the impact of the effectiveness of the management system. Unsurprising, achieving the goal of bycatch <10% of PBR (i.e. the TRP long-term goal) leads to a markedly higher probability of recovery within 100 years than expected from the base case analysis, where management efficiency equals one (Figure 6). However, a higher management effectiveness, i.e. $\alpha < 1$ (or lower values than one for the recovery factor, as discussed earlier), is needed for the management system to be robust to the types of uncertainty such those explored in Experiment 2 that could be reasonably expected when managing bycatch of marine mammal stocks (Wade, 1998). Alternatively, a more robust management system can be achieved by improving the precision of abundance and bycatch estimates to the level recommended by NMFS ($CV \leq 0.3$) (NMFS, 2004; GAO, 2008).

Caveats

The MSE has a closer representation of how marine mammal–fishery interactions are managed in the United States than those conducted previously. However, it is not, and could not be, a perfect representation of the management system. For example, we did not try to mimic the process of concluding a stock is no longer strategic, owing primarily to the lack of rules for making this determination that can be implemented in a simulation study. One of consequences of this is that recovery rates are higher than would be the case if a stock was incorrectly declared to have recovered and hence restrictions on fisheries eased. In addition, the classification of fisheries was performed every five years rather than annually. This mimics the actual process for cases such as fisheries interacting with gray whales in the US Pacific region, where estimates of bycatch and abundance are not updated annually, but not for other cases (e.g. Hawaii deep and shallow set longline fisheries interacting with false killer whales). Given that stocks designated as strategic are always managed as strategic in these simulations means that this assumption is non-consequential for statistics related to recovery rates. Also, conducting the evaluation of classification performance every 5 years means that the probability of classification error can be computed based on subsequent 5-year periods rather than overlapping 5-year periods.

As noted earlier, we also did not try to mimic the process for assessing F_R by stock [in common with Wade (1998) and Brandon *et al.* (2017)] owing to the lack of rules that can be included in a simulation protocol that does not include all the factors taken into account when selecting F_R, some of which are qualitative. However, we did explore this issue generically in Supplementary Figures S6 and S7.

Conclusions

The analysis of the full management system suggests that the PBR formula has the largest impact on the ability to achieve management goals related to marine mammal stock recovery because (for stocks depleted to 10–45% of the carrying capacity) the consequences of not detecting a stock to be strategic and errors classifying fisheries are largely inconsequential. The latter occurs, at least for the scenarios that were investigated, because the errors in assigning fisheries to categories and evaluating whether a stock is strategic were low. In particular, fisheries in Category I were very seldom incorrectly assigned to Category III.

Of most significance to management of marine mammal stocks are the findings of a slower recovery (compared with results from Wade, 1998) when allowance is made for more realistic population dynamics (parameterizing the operating model to represent a humpback whale, a bowhead whale or a bottlenose dolphin) and the notable effect of carrying capacity (i.e. considering scenarios other than the equivalent to an infinite population size as in Wade, 1998). Although more optimistic recovery outcomes were obtained with higher maximum rates of increase ($\lambda_{max} > 1.04$) and by decreasing the recovery factor (F_R=0.5), the recovery objective (stock at/above MNPL after 100 years) was still not achieved for bottlenose dolphin stocks when carrying capacity is low ($<\sim$1000 individuals), which is not uncommon for many of the stocks in bays and estuaries. This further emphasizes the need to examine the behaviour of management systems for specific cases, and if necessary adjusting management controls for groups of species/stocks or even at the individual stock level.

This MSE is a first step toward a better understanding the trade-offs between the precision of key marine mammal assessment estimates (bycatch and abundance) and the ability to correctly classify fisheries over a broad range of scenarios, namely multiple fisheries with low to high bycatch impact. Specifically, this study demonstrates the benefits from improving the precision of abundance and bycatch estimates for achieving the conservation goal of protecting marine mammal stocks and correctly classifying fisheries.

The framework developed here allows the impact of sex and age-structured effects on the performance of systems for managing bycatch to be explored, in addition to the consequences of different monitoring systems (i.e. observer effort) to estimate for bycatch and abundance. The full suite of possible scenarios could be examined in future studies (multiple fisheries, each with different levels of observer coverage, and sex-specific vulnerability to bycatch, etc). The analyses have the broadest application to the US. However, the requirements for nations to have standards equivalent in effectiveness to those of the MMPA to allow them to import seafood into the United States (Williams *et al.*, 2016) means that other jurisdictions need to consider whether their management systems perform as well as the US system, which this article attempts to quantify.

Supplementary data

Supplementary material is available at the *ICESJMS* online version of the manuscript.

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Nineteenth-century Ship-based Catches of Gray Whales, *Eschrichtius robustus*, in the Eastern North Pacific

RANDALL R. REEVES, TIM D. SMITH, JUDITH N. LUND,
SUSAN A. LEBO, and ELIZABETH A. JOSEPHSON

Introduction

In a broad analysis of global whaling, Reeves and Smith (2006) identified no fewer than 22 different whaling "operations" that targeted gray whales, *Eschrichtius robustus*, in the North Pacific Ocean, ranging from aboriginal hunts that began many hundreds or even thousands of years ago, to the more recent factory ship activities using modern searching, killing, and processing methods. Among those 22 operations, they identified five American-style pelagic (or ship-based) operations that took gray whales (Dutch, French, German, Russian, and American; operation numbers 54–56, 61, and 64 in their Appendix). In addition, during this study, we have established that vessels registered in Great Britain and Hawaii also took gray whales (operation numbers 57 and 58 in Reeves and Smith, 2006). These seven operations, along with the other whaling on this species, had reduced gray whale numbers to an unknown, but apparently considerable, extent in both the eastern and western North Pacific by the end of the 19th century.

Randall R. Reeves is with Okapi Wildlife Associates, 27 Chandler Lane, Hudson, Quebec J0P 1H0, Canada (email: rrreeves@okapis.ca). Tim D. Smith is with the World Whaling History Project, 1562 Purple Way, Redding, CA 96003. Judith N. Lund is at 7 Middle Street, Dartmouth, MA 02748. Susan A. Lebo is with Applied Research in Environmental Science, 1031 Nuuanu Avenue, #2104, Honolulu, HI 96817. Elizabeth E. Josephson is with Integrated Statistics, 16 Sumner Street, Woods Hole, MA 02543.

The widely held view that the eastern population (often called the California population or stock) has recovered to its pre-whaling abundance was recently challenged by a study suggesting an average long-term abundance of about 96,000 gray whales in the North Pacific Ocean (Alter et al., 2007). This figure is several times higher than the number of gray whales estimated alive today. If the DNA-based estimate were considered accurate and were applied to the period just before large-scale commercial exploitation began in the 1840's, it would imply that a far greater number of animals had been removed from the California population by whaling than generally assumed. Even without that DNA-based estimate, however, there are concerns about the accuracy of the catch record used in population modeling of eastern North Pacific gray whales (IWC, 1993; Butterworth et al., 2002: Table 2). Wade (2002:85–86), for example, stated:

> "An unresolved issue regarding the eastern North Pacific gray whale is that it has not been possible to reconcile the catch history from the 1800s with the recent time series of abundance data in a simple way. Several attempts have been made to project population models

ABSTRACT—The 19th century commercial ship-based fishery for gray whales, Eschrichtius robustus, *in the eastern North Pacific began in 1846 and continued until the mid 1870's in southern areas and the 1880's in the north. Henderson identified three periods in the southern part of the fishery: Initial, 1846–1854; Bonanza, 1855–1865; and Declining, 1866–1874. The largest catches were made by "lagoon whaling" in or immediately outside the whale population's main wintering areas in Mexico—Magdalena Bay, Scammon's Lagoon, and San Ignacio Lagoon. Large catches were also made by "coastal" or "alongshore" whaling where the whalers attacked animals as they migrated along the coast. Gray whales were also hunted to a limited extent on their feeding grounds in the Bering and Chukchi Seas in summer.*

Using all available sources, we identified 657 visits by whaling vessels to the Mexican whaling grounds during the gray whale breeding and calving seasons between 1846 and 1874. We then estimated the total number of such visits in which the whalers engaged in gray whaling. We also read logbooks from a sample of known visits to estimate catch per visit and the rate at which struck animals were lost. This resulted in an overall estimate of 5,269 gray whales (SE = 223.4) landed by the ship-based fleet (including both American and foreign vessels) in the Mexican whaling grounds from 1846 to 1874. Our "best" estimate of the number of gray whales removed from the eastern North Pacific (i.e. catch plus hunting loss) lies somewhere between 6,124 and 8,021, depending on assumptions about survival of struck-but-lost whales. Our estimates can be compared to those by Henderson (1984), who estimated that 5,542–5,507 gray whales were secured and processed by ship-based whalers between 1846 and 1874; Scammon (1874), who believed the total kill over the same period (of eastern gray whales by all whalers in all areas) did not exceed 10,800; and Best (1987), who estimated the total landed catch of gray whales (eastern and western) by American ship-based whalers at 2,665 or 3,013 (method-dependent) from 1850 to 1879.

Our new estimates are not high enough to resolve apparent inconsistencies between the catch history and estimates of historical abundance based on genetic variability. We suggest several lines of further research that may help resolve these inconsistencies.

forwards from the1800s assuming the population was at carrying capacity prior to the start of commercial whaling in 1846, but such projections cannot produce a trend that agrees with the recent abundance estimates, which indicate the population roughly doubled between 1967 and 1988 … . The catch history and current trend can only be reconciled through fairly dramatic assumptions, such as an increase in the carrying capacity from 1846–1988 of at least 2.5 times, an underestimation of the historic commercial catch from 1846–1900 of at least 60%, or annual aboriginal catch levels prior to 1846 of at least three times the level previously thought (Butterworth et al. 2002)."

Figure 1.—Whole plate ambrotype of the New Bedford whaleship *Saratoga*, labeled "1856 Frederick Slocum, master." The photographer and his location are unknown. Depending on where it was taken, New Bedford or Honolulu, this image would be the oldest or second-oldest known photographic representation of a whaleship. At the time, *Saratoga* was part of the fleet of vessels engaged in whaling for gray whales in Mexico during the winter season. Courtesy of New Bedford Whaling Museum.

In a separate paper in this issue, Reeves and Smith (2010) reviewed and reanalyzed the history of commercial shore-based whaling for gray whales and humpback whales, *Megaptera novaeangliae*, along the coast of California in an initial attempt to address Wade's (2002) "dramatic assumption" that the historic commercial catch has been substantially underestimated. This paper considers another aspect of the gray whale's catch history that bears on the same assumption. Thus, we review commercial 19th century ship-based whaling on gray whales in the eastern North Pacific and evaluate the extent to which previous compilations have led to underestimation of removals by that component of the overall whaling effort on this species.

Previous Gray Whale Catch Estimates in the Eastern North Pacific

By ship-based whaling we mean the whaling by crews of ships (rigged as brigs, schooners, barks, or ships) that went to sea from a home port and hunted whales using this main vessel as a "mother-ship," pursuing the whales from small boats and towing their catch back to the main vessel (or in some scenarios to a "tender" vessel) for processing (Fig. 1). Although ship-based whaling was usually a pelagic activity, in some circumstances, for example when hunting gray whales in their breeding and calving lagoons, the ships were anchored near shore or in a bay while the boats scouted for and caught the whales. Such whaling is sometimes called "bay whaling," a term that is not, however, without ambiguity. For example, Dall (1872 as quoted in Scammon, 1874:22) referred to what has been called shore whaling at Monterey, Calif. (Sayers, 1984; Reeves and Smith, 2010), as "the bay-whaling of that locality." Scammon (1874:23), in contrast, referred to the start of "bay-whaling" for gray whales in 1846 in a clear reference to the start of ship-based whaling in Magdalena Bay, Baja California. Although gray whales were taken in the eastern North Pacific by both offshore or alongshore whaling and by bay whaling, the latter apparently was responsible for the bulk of the removals.

Scammon (1874:23) estimated that no more than 10,800 California (i.e. eastern Pacific) gray whales had been "captured or destroyed" by whalers between 1846 and 1874. Given his estimate of 2,916 killed by shore-based whalers, this would imply that about 7,900 were killed during that period by the lagoon, alongshore, and offshore commercial whalers and aboriginal whalers, combined.

Henderson (1984:169, his Table I) estimated lower total removals (including hunting loss) of gray whales from the "California herd" by commercial whalers (i.e. taking no account of catches by aboriginal whalers): 8,044–8,099 from 1846 to 1874. Of that number, 2,592 were killed by shore whalers, leaving roughly 5,500 (5,452–5,507) to have been taken by ship-based whalers operating in the lagoons (3,235–3,290), alongshore (1,678), and in northern areas (539). Henderson (1972:260), in compiling

Lithograph of a northern whaling scene from Scammon (1874).

his catch record, had deliberately tried to err "on the side of exaggeration" because he was concerned that his estimates were lower than Scammon's. Although Henderson appears to have redressed that bias to some extent in his 1984 reanalysis, the net overall effect of the changes between his 1972 and 1984 estimates was, in his estimation, negligible (Henderson, 1984:166).

Best (1987) estimated even lower catches of gray whales by American ship-based whalers throughout the North Pacific between 1850 and 1879. One of his estimates was based on oil production (2,665 whales landed) and the other on logbook-recorded catch per voyage (3,013 whales landed). However, these estimates are difficult to compare to those by Scammon and Henderson as they include whales taken from the western North Pacific population and do not include catches by non U.S. vessels.

Three related estimates of the catches of eastern North Pacific gray whales over time have been used in modeling the status of the population. Reilly (1981) divided the commercial whaling era into three periods, defined according to the nature of his sources: 1846–1874, 1875–1911, and 1912–1981. For the first period, which is the main focus of this paper, Reilly relied principally on Henderson (1972). The second catch series, compiled by Lankester and Beddington (1986, their Appendix 1), benefited from the comprehensive review and analysis of ship-based whaling by Henderson (1984). Cooke (1986) used the Reilly (1981) catch series in his analysis, noting that it was "very similar to more recent compilations by Henderson (1984) and Lankester and Beddington (1986)." The third series was produced (by Butterworth et al., 1990, 2002) for a special meeting of the IWC Scientific Committee in 1990 to assess gray whales. The commercial component (at least) of that catch series was "based primarily upon Lankester and Beddington's (1986) table" (IWC, 1993:243). Although the Butterworth et al. (1990) catch series was considered the "best available" at the time of the special meeting, participants suspected that it was incomplete and that the commercial catches could have been underestimated by up to 1.5 times (IWC, 1993).

The IWC special meeting agreed (based on Mitchell, 1993) that although Henderson's (1972, 1984) studies of American ship-based whaling for gray whales off Mexico and California had been definitive in some respects, at least two things deserved reconsideration

(IWC, 1993). One was Henderson's use of 35 barrels (bbl)/whale as an average yield for converting oil production statistics into gray whales secured and processed. The other was the smallness of the loss rates (i.e. whales struck but lost as a fraction of the total killed) applied by Henderson (1972, 1984).

A number of additional issues that were not cited in the IWC report deserve attention. One is the possibility that some gray whales taken by non-American ships operating in the North Pacific, including the Mexican lagoons and the Bering Sea, were not accounted for in Henderson's published work. Another is the possibility that the oil returns used by Henderson to estimate catches were not complete. A countervailing (positive) bias might have come from the inclusion of oil from humpback whales, blackfish (mainly pilot whales, *Globicephala macrorhyncha*), and occasionally right whales, *Eubalaena japonica*, fin ("finback") whales, *Balaenoptera physalus*, and blue (sulphur bottom) whales, *Balaenoptera musculus*, in the whale oil returns of vessels visiting the gray whale grounds along the Mexico and California coasts. We have attempted to address all of these concerns, with varying success, in this study.

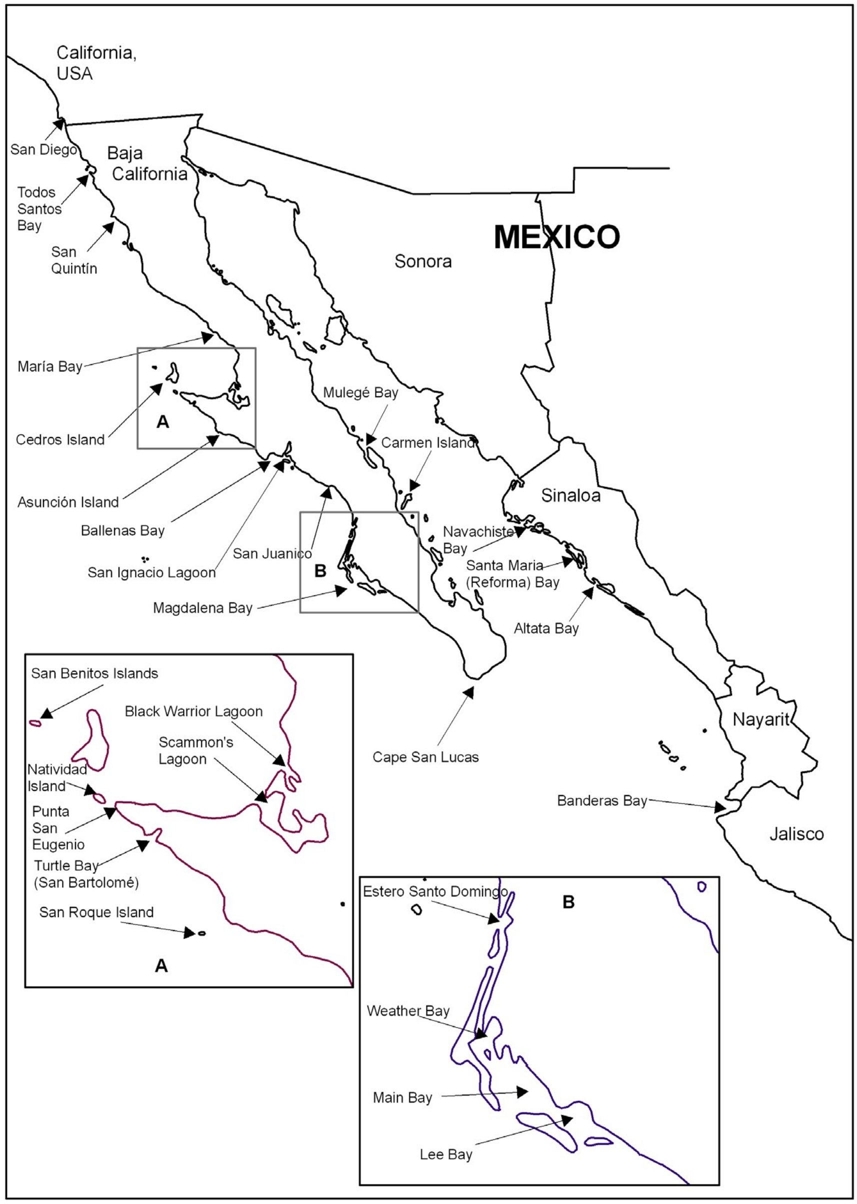


Figure 2.—Map of Baja California and Mexican mainland gray whaling region, with insets of Scammon's Lagoon (A) and Magdalena Bay (B).

Review of Ship-based Gray Whale Fishery

Henderson's Work

A central feature of the present study was a detailed examination of Henderson's published work (1972, 1984) and his extensive notes and files held by the library of the New Bedford Whaling Museum. We reviewed how Henderson made his estimates and attempted to evaluate their accuracy and completeness. The new estimates of catches and removals presented herein are based to a considerable extent on the Henderson material, supplemented by data from our own searches of logbooks, newspapers, and customs records.

Henderson's (1972) monograph on the fishery for gray whales in the eastern North Pacific focused on Scammon's Lagoon (Fig. 2) but included consideration of the entire species range. It was one of the earliest attempts to reconstruct a whale population's catch history from logbook and other data. He used, in particular, period newspapers such as the *Seaman's Friend and Temperance Advocate* and the *Pacific Commercial Advertiser* (Fig. 3), both published in Honolulu, Hawaii, the *Whalemen's Shipping List and Merchants' Transcript*, New Bedford, Mass., and various California newspapers, including the *San Francisco Alta California*, *San Francisco Chronicle*, *San Francisco Bulletin*, *San Diego Herald*, and *San Diego Union*.

In a follow-up study, Henderson (1984) reconsidered his earlier estimates. For his overall catch summary for the eastern Pacific population (his Table I, p. 169), he appears to have relied on a combination of newspaper reports, the Dennis Wood Abstracts (Wood, N.d.),

Figure 3.—Right: List of arrivals at Honolulu port, *Pacific Commercial Advertiser*, 5 April 1860. This illustrates some of the challenges of interpreting ambiguous data. For example, vessels that clearly visited the gray whaling grounds in Baja California in the winter of 1859–60, judging by the “From” column, had been at sea for many months, in some cases almost three years, and had given as their original destination (“Where Bound” column) Arctic, Ochotsk (Okhotsk Sea), or Kodiack (Gulf of Alaska). Much of the whale oil returned by such voyages (the “Wh.” column under “Season’s Catch”) would have been from gray whales taken in the Mexican lagoons and alongshore.

Spring Fleet of Whalers.

Arrival.	Ship's Name.	Captain.	From.	Months Out.	Season's Catch: Sp.	Wh.	Bn.	Where Bound.	Sailed.
January 28	*Hibernia	Booker	Huahine	27	45	....	.....	Condemned	
February 11	*George Washington	Brightman	Off Hawaii	28	....	....	.....	Arctic	Feb. 28
13	*Republik (Bremen)	Sayer	Society Islands	16	....	....	.....	Arctic	Feb. 28
14	*Omega	Sanborn	Tahiti	28	....	....	.....	Arctic	March 19
19	America	Bryant	Cape St. Lucas	28	....	40	.....	Arctic	Feb. 22
21	*Comet (Oldenburg)	Wilhelm	Bremen	6½	....	....	.....	Ochotsk	March 14
27	*Majestic	Chester	Marguerita Bay	31	....	50	.....	Ochotsk	19
27	*Monmouth	Ormsby	Marquesas	30	....	....	.....	Ochotsk	12
March 1	*J. D. Thompson	Crosby	Coast of California	18	....	75	.....	Kodiack	19
1	*Republik (Bremen)	Sayer	Sea, mutiny on bo'rd	16	....	....	.....	Arctic	12
3	*Lewis	Neal	Marguerita Bay	31	....	....	.....	Arctic	20
5	Electra	Brown	New London	6	....	70	.....	Kodiack	5
9	Montezuma	Homan	Coast of California	30	....	120	.....	Ochotsk	13
11	Alice	Beebe	Line	16	90	....	.....	Ochotsk	14
12	Julian	Winegar	Line and Tahiti	18	25	....	.....	Kod'k & Arc.	21
13	Congress 2d	Stranburg	Marquesas	18	90	....	.....	Ochotsk	16
15	Coral	Sisson	Line	17	....	....	.....	Ochotsk	15
16	Phillip 1st	Hempstead	Lahaina	18	....	....	.....	Ochotsk	19
18	Marcia	Billings	Line	30	96	....	.....	Arctic	27
19	*Eliza Adams	Thomas	Marguerita Bay	30	....	700	.....	Arctic	In port
20	Cambria	Pease	Coast and Line	17	....	....	.....	Ochotsk	March 23
21	Florida	C. P. Fish	Home	7	40	120	700	Arctic	23
21	Callao	Fuller	Line	19	....	....	.....	Kamschatka	21
21	*Planet (Oldenburg)	Dallman	Bremen	5	....	....	.....	Ochotsk	In port
22	Jeannette	Winslow	Gallipagos	17	....	....	.....	Ochotsk	March 27
23	*George Howland	Pomeroy	Marguerita Bay	29	....	800	.....	Ochotsk	28
24	Navy	Sarvent	Home	7½	180	....	.....	Arctic	26
25	Hercules	Athearn	Marquesas	30	26	36	.....	Arctic	25
25	Martha	Dailey	Coast of California	20	....	....	.....	Arctic	25
25	Onward	Allen	Marguerita Bay	18	....	750	.....	Ochotsk	27
25	John Wells	Woodbridge	Coast of California	29	....	....	.....	Ochotsk	28
25	Constantine (Russ'n)	Lindholm	Scammon's Lagoon	20	....	160	.....	Ochotsk	27
25	*L. C. Richmond	Hatheway	Marguerita Bay	29	....	700	.....	Ochotsk	In port
26	Nimrod	Howes	Gallipagos	30	....	....	.....	Ochotsk	March 28
27	Thomas Nye	Holly	Line	29	....	....	.....	Ochotsk	28
27	*Henry Kneeland	Kelly	Scammon's Lagoon	21	....	350	.....	Arctic	In port
28	*Ripple (bark)	Morgan	Scammon's Lagoon	30	....	500	.....		In port
29	Helen Mar	Worth	Line	38	....	....	clean	Arctic	March 29
29	*Tempest (bark)	Fish	Scammon's Lagoon	34	....	550	.....		In port
30	*New England	Hempstead	Scammon's Lagoon	30	....	480	.....		In port
April 1	General Williams	Fish	California Coast	30	....	1000	.....		Outside
4	Rebecca Simms	Howes	Gallipagos	28	....	30	.....	Arctic	
4	Oliver Crocker	Cochran	Marguerita Bay	17	....	700	.....	Ochotsk	

Vessels marked (*) entered the harbor. Those not marked, simply touched outside.

Left: Article in *Pacific Commercial Advertiser*, 1 April 1862, with relatively detailed information on activities of various Honolulu-based vessels in the winter 1861–62 whaling season. Note that for some, the catch is given as whales landed and for others, as barrels of whale oil. Reference is made to activities in all three of the main gray whaling lagoons: Ballenas (San Ignacio), Scammon’s, and Margarita (Magdalena) Bay.

Bottom: Brief, but informative, squib in *Pacific Commercial Advertiser*, 12 April 1860. Note that nearly all of the vessels mentioned here, *Sharon*, *Harmony*, *Ocmulgee*, *Fabius*, *George and Mary*, *Fortune*, *Delaware*, and *Lark*, are not included in the “Spring Fleet of Whalers” listed in the same newspaper a week earlier (see above). This example demonstrates the importance of combining multiple sources of information for a comprehensive accounting of catches.

MEMORANDA.

Report of brig Victoria, Dauelsberg.

Left Ballenas Bay, 13th March, with 450 brls this season. Reports the following vessels:

Brig Kohola, Brumerhop, Feb. 3d, at Scammon's Lagoon, with 11 whales. Brig Comet and schooner Kalama, at same place and date, with 21 whales between them.

At Margarita and Ballenas Bays—Ship Harvest, 37 whales; bark Harmony, 1000 brls.; schooner Emma Rooke, 500; ship C. W. Morgan, 14 whales; ship John Howland, 19 whales; bk Carib, 340 brls; bark Sarah Warren, 300 brls.

☞ Ship *General Teste*, Lopes—Left Honolulu, October 5. Cruised on the coast of New Zealand. In lat. 46° S., long. 160° W., fell in with immense quantities of field ice and very large islands of ice; was four days in going through. Left N. Z. Jan. 22; touched at Marquesas on the passage back, and saw there the Am. sperm whale bark *Sunbeam*, with 400 brls. sperm. Spoke the *General Scott* off New Zealand Jan. 10—he had taken nothing since leaving Honolulu.

☞ Ship *Reindeer*, Raynor, reports—Left Honolulu Dec. 4, and arrived at Margarita Bay on the 26th. Took the first whale on the 5th Jan., but did not fairly commence whaling till the 10th. Found whales most plentiful about the middle of January. Left the Bay February 28, put into Man-o'-War Bay for firewood, and sailed again March 5th. First three days, had light westerly winds, after that strong trades all the way. Arrived at Honolulu March 18, with 1,125 brs. oil this season, having been absent only 3½ months. Reports the following vessels:—In Margarita Bay, March 5. ship Harvest, Manchester, with 1000 brls. oil this season. Heard from, Feb. 22:

Bark Harmony, Molteno......................15 whales.
Schooner Emma Rooke, Wilbur................11 "
Brig Maria..................................3 "

☞ Capt. J. H. Swift, of ship *Sharon*, of Fair Haven, from Coast of California, with 450 brls oil, reports—Arrived at Scammon's Lagoon Jan. 2d; took the first whale on the 3d, and last one the 1st of March. Left on the 6th in company with ship New England, of N. L., and bark Harmony, of Honolulu; arrived at Turtle Bay the 7th; saw a number of whales until the 13th, when they became scarce. Left Turtle Bay on the 15th, in company with ship Ocmulgee and bark Harmony, both bound to the islands. Left at Turtle Bay, ship Fabius, Smith, of N. B., 500 brls this season; barks George & Mary, of N. L. 400 brls, Fortune, Comstock, of N. L., 400, Delaware, Kenworthy, of N. L., 550, Lark, of N. L., 600. The Lark leaves on the 20th for Marguerita Bay, to take the bark Ripple's oil home for her; all the other ships will touch at the islands.

logbooks, and a few published sources. He probably also consulted *The Polynesian*, a Honolulu-based newspaper that provided sometimes-detailed reports on whales taken per vessel, referring to the "California Coast" and at least occasionally to specific locations such as Turtle Bay or Magdalena Bay (Fig. 2). For the northern kills, Henderson used unpublished data provided by John Bockstoce (Bockstoce and Botkin, 1983). Henderson's final conclusion (1984:166) was that his earlier estimate of the total kill of eastern gray whales for the period 1846 to 1874 had been about right, i.e. ca. 8,000 gray whales, even though some of the details differed between his 1972 and 1984 analyses.

Henderson's 1972 book included the identities of the specific vessels that whaled in Scammon's Lagoon in each season from 1857 to 1873. His later book chapter (1984) had a broader focus, encompassing gray whaling in additional lagoons and bays in Mexico between 1846 and 1874, but without specifying the vessels and seasons. His summary totals of whaling vessel visits, which he termed cruises and which we term vessel-seasons, and his associated text led us to conclude that he had identified most, and probably nearly all, of the gray whaling activity in Mexico. We therefore assumed that, by scrutinizing his published work (Henderson, 1972, 1984) and his unpublished notes and files, we would be able to identify most of the vessel-seasons of whaling on the gray whaling grounds, including specific lagoons, bays, and "alongshore" areas.

Henderson's material included references to roughly 300 apparently uniquely named vessels that whaled for at least one season in Mexico beginning in 1846, for a total of roughly 500 vessel-seasons.[1] These vessel-seasons included many that were gray whaling, but also some that were taking sperm whales, *Physeter macrocephalus*, humpback whales, or elephant seals, *Mirounga angustirostris*, either exclusively or in addition to gray whales.[2] Some of the vessel-seasons proved to be spurious because a vessel's name had been spelled differently in different sources; this variation included instances where the appropriate Roman numeral was present in one source but missing in another (e.g. *Congress* vs. *Congress II*). Moreover, for some vessel-seasons, we were unable to determine the species targeted.

Henderson (1972:81) believed that gray whales had been largely or entirely "unmolested" by commercial whalers from 1795, when they were first observed and reported by Captain John Locke of the British whaleship *Resolution* ("the first captain to engage in a genuine whaling venture in the eastern North Pacific Ocean": Henderson, 1972:17, also see Henderson, 1975), to 1846, when, according to Scammon (1874), gray whaling began in Magdalena Bay. This large lagoon complex of smaller bays and channels had been visited by sperm whalers well before 1846, but apparently there is no record of a single gray whale having been taken before then, even though they must have been available in relatively high densities in winter. Henderson (1984:163) concedes that some whalers "chased" gray whales but he concludes that "so far as the record shows they never caught any."

General Characteristics of the Fishery

Henderson's extensive examinations of logbooks and newspapers allowed him to define the typical seasonal rounds, or itineraries, followed by the North Pacific whaling fleets. The ships usually sailed from the Hawaiian (Sandwich) Islands to the summer sperm, right, or bowhead, *Balaena mysticetus*, whaling grounds to the north and returned to Hawaii in the autumn and thence to one or more southern grounds, e.g. off New Zealand or Chile, along The Line (the equator), in the Marianas, or along the Coast of California, which mainly meant the western coast of Baja California (Henderson, 1984:162). Although there is little evidence that ship-based whalers hunted gray whales in low latitudes in the western Pacific as they did in the east (Henderson, 1990), considerable numbers of gray whales were taken in the Sea of Okhotsk (Reeves et al., 2008). This meant that on a given voyage, a vessel may have pursued eastern gray whales in the lagoons or alongshore Mexico and California in the winter, and western gray whales in the Sea of Okhotsk in the summer. In his synthesis, Henderson (1984) appears to have maintained the distinction and included in his Table I (1984:169) northern catches only from the "California herd," i.e. the Bering and Chukchi Seas. Therefore, there is no systematic compilation of gray whale catches by ship-based whalers in the Sea of Okhotsk (see Henderson, 1984:176, footnote 14; Kugler, 1984:157, footnote 6) although these are implicitly included in the estimates by Best (1987).

Henderson (1972:81) reported that American whalers arrived at the shores of Baja (Lower) California in Mexico and Alta (Upper) California in the Unites States in the early 19th century and that there was a "major movement of American whalers into the North Pacific from Hawaii after 1820." The vessels often provisioned at San Francisco and Monterey before heading to the Californias for winter sperm whaling. By the 1830's, scores of vessels were doing this. During 1846–47, the number of ships visiting Magdalena Bay for gray whaling rose rapidly from several to perhaps 50 (according to Scammon) or 20–25 (according to Henderson, 1972:83; 1984:165) in 1847–48. Apparently all of these represented "between the seasons" cruises by New England (especially Connecticut)

[1] Throughout this paper, a vessel-season is understood to encompass the period from late autumn one year to spring the next. Thus, 1846–47 would mean approximately November 1846 through April 1847. In some of the tabular material where vessel-seasons are identified by only one year, this refers to the latter part of the season and thus, in this example, it would be 1847 not 1846.

[2] As an example, *Cynosure* of San Francisco visited grounds between Cedros Island and Cape San Lucas, including Magdalena Bay, in the season 1855–56. The logbook makes no mention of gray whales but records the capture of one humpback whale (another struck/lost), 36 blackfish (pilot whales, *Globicephala* sp.), 22 elephant seals, and 20 turtles. In addition, the crew chased killer whales, *Orcinus orca*, unsuccessfully and struck but lost a blue whale. After a stopover in San Francisco from early February to late March, *Cynosure* returned to the Baja California and mainland grounds south to Central America, chasing right whales and humpback whales in April, and then only sperm whales and blackfish through the summer and autumn before returning to San Francisco in November 1856.

vessels or by foreign vessels (including some from French, Dutch, and German ports) that, in summer, had been engaged primarily in right whaling in the northern North Pacific.[3] There is a suggestion by Henderson that this phase of lagoon whaling was facilitated by the U.S.–Mexico war. As he put it, during the hostilities the Mexican government was "even less able to control, or benefit from, the whaling than prior to 1846" (Henderson, 1972:83).

Interest in gray whaling waned temporarily after 1848, a trend attributed by Henderson (1972:84, citing Williams, 1964; also Henderson, 1984:165) to "the inferior quality and low price of the dark-colored gray whale oil, the low quality and quantity of whalebone from the gray, and the dangers of lagoon whaling." In fact, lagoon whaling for gray whales stopped entirely for three seasons—1848–49, 1849–50, and 1850–51. A San Francisco ship (*Aquetnet*) whaled at Magdalena Bay in 1852–53 (Henderson, 1984:164), followed in the mid 1850's by, among others, the ship *Leonore* and schooner *Hopewell* (Henderson, 1972:84). As Scammon (1874:270) noted, "… Magdalena Bay whaling was resumed with ardor about the years 1855 and 1856, and was continued and extended along the whole coast of both Upper and Lower California." Many vessels returned to San Francisco after the winter season and then went back to Mexico for sperm and humpback whales in the summer.[2] It was not until 1861, when the barks *Sarah Warren* and *Carib* did so, that San Francisco vessels began to participate in the northern summer hunt for bowheads and right whales (Henderson, 1972:86).

By the early 1860's, a gray whaling circuit had been established, consisting of summer cruises out of Hawaii or San Francisco to the Gulf of Alaska, Bering Sea, Arctic Ocean, coast of Kamchatka, or Sea of Okhotsk principally for right whales and bowhead whales, followed by winter cruises to Baja California and along the mainland Mexican coast (Henderson, 1972:85). Some of the ships discharged their cargoes and refitted in Hawaii or San Francisco before going south while others proceeded directly to Mexico, often still carrying their cargo of northern oil and whalebone. Lagoon whaling for gray whales continued to be dominated by Hawaii and New England vessels operating out of Hawaiian ports. So-called "pick-up" cruises by small vessels out of San Francisco going for various whale species in addition to gray whales, plus elephant seals, sea turtles (probably mainly Cheloniidae), and even abalone (family Haliotidae) were also common in the late 1850's and early 1860's (Mulford, 1869; Henderson, 1972:94–6; 1984:171).

Henderson (1972, 1984) recognized three distinct contexts or phases of ship-based gray whaling: lagoon whaling, coastal or alongshore whaling (including kelp-whaling, where the boats were stationed in or near the kelp beds and waited for the whales to swim within shooting range; Scammon, 1874:26–27, 258–259), and pelagic whaling on the northern summering grounds. In his statistical scheme for organizing the catch history of eastern gray whales, Henderson (1972, 1984) divided the 19th century ship-based era into three periods, as follows: Initial, 1845–46 to 1853–54; Bonanza, 1854–55 to 1864–65; Declining 1865–66 to 1873–74.

Unfortunately, the lack of lists of the vessels and voyages included in Henderson's analyses seriously hampers attempts to trace his reasoning and verify his catch totals, which in any event are presented in his various published tables only as quasi-decadal aggregates. Following Henderson, we have organized our review according to three phases (lagoon, alongshore, pelagic), further subdivided by time intervals as appropriate.

Lagoon Whaling

Lagoon whaling was centered in three lagoons along the outer (Pacific) coast of Baja California: Magdalena (Margarita) Bay (a deep basin with appended lagoons and shallow margins where gray whales concentrated; Mulford, 1869; Henderson, 1972:30), San Ignacio (Ballenas) Lagoon (not to be confused with Ballenas Bay on the outside where alongshore whaling occurred), and Ojo de Liebre (Jack Rabbit Spring; see Henderson, 1984:183) Lagoon (now better known as Scammon's Lagoon; Fig. 2). Black Warrior Lagoon (Laguna Guerrero Negro), although named after the whaling bark *Black Warrior* of Honolulu, was not a significant whaling lagoon, and Henderson (in Scammon, 1970:38, note 52) concluded that it was only visited in 1858–59 when "the captains of the few vessels from Honolulu which entered the lagoon probably mistook the mouth for that of Scammon's Lagoon."

In the Initial Period, there was no lagoon whaling in 3 of the 9 years (1848–49, 1849–50, and 1850–51). The entire lagoon catch in this period was in Magdalena Bay, where ships sailing from Connecticut ports predominated, accounting for about half of the 50–60 vessel-seasons. Also, vessels from Havre (5 seasons), Bremen (1), and Amsterdam (1) visited Magdalena Bay and whaled for gray whales there. Presumably, Henderson's (1984:165, 169) estimate of the lagoon catch in this period (400–450 by 50–60 cruises) includes the activities of non U.S. registered vessels. He accounted for the downward revision of his earlier estimate of 500–550 for this period (Henderson 1972, his Table I) by suggesting that about 100 catches of sperm and humpback whales had been inadvertently included with the earlier tally (Henderson, 1984:165).

Henderson (1984:165) stressed that some vessels and crews were especially adept at gray whaling in the lagoons (and perhaps also alongshore) and took many whales, while others left the grounds "without a drop of oil." The difficulty of approaching and securing the whales could well have increased with time. Even by the mid 1850's, Mulford (1869) found, for example, that the gray whales in Magdalena Bay were extremely wary:

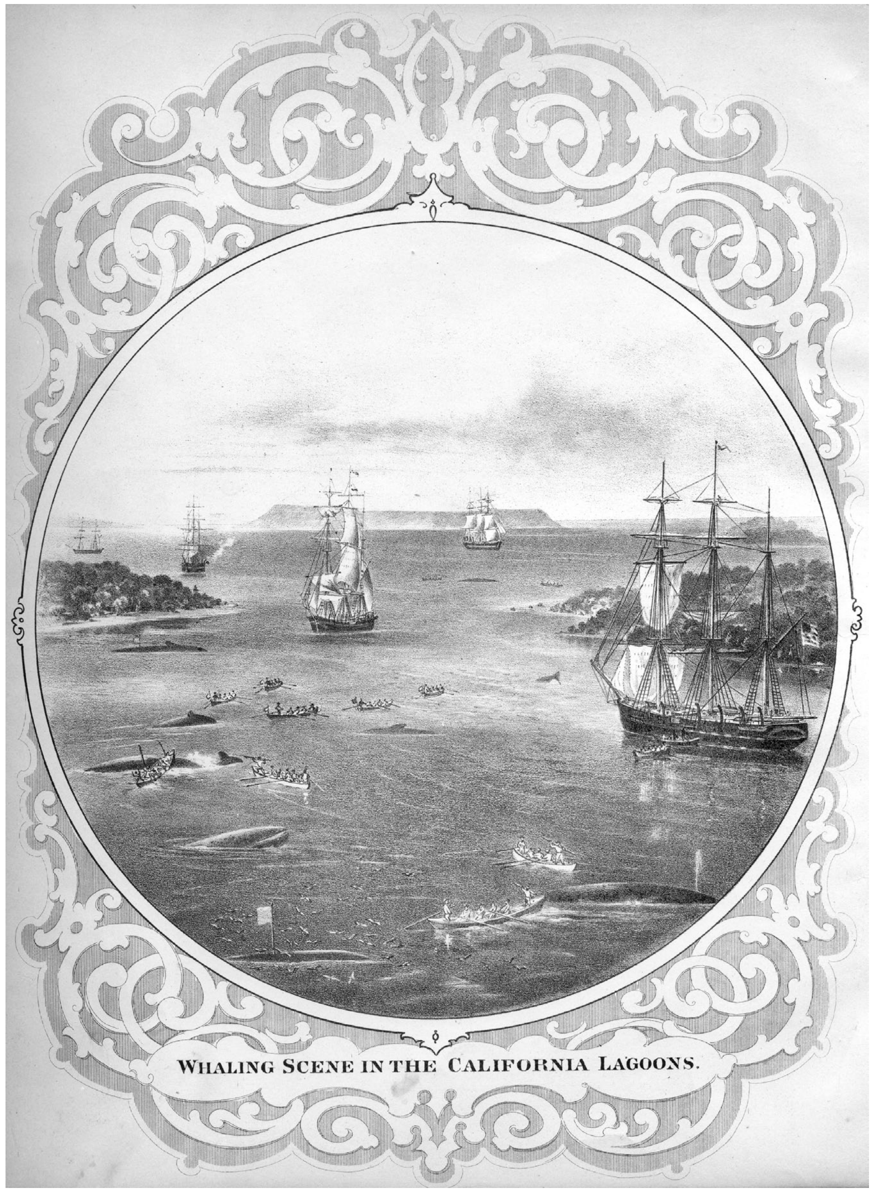
> "Near as the Graybacks came to the schooner, they were shy of the boats. They had been chased before and know something of our deadly intentions. Two hours

[3] In the 3 years from 1846 to 1848, 32 American, 4 French, and 2 Dutch vessels reportedly took 338 whales in Magdalena Bay (Henderson, 1972:83).

elapsed before we managed to creep up near one of the great fish. The oars were handled without noise; the men spoke not a word; they came within a few yards of the black mass; the suspense and half dread was akin to that experienced by the soldier in the hush before the battle."

Indeed, the literature (not just Henderson) consistently characterizes lagoon whaling for gray whales as a specialized endeavor that attracted only a particular subset of whalemen. Scammon (1874:268–269) claimed that lagoon whaling was not equally attractive to all who tried it. For example, many of the 50 ships that visited Magdalena Bay in the winter of 1848 left after only a few days, choosing instead to spend the between-seasons period sperm whaling in the open sea. This pattern described by Scammon may have changed to some extent in later years (the Bonanza period) when in some seasons a very high proportion of the Honolulu- and San Francisco-based fleets were engaged in lagoon (and alongshore) whaling for gray whales. Improved practices, techniques, and equipment, particularly wider use of the bomb-lance (see later), evidently made gray whaling in and outside the lagoons more feasible and less dangerous (Henderson 1984:171).

The catch (and kill) in lagoon whaling was strongly biased toward adult females and calves of the year. In Magdalena Bay, there was a distinct break in timing between the cow/calf season (approximately late December through mid February) and the season for "the bulls" (approximately the second half of February), and the two seasons were also spatially separate, with mothers and calves being hunted in Lee (Almejas) Bay and bulls in Weather or Main Bay (*Saratoga*, 1857–1858, logbook; Fig. 4). Some shifting of the center of whaling activity through the season also occurred in Scammon's Lagoon. For example, in the 1858–59 season, Scammon (1970:66–8) took most of his whales (apparently all cows and calves) in the inner lagoon in January and early February, then relocated toward the outer (Weather) lagoon in mid February where whaling continued into early March.



Lithograph from Scammon (1874).

Modern studies of gray whales in the Mexican lagoons (mainly centered in San Ignacio Lagoon) indicate that mother-calf pairs tend to remain inside the lagoons about three times longer than single whales (including males as well as females unaccompanied by calves) (Urbán et al., 2003). Calving females are among the earliest whales to arrive at the lagoons and the cows, with their calves, are the last to leave on the spring northward migration (Norris et al., 1983; Swartz, 1986). There is a sharp distinction between the cow-calf pairs and "courting" whales in how they use the lagoons. The former tend to occupy the very shallow channels deep inside the lagoons while the latter generally remain in and near the lagoon entrances. Also, although cow-calf pairs do circulate among the different lagoons to some

Gray whale in San Ignacio Lagoon. Photo: Sergio Martinez Aguilar.

Pair of adult gray whales in San Ignacio Lagoon. Photo: Sergio Martinez Aguilar.

Breaching gray whale in San Ignacio Lagoon. Photo: Sergio Martinez Aguilar.

Mother and calf gray whale in San Ignacio Lagoon. Photo: Sergio Martinez Aguilar.

Calf in San Ignacio Lagoon. Photo: Sergio Martinez Aguilar.

Calf riding onto the back of an adult gray whale, presumably its mother, in San Ignacio Lagoon. Photo: Sergio Martinez Aguilar.

extent, the turnover rate of courting animals appears to be higher.

For some years, there is precise information on lagoon catches. For example, at the end of *Paulina*'s 1858–59 season, its logbook entry for 21 February summarizes the Magdalena Bay catches to that date in two parts of the Magdalena Bay complex, as follows: in the outer or Main Bay—*L.C. Richmond* 12 whales, *Majestic* 6, *Benjamin Morgan* 6, *Paulina* 10, *Fortune* 6, *Hibernia* 3, *Hawaii* 1; in Weather Bay—*Reindeer* 8, *Rambler* 8, *Addison* 8, *Scotland* 5, *Massachusetts* (of Nantucket) 7, *Levi Starbuck* 5, *Benjamin Rush* (no report), *Euphrates* (no report), *Dromo* 8, *Tenedos* 6, *Hercules* 4. The *Paulina* log also notes that there was no definite information from vessels whaling in the upper lagoon, "but they are reported as doing extraordinarily well." If all of the whales taken in Main Bay and Weather Bay were grays, this would mean that well over 103 had been secured in the Magdalena Bay complex that season prior to 21 February.

Henderson (1984) assumed that in lagoon and alongshore whaling, one whale was killed and lost for every ten secured (loss rate factor: 1.1). This appears to have been intended to account for non-calf whales that were harpooned or shot but never secured and processed, and thus would not account for killed, injured, or orphaned calves (discussed later). According to Henderson (his Editor's footnote 86 in Scammon, 1970:68), "Scammon may not have bothered to record all of the calves killed or he may have instructed his men to stay clear of the calves in order to avoid infuriating the cows." *Ocean Bird*'s tally in 1858–59 consisted of 47 cows and 5 calves. "It would appear that, after taking four calves with the first seven whales killed [in 1858–59], Scammon's boat crews had tried to avoid killing calves and thus enraging the cows, or that Scammon simply ceased recording the calves taken" (Henderson, in Scammon, 1970:57, Editor's footnote 74). In a later voyage on *Ocean Bird* (1860–61), Scammon "captured many calves along with their mothers" in San Ignacio Lagoon (Henderson, in Scammon 1970:68, his note 86; and see Henderson, 1972:138–139). "The calves, however, were not calculated in the catches of the gray whalers. Some very large calves killed at end of the season at the lagoon may have been counted as adult whales" (Henderson, Editor's footnote 86 in Scammon, 1970:68, citing *San Francisco Alta California* 1 January 1860:4).

The detailed, legible logbook of *Saratoga* (1857–1858) provides further insights. Of 14 gray whales landed by *Saratoga* in the 1857–58 season in Magdalena Bay, 13 were "cows" and only one a "bull" (Fig. 5). In a number of instances, the logbook offers hints at how the whalers did, or did not, strike the calf to improve their chances of securing the cow. For example, on 20 January 1858 one of the boats passed between a mother and calf, and the calf was harpooned —"in an instant the cow stove the stern of the boat," then wreaked havoc. Two days later, a cow was taken whose calf was judged to be less than 24 hours old, and "way too small to fasten to, as an iron would have killed it and the cow then, would have made 'music' among the boats." The next day, one of *Saratoga*'s boats was "stove" (damaged) by a calf. On 29 January the logbook records that a boat from another vessel (*Splendid*) "struck a calf … and killed it instantly, the cow then left, before they could fasten to her, and they lost her." A day later, the crews from *Saratoga* and *Draper*, working together ("mated"), struck both members of a cow-calf pair but the lines fouled and "parted," and the whale (singular) was lost. The same approach was taken on 1 and 6 February, but these times successfully, with the cow secured and the fate of the calf not mentioned in the logbook. Also on 6 February, a *Saratoga* boat "fastened" to another calf but the iron "drew" and "they lost the cow." On 10 February *Saratoga* and *Draper* killed three cows but lost one of them, "the calf drawing the irons out of the cow, the lines being foul and she sinking." Yet another description was provided by Mulford (1869:64), who mentioned an incident in which a harpooned cow became enraged and smashed the whaleboat after her calf had "received the lance intended for the mother." Although it is impossible to be sure, it seems that in this instance the whalers had not intended to lance the calf.

The notion that more calves were at least struck, if not killed outright, than is suggested in the tallies of whales killed, or indeed than is implied by the amounts of oil landed, was echoed by other authors, including Scammon himself. He stated (Scammon, 1874:259), "A cow with a young calf is usually selected, so that the parent animal may be easily struck." Although the usual practice was to avoid striking calves, they were lanced at least occasionally by accident when they got in the way at a critical moment during the capture of the cow (Scammon, 1874:29). Also, at times the whalers deliberately harpooned the calf instead of the cow. Scammon (1874:29) described two occasions when a particularly wary cow was taken only after the calf was harpooned and hauled into shallow water where the attendant

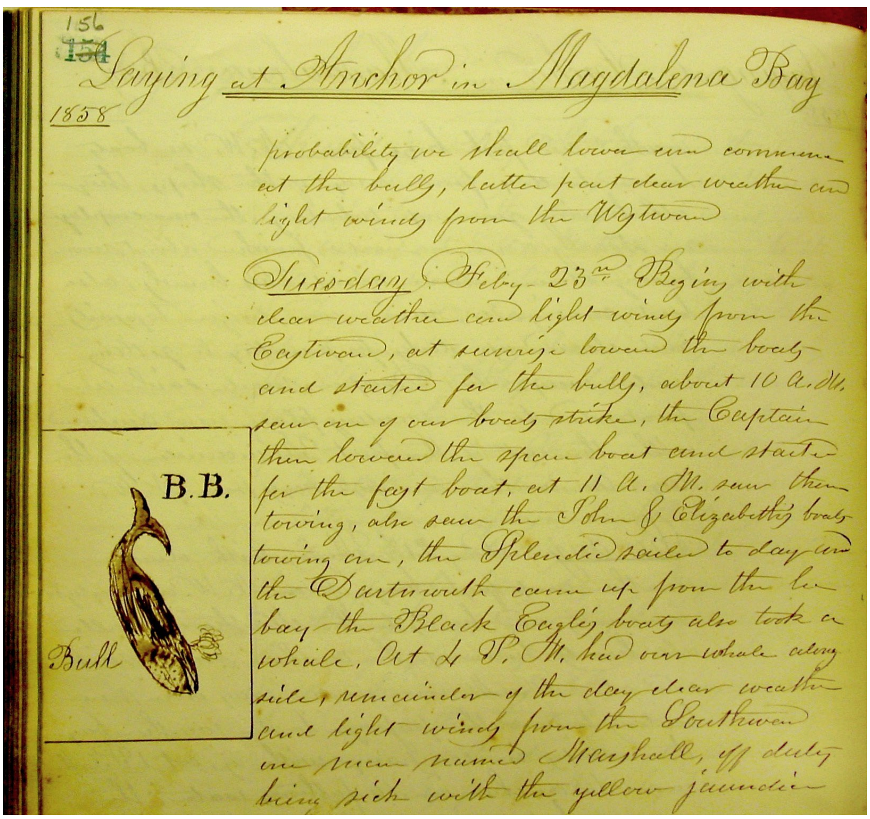

156
~~154~~
Laying at Anchor in Magdalena Bay
1858
probability we shall lower and commence at the bulls, latter part clear weather and light winds from the Westward
Tuesday Feby 23rd Begins with clear weather and light winds from the Eastward, at sunrise lowered the boats and started for the bulls, about 10 A.M. saw one of our boats strike, the Captain then lowered the spare boat and started for the fast boat, at 11 A.M. saw them towing, also saw the John & Elizabeth's boats towing one, the Splendid sailed to day and the Dartmouth came up from the lower bay the Black Eagle's boats also took a whale. At 4 P.M. had our whale alongside, remainder of the day clear weather and light winds from the Southward one man named Marshall, off duty being sick with the yellow jaundice
B.B.
Bull

Figure 4.—Detail of a page from the logbook of the ship *Saratoga*, 22–23 February 1858, with the vessel initially at anchor in Magdalena Bay. *Saratoga* relocated from the Lee Bay to the Weather Bay on 21–22 February, with the logbook stating (top of this page), "… we shall lower and commence at the bulls." Indeed, "at sunrise [23 February] lowered the boats and started for the bulls." One bull was secured by *Saratoga*, as shown by the sketch in the margin, and other whales were taken in the same area by *John and Elizabeth* and *Black Eagle*. Courtesy of New Bedford Whaling Museum.

mother could be shot with a bomb-gun from the beach. The published journal of a whaleman's wife who spent the 1846–47 season in Magdalena Bay (Druett, 1992:177) states that gray whales "can only be taken when they have a young one which they [the whalemen] fasten to and by this means secure the mother who will never forsake it till dead. … When dead they tow the whale [i.e. the mother] to the ship. …"

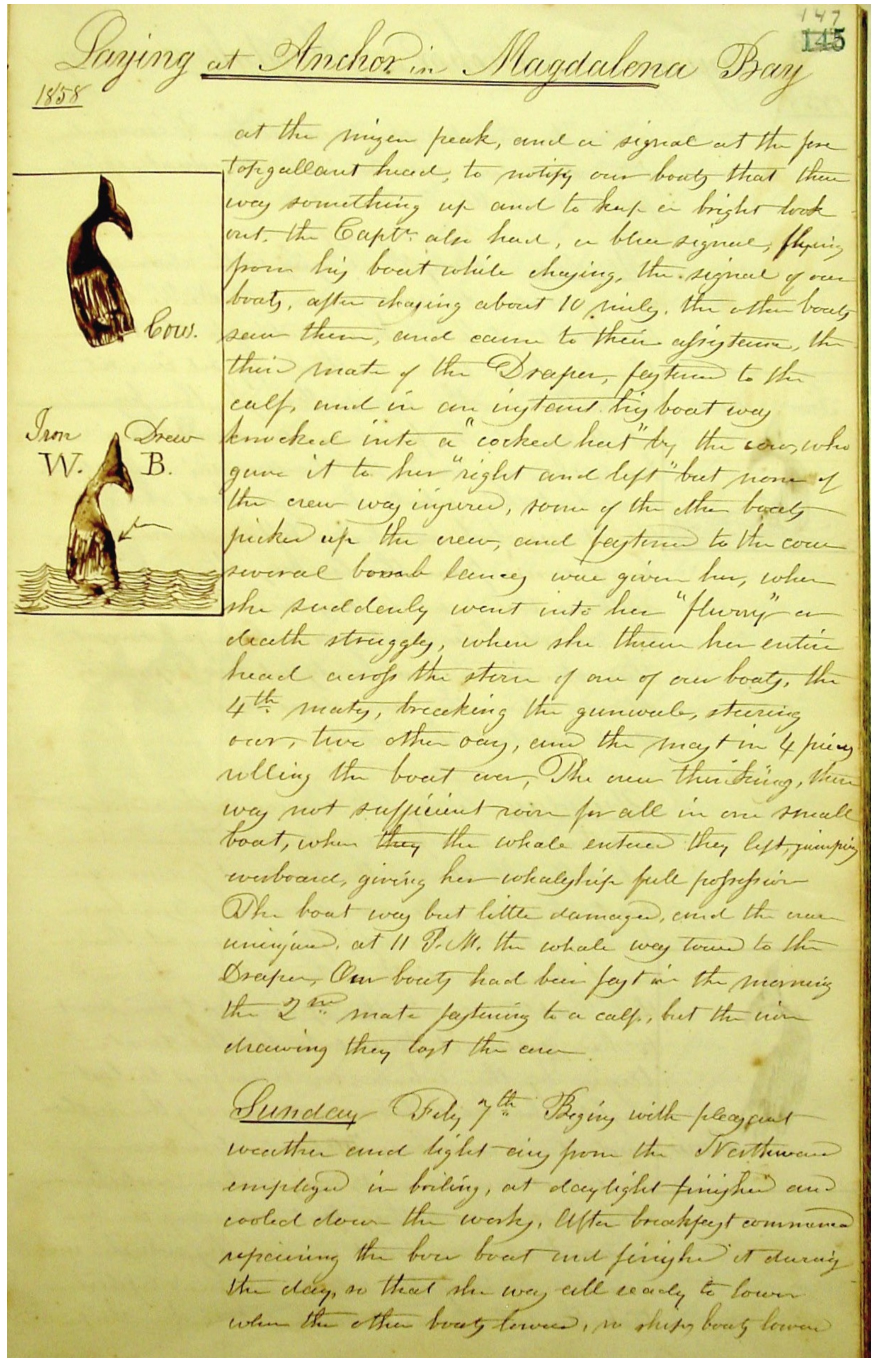
Overall, Henderson (1984:178) found that tactics varied. "Whalers handled attacks on calves in two ways: some preferred to harpoon the calf first so that the cow would stay close by; others left calves alone out of fear that wounded and dying calves provoked the cows into more destructive behavior." Regardless of whether calves were struck, killed, or left alone by the whalers, however, their death was virtually certain, and therefore it is reasonable to infer that one calf was killed for every cow killed in the lagoons (Fig. 5). Again, Mulford (1869:42) provides a clear example of what must have been a typical outcome:

> "We towed the upturned carcass to our vessel. But the poor calf still followed the dead mother. It was playing about the body in the morning, ... and still after we had stripped from the carcass the blubber and turned it adrift to float up and down the lagoon … the poor, helpless, starving creature still swam by the dead mother's side."

Henderson (1972:132) observed:

> "… as the catch on the calving grounds consisted largely of cows, many of which had calves that were killed or died without their mothers, the current and future reduction of the population exacted in the calving waters was far greater than the actual reported catch there, which usually did not account for calves, would indicate."

Scammon (and presumably other whalers in the mid 19th century) regularly used explosives ("bombs") to hunt


147
145
Laying at Anchor in Magdalena Bay
1858
Cow.
Iron Drew
W. B.
at the mizen peak, and a signal at the fore topgallant head, to notify our boats that there was something up and to keep a bright look out. the Captn also had a blue signal flying from his boat while chasing, the signal of our boats, after chasing about 10 miles, the other boats seen them, and came to their assistance, the third mate of the Draper, fastened to the calf, and in an instant his boat was knocked into a "cocked hat" by the cow, who gave it to her "right and left" but none of the crew was injured, some of the other boats picked up the crew, and fastened to the cow several bomb lances were given her, when she suddenly went into her "flurry" or death struggle, when she threw her entire head across the stern of one of our boats, the 4th mates, breaking the gunwale, steering oar, two other oars, and the mast in 4 pieces, rolling the boat over, The crew thinking, there was not sufficient room for all in one small boat, when they the whale entered they left, jumping overboard, giving her whaleship full possession The boat was but little damaged, and the crew uninjured, at 11 P.M. the whale was towed to the Draper, Our boats had been fast in the morning the 2nd mate fastening to a calf, but the iron drawing they lost the cow

Sunday Feby 7th Begins with pleasant weather and light airs from the Northward employed in boiling, at daylight finished and cooled down the works, After breakfast commenced repairing the bow boat and finished it during the day, so that she was all ready to lower when the other boats lowered, no ships boats lowered

Figure 5.—A page from the logbook of the ship *Saratoga*, 6–7 February 1858, with the vessel at anchor in Magdalena Bay. The sketches in the margin indicate that one cow was killed and secured and another whale was struck but lost when the "iron drew." The text for 6 February refers to a boat from *Draper* having harpooned a calf, then being "knocked into a 'cocked hat' by the cow." The cow was finally killed and towed to the mother ship, but not until it had damaged two boats and forced their crews overboard. Earlier in the day a boat from *Saratoga* had harpooned another calf and then its mother, which was lost when the iron drew. Courtesy of New Bedford Whaling Museum.

gray whales in the lagoons (Scammon, 1970:31, 46; Henderson, Editor's footnote 41 in Scammon, 1970:30). A bomb lance was a small, metal cylinder filled with gunpowder and fitted with a time-delay fuse that allowed it to explode a few seconds after entering the whale (Bockstoce, 1986). It was fired from a shoulder gun. The use of bomb lances allowed the operation in Scammon's Lagoon to become a "shoot and salvage" operation (Reeves et al., 2002), with the whalers simply shooting the whales and hoping to retrieve the floating carcasses either soon afterward or the next day (Scammon, 1874:264; Henderson, 1984:178–179). This practice of shooting the whales without first fastening to them with a harpoon would have contributed to hunting loss although in lagoon whaling the prospects of recovering bombed whales that escaped or sank certainly would have been higher than in the open ocean (Henderson, 1984:166). Some whalers clearly fastened first and then fired bombs, but even then the whale could be lost. For example, in Magdalena Bay in 1861, boats from the Hawaiian schooner *Maria* reported having "fastened to another cow whale, and fired two bomb lances, which set her spouting thick blood, but unfortunately the iron drew and we lost the whale, being close to the passage at the time" (*Pacific Commercial Advertiser*, 18 April 1861, 5(42):2).

Within the confines of a lagoon, carcasses could be found "washed ashore or drifting . . . if the internal decomposition had generated gasses to float the whales" (Henderson, Editor's footnote 43 in Scammon, 1970:32). Sometimes the position of the carcass was marked with a buoy to aid in relocating it (Editor's footnote 49 in Scammon, 1970:34; Henderson, 1984:178). It seems consistent with both the circumstances (i.e. sheltered or enclosed conditions) and the evidence from logbooks to infer that the rate of recovery of gray whale carcasses was much higher inside the lagoons than outside.

At least one "shore party" was active in Magdalena Bay in the late 1850's (*Saratoga*, 1857–1858 logbook; also see Henderson, 1972:100, 126–127; 1975; 1984:170). On 18 January 1858 a trypot and three empty casks from *Saratoga* were towed to shore where a group of "Spaniards" had agreed to "take the oil from the carcasses, on halves." We interpret this to mean that the team on shore received whale carcasses after the blubber had been stripped for cooking aboard the vessel, and that for their efforts they were allowed to keep half of the oil produced from the flensed carcasses. On 23 January 1858 the *Saratoga* logbook notes:

> "The shore party of Spaniards came off and assisted us [in cutting in a gray whale taken the day before]. They try out the carcasses for us and two other ships on halves. . . . They keep a sharp look out on shore with a telescope and when they see either of the three ships cutting, immediately put off in their boat, and when we have finished cutting, tow the carcass on shore to their works."

On 31 January, the logbook records that *Saratoga* received 6 bbl of oil and "settled up" with the shore party, as did the other two ships. The shore camp was dismantled on 19 February but there is no further mention in the *Saratoga* logbook of oil received from the camp.

"Carcassing" (Henderson, 1972:127; 1984:170) complicates catch estimation for lagoon whaling in a number of ways. The returns of vessels whaling in Magdalena Bay were sometimes reported in terms of "body" oil versus "carcass" oil. For example, *Massasoit* was reported as "full" in April 1861 (*Polynesian*, 20 April 1861, 17(51):3), having taken 20 whales yielding 860 bbl of "body" and 93 bbl of "carcass" oil. The latter may refer to oil obtained from carcasses found and tried out by the crew of *Massasoit*. *Massasoit* reportedly also "bought 78 bbls besides," which could refer to oil obtained from carcassers.

In some instances, operations on shore seem to have been directly integrated with the ship's whaling strategy (as could be true of the *Saratoga* example, above, but it is impossible to know for certain). In 1860, when the Hawaiian schooner *Maria* arrived at Magdalena Bay on 3 December, the crew immediately went ashore, constructed tryworks and huts, and prepared a scow for transporting blubber to land (*Pacific Commercial Advertiser*, 18 April 1861, 5(42):2). From 24 December, when the first gray whale was observed, through the end of March, *Maria*'s crew, along with those from several other vessels, apparently deployed from the anchorage and took more than 65 gray whales.

Floaters or "stinkers" that were found by a ship's crew or a shore party may have yielded lower-than-average amounts of oil, whether due to putrefaction and leakage or to scavenging by sharks. Best (1987:417) noted that in Townsend's (1935) sample of logbook data, 11 of the gray whales processed had been found dead (representing 4.4% of the total listed as landed). Best considered this an underestimate of the true proportion and assumed that most found carcasses were of whales that had died as a result of whaling-related injuries (as opposed to natural causes). "If so, this fact should be borne in mind when corrections are applied to the landed catch to account for whales struck and lost that subsequently died" (Best, 1987:417). On one occasion when *Saratoga* (mated with *Draper*) lost a cow in Magdalena Bay due to sinking, the carcass was secured two days later "but was so much blasted that it was a stinker in every sense of the word" (*Saratoga*, 1857–1858, 12 February 1858 logbook entry). Still, the whalemen managed to make 40 bbl from it. Scammon made no mention of shark damage, but Henderson (Editor's footnote 43 in Scammon, 1970:32) cited evidence from other whalemen that this could be a serious problem (e.g. in Banderas Bay and in Estero Santo Domingo at the northern end of Magdalena Bay).

Coastal or Alongshore Whaling

Whaling outside the lagoons but along continental or island coasts was generally a mixed-species hunt: humpback whales and sperm whales were as or more likely to be taken than gray whales (humpbacks were also taken in

Magdalena Bay). Henderson (1984) estimated that only 25 grays were taken alongshore in five vessel-seasons during the 9-year Initial period (1845–46 to 1853–54). However, the intensity of alongshore whaling increased greatly thereafter, with Henderson (1984:168) estimating about 900 grays taken in 80 vessel-seasons during the 11-year Bonanza period (1854–55 to 1864–65). Referring to the seasons of 1858 and 1859 (presumably meaning 1857–58 and 1858–59), Scammon (1874:270) stated:

> ". . . not only the bays and lagoons were teeming with all the varied incidents of the fishery, but the outside coast was lined with ships, from San Diego southward to Cape St. Lucas. A few vessels of this fleet cruised near the shore by day, standing a little way off at night; but by far the largest number anchored about the islands, points, and capes, wherever the animals could be most successfully pursued."

Henderson (1972:97) concluded that 1860–61 was the peak year of alongshore whaling for gray whales.

The principal places for alongshore whaling included: San Quintín, Natividad Island, Punta San Eugenio, Turtle Bay (San Bartolomé), San Roque Island, Asunción Island, San Juanico, Cape San Lucas, and the near-shore waters off and inside Todos Santos, Ballenas, and María Bays (Henderson, 1972:97). Some gray whales may have been taken near the San Benitos Islands and Cedros Island as well (Henderson, 1984:168). Although generally not viewed as part of the main theater for gray whaling, several bays along the mainland Mexico coast of Sonora, Sinaloa, and Jalisco were used by gray whales and were visited by the whalers. These included Altata (Scammon, 1970:16, his note 10), Navachiste, Santa María (Reforma), and Banderas Bays (Henderson, 1972:31; also see Gilmore et al., 1967).

One additional area where gray whales were hunted, but which has not been mentioned by previous authors, is Mulegé Bay on the eastern coast of the Baja California peninsula. The New Bedford bark *South America* hunted gray whales (referred to as "devilfish" and "ripsacks") in the bay for most of January and February 1858, taking two large whales (27 January, 2 February; Fig. 6). The 27 January whale was taken "in company" with the New Bedford bark *Sarah Sheafe* and therefore at least one other vessel was hunting gray whales in Mulegé Bay that season. The logbooks of both *South America* and *Saratoga* provide insights on the apparently opportunistic nature of some coastal gray whaling. In early December 1857, *South America*, *Saratoga*, *Sarah Sheafe*, the bark *Islander* of Nantucket, and the bark *Tybee* of Stonington were all "endeavoring to work up the Gulf [of California]." Working in company until mid December, *South America*, *Saratoga*, and *Sarah Sheafe* reached as far north as Carmen Island (lat. 25°57′N, long. 110°50′W), where the crew of *Saratoga* went ashore and interrogated local people concerning whales. On 16 December, the logbook of *Saratoga* states: ". . . giving up all further intention of proceeding up the gulf and starting for Magdalena Bay." In contrast, *South America* and *Sarah Sheafe* continued sailing northward and stayed in the gulf, coming to anchor in Mulegé Bay in the third week of December and remaining in the area until 27 February. Time was spent on shore—fishing, clamming, and gathering wood—from their arrival in the bay until mid January. Humpback whales were sighted "bound up the bay" on 6 January (*South America* log), but no effort was made to chase them. On 13 January, the log notes, "waiting for whales, expect them any day," implying that the whalers had come to Mulegé Bay for the explicit purpose of hunting gray whales. More humpbacks were seen on 23 and 25 January, and then "a few California grays" were chased on the 26th.

After taking their second gray whale (on 2 February), *South America*'s crew saw whales on only four more days before leaving the bay on about 20 February. Two of those sightings were of humpbacks, one of which was chased without success. *South America* sold 372 gallons of oil and 7 barrels of "slush"[4] locally—the oil being a reminder that catch estimates based on oil returns may be negatively biased. While working out of the Gulf of California (en route to Hawaii, where it arrived at the port of Wohoo on 21 March), *South America* struck but lost a "sulphur bottom" (blue whale). Also, the boats were lowered for humpbacks as the bark passed Cape San Lucas on 2 March.

Henderson (1972:166, also his Table I) seems simply to have guessed that about 150 grays were secured between southern Sonora and Banderas Bay during the Bonanza period, and the same number again during the Declining period. He noted that the whalers who whaled there were interested primarily in sperm and humpback whales—they "probably took gray whales only when sperms and humpbacks were scarce or absent" (Henderson, 1972:166). Without explanation, Henderson (1984:174) concluded that the gray whale catch along the Mexico mainland during the Declining period was only 50 (in 10 vessel-seasons), rather than 150 as he had estimated earlier (Henderson, 1972, above). A recent study of gray whale usage of these mainland sites found that calving no longer occurs there, and that this situation is unlikely to change given present levels of fishing activity and maritime traffic in the region (Findley and Vidal, 2002). We are unaware of recent investigations in Mulegé Bay and therefore cannot comment on whether some gray whales still visit that area.

As mentioned earlier, some coastal whaling was described as "kelp-whaling," where the boats were stationed in or near the kelp beds and waited for the whales to swim within shooting range. In later years of the fishery, when the whales had become wary of the whaleboats, small 2-man boats were used, with one man to scull and the other to

[4] Slush was the fatty residue left from boiling salt horse (dried beef and/or pork). It was allotted to the cook in his contract and he was able to sell it for added profits to himself. Later, that term was used for the grease that was used to grease the mast and spars.

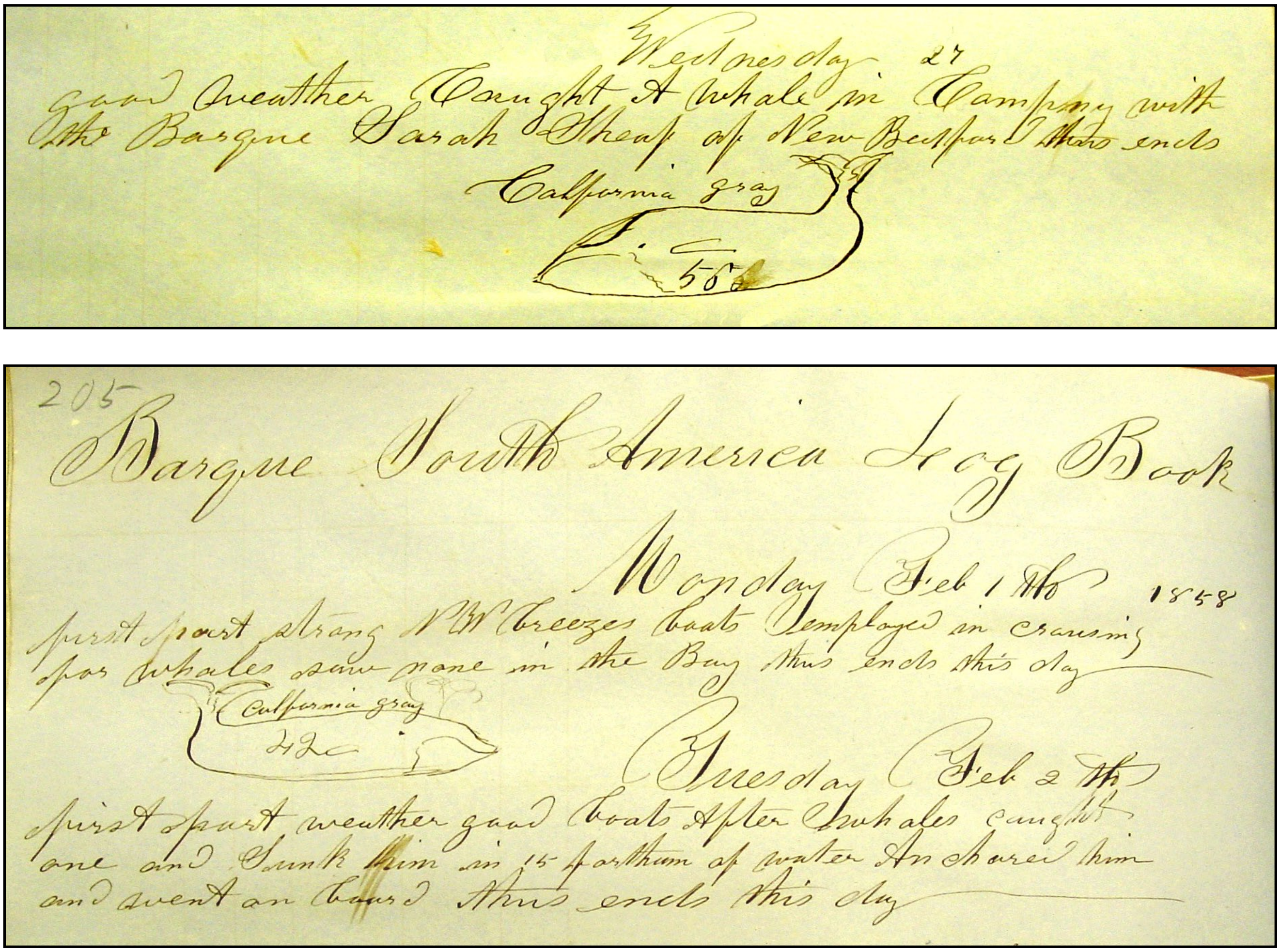


Figure 6.—Top: Detail of a page from the logbook of the bark *South America* for 27 January 1858, while in Mulegé Bay on the east coast of Baja California, describing the taking of a large (55 barrel) gray whale "in Company with" the bark *Sarah Sheafe.* Bottom: Another page from the logbook of *South America*, referring to the capture of a "California gray" in Mulegé Bay, Gulf of California, this one on 2 February 1858. Courtesy of New Bedford Whaling Museum.

shoot. Still later, as the whales passed farther offshore, the whaleboats were anchored outside the kelp, chasing the whales as they passed inshore. Evidently, much of the whaling was "shoot-and-salvage." Even if a line was secured before the whale died, the carcass often sank and would only be secured after it rose to the surface as much as a day later. Sometimes the blubber was tried out in "pots set for that purpose upon the beach" although most often the flensing was conducted alongside the ship. Scammon described another variant of coastal whaling for gray whales as "whaling along the breakers" (Henderson, 1972:96).

As indicated above, Henderson (1984) used the same loss rate factor for adjusting catches in alongshore whaling as in lagoon whaling even though he acknowledged that the chances of eventually securing a struck/lost whale were better inside a lagoon or embayment than outside in the open ocean. Our own findings in this regard are discussed later.

Pelagic Whaling

Almost no whaling for gray whales occurred in offshore waters of Mexico and California, presumably because the whales themselves tended to remain close to shore and congregated mainly in bays or lagoons. Most of the pelagic catch therefore centered in high latitudes, particularly in the Bering and Chukchi Seas. Although whalers searching for right whales in the Gulf of Alaska chased gray whales occasionally (Henderson, 1972:26), there is no evidence to suggest that they made significant catches there. Henderson (1984:166), with unaccounted-for precision, gave "probably … only about 52" as the number taken in 20 vessel-seasons on the northern grounds in the Initial period, followed by about 175 (80 vessel-seasons) in the Bonanza period, and 175 (40 vessel-seasons) in the Declining period for a total catch of 402

(539 killed) over the entire period from 1845–46 to 1873–74 (1984:169). He further stated (1984:170–171) that on the northern grounds, many gray whales were lost under the ice or in foggy conditions and that "more whales were lost [there], relative to those caught, than in any other sector of the gray whale fishery."

Bockstoce (1986:72–73, 132) estimated that about 500 gray whales were taken over the entire life of the ship-based commercial fishery for bowheads in the Bering Sea and Arctic Ocean (1848–1914), and that about 300 more were killed but lost (implying a loss rate factor of 1.6, as compared with 1.34 implied by Henderson's numbers [539/402]). In considering why so few gray whales were taken, Bockstoce (1986:72–73, 132) noted that 1) they lacked commercially valuable baleen, 2) they yielded comparatively little oil, which in any event was priced at about 5 cents less per gallon than "whale" oil, 3) they were both difficult and dangerous to subdue, and 4) most importantly (according to Bockstoce), by the mid 1860's their numbers had been reduced considerably by the lagoon whaling in Mexico.

Regarding the difficulty of capturing gray whales, noted whaling captain Thomas Welcome Roys described them as fast swimmers that "generally could not be taken with hand harpoons from open boats" (Schmitt et al., 1980:25). Further, according to Roys (in Schmitt et al., 1980:64), gray whales, along with humpback whales and blue whales, "will not generally allow a boat to come nearer than three or four rods of them, hence the difficulty of fastening."

Bockstoce and Burns (1993:568) stated that by 1866 the bowhead whale population in the Bering and Chukchi Seas was in "steep decline" owing to nearly two decades of intensive commercial whaling. As a result, the American whalers tried to "offset poor catches" by hunting walruses, *Odobenus rosmarus*, and gray whales during the "middle season" between late spring and autumn. Elsewhere (Bockstoce and Botkin, 1982:184), it was suggested that most of the walrus hunting took place between mid June and early August, at a time when the bowheads were "generally inaccessible to the whaleships."

In their analysis of the walrus kill, Bockstoce and Botkin (1982) extrapolated from logbook data covering 516 complete cruises, or about 19% of the total number of whaleship cruises to the western Arctic from 1849 to 1914. No similar extrapolation to estimate the total kill of gray whales has been published, but Bockstoce and Burns (1993) stated that the kill amounted to "about 840 . . . , of which 539 were captured (Bockstoce in Henderson, 1984: Table I) and another 300 were lost (Bockstoce 1986:73)." Those authors' statement is not consistent with Henderson's (1984) conclusion (his Table I) that only 402 gray whales were "captured" on 140 cruises to the "Northern Summer Grounds" from 1845 to 1874, the total killed (including hunting loss) amounting to 539. Nowhere is it made clear whether the values of 402 and 539 refer to numbers of gray whales recorded in the logbooks of 516 cruises examined by Bockstoce and Botkin (1982, 1983), or instead are extrapolations meant to account for the whales taken on those plus the other 81% of the total cruises to the western Arctic between 1849 and 1914.

Non-American Whaling Vessels

As mentioned earlier, whaleships from countries other than the United States visited the coasts of Baja and Alta California during the 19th century. The British whaler *Toward Castle* wrecked on the Malarrimo coast just southwest of the mouth of Scammon's Lagoon in 1836 (Henderson, Editor's footnote 16 in Scammon, 1970:20; but see Henderson, 1984:182, footnote 18). The French ship *Valiant* of Havre wrecked near the entrance of Magdalena Bay at the end of December 1847 with 600 bbl of oil on board (*The Friend*, 1 April 1847, as quoted in Druett, 1992:184, footnote 33). Some of *Valiant*'s oil (200 bbl) was salvaged by *J.E. Donnell* of New Bedford and is presumably subsumed within that vessel's returns (which included 3,066 bbl of whale oil for its voyage of 1845–49; Starbuck, 1878:422–423).

German and French whalers, as well as one Russian vessel (from Finnish Russia, captained by a Swede), participated in lagoon whaling for gray whales between 1854–55 and 1864–65 (Henderson, 1984:172). Henderson (1972, his Table II, p. 261–263) included in his list of vessels whaling in Scammon's Lagoon between 1857–58 and 1872–73 the following foreign vessels: bark *Cleopatra* from New Granada (presumably present-day Colombia; probably sailing out of San Francisco with New Granada as a "flag of convenience" according to Henderson, 1984:184), brig *Stoofursten Constantin* of Russia, brig *Comet* from the German port of Oldenburg (purchased in Honolulu and put under the Hawaiian flag in 1868), and a variety of vessels from Honolulu—four barks (*Faith*, *Metropolis*, *Harmony*, *Cynthia*), two schooners (*John Dunlap*, *Kalama*), and two brigs (*Victoria*, *Kohola*). *Kalama* was a tender to the brig *Comet* at Turtle Bay in 1862.

There is ambiguity concerning the rig and name of the so-called *John Dunlap*, which apparently also cruised as a brig under the name *Alice*, but in any event it whaled for gray whales at Scammon's Lagoon in at least the 1858–59 season (Henderson, Editor's footnote 68 in Scammon, 1970:50). Some gray whales may have been taken by French whalers between 1842 and 1868 (Du Pasquier, 1986:274). In Du Pasquier's (1982) list of voyages, 15 are identified as having visited locations in California or Mexico where they could have taken gray whales between 1843 and 1864. At least three of those voyages included visits to Magdalena Bay (Ste-Marguerite or Baie Ste-Marguerite) and at least one to Lower California (Basse Californie). The voyage of *Valiant* of Havre, which wrecked in 1847 as noted above, is not among the 15.

The ship-based fisheries for right whales in the North Pacific Ocean and Bering Sea and for bowhead whales in the Bering Sea and Arctic Ocean were both dominated by vessels from the United States. Scarff (2001:266), however, estimated that non-U.S. ships might have constituted as much as 15–20% of the fleet on the right whale grounds, whereas Bockstoce (1986:94) referred to ships from Bremen, Havre, Nantes, and Hobart (Tasmania) as having flocked along with the American fleet to the Bering Strait in 1850 immediately after discovery of the bowhead whaling grounds there. According to Bockstoce and Botkin (1983:110), the western Arctic fishery included vessels from the United States, Hawaii, Germany, France, and Great Britain (Australia). Some foreign vessels stopped to recruit crew and obtain provisions at Hawaiian ports, primarily Honolulu and Lahaina. Beginning in the early 1850's, some of these vessels were purchased by a small number of foreign residents in Hawaii. This burgeoning Honolulu-based fleet included vessels that continued to sail under foreign flags. By 1856, many vessels in this fleet began to be placed under the Hawaiian flag, including some whose owners did not meet the legal requirements for obtaining Hawaiian registry.

Oil Returns and Average Yield

As mentioned earlier, concern has been expressed that the average oil yield used by Henderson to estimate catches from oil production data may have caused him to underestimate the number of gray whales taken (Mitchell, 1993). A large proportion of Henderson's (1972, 1984) catch estimates was derived from oil returns. However, the idiosyncratic nature of his catch tallying method makes it impossible, in many cases, to determine whether the catch attributed to a given voyage represents a count of whales taken (e.g. as reported in the voyage logbook) or instead an estimate made (after the fact) by converting an amount of oil on board or returned to port.

Often, the latter was clearly true, and therefore the average oil yield used by Henderson as the denominator for his conversions takes on particular importance. He recognized that some oil was shipped from the whaling grounds on cargo vessels or "sent home" on a different vessel, and he attempted to account for this in his compilation of catches (Henderson, 1972:259). He nevertheless cautioned that reports emanating from the whaling grounds (e.g. as a result of message exchanges between vessel captains) tended to exaggerate the amounts of oil inboard (we have not been able to corroborate this statement by Henderson).

Another consideration is whether oil inboard or returned by a given vessel came from gray whales rather than from one or more other species. The oil inboard a "gray whaler" obtained from sperm whales, elephant seals, and other seals was, according to Henderson (1972:259), "regularly distinguished," but so-called polar oil from right or bowhead whales taken in the previous summer season, humpback oil, and oil from other balaenopterids (such as fin and blue whales) "usually was not distinguished from the gray whale oil." In Henderson's view, this meant that oil-based estimation of gray whale catches are inherently positively biased. However, there must have been an economic incentive to mix gray whale oil with that of other species as, according to Scammon (1874:269), it was "of an inferior quality." Therefore, it would have been more profitable to adulterate other oils with gray whale oil rather than vice versa.

In our own reading of one logbook, it was noted that when *Mary and Helen II* had taken and processed three gray whales in the northern Sea of Okhotsk, the logbook entry for 24 September 1885 stated, "... stowing in lower mainhold the oil of the last Bowhead taken and what we have boiled of these last [gray or "ripsack"] whales mixed together." In this instance, without checking the logbook, the whale oil returned by the voyage would be considered to have come entirely from bowhead (and right?) whales as there would be no way to distinguish the contribution made by gray whales.

Mixing gray whale oil with other more valuable oils that would be reported and landed as such would tend to bias the data toward underestimation of the gray whale catch. At the same time, however, humpback whales, in particular, were hunted along the coast of Baja California and even inside Magdalena Bay during the gray whale season (Henderson, 1972:89; *Josephine*, 1863–1867, 5 January 1866 logbook entry), and they were at least seen in San Ignacio Lagoon in May and June (Henderson, 1972:195). This creates the potential to overestimate gray whale catches if it is assumed that all whale oil from a given cruise in the Mexican whaling grounds came from gray whales.

Henderson (1972) noted that "coast oil," at least in the context of San Francisco-based whaling in the mid 19th century, generally meant oil from gray whales. For example, the bark *Carib* of San Francisco returned to port in April 1859 after 10 months at sea with 800 bbl of coast oil, 50 bbl of sperm oil, and 300 bbl of humpback oil, and Henderson (1972:89) explicitly considered the coast oil to be from gray whales. In his catch compilations, Henderson (1972) sometimes corrected what he assumed were reporting errors. For example, the New London barks *Tempest* and *Ripple* were reported as returning 550 and 500 bbl, respectively, of humpback oil to Honolulu following a 1859–60 cruise to Scammon's Lagoon, but Henderson (1972:265) concluded that "the kind of oil ... must have been in error," noting that "no other vessel was ever reported to have taken humpback whales" in this lagoon. In another instance, Henderson inferred that a newspaper report of 400 bbl of sperm oil returned to Honolulu by the New London bark *Pearl* (1863–64) "may have been erroneous" because this vessel had been reported at Scammon's Lagoon with 190 bbl of oil (unspecified) on board two months earlier. He assigned a gray whale catch of "5+" to *Pearl* for that season.

Scammon's *Ocean Bird* returned to San Francisco in 1859 with a cargo of 1,600 bbl of oil from 47 gray whales (all "cows"), which led Henderson to conclude that 35 bbl/whale was a reasonable average yield (Scammon, 1970:68). One whale secured by Scammon in December 1858 yielded 55 bbl (Scammon, 1970:37), and one large cow taken in Magdalena Bay by *Saratoga* yielded 62 bbl, another 63½ bbl, both in January 1858 (*Saratoga*, 1857–1858, logbook). Scammon (1874), who had extensive first-hand knowledge of gray whales and the ship-based whaling industry, gave the average yield of gray whales as 20 bbl, with males sometimes producing up to 25 bbl (1874:21) and "some individuals" as much as 60–70 bbl (1874:20).

Rice and Wolman (1971:35) observed that the mean body weights and yields of oil, meal, and meat from southbound gray whales were 2.5–3.0 times those of northbound whales. As summarized by Sayers (1984:123), gray whales taken during the "going down" season (December–February) were "fat, well nourished, and rendered a fine quality of oil," whereas those taken during the "going up" season (February–April) were much leaner as a result of fasting and, in the case of adult females, nursing their calves. In addition to the variability in oil yield due to seasonal changes in body condition, towing distance, shark scavenging, sea conditions, and various other circumstances could affect processing efficiency.

Bockstoce (1986) considered the average yield of gray whales on their northern feeding grounds to be 25–30 bbl (1986:72), 25 bbl (1986:132), or 30 bbl (1986:95). Henderson (1972, 1984), who was convinced that 35 bbl/whale was a good overall average for gray whales, acknowledged that yields tended to be lower on the northern grounds, reasoning as follows (1972:137):

> "Captures of small, young gray whales probably were more common on the northern summer grounds than along the coast of California, where the few slaughtered calves were not usually counted as part of the catch, and where rapidly growing young whales, returning to their place of birth, were at least a year old."

The question of average oil yield becomes relevant in the present context only, or at least primarily, if it is to be applied in catch estimation. In one of the earliest efforts to estimate whale catch from both oil returns and logbook data, Ross (1974:95) ended up averaging the "conflicting figures [on bowhead whale catches by American whalers in Hudson Bay] obtained by different methods . . . , there being no satisfactory criteria for choosing either one or the other." Similarly, Mitchell and Reeves (1983) presented estimates from both "oil yield" (from Starbuck, 1878 and Hegarty, 1959) and "catch-per-voyage" (from logbooks), and then arbitrarily used midpoints of the two in their table of annual catches of humpback whales in the West Indies attributed to the ship-based American fishery. Both Bockstoce and Botkin (1983) and Smith and Reeves (2003) employed data on oil returns to stratify vessel-seasons and to guide logbook sampling, but in the end used only average numbers of whales landed per vessel-season (mainly from logbooks and newspaper accounts) as the basis for estimating catches of bowhead whales and humpback whales, respectively. Finally, in his multispecies study of the American 19th century ship-based fishery for baleen whales, Best (1987) estimated catches in 5-year intervals using both production (oil averages to 1879 and whalebone thereafter until 1909; all from Starbuck, 1878 and Hegarty, 1959) and whale catch per voyage (1805–1914, from Townsend, 1935). He made no attempt to reconcile the two alternative sets of estimates but instead simply reported them as a range, such as 2,665 ("based on oil production") to 3,013 ("as calculated from the catch per voyage") gray whales taken over the period 1850–1879 (1987:416). Best found that the two approaches gave "somewhat similar" results, differing by less than 10% in all cases except three: for South Atlantic right whales, *E. australis*, and humpback whales, the overall production-based estimates exceeded the catch per voyage estimates by 13% and 29%, respectively, and for gray whales, the overall catch per voyage estimate exceeded the production estimate by 13% (as indicated above).

Although Henderson (1984) appears to have depended primarily on oil returns to estimate gray whale catches, our own extensive experience with production data has led us to share the skepticism expressed by Bockstoce and Botkin (1983:110), who note the difficulty of allocating quantities of products to vessel-seasons (as opposed to entire voyages) and the risk that oil from multiple species (especially humpback whale and pilot whale oil in the present context) has often been included in whale oil returns. Therefore, like those authors, we consider data on numbers of whales taken, as recorded in logbooks and newspapers, to provide a more direct and reliable basis for interpolation and extrapolation, as explained in the following section.

New Catch Estimates from Voyage and Vessel-season Analyses

Our review of the literature and of Henderson's files and notes in the library of the New Bedford Whaling Museum (described earlier) led us to an approach for producing a more detailed alternative catch series. Rather than adopting Henderson's method of tracking and evaluating the intricacies of whale oil reports, newspaper snippets, and logbook entries in a largely opportunistic and ad hoc fashion, we chose to rely primarily on two sets of data sources for estimating the ship-based catch of gray whales.

First, we used the catch data in a sample of voyage logbooks (including some also checked by Henderson) and newspaper sources to estimate the average number of gray whales taken (both secured/processed and struck/lost) per vessel-season in Mexico. Second, we used the information from a broad search of published and unpublished sources to identify and count the vessels that whaled for gray whales in Mexico (and to a limited extent southern California) each year beginning in the winter of 1845–46.

Together, these two sets of sources allowed us to estimate the number of gray whales taken each year by the ship-based fishery in the winter season. Because the greatest catches of gray whales were made in Mexico on the whales' calving and breeding grounds, we focused our logbook sampling and catch estimation on the winter portions of voyages spent there rather than on portions of voyages in the northern summering areas. For the ship-based catches in northern waters, we had no reason to believe that we could improve significantly on the gray whale catch and removal estimates (approximately 400–500 and 800, respectively; see earlier) presented by Henderson (1984) and Bockstoce (1986).

Logbook and Newspaper Sampling

Photocopied sections of some logbooks were available in the Henderson material in New Bedford, and these were examined for information on numbers of whales secured. We also checked (either directly or on microfilm) the relevant sections of additional logbooks selected to make the overall sample as representative as possible, especially over time. For those logbooks that provided sufficient detail, we also extracted the information on "condition" of whales that escaped (e.g. whether the harpoon iron drew, the line broke, the whale sank or was "spouting blood" when it escaped), the sex of caught whales, and the presence and fate of any calves mentioned.

To supplement that logbook sample, we used 1) Townsend's (1935) worksheets containing logbook data for about 800 voyages by vessels with names beginning with the letters A through J and 2) data that we had collected in previous studies from logbooks of about 160 voyages. Further, we used gray whale catch data found in 19th century Hawaiian newspapers. In a few cases, the same vessel-seasons were represented in two of the four types of sources, allowing us to check for consistency. For example, the numbers of gray whales indicated on three Townsend worksheets (5, 46, 10) were both higher and lower than those indicated in newspaper entries (4, 47, 14, respectively). Similarly, the Townsend data, which normally include only landed whales, were generally consistent with the more detailed data (catch, struck/lost whales, daily positions) taken directly from logbooks.

In some instances, logbook entries fail to identify whales to species. Where possible, we inferred the species from the circumstances surrounding the whaling activity or from the described behavior or other characteristics of the whales. Unless there was a marked change in whaling pattern or location, the other catches (including struck/lost) for that vessel-season were assumed to have been gray whales. For unidentified whales tried out during vessel-seasons for which catches of both gray whales and humpback whales were reported, we prorated the unidentified whales according to the ratio of grays and humpbacks reported in the logbook for that vessel-season.

Table 1.—Mean numbers of gray whales landed per vessel-season (WPV), their standard errors (SE), and numbers of vessel-seasons sampled (N) from logbooks (directly or via Townsend worksheets) and newspapers.

Period	WPV	SE	N
1846–1854	14.0	3.32	7
1855–1860	14.0	2.28	23
1861–1865	10.1	1.14	30
1866–1874	7.9	1.36	18

Data on landings were available for 94 unique vessel-seasons. Of that number, 51 were covered by logbooks read specifically for this analysis, 18 were covered by the Townsend worksheets, 17 were covered by newspaper accounts, and 8 were covered by logbooks read for our previous studies. Seventy-seven of the 94 vessel-seasons involved gray whaling while the other 17 focused entirely on other species, notably humpback whales, sperm whales, and pilot whales. The mean number of gray whales taken (i.e. secured and processed) per vessel-season for the 78 vessel-seasons that involved gray whaling was calculated for four time periods selected to reflect the varying intensity of the fishery (without regard to Henderson's Initial, Bonanza, and Declining periods, noted earlier), and ranged from 14.0 down to 7.9 whales. The rates were higher in the earlier periods (Table 1).

Some information on the sex and maturity status of struck whales was obtained for a portion of the vessel-seasons covered by logbooks read specifically for this study. As expected, given the information summarized from the literature (above), 32 of the 35 whales (92%) for which sex was identified were cows. Although, as noted earlier, whaling inside the lagoons often involved calves, this was mentioned only 11% of the time (52 of 460 logbook entries). The subsample of logs with entries referring to calves included 18 vessel-seasons, and the percentage of strikes involving calves for those vessel-seasons averaged 29.7%, with a range from 6.2 to 100%. The logs of three vessel-seasons indicated that more than 60% of the strikes involved calves. The fates of 40 of the 52 calves (76.9%) were reported, with 39 of them struck or killed but apparently only one of them processed for its oil. Although this information from logbooks on sex of adults taken and the involvement of calves is clearly incomplete, it reinforces the general understanding from the literature (see above) that lagoon whaling in Mexico focused primarily on adult females and that calves were involved, often dying as a result.

Table 2.—Proportions (P) of 408 struck gray whales that were reported lost under different conditions: when the harpoon drew or the line parted (Drew-Parted), when the animal sank or escaped spouting blood (Sank-Bleeding), and combining those two conditions. Also shown are the standard errors of the proportions (SE(P)), the ratios of the number struck to the number landed (loss rate factor, LRF), and their standard errors (SE(LRF)).

Conditions	P	SE(P)	LRF	SE(LRF)
Drew-Parted	0.24	0.021	1.32	0.037
Sank-Bleeding	0.05	0.011	1.06	0.012
Combined	0.29	0.023	1.42	0.050

Using a subset of the logbook data for 36 vessel-seasons for which sufficient detail was recorded, we estimated the proportion of struck animals that were lost. The 408 struck whales were each assigned to one of three classes: 1) landed and processed, 2) escaped when the harpoon drew or the line parted, and 3) either escaped spouting blood (interpreted to mean the whale was mortally wounded) or actually died and sank before being secured by the whalers. The proportion lost when the harpoon drew or the line parted was much higher than that for animals that escaped spouting blood or sank (28% and 6%, respectively; Table 2). This makes it difficult to estimate total removals. Although it can be assumed that the 5% of struck animals that were lost because they sank or escaped spouting blood were effectively dead, at least some of the 24% of the struck animals that escaped when the harpoon drew or the line parted probably survived, considering that wounds and scars from previous encounters with whalers have been observed on some caught whales (Jordan, 1887; Starks, 1922). We have no basis for estimating the proportion that survived.

Following Henderson's suggestion that the loss rate was higher in alongshore gray whaling (i.e. "outside" rather than "inside" the bays or lagoons), we also classified the reported vessel locations for strikes reported in the logbooks according to whether they were "inside" or "outside" and computed the respective loss rate factors. The alongshore Drew-Parted (DP) LRF (1.41, SE = 0.080) and the Sank-Bleeding (SB) LRF (1.08, SE = 0.027) were both larger than the corresponding "inside" LRF's (DP: 1.26, SE = 0.043 and SB: 1.05, SE = 0.016, respectively). One-sided t-tests suggest that the outside Drew-Parted LRF was significantly greater than the inside (p=0.013), while the difference between the two Sank-Bleeding LRF's was not significant (p=0.084).

However, for most vessel-seasons we were unable, in the absence of the relevant logbook data, to distinguish catch locations on a sufficiently fine geographic scale to apply loss rate factors differentially. As Henderson (1984:168) noted, it was "sometimes difficult to determine if a particular ship captured a whale inside or outside the lagoon itself; only if one has logbook records at hand, rather than newspaper accounts, can he determine how many whales were taken inside or outside the lagoon." For example, the newspaper *Polynesian* reported (29 March 1862, 18(48):3) that the Hawaiian brig *Victoria* arrived in Honolulu in late February from the "coast of California" with 400 bbl of oil on board, having left Margarita (Magdalena) Bay 14 days earlier. The report indicates only that the oil had been obtained "in Bollnas [Ballenas] and Margarita Bays." In order to apply differential loss rate factors, it would be necessary to know or estimate the fraction of the 400 bbl obtained alongshore (i.e. in Ballenas Bay) rather than in the Magdalena Bay complex, which is classified as a lagoon-whaling site. Like Henderson (1984), then, despite the significant difference in loss rates, we had to use the same loss rate factor to estimate total kills from numbers secured in both lagoon and coastal whaling.

Number of Vessel-seasons

In addition to the vessel-seasons identified directly from the Henderson material, we made use of port and newspaper records concerning arrivals and departures of whaling vessels in Hawaii compiled by Lebo for this paper. The Hawaii data generally included the vessel's name (adjusted for obvious misspellings) and its dates of arrival and/or departure in Hawaiian ports. Most of the records also included the vessel's nationality of registry, master, and rig (e.g. schooner, bark, ship). In many instances, the records indicate where the vessel had come "in from" or where it was "bound for." Some of these geographical entries refer to specific places that are well known for gray whaling, such as Magdalena (more often given as "Margarita") Bay, but many are more general. These latter include the obvious and uninformative (e.g. "Pacific") and the somewhat more specific and informative (e.g. "South Pacific," "Japan," "Okhotsk"). Some entries are informative but difficult to interpret at first glance, such as "coast of cala," clearly meaning Coast of California but leaving open various possibilities other than the Mexican gray whaling grounds (e.g. humpback whaling around the Socorros or Revillagigedos Islands, sperm whaling off Cedros Island or in the Gulf of California, whaling for one or several species, including gray whales, along the coast of what is now the U.S. State of California).

For voyages with incomplete or conflicting information, we consulted the Dennis Wood Abstracts (Wood, N.d.),which include, for example, selected dates and specific locations where the vessel was known to have been during the voyage and the quantities of oil and whalebone on board at the time.

We combined the Hawaii arrival and departure records with those obtained from the Henderson material (and supplemented by any relevant details found in the Dennis Wood Abstracts) into a single list of vessel-seasons of whaling in Mexico, using a stepwise procedure as follows.

First, we used the Henderson material, maps, and our general understanding of the fishery to identify a set of geographical entries likely to represent whaling areas in the region. We then selected those vessels that arrived in Hawaiian ports late in or soon after the gray whaling season (i.e. between about February and May, or "spring") or that departed shortly before the season (i.e. between October and December, or "autumn"), with locations (either outgoing or incoming) indicative, or least suggestive, of time spent in Mexico. We did not try to account for vessels in the Hawaii records associated with only generalized geographical locations (e.g. Pacific or North Pacific), but see later discussion.

Second, we compared the two lists of vessel-seasons (one Henderson-based and one Hawaii-based) to two lists of whaling voyages, the American Offshore Whaling Voyage list (AOWV) (Lund et al., 2008; available through National Maritime Data Library, www.nmdl.org) and the French whaling voyages listed in Annex 7 of du Pasquier (1982:242–9; numbered in our system as 30,000 plus the numerical sequence). We thus attempted to identify specific multiyear voyages corresponding to each vessel-season, accounting for dates, master, and rig as available.

Because some vessels had the same name and because key information was missing from some records, it proved impossible to assign all of the vessel-seasons to their appropriate voyage with certainty. Also, we were hampered by the lack of systematic voyage lists from nations other than the United States and France. However, the registry information reported in the Hawaii arrivals and departures records, especially for the Hawaiian fleet, made it possible to identify the nationality for most of the non-American and non-French vessels.

Where more than one vessel had the same name, and especially in the few cases when such vessels were whaling in Mexico in the same season, it was sometimes impossible to pin down and track the vessel-season with complete confidence. Newspapers and other sources proved useful for resolving some of these problems. For example, they allowed us to distinguish among the American *Maria*, the Hawaiian *Maria,* and the Chilean *Maria* in the 1861 and 1862 seasons. The latter two vessels were gray whaling in Mexico, while the first was on a sperm whaling voyage.

Third, we merged the Henderson and Hawaii lists, and this resulted in 660 unique vessel-seasons that were considered candidates for having involved some whaling in Mexican waters between 1846, when gray whaling began there, and 1875, by which time it had essentially ended there (although some killing of gray whales in the northern feeding areas continued into the 1880's). Of these 659, 480 were identified from the Henderson material and 179 from other sources only, especially the Hawaii port records. We then used the multiple sources of information available to classify each vessel-season according to the likelihood that it involved gray whaling in Mexico. For some vessel-seasons, we found no information that could be used as a basis for classification. For others, there was enough information to classify as definitely or likely gray whaling, definitely or probably not gray whaling, or possibly gray whaling. For analysis, we established four categories of the likelihood of gray whaling, as follows: Yes (definitely or probably gray whaling), Maybe (possibly gray whaling), No (definitely or probably not gray whaling), and Unknown.

The proportions of vessel-seasons that fell into these categories varied according to the source (Table 3), with, for example, 17% (82/478) of the vessel-seasons identified from the Henderson material judged as "definitely not" gray whaling compared to 29% (52/179) of those from the Hawaii port records. The proportions also varied over time, with, for example, a higher proportion Unknown after 1860.

Table 3.—Numbers of vessel-seasons according to the original sources of information and our judgments on the likelihood that they involved gray whaling.

Source	Yes	Maybe	No	Unknown	Total
Henderson	323	45	82	28	478
Hawaiian	54	32	52	41	179
Total	377	77	134	69	657

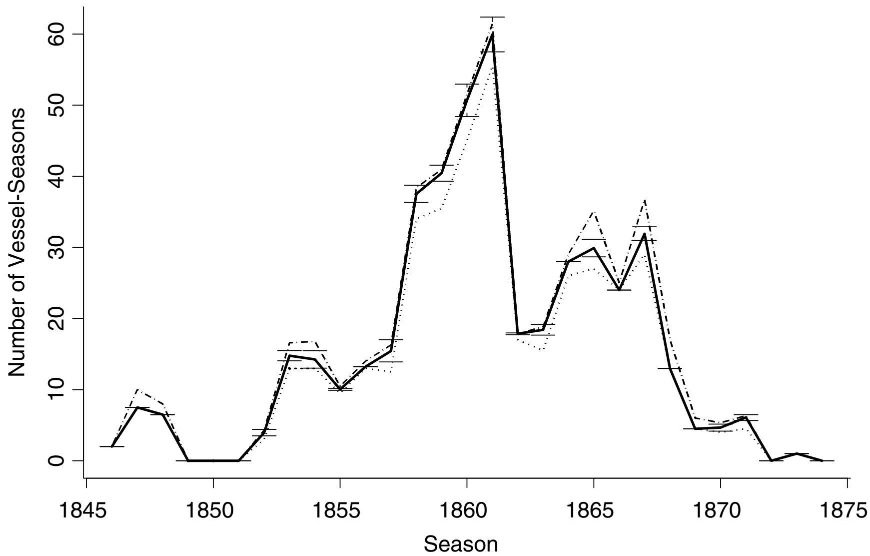


Figure 7.—Estimated numbers of vessel-seasons of gray whaling in Mexico from 1846 to 1874, by year, with three ways of accounting for uncertainty (as described in the text). Cases: low = dotted line, medium = solid line, high = dashed line. The 95% confidence intervals about the estimates are shown for the medium case.

To account for such differences, we addressed the uncertainties in the vessel-season data separately by source (i.e. Henderson vs. Hawaii) and by year. We addressed the uncertainty inherent in the Maybe and Unknown categories in two ways. First, we assumed that at least half of the vessel-seasons categorized as Maybe gray whaling were in fact gray whaling (i.e. we treated that half as Yes). Second, we prorated the number of Unknown vessel-seasons according to the frequency of Yes, Maybe, and No vessel-seasons.

We then considered three cases—low, medium, and high—to compute the total number of vessel-seasons. For the low vessel-season case, we took the total vessel-seasons to be the number categorized as Yes and half the number categorized as Maybe. For the high case, we took the total to be the sum of those categorized as Yes, those prorated to be Yes, and those prorated to be Maybe. Finally, for the medium case, we summed the number categorized as Yes and prorated as Yes, plus half of the number categorized as Maybe and half of the number prorated as Maybe. This procedure resulted in total numbers of vessel-seasons of 416, 466, and 489 vessel-seasons for the low, medium, and high cases, respectively, with standard errors due to the proportions used in the prorating. The numbers of vessel-seasons for the three cases for each year are shown in Figure 7, along with 95% confidence intervals for the medium case.

The identified vessel-seasons of whaling in Mexican waters are listed in the Appendix, which includes each combination of vessel name and season, the vessel's known or likely nationality, whether the vessel-season was identified from the Henderson material, and the likelihood that the vessel-season involved some gray whaling. Also included, where available, are the known or probable vessel and voyage identification numbers (see above). In some cases, we indicated a likely AOWV vessel number corresponding to the vessel name, even though a precisely corresponding voyage number could not be identified because the departure and arrival dates were not consistent with the vessel's being in the gray whaling grounds at the appropriate season. It is possible that a few vessel-seasons are listed twice because of inaccuracies and inconsistencies in vessel names, although we tried to minimize this by evaluating the voyage records carefully to account for vessels with similar names.

Vessels with American registry were responsible for nearly 89% of the whaling activity, with 272 vessels involved in some 587 vessel-seasons. Hawaii-registered vessels were the next most common, with 17 vessels involved in 32 vessel-seasons, followed by French-registered vessels, with 6 involved in 10 vessel-seasons. In addition, vessels registered in German states (e.g. Bremen), the Netherlands, Russia, Great Britain, Colombia, and Chile were identified as having spent one or more seasons in the Mexico whaling grounds. Only 14 vessels were unidentified as to nationality, and they were responsible for 14 vessel-seasons.

Estimates of Gray Whale Catches and Total Removals

The number of gray whales taken (i.e. secured and processed) was estimated for each gray whaling season between 1846 and 1874 (Fig. 8; with, for example, the 1858–59 season denoted as 1859) as the product of the estimated number of vessel-seasons that were, or maybe were, gray whaling in the low, medium, and high vessel-season cases (Fig. 7) times the average number of gray whales secured per vessel-season in the respective time periods (Table 1). The standard errors of the estimated takes were computed from the corresponding sample standard errors of the number of vessel-seasons and of the mean gray whales landed per vessel-season for each of the three cases (Table 4). For the medium case, the estimated catch reflects a combination of differences in the average catch rates by period and the variability in numbers of vessels whaling each year, with the number of vessel-seasons rising to a peak in the early 1860's and then declining rapidly (Fig. 7).

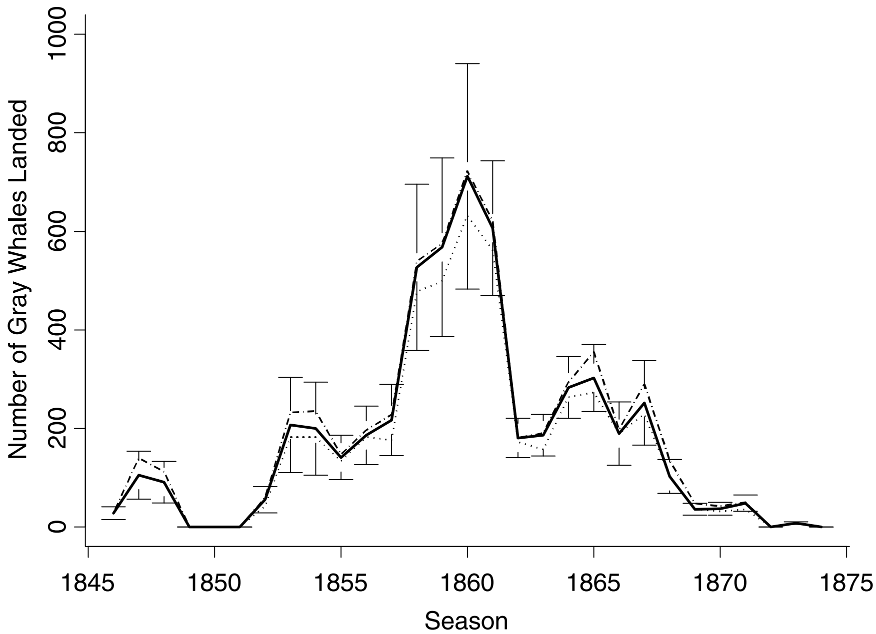


Figure 8.—Estimated numbers of gray whales landed in Mexico from 1846 to 1874, with the three cases for addressing uncertainty as to whether vessels were gray whaling (as described in the text). Vessel-season cases: low = dotted line, medium = solid line, high = dashed line Confidence intervals about the estimates (95%) are shown for the medium vessel-season case.

Table 4.—Estimated gray whale landings (whales) in Mexico from 1846 to 1874, with the three vessel-season cases (Low, Medium, High) to account for uncertainty regarding whether vessels were gray whaling. SE = standard errors of the estimates.

	Low Case		Medium Case		High Case	
Season	Whales	SE	Whales	SE	Whales	SE
1846	28	6.6	28	6.6	28	6.6
1847	105	24.9	105	24.9	140	33.2
1848	91	21.6	91	21.6	112	26.6
1849	0	0.0	0	0.0	0	0.0
1850	0	0.0	0	0.0	0	0.0
1851	0	0.0	0	0.0	0	0.0
1852	42	10.0	55	13.5	60	14.3
1853	182	43.2	207	49.4	232	55.3
1854	182	43.2	200	48.2	235	56.4
1855	133	21.7	141	22.9	147	23.9
1856	183	29.6	186	30.2	197	31.9
1857	176	28.5	217	37.0	228	38.6
1858	477	77.5	527	86.0	539	88.0
1859	499	80.9	568	92.6	575	93.7
1860	632	102.6	712	116.8	723	118.5
1861	561	63.5	606	69.7	621	71.4
1862	172	19.4	181	20.4	181	20.4
1863	157	17.7	186	21.4	190	21.8
1864	263	29.7	283	32.0	293	33.2
1865	273	30.9	303	34.8	355	40.6
1866	189	32.7	189	32.7	197	34.1
1867	229	39.5	252	43.7	290	50.1
1868	103	17.7	103	17.7	134	23.2
1869	36	6.1	36	6.1	47	8.2
1870	32	5.4	37	6.7	42	7.5
1871	36	6.1	48	8.5	50	8.7
1872	0	0.0	0	0.0	0	0.0
1873	8	1.4	8	1.4	8	1.4
1874	0	0.0	0	0.0	0	0.0
Total	4,789	199.5	5,269	223.4	5,624	234.7

There is a greater spread between the estimated landings for the three vessel-season case lines in some years than in others, especially during the middle years of the fishery, which are also the years that contribute most to the cumulative catch. In most of those years, the spread between the estimated landings for the three case lines is less than the width of the confidence intervals around the medium-case estimates (Fig. 8). In other words, the uncertainty in the estimated landings due to the standard errors (as reflected by the confidence intervals) is greater than the uncertainty due to the cases (as reflected by the spread between the case lines in the figure). We interpret this to mean that our estimation of landings would be improved most efficiently by reading more logbooks and not by simply trying to resolve more of the Unknown or Maybe gray whaling vessel-seasons.

The estimated total number of gray whales taken (secured and processed) by whalers in Mexican waters was 5,269 (SE = 223.4) for the medium vessel-season case, and ranged to roughly 9% lower and 7% higher for the low and high cases, respectively (Table 4). To estimate the total number of whales removed, an adjustment needs to be made to account for whales that were struck and lost (Table 2). At a minimum, a LRF of 1.06 can be applied to landings to account for the animals that were lost because they sank, because of poor weather, or because they escaped spouting blood (considered by the whalers as an indication of certain death). Alternatively, landings can be multiplied by 1.42 to account for all whales struck, regardless of their "condition" (Table 5).

Table 5.—Estimated numbers of gray whales removed by ship-based whalers in Mexican whaling grounds from 1846 to 1874 for the Low, Medium, and High cases for numbers of vessel-seasons and using the "Sank-Bleeding" or "combined" loss rate factor (LRF) (see Table 2), with standard errors (SE) accounting for the standard errors of both the landings and the LRF. See text for details.

Case	Low		Medium		High	
LRF	N	SE	N	SE	N	SE
1.06	5076	219.2	5585	245.1	5961	257.8
1.42	6800	371.1	7482	412.5	7986	436.2

Thus, actual removals would be at least 5,076 to 5,961, using the LRF of 1.06, although it is unreasonable to assume that no other struck whales died of their injuries. The estimated total number of struck whales would be between 6,800 and 7,986. However, it is also unreasonable to assume full mortality of all struck whales. Even though, as mentioned earlier, bomb lances were frequently used to subdue gray whales in the Mexican whaling grounds, not all bomb lances exploded. This is evidenced by the report from one California shore station where the equipment was said to be "of marginal quality" and "two thirds of the whales wounded were lost due to the harpoon's failure to explode" (Nichols, 1983:109, citing the diary of a judge who visited the whaling station at Ballard Point in 1860). In another example from the shore fishery (at Point Conception, California, 1879–80), all but one of 16 gray whales secured bore wounds attributed to previous strikes by bomb-lances (Jordan, 1887).

We are aware of two other studies that attempted to address the struck-lost issue in novel ways. Bannister et al. (1981), in their study of sperm whaling on the Japan Ground, sorted logbook records into three classes: whales tried out, whales struck and lost, and whales lost spouting blood. They then provided alternative LRF's, dependent on assumptions—one that only those lost spouting blood were "removed" (LRF: 1.20) and the other that all struck whales were removed (LRF: 1.61). This allowed them to offer two alternative estimates of total removals by year, essentially one high and one low, i.e. "a range within which total removals from the stock may lie during the study period …" (Bannister et al., 1981:830). Because their main interest was in trends in catches and catch per unit of effort, rather than in aggregate totals of whales removed (as here), Bannister et al. apparently saw no need to comment on which of their sets of estimates was likely the more accurate.

The other study (Mitchell and Reeves, 1983) assigned logbook records of humpback whale catches to six classes: 1) whales tried out, 2) whales known to have been killed but that were lost, 3) whales struck and lost but with no specific details on the circumstances, 4) whales struck and lost because the "iron drew," 5) whales struck and lost carrying gear, and 6) calves whose mothers were known to have been killed (i.e. they were orphaned on the calving grounds). These authors then developed a single LRF (1.86), based on the assumption that all of the whales in classes 1, 2, 5, and 6 and half of the whales in classes 3 and 4 were removed. They then used this single LRF to estimate removals from landings.

We are not able to evaluate in a meaningful way the potential of gray whales to survive various types of encounters with 19th century ship-based commercial whalers on the breeding grounds. Therefore, we have chosen to present multiple options according to assumptions, essentially following the lead of Bannister et al. (1981).

To account for the total effect of ship-based whaling on the gray whale population, the estimated 539 whales removed on the feeding grounds in the Bering and Chukchi Seas (Henderson, 1984) would need to be added.

Discussion

Comparisons to Earlier Estimates

Estimates of catches or total removals of gray whales by other authors have accounted for the various relevant whaling operations in different ways, and this makes it difficult to compare those estimates with ours. Henderson (1984) estimated that 4,466–4,516 eastern gray whales were secured and processed by ship-based whalers in Mexico between 1846 and 1874. This compares with our medium-case estimate of total landings of 5,269 (SE = 223.4). Henderson's estimates of landings were based largely on reported whale oil production, while ours are based on average landings per vessel-season. Our decision to consider the medium case for vessel-season uncertainty (Table 4) as providing our "best" estimates of total landings reflects our considered judgment concerning the many uncertainties surrounding the 19th century commercial catch history.

Henderson (1984) assumed that on the Mexican grounds, one whale was "mortally wounded" for every 10 secured, so his loss-adjusted estimate of total removals from those grounds was 4,913–4,968. Our medium-case estimate of total removals is 5,585 when we account only for whales that were lost due to sinking or escaped spouting blood and 7,482 if we assume (unrealistically) that all struck whales eventually died of their wounds. Thus, our medium-case estimate of removals in Mexico is somewhere between about 12 and 52% higher than that of Henderson (1984). We have made no attempt to investigate catches in the northern summering areas and therefore accept Henderson's (1984) estimate of an additional 402 eastern gray whales landed there, which he adjusted to 539 removed, assuming that in the north one whale was mortally wounded for every five secured. Adding that value to our range of Medium-case estimates suggests that a total of 6,124 to 8,021 gray whales were removed from the eastern North Pacific population.

Scammon (1874:23) stated: "From what data we have been able to obtain, the whole number of California Gray Whales which have been captured or destroyed since the bay-whaling commenced, in 1846, would not exceed 10,800." Because Scammon was well acquainted with whaling activities throughout the range of this gray whale population, we infer that his figure of 10,800 was meant to include all removals (catches plus hunting loss) by 1) ship-based commercial whalers in the Mexican breeding areas as well as in the northern feeding areas, 2) shore-based commercial whalers in California (Scammon, 1874:251), and 3) shore-based aboriginal whalers in northern latitudes (Scammon, 1874:29–32). We are not aware of any specific estimates of commercial ship-based catches by Scammon, but he gave the shore-based commercial catch between about 1850 and 1874 as "not less than 2,160," to which he proposed adding 20% to account "for the number of whales that escaped their pursuers, although mortally wounded, or were lost after being killed either by sinking in deep water or through stress of weather" (1874:251).

Scammon did not attempt to quantify the removals by aboriginal whalers but made a number of statements implying that he was aware of how widespread this whaling was and of its importance to some aboriginal communities. For example, in describing gray whale hunting by Indians of Washington and British Columbia and by Eskimos in the Arctic, he notes (1874:32) that in those northern latitudes the gray whale "is exposed to attack from the savage tribes inhabiting the sea-shores, who pass much of their time in the canoe, and consider the capture of this singular wanderer a feat worthy of the highest distinction." Given the incompleteness of information on how Scammon derived his estimate of total removals from the population, we cannot meaningfully evaluate the differences between his estimate of the ship-based commercial component and our own.

Finally, our estimates are considerably higher than those of Best (1987), who estimated landings on a voyage by voyage basis in two ways: 1) using published oil returns and Henderson's estimate of 35 barrels/whale for an estimate of 2,665 gray whales secured, and 2) using an average catch per voyage derived from Townsend (1935) for an estimate of 3,013 gray whales. He made no attempt to account for whales struck but lost. Moreover, he suggested that his catch estimates were 6–19% too low because he, unlike Henderson (1984), did not account for catches by non-U.S. registered vessels. Importantly, Best (1987) made no attempt to distinguish between eastern and western gray whales even though whales from both "stocks" were included in the oil data and the Townsend tabulations. It is unlikely that our inclusion of non-U.S.-registered vessels would account for the differences between our estimates and Best's estimates, considering that American vessels were responsible for 89% of the total ship-based gray whaling activity.

Uncertainties in the Estimates

Several of the uncertainties in our estimates of gray whale landings and removals are accounted for in the estimation variances, including the variability in the number of whales landed per vessel-season, the loss rate factor, and the prorating of the vessel-seasons for which we had no information about gray whaling activity. In sum, the width of the confidence interval for the medium-case estimate of total landings (4,811–5,726, Table 4), which reflects the sampling uncertainty, is 17% of the estimate. That percentage is similar to the difference between the low-case estimate and the high-case estimate (4,789 and 5,624, respectively), which is 15.8% of the medium-case point estimate and reflects the case variability.

We also explored the sensitivity of our estimates to the arbitrary assumption that half of the vessels in Mexican waters judged to have been "maybe" gray whaling actually were gray whaling. To do this, we computed estimates assuming that as few as one quarter or as many as three quarters of the "maybe" vessels actually were gray whaling. This resulted in differences of less than 5% in the estimated total landings. Thus, the magnitude of this uncertainty is small compared to that of uncertainty due to sampling variability and also small when compared to the differences among the three cases of numbers of vessel-seasons.

Another point to consider is that it was not always possible to distinguish vessels that gray whaled unsuccessfully (i.e. chased gray whales but made no catch) from those that pursued only other species (e.g. humpback whales or sperm whales). This inability to identify such "zero-catch" vessel-seasons would have biased our list of gray whaling vessel-seasons downward, but at the same time it would have biased our estimates of the average catch of gray whales per vessel-season upward. The two effects would tend to offset each other to an unknown extent, but the latter would likely be greater than the former because of the relatively small size of the sample used to estimate average catch per vessel-season.

Temporal Changes in Catch Levels

Gray whaling in the eastern North Pacific by 19th century ship-based whalers was concentrated in a 3-decade period, with the bulk of the landings occurring between 1853 and 1863. Levels of both whaling activity (Fig. 7) and landings (Fig. 8) increased steadily over the decade beginning in 1853. Effort dropped abruptly in 1861, at the start of the U.S. Civil War, although it rapidly recovered to levels lying between the 1861 low and the pre-1861 high. Landings per vessel-season declined disproportionately as whaling became much less productive, with landings dropping by 45% from the peak level of 14.0 from 1856 to 1860 to a low of 7.9 from 1866 to 1874 (Table 1).

The decline in ship-based whaling activity paralleled the decline in shore-based gray (and humpback) whaling along the coast of California (Reeves and Smith, 2010). It is unlikely that the decline in either fishery was due to changes in the price of whale oil because, although the price declined briefly in the 1860's, it had recovered by the 1870's, even as gray whaling continued to decline. It is difficult to judge whether catch rates or effort to kill gray whales in the northern feeding areas also declined, given the relatively small catches there and the fact that the available tabulations (Henderson, 1972, 1984) provide only very coarse temporal resolution (i.e. totals approximately by decade).

The overall decline in gray whale catches in the 1860's was interpreted by some contemporary observers as a reflection of whale depletion. For example, when an American employee of a land-concessions company visited Baja California in 1866, he claimed that lagoon and alongshore whaling was no longer profitable and nearly abandoned, noting that two whaleships in Magdalena Bay had taken only two whales so far that season "though they had scoured the waters of the bay for two months" (Browne, 1966:60–61, as cited by Nichols, 1983:33). Scammon (1874:33) described the large bays and lagoons "where these animals once congregated, brought forth and nurtured their young" as "nearly deserted" by the early 1870's.

Gray whaling in the eastern North Pacific nearly ceased after the mid 1870's and until the early 20th century, except for aboriginal whaling (Mitchell, 1979; O'Leary, 1984; Mitchell and Reeves, 1990), small and sporadic catches by California shore whalers (Reeves and Smith, 2010), and occasional ship-based whaling on the feeding grounds (Bockstoce, 1986). Even if the eastern gray whale population was as depleted as suggested by first-hand observers in the late 1860's and 1870's, the lower intensity of whaling in subsequent decades should have allowed it to recover to some degree in the latter 19th and early 20th centuries. The extent of such recovery has not been revealed by assessment models that incorporate previous estimates of 19th century removals (as discussed above), which appear to be inconsistent with the population increases observed in the latter half of the 20th century.

Modern factory-ship whaling on gray whales began in 1914, and, by 1946, Norway, the United States, the Soviet Union, and Japan had taken a total of about 940 eastern gray whales in various parts of the population's range (Reeves, 1984). In addition, an uncertain number of gray whales (possibly several hundred) were taken in the 1930's off southern California by the U.S. factory ship *California* (Brownell and Swartz, 2007). The biological or population-level significance of these removals would have been considerable if the population was near extinction in the early 20th century as assumed by some contemporary observers (Andrews, 1916; Starks, 1922). The degree of depletion of eastern gray whales caused by 19th and early 20th century commercial whaling remains uncertain, but a recent assessment model, which incorporates 20th century population increases but uses only the record of removals since 1930, suggests that the population was on the order of a few thousand in 1930 (Brandon and Punt, 2009).

Implications for Population Assessment

We have no doubt that this effort of ours to build upon the legacy of David Henderson has provided a more complete and accurate picture than was previously available of the numbers of whales removed by ship whalers in the 19th century. The total estimates presented here for 19th century ship-based whaling in Mexico, along with those in our recent reanalysis of 19th century California shore-based gray whaling (Reeves and Smith, 2010), are not, however, substantially different from previously available estimates of removals by these two components of the overall commercial fishery.

Further, we are not aware of any substantial improvements on the earlier estimates for aboriginal gray whaling (IWC, 1993) and ship-based gray whaling north of Mexico (Henderson, 1984). The only significant improvement on estimates of 20th century landings is the previously overlooked 20th century removals by *California* (see above). Therefore, judging by the sensitivity analyses of Butterworth et al. (2002) and Wade (2002), there is no reason to expect that uncertainties about population status associated with previous population modeling approaches would be resolved by incorporating our new estimates of removals.

It is relevant to consider the possibility that lagoon whaling had a more severe effect than would be evident solely from the record of removals. As indicated above, our logbook data confirm that lagoon whaling in Mexico focused on adult females with calves. Further, although calves apparently were seldom tried out (i.e. secured and processed), many were wounded if not killed outright as the whalers attempted to secure their mothers, and many more were orphaned when their mothers were killed. Given that logbooks do not consistently record the presence and fate of calves, it is unlikely that data needed for rigorous quantitative estimates of calf "removal" levels can be obtained.

Although we currently have no way of apportioning the aggregate catch data by area, i.e. inner lagoons vs. lagoon entrances vs. outer coasts (alongshore whaling), it is possible that, with closer scrutiny of logbooks and other sources, this could be done. For example, in the early years of exploitation of a given lagoon, the hardest hit group may have been the cows with calves in the inner reaches. Only after a few years, as that component became depleted, would the whalers have spent substantial time pursuing the more difficult-to-catch and individually lower-yield quarry (bulls, juveniles, and resting females) that congregated in the outer parts of the lagoons and along the outer coasts (Norris et al., 1983; Swartz, 1986). Thus, the composition of catches (specifically the proportion of calving/nursing cows and, in turn, the numbers of killed, mortally wounded, or orphaned calves) could be estimated, based on the pattern of discovery and exploitation of each lagoon.

In any event, the lagoon fishery for gray whales must have had a greater effect on the population than either an unbiased removal regime or a regime biased toward an age or sex class other than adult females (Cooke, 1986). Friday and Smith (2003) showed that the harvest pattern associated with lagoon whaling would have the highest per capita impacts of any pattern considered. A complete assessment of the status of the population will require accounting in some way not only for the sex ratio of the adults removed, but also for the calves that were killed or orphaned, and presumably died, as a consequence of whaling operations.

Further Research

As noted above, our new estimates of the commercial catch history do not come anywhere near to the 60% increase needed to fit existing population models of the eastern gray whale population (Butterworth et al., 2002; Wade, 2002). Also, our numbers, when combined with the relatively well-documented catch levels of the 20th century and the best available estimates of aboriginal catches, do not appear consistent with the genetically derived estimate of average long-term abundance of about 96,000 by Alter et al. (2007), which refers to the entire North Pacific basin and thus encompasses both eastern and western populations.

Thus, two major problems remain. One is the difficulty of obtaining reasonable estimates of historical carrying capacity from catch-based population models. The other is that estimates of historical abundance derived from analyses of genetic variability seem far too high, given what is known about total removals by whaling and recent or current estimated population size.

At least four avenues of investigation to address these problems come to mind: 1) further reconstruction of the catch history, 2) reassessment of the demographic and social effects of lagoon whaling, especially in regard to calving, nursing, and breeding, 3) searching for a better understanding of environmental or ecological factors that determine carrying capacity for gray whales, and 4) reevaluation of the underlying assumptions and methods of genetic variability-based estimates of abundance.

With regard to the first of these, catch history, we suggest that future effort should focus on the poorly documented but long history of whaling for gray whales by aboriginal people throughout the North Pacific, including the Bering and Chukchi Sea coasts (Mitchell, 1979; O'Leary, 1984; Krupnik, 1984; Mitchell and Reeves, 1990) and on the better documented but incomplete history of gray whaling in the western North Pacific. Although there are reasonably good records from Japan (Omura, 1984; Kato and Kasuya, 2002), this is not the case for Korea and China (e.g. Reeves et al., 2008).

In addition, improvements could be made in our present estimates for the eastern North Pacific by sampling additional logbooks to determine landings per vessel-season. Linking the vessel-season data in the Appendix to information in the American Offshore Whaling Voyage database (Lund et al., 2008) reveals that we have sampled about 25% of the extant relevant logbooks. Sampling more logbooks would address uncertainties in our estimation procedures in two ways: 1) by reducing the numbers of Maybe and Unknown vessel-seasons (Table 3) and 2) by reducing the standard errors of the average numbers of whales taken in vessel-seasons that we know involved gray whaling (Table 1).

The resources available for this study were not sufficient to allow additional logbook sampling, but with the information provided here concerning the uncertainties, together with the information in the Appendix and the AOWV database on logbook availability, it should be possible to design an efficient sampling scheme to improve our estimates in a number of ways. Such a scheme would allow greater statistical precision and, with more emphasis on catch locations (e.g. deep inside the lagoons, in the lagoon entrances, or along the outer coast) than was possible in this study, allow us to partition removals by area and hence age/sex class, at least to some extent. It is also worth noting that the estimate of ship-based landings north of Mexico (Henderson, 1984) is not well documented, and further examination of the data on which it is based could be useful.

With regard to the second avenue of investigation, the effects of lagoon whaling, it may be useful to explore population models that would better account for the effects of whaling on a population's breeding grounds. This issue was raised previously by Cooke (1986) and subsumed by Butterworth et al. (2002:66) under the rubric of depensation, which they defined as "the phenomenon of a decrease in the per capita growth rate of a resource when population size is reduced below a certain level." However, the issue deserves further exploration and should explicitly include consideration of the differential sex ratio of the catches, the deaths of calves, and the disruptive effects of whaling at the point in the life cycle when females give birth, nurse their young, and conceive (Friday and Smith, 2003).

With regard to the third avenue, carrying capacity, there has been considerable speculation in the literature on how and to what extent the environmental carrying capacity for gray whales has changed over time. For this species, with its long-distance migration and the sharp geographical separation between its feeding and breeding habitat, population size could be limited either by the size and condition of Mexican lagoons or by the extent and productivity of boreal and Arctic shelf waters. Half a century ago, there was lively debate concerning how much gray whale breeding habitat had been lost in southern California and Mexico, whether due to inshore vessel traffic (Gilmore and Ewing, 1954), cooling sea temperatures (Hubbs, 1959), or sea level fluctuations and other geophysical processes (Gilmore, 1976).

More recently, the emphasis has been on food limitation. A large-scale die-off along the west coast of North America in 1999 fueled speculation that foraging conditions for gray whales in the Bering and Chukchi Seas had deteriorated, leading to poor survival and low calf production (Le Boeuf et al., 2000). The die-off continued in 2000, with a relatively high proportion of the mortality consisting of subadult and adult whales and with some but not all of the dead animals exhibiting signs of nutritional stress (Gulland et al., 2005). Annual strandings returned to background levels from 2001 through 2006 (Brownell et al., 2007), and Moore et al. (2001) concluded, "The causes of the recent spate of gray whale deaths may never be discovered." The factors determining carrying capacity for gray whales are not clearly known, and alternative model formulations may be useful for exploring this issue further.

Finally, with regard to the fourth avenue, the reliability of genetic variability-based estimates of average long-term abundance, concerns have been raised about such things as the mutation rate attributed to gray whales, the relationship of effective and census population size, the demographic and social characteristics assumed, and the applicability of genetic variability-based estimates of abundance to contemporary (or recent historic) populations (Palsbøll et al., 2007; Alter and Palumbi, 2007; Palsbøll, 2009). Although such concerns were addressed to some degree by Alter et al. (2007) and Alter and Palumbi (2007), further testing is needed of both the methodology and the assumptions leading to those authors' seemingly very high estimate of average long-term abundance compared to estimates of pre-whaling abundance derived from other methods.

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Appendix

Identity of vessels whaling in Mexico during the gray whaling winter season from 1846 to 1874 showing the vessel name (Vessel), the nationality of registry (Nat), the vessel number (Ves), and the voyage number (Voy). Also shown are the source of information on each vessel-season (VS) and the likelihood that each vessel-season involved gray whaling (GW). For vessel-seasons where we had information on landings, the estimated number of gray whales taken during that season (EGW) and the nature of the source of those landings (LS) is indicated. Voyage and vessel numbers for American vessels are from the American Offshore Whaling Voyage database (Lund et al., 2008) and the voyage numbers for the French vessels are from Annex 7 of du Pasquier (1982:242–9, as 30,000 plus the numerical sequence). Details of the American vessels and voyages can be obtained by tracing the Ves and Voy values given here into the National Maritime Data Library (www.nmdl.org).

Coded Fields:

VS (Vessel Source): H = Henderson (1972, 1984, and unpublished notes and files), O = Other, primarily Hawaii port records

GW (Gray Whaling): Y = Yes, M = Maybe, N = No, U = Unknown

LS (Landings Source): L = logbook we read, T = logbook read by Townsend (1935), N=newspaper.

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
A. M. Simpson	1860	American	809	35	H	N		
Addison	1859	American	3	229	H	Y		
Adeline	1854	American	2	257	O	U		
Adeline	1863	American	2	259	H	Y	16	L
Adeline	1864	American	2	259	H	Y	21	L
Agate	1857	American	795	341	O	U		
Agate	1858	American	795	341	H	Y		
Agate	1859	American	795	341	H	Y		
Alexander	1854	American	5	465	H	M		
Alexander Coffin	1854	American	13	517	O	U		
Alice	1859	Hawaiian			H	Y	9	N
Alice	1861	American	842	550	H	Y		
Almira	1861	American	806	672	O	U		
Almira	1866	American	806	763	O	Y	4	T
Almira	1867	American	806	673	H	Y		
Aloha	1860	Hawaiian			O	Y		
Alpha	1865	American	36	693	H	M		
Alpha	1866	American	36	694	H	Y	14	N
Alpha	1867	American	36	694	O	M		
America	1847	American	6	818	H	M		
America	1853	American	6	825	H	U		
America	1854	American	6	825	H	U		
Antilla	1859	Hawaiian			H	Y		
Antilla	1860	Hawaiian			O	Y		
Aquetnet	1852	American	898	1146	O	U		
Aquetnet	1853	American	898	1146	H	Y	5	L
Arab	1856	American	899	1166	H	N		
Arab	1864	American	39	1173	O	U		
Architect	1857	American	902		O	U		
Arnolda	1854	American	18	1254	O	M		
Arnolda	1865	American	18	1257	H	Y		
Arnolda	1866	American	18	1257	H	Y		
Aurora	1868	American	37	1438	H	N		
Baltic	1854	American	73	1526	O	N		
Barnstable	1858	American	718	1592	H	Y		
Barnstable	1863	American	718	1593	H	Y	2	L
Bartholomew Gosnold	1858	American	72	1600	O	U		
Bartholomew Gosnold	1861	American	72	1602	O	N		
Bartholomew Gosnold	1864	American	72	1603	H	Y		
Bartholomew Gosnold	1865	American	72	1603	H	Y		
Bay State	1854	Undetermined			H	N		
Belle	1855	American	963	1645	O	N		
Belle	1855	American	964	1647	O	N		
Bengal	1854	American	968	1735	H	N		
Bengal	1855	American	968	1735	H	N		
Benjamin Morgan	1858	American	970	1765	O	Y		
Benjamin Morgan	1859	American	970	1765	H	Y		
Benjamin Rush	1858	American	971	1776	O	Y		
Benjamin Rush	1859	American	971	1776	H	M		
Benjamin Rush	1865	Undetermined			O	U		
Benjamin Tucker	1858	American	63	1786	H	Y		
Bingham	1848	American	986	1871	H	Y		
Black Eagle	1853	American	78	1880	O	N	0	T
Black Eagle	1858	American	78	1881	O	Y		
Black Prince	1863	Undetermined			H	U		
Black Warrior	1857	Hawaiian			O	M		
Black Warrior	1858	Hawaiian			O	Y		
Black Warrior	1859	Hawaiian			H	N		
Boston	1857	American	1000	1945	H	Y		

continued

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Appendix (continued)

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
Boston	1858	American	1000	1946	H	Y		
Bowditch	1848	American	1001	1976	H	N		
Braganza	1858	American	69	2004	H	Y		
Brookline	1847	American	1011	2060	H	Y	29	N
Brunswick	1863	American	71	2107	H	Y	12	T
Brunswick	1864	American	71	2107	H	Y		
Brunswick	1865	American	71	2107	H	U		
Cabinet	1847	American	1016	2132	H	M		
California	1854	American	93	2193	O	U		
California	1861	American	93	2195	H	Y		
California	1863	American	93	2196	H	Y		
California	1864	American	93	2196	H	Y	4	L
California	1865	American	93	2196	H	Y	9	T
California	1868	American	93	2197	O	M		
Callao	1857	American	80	2227	H	N		
Callao	1861	American	80	2228	H	U		
Cambria	1861	American	82	2243	H	Y	11	T
Camilla	1864	American	132	2255	H	N		
Camilla	1865	American	132	2255	H	N		
Camilla	1866	American	132	2255	H	Y		
Camilla	1867	American	132	2255	H	N		
Candace	1855	American	1029	2284	H	Y		
Canton Packet	1865	American	88	2334	H	Y		
Carib	1858	American	1034	2364	H	Y		
Carib	1859	American	1034	2365	H	Y		
Carib	1860	American	1034	2365	H	Y		
Carib	1862	American	1034	16805	H	Y		
Carlotta	1871	American	1035	2373	H	Y		
Caroline E. Foote	1864	American	1038	2401	H	Y		
Caroline E. Foote	1865	American	1038	16783	H	Y		
Caroline E. Foote	1866	American	1038	2402	H	Y		
Caroline E. Foote	1871	American	1038	2403	H	Y		
Catharine	1847	American	1055	2470	H	M		
Catharine	1863	American	1054	2468	H	Y		
Catharine	1864	American	1054	2468	H	Y		
Catharine	1865	American	1054	2468	H	M		
Cavalier	1853	American	125	2497	H	M		
Champion	1858	American	1064	2526	H	U		
Champion	1867	American	1064	2528	O	N		
Chandler Price	1861	American	116	2556	H	Y		
Chariot	1854	American	1068	16947	O	U		
Charles Carroll	1856	American			H	N		
Charles Frederick	1853	American	90	2676	H	N		
Charles Phelps	1846	American	1085	2696	H	N	0	L
Charles Phelps	1852	American	1085	2698	O	N	0	T
Charles W. Morgan	1858	American	89	2716	O	N		
Charles W. Morgan	1859	American	89	2716	O	U		
Charles W. Morgan	1861	American	89	2717	H	Y		
Charles W. Morgan	1862	American	89	2717	H	Y	13	N
Cherokee	1853	American	101	2811	H	N		
Cherokee	1854	American	101	2811	O	N		
Citizen	1848	American	115	2902	H	N		
Citizen	1853	American	1104	2898	O	N		
Citizen	1854	American	1104	2898	O	Y		
Clematis	1855	American	1112	2967	H	N		
Clement	1853	American	1113	2974	H	Y		
Clementine	1848	German			O	Y		
Cleone	1861	American	121	2977	H	Y	14	T
Cleopatra	1859	Columbia			H	Y		
Columbia	1852	American	1121	3021	H	N		
Columbia	1853	American	1121	3021	H	M		
Columbus	1858	American	110	3092	H	Y		
Comet	1861	German			H	Y	11.5	N
Comet	1862	German			H	Y		
Comet	1863	German			H	Y		
Comet	1864	German			H	Y		
Congress	1865	American	112	3254	O	Y		
Congress	1866	American	112	3254	H	N	0	L
Congress	1867	American	112	3254	H	Y	3	L

continued

Appendix (continued)

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
Congress II	1861	American	113	3258	H	Y		
Congress II	1862	American	113	3258	O	Y		
Coral	1861	American	109	3323	H	Y	17.5	N
Corinthian	1859	American	97	3357	O	U		
Corinthian	1861	American	97	3357	O	Y		
Corinthian	1867	American	97	3359	O	N		
Corinthian	1868	American	97	3359	H	N		
Cornelius Howland	1865	American	103	3405	H	Y	5	L
Cornelius Howland	1866	American	103	3405	H	Y	19	L
Cornelius Howland	1867	American	103	3405	H	Y		
Cornelius Howland	1870	American	103	3407	O	Y	2	L
Cosmopolite	1848	French		30511	H	M		
Cowper	1854	American	117	3476	O	N		
Cynthia	1859	Hawaiian			H	Y		
Cynthia	1860	Hawaiian			O	Y		
Cynthia	1861	Hawaiian			H	Y		
Dartmouth	1857	American	145	3599	H	Y	27	L
Delaware	1855	American	1198	3659	H	Y	6	L
Delaware	1860	American	1198	3663	H	Y		
Delaware	1861	American	1198	16809	H	Y		
Delaware	1862	American	1198	16809	H	N		
Draper	1857	American	147	3858	H	Y		
Draper	1858	American	147	3858	O	Y		
Dromo	1846	American	1232	3864	H	N		
Dromo	1852	American	1232	3866	H	Y		
Dromo	1859	American	1232	3869	H	Y		
Eagle	1857	American	1244	3988	H	U		
Eagle	1858	American	177	3982	H	Y		
Eagle	1867	American	177	3984	O	M		
Eagle	1868	American	177	3984	H	Y	9	T
Eagle	1868	American	2811	16952	H	Y		
Eagle	1869	American	2811	16953	H	Y	14	N
Eagle	1869	American	177	3984	H	Y	9	T
Edward	1848	American	180	4020	H	M		
Edward L. Frost	1852	American	2813	17047	H	U		
Edward L. Frost	1855	American	2813	16957	O	Y		
Edward L. Frost	1857	American	2813	16957	H	Y		
Edward L. Frost	1858	American	2813	16958	H	Y		
Electra	1861	American	1261	4119	H	Y		
Eliza	1858	American	193	4141	H	Y		
Eliza Adams	1853	American	199	4171	H	N	0	L
Eliza Adams	1854	American	199	4171	O	N		
Eliza Adams	1860	American	199	4173	H	Y		
Eliza Adams	1865	American	199	4174	H	N		
Eliza Adams	1866	American	199	4174	H	N		
Elizabeth Swift	1865	American	190	4268	H	N		
Ellen	1859	American	1283	4271	H	U		
Emeline	1855	American	1288	4349	H	U		
Emerald	1858	American	178	4371	O	M		
Emerald	1859	American	178	4371	H	Y		
Emerald	1860	American	178	4371	H	Y		
Emerald	1861	American	178	4371	H	Y		
Emily Morgan	1868	American	170	4407	H	N		
Emily Morgan	1871	American	170	4409	H	N		
Emma Rooke	1862	Hawaiian			O	Y		
Emperor	1852	American	1299		H	N		
Emperor	1853	American	1299		H	N		
Endeavor	1866	American	173	4492	H	M		
Endeavor	1867	American	173	4492	H	M		
Erie	1851	American	2753	4583	H	U		
Erie	1860	American	2753	4585	H	Y		
Espadon	1854	French		30554	O	N		
Eugenia	1867	American	198	4656	H	U		
Euphrates	1859	American	175	4688	H	N	0	T
Euphrates	1860	American	175	4688	O	Y	1	T
Euphrates	1864	American	175	4689	H	Y		
Euphrates	1865	American	175	4689	H	M		
Europa	1861	American	1328	4692	H	Y		
Europa	1864	American	1328	4693	H	Y		

continued

Appendix (continued)

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
Europa	1865	American	1328	4693	H	U		
Europa	1868	American	1328	4694	H	Y	2	L
Fabius	1860	American	222	4784	H	Y	20	L
Fabius	1861	American	222	4784	H	Y	13	L
Fabius	1863	American	222	4785	H	Y		
Fabius	1864	American	222	4785	H	Y	3	L
Fabius	1865	American	222	4785	H	Y	3	T
Faith	1859	British			H	Y		
Fame	1852	Undetermined			H	N		
Fanny	1858	American	1361	4887	O	U		
Fanny	1860	American	1361	4887	O	U		
Fanny	1866	American	1361	4889	H	Y	1	T
Fanny	1867	American	1361	4889	H	N	0	T
Fanny	1868	American	1361	4889	H	N		
Fanny	1871	American	1361	4890	H	N		
Favorite	1856	American	2817	16992	H	Y		
Florence	1864	Hawaiian			H	Y		
Florida	1861	American	213	5004	H	Y	3	L
Florida	1862	American	213	5004	H	U		
Florida	1866	American	213	5005	H	Y		
Florida	1867	American	213	5005	H	M		
Florida II	1861	American	1376	5009	H	U		
Fortune	1858	American	224	5041	O	M		
Fortune	1859	American	224	5041	H	Y		
Fortune	1860	American	224	5041	H	Y		
Frances Henrietta	1854	American	217	5133	H	Y		
Frances Palmer	1858	American	1392	16996	H	Y		
Francis	1856	American	1399	5163	H	Y		
Francis	1857	American	1399	5165	O	Y		
Francis	1858	American	1399	5165	H	N		
Franklin	1858	American	1411	5300	H	N		
Franklin	1860	American	1411	5300	O	N		
Gay Head	1867	American	253	5405	H	Y		
Gay Head	1868	American	253	5405	H	M		
General Pike	1860	American	235	5499	O	N		
General Scott	1858	American			O	N		
General Scott	1861	American	263	5511	H	Y		
General Scott	1867	American	1441	5513	O	M		
General Scott	1868	American	1441	5513	H	Y		
General Teste	1852	French		30529	O	U		
General Teste	1854	French		30555	O	N		
General Williams	1860	American	1445	5534	H	Y		
General Williams	1861	American	1445	5534	H	Y		
George	1853	American	1464	5594	H	U		
George	1856	American	2820	16999	O	U		
George	1867	American	234	5578	H	M		
George	1871	American	234	5579	O	M		
George Howland	1855	American	236	5694	O	N		
George Howland	1860	American	236	5695	H	Y	16	T
George Howland	1861	American	236	5695	H	Y	8	T
George Howland	1864	American	236	5696	H	Y	14	T
George Howland	1868	American	236	5697	H	Y	10	L
George Howland	1869	American	236	5697	H	N	0	L
George Washington	1860	American	2735	5747	O	U		
George and Mary	1860	American	1450	5633	H	Y		
George and Mary	1860	American	259	5645	H	U		
Good Return II	1854	American	218	5903	O	N	0	L
Good Return II	1860	American	218	5905	O	M		
Governor Troup	1860	American	247	5952	O	N	0	L
Governor Troup	1864	American	247	5955	H	Y	5	T
Governor Troup	1865	American	247	5955	H	Y	2	L
Governor Troup	1866	American	247	5955	H	Y	12	L
Gratitude	1864	American	248	6011	O	Y		
Gustave	1861	French		30582	O	Y		
Hae Hawaii	1868	Hawaiian			O	Y		
Hansa	1848	German			O	Y		
Harmony	1860	Hawaiian			H	Y		

continued

Appendix (continued)

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
Harmony	1861	Hawaiian			H	Y	18.5	N
Harmony	1862	Hawaiian			O	Y		
Harrison	1867	American	279	17049	O	M		
Harvest	1862	American	282	6256	H	Y		
Helen Mar	1867	American	290	6337	H	N		
Helen Mar	1868	American	290	6337	H	N		
Helen Snow	1874	American	284		O	U		
Henry	1855	American	1581	6394	O	Y		
Henry	1857	American	1584	6414	H	Y	19	N
Henry Kneeland	1860	American	280	6438	H	Y		
Henry Kneeland	1861	American	280	6438	H	Y		
Hercules	1856	American	271	6542	O	N		
Hercules	1859	American	271	6543	H	Y		
Hercules	1865	American	271	6544	H	Y		
Hercules	1869	American	271	6545	O	M		
Hercules	1870	American	271	6545	H	Y	13	N
Heroine	1854	American			O	M		
Hibernia	1855	American	273	6667	H	Y	5	L
Hibernia	1856	American	273	6667	H	N	0	L
Hibernia	1857	American	273	6667	O	N	0	L
Hibernia	1859	American	273	6668	H	Y		
Hibernia II	1846	American	285	6678	H	Y	22	N
Hibernia II	1847	American	285	6678	H	Y		
Hibernia II	1870	American	285	6676	O	M		
Hillman	1859	American	287	6704	H	Y		
Hillman	1864	American	287	6705	O	Y		
Hillman	1865	American	287	6705	H	Y		
Hope	1848	American	210	6771	H	N		
Hopewell	1856	American	1622	6792	H	Y		
Huntsville	1853	American	1633	6901	O	N		
Iris	1867	American			O	U		
Isabella	1861	American	311	7167	H	Y	2	L
Isabella	1862	American	311	7167	H	Y		
Isabella	1864	American	311	7168	H	N		
Isabella	1865	American	311	7168	H	Y	2	N
Islander	1858	American	312	7184	O	N		
J. D. Thompson	1860	American	345	7208	O	Y		
J. D. Thompson	1865	American	345	7211	H	N		
J. D. Thompson	1866	American	345	7211	H	Y		
J. D. Thompson	1867	American	345	7211	H	Y		
J. E. Donnell	1847	American	331	7216	H	M		
James Allen	1867	American	329	7260	H	Y		
James Allen	1868	American	329	7260	O	M		
James Andrews	1856	American	335	7278	H	Y		
James Andrews	1857	American	335	7278	H	Y		
James Loper	1853	American	1675	7303	O	N		
James Loper	1854	American	1675	7303	O	N		
James Maury	1853	American	330	7308	H	Y	9	L
James Maury	1854	American	330	7308	H	Y	7	L
James Maury	1855	American	330	7308	H	Y	15	L
James Maury	1858	American	330	7309	O	N		
James Trosser	1857	Undetermined			H	Y		
Jane	1859	Undetermined			O	Y	22	N
Janus II	1857	American	324	7379	O	U		
Janus II	1861	American	324	7380	H	M		
Janus II	1867	American	324	7382	O	M		
Janus II	1868	American	324	7382	O	M		
Jeannette	1860	American	328	7497	H	Y		
Jeannette	1861	American	328	7497	H	Y		
Jesse D. Carr	1858	American	2873	17012	O	Y		
Jireh Perry	1867	American	337	7530	H	Y		
John Howland	1860	American	321	7745	H	Y		
John Howland	1861	American	321	7745	H	Y		
John Howland	1862	American	321	7745	H	Y	20	L
John Howland	1863	American	321	7745	H	Y	14	L
John Howland	1866	American	321	7747	H	Y		
John Howland	1867	American	321	7747	H	M		

continued

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
John Howland	1868	American	321	7747	O	Y		
John Howland	1869	American	321	7747	H	Y		
John P. West	1861	American	350	7772	H	Y		
John P. West	1864	American	350	7774	H	M		
John P. West	1865	American	350	7774	H	Y		
John P. West	1866	American	350	7774	H	Y		
John P. West	1867	American	350	7774	H	Y		
John and Edward	1853	American	325	7639	H	N		
John and Edward	1854	American	325	7639	H	Y		
John and Elizabeth	1846	American	1707	7654	H	N		
John and Elizabeth	1853	American	1707	7656	O	N		
John and Elizabeth	1858	American	1707	7659	O	Y		
Joseph Haydn	1854	German			H	Y		
Josephine	1861	American	346	7886	H	Y		
Josephine	1865	American	346	7887	O	Y	6	L
Josephine	1866	American	346	7887	O	Y	1	L
Judson	1852	Undetermined			H	N		
Julian	1858	American	323	7936	O	N		
Jupiter	1852	American	1744		H	N		
Jupiter	1853	American	1744	8011	H	N		
Kalama	1862	Hawaiian			H	Y		
Kamchatka	1865	Undetermined			H	M		
Kamehameha V	1864	Hawaiian			O	Y		
Kamehameha V	1865	Hawaiian			O	M		
Kate	1860	American	1749	8030	H	N		
Kate	1862	American	1749		H	N		
Kate Darling	1857	Undetermined			H	Y		
Kathleen	1863	American	357	8042	H	M		
Kauai	1860	German			O	Y		
Kohola	1862	Hawaiian			H	Y		
Kutusoff	1854	American	356	8094	O	M		
L. C. Richmond	1856	American	377	8103	H	Y	17	L
L. C. Richmond	1859	American	377	8104	H	Y		
L. C. Richmond	1860	American	377	8104	H	Y		
L. C. Richmond	1861	American	377	8104	H	Y		
L. P. Foster	1866	American	1758	17050	H	Y		
L. P. Foster	1867	American	1758	17051	H	Y		
Lagoda	1848	American	381	8156	O	N		
Lagoda	1858	American	381	8161	O	Y		
Lark	1856	American	1770	8236	H	Y		
Lark	1859	American	1770	8238	H	Y		
Lark	1860	American	1770	8238	H	Y		
Leonore	1852	American	1790		H	Y		
Leonore	1856	American	1790	8369	H	Y		
Leverett	1857	American	1795	16834	O	M		
Levi Starbuck	1852	American	385	8385	O	M		
Levi Starbuck	1859	American	385	8387	H	Y		
Levi Starbuck	1861	American	385	8387	H	Y		
Lewis	1860	American	380	8400	O	Y		
Liverpool	1856	American	373	8497	H	Y		
Liverpool	1865	Undetermined			O	U		
Louisa	1854	American	388	8578	O	N		
Louisa	1873	American	388	8583	H	Y	2	N
Louisa	1874	American	388	8583	H	U		
Lydia	1867	American	397	8715	H	Y	2	L
Lydia	1868	American	397	8715	H	M		
Magnolia	1847	American	419	8768	H	M		
Magnolia	1848	American	419	8768	H	M		
Majestic	1859	American	453	8795	H	Y	5	L
Majestic	1860	American	453	8795	H	Y	1	L
Manuella	1866	American	1837	8826	H	N		
Manuella	1867	American	1837	8827	H	Y		
Marengo	1853	American	461	8916	H	N	0	L
Marengo	1858	American	461	8917	H	Y		
Maria	1861	Hawaiian			H	Y	20	N
Maria	1862	Chilean			O	Y		
Martha	1859	American	1869	9096	O	U		
Martha	1861	American	1869	9096	H	Y		

continued

Appendix (continued)

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
Martha	1861	American	401	9141	H	Y		
Martha	1865	American	401	9143	H	Y		
Martha	1867	American	401	9143	H	M		
Martha II	1861	American	2852	9163	O	U		
Mary and Martha	1854	American	469	9232	O	N	0	L
Mary and Susan	1853	American	1875	9261	O	M		
Mary and Susan	1871	American	481	9241	H	Y		
Massachusetts	1853	American	444	9420	H	M		
Massachusetts	1858	American	444	9422	H	N		
Massachusetts	1859	American	1906	9413	H	Y		
Massachusetts	1859	American	444	9422	H	Y		
Massachusetts	1867	American	444	9424	H	Y		
Massachusetts	1868	American	444	9424	O	N		
Massachusetts	1870	American	444	9427	H	N		
Massachusetts	1871	American	444	9426	H	Y		
Massasoit	1859	American	1907	9433	O	Y		
Massasoit	1860	American	1907	9433	O	Y		
Massasoit	1861	American	1907	9433	H	Y	16	N
Maunaloa	1871	Hawaiian			O	U		
Mechanic	1853	American	1915	9506	H	U		
Mechanic	1854	American	1915	9506	H	Y		
Menschikoff	1871	American	1922	9533	H	U		
Mercator	1855	American	408	9569	O	N		
Meteor	1853	American	1937	9689	H	U		
Metropolis	1859	American	2821	17002	H	Y		
Milo	1861	American	400	9774	H	Y		
Milo	1863	American	400	9774	H	U		
Milo	1865	American	400	9775	H	Y		
Milo	1866	American	400	9775	H	Y		
Milo	1867	American	400	9775	H	Y		
Milton	1860	American	420	9784	O	U		
Milton	1864	American	420	9785	H	Y		
Minerva	1853	American	407	9871	O	N		
Minerva II	1850	American	424	9896	H	N		
Mogul	1854	American	1958	9946	H	Y		
Mogul	1855	American	1958	9946	H	Y		
Mogul	1856	American	1958	9946	H	Y		
Monmouth	1861	American	1962	9966	H	Y		
Montauk	1858	American	1966	9976	H	Y		
Montezuma	1860	American	1970	10002	H	Y		
Montezuma	1861	American	1970	10002	H	Y		
Montezuma	1862	American			H	Y		
Montgomery	1850	American	472		O	U		
Monticello	1867	American	1978	10047	O	Y		
Montreal	1859	American	467	10062	H	Y	14	L
Montreal	1861	American	467	10062	O	U		
Morea	1846	American	458	10063	H	N		
Mount Wollaston	1865	American	465	10131	H	M		
Nassau	1865	American	492	10284	H	M		
Nathaniel S. Perkins	1866	American	2021	17052	H	Y		
Nathaniel S. Perkins	1867	American	2021	17052	O	M		
Navigator	1857	American	2023	10325	H	Y		
Neptune	1856	American	2032	10376	H	M		
Nevada	1860	American	2038	10410	H	Y		
New England	1860	American	488	10422	H	Y		
New England	1861	American	488	10422	H	Y		
Nile	1854	American	2046	10485	O	M		
Nile	1859	American	491	10491	O	U		
Nile	1861	American	491	10491	H	Y		
Nile	1863	American	491	10491	H	Y		
Nile	1864	American	491	10491	H	Y		
Nile	1865	American	491	10491	H	Y		
Nile	1866	American	491	10491	H	Y		
Nile	1867	American	491	10491	H	Y		
Nimrod	1855	American			O	Y		
Nimrod	1865	American	494	10513	H	M		
Norman	1868	American	505	10576	O	M		
Norman	1871	American	505	10576	O	N		

continued

Appendix (continued)

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
North Star	1853	American	2059	10615	H	Y		
North Star	1854	American	2059	10615	H	Y		
Northern Light	1860	American	503	10622	H	U		
Nye	1863	American	477	10666	H	U		
Oahu	1858	Hawaiian			H	Y		
Oahu	1859	Hawaiian			H	Y		
Oahu	1860	Hawaiian			O	Y		
Ocean	1860	American	2073	10698	H	Y		
Ocean	1861	American	2073	10698	H	Y		
Ocean	1862	American	2073	10698	O	Y		
Ocean	1863	American	2073	10698	H	Y		
Ocean	1867	American	515	10692	H	Y		
Ocean Bird	1859	American	2065	10718	H	Y	46	L
Ocean Bird	1860	American	2065	10718	H	Y		
Ocean Bird	1861	American	2065	17053	H	Y		
Ocmulgee	1859	American	2076	10730	O	U		
Ocmulgee	1860	American	2076	10730	H	Y		
Ohio	1859	American	516	10781	H	Y		
Ohio	1860	American	516	10781	H	Y		
Olive	1860	American	2091	10825	H	Y		
Oliver Crocker	1859	American	519	10844	O	U		
Oliver Crocker	1860	American	519	10844	O	Y	35	L
Oliver Crocker	1861	American	519	10844	H	Y	5	L
Oliver Crocker	1864	American	519	10845	O	U		
Oliver Crocker	1867	American	519	10847	H	Y		
Olivia	1861	American	2093	10852	H	Y		
Omega	1853	American	2095	10863	H	N		
Ontario	1861	American	2104	10914	H	Y		
Onward	1860	American	730	10920	H	Y		
Onward	1861	American	730	10920	H	Y		
Onward	1864	American	730	10921	H	Y		
Onward	1865	American	730	10921	H	Y		
Onward	1866	American	730	10921	H	Y		
Onward	1867	American	730	10921	H	U		
Onward	1870	American	730	10923	H	N		
Oriole	1865	American	735	10971	H	Y		
Oriole	1868	American	735	10972	H	M		
Orion	1853	French		30552	H	Y		
Oscar	1853	American	2118	11025	H	Y		
Oscar	1854	American	2118	11025	H	N		
Pacific	1860	American	530	11147	O	U		
Pacific	1861	American	530	11147	H	Y		
Page	1865	American	2134	17056	H	M		
Page	1866	American	2134	17057	H	Y		
Paulina	1859	American	543	11321	H	Y	11	L
Paulina	1860	American	543	11321	H	Y	8	L
Paulina	1861	American	543		O	U		
Pearl	1864	American	2158	11341	H	Y		
Pfeil	1857	Hawaiian			O	N		
Phenix	1853	American	526	11538	O	N		
Phenix	1858	American	526	11539	O	N		
Philip	1861	American	2183	11567	H	Y		
Phoenix	1853	American			H	N		
Phoenix	1860	American	2188	11631	H	Y		
Phoenix	1861	American	2188	11631	H	Y		
President	1867	American	548	11927	H	Y		
Prince de Joinville	1856	American	2241	11986	H	Y		
Progress	1868	American	554	11989	O	M		
Progress	1873	American	554	11990	O	N		
Rajah	1853	American	576	12111	H	N	0	L
Rajah	1854	American	576	12111	H	N	0	L
Rambler	1857	American	588	12125	H	U		
Rambler	1859	American	588	12125	H	Y		
Rebecca Sims	1858	American	574	12204	H	N		
Rebecca Sims	1859	American	574	12204	O	N		
Reindeer	1858	American	574	12219	O	Y		
Reindeer	1859	American	589	12219	H	Y		

continued

Appendix (continued)

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
Reindeer	1862	American	589	12220	H	Y		
Reindeer	1863	American	589	12220	H	Y		
Reindeer	1866	American	589	12221	H	Y		
Reindeer	1867	American	589	12221	H	Y		
Reindeer	1868	American	589	12221	H	Y		
Revello	1854	Chilean			O	N		
Richard Mitchell	1854	American	2288	12296	H	N		
Richmond	1864	American	573	16962	H	Y		
Richmond	1866	American	573	16966	H	Y		
Ripple	1860	American	2295	12348	H	Y		
Robert Edwards	1856	American	575	12424	O	M		
Robert Edwards	1861	American	575	12425	H	Y		
Robert Morrison	1853	American	586	12430	H	Y		
Robin Hood	1861	American	2305	12445	H	Y		
Roman	1853	American	579	12469	H	N		
Roman	1857	American	579	12470	H	M		
Roman	1858	American	579	12470	H	Y	10	L
Roman II	1853	American	580	12482	H	Y		
Roscoe	1867	American	564	12571	O	M		
Rousseau	1855	American	578	12623	H	N		
Rousseau	1858	American	578	12624	O	U		
Rousseau	1867	American	578	12626	O	U		
S. F. Constantin	1860	Russian			O	Y		
S. H. Waterman	1853	American	2327	12689	H	Y		
Sarah	1846	American	2358	12867	H	N		
Sarah	1861	American	2359	12858	H	M		
Sarah McFarland	1856	American	2351	17043	H	Y		
Sarah McFarland	1861	American	2351	17043	H	M		
Sarah Sheafe	1858	American	617	12947	O	Y		
Sarah Warren	1858	American	2354	12957	H	Y		
Sarah Warren	1859	American	2354	12958	H	Y		
Sarah Warren	1860	American	2354	12958	H	Y		
Sarah Warren	1861	American	2354	12959	H	Y		
Sarah Warren	1862	American	2354	12960	H	Y		
Sarah Warren	1863	American	2354	12961	H	Y		
Sarah Warren	1864	American	2354	12961	H	M		
Saratoga	1854	American	614	12964	H	N		
Saratoga	1855	American	614	12964	H	N		
Saratoga	1858	American	614	12965	O	Y	14	L
Scotland	1859	American	618	12979	H	Y	6	L
Scotland	1861	American	618		O	U		
Sea Breeze	1867	American	628	12991	H	Y	11	L
Sea Breeze	1868	American	628	12991	H	Y	14	L
Sea Breeze	1869	American	628	12991	H	N		
Sea Breeze	1870	American	628	12991	O	M		
Sea Breeze	1871	American	628	12991	H	U		
Seine	1860	American	610	13102	O	U		
Seine	1868	American	610	13105	O	N		
Sharon	1860	American	2382	13146	H	Y		
Sharon	1861	American	2382	13146	H	Y		
Sheffield	1850	American	2384	13152	O	U		
Sheffield	1856	American	2384	13153	H	Y		
Sheffield	1858	American	2384	13153	H	U		
Sophie	1860	Undetermined			H	M		
South America	1858	American	620	13265	O	Y	2	L
Speedwell	1858	American	2414	13328	O	N		
Speedwell	1861	American	2414	13328	H	Y		
Splendid	1857	American	2420	13348	H	Y	14	L
Splendid	1858	American	2420	13350	O	Y		
Splendid	1867	American	2420	13350	O	U		
St. George	1854	American	591	13366	O	N		
St. George	1866	American	591	13368	H	Y		
St. George	1867	American	591	13368	H	Y		
Superior	1855	American	616	13550	H	N		
Susan Abigail	1864	American	13601		H	Y		
Susan Abigail	1865	American	2451		H	Y		
Tamerlane	1861	American	656	13695	O	N		
Tamerlane	1864	American	656	13696	H	Y		

continued

Appendix (continued)

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
Tempest	1860	American	2480	13747	H	Y		
Tenedos	1854	American	2481	13755	H	Y		
Tenedos	1855	American	2481	13755	H	Y		
Thomas Dickason	1858	American	657	13797	H	Y		
Thomas Dickason	1863	American	657	13798	H	Y	13	L
Thomas Dickason	1864	American	657	13798	H	Y		
Thomas Dickason	1865	American	657	13798	H	N		
Thomas Dickason	1866	American	657	13799	H	N		
Thomas Dickason	1870	American	657	13801	H	Y		
Three Brothers	1867	American	662	13948	H	Y		
Tiger	1847	American	2501	13970	H	Y	16	L
Trader	1869	Undetermined			H	M		
Trescott	1847	American	2505	14013	H	Y		
Trescott	1848	American	2505	14013	H	Y		
Trident	1869	American	651	14044	O	M		
Trident	1870	American	651	14044	O	U		
Two Brothers	1853	American	648	14200	H	N	0	L
Tybee	1858	American	2521	14213	O	N		
Uncas	1853	American	665	14237	H	Y		
Union	1854	Undetermined			O	N		
United States	1846	American			H	Y	10	N
United States	1847	American			H	Y		
Valparaiso	1854	American	671	15089	O	N		
Venezuela	1853	American	2552	17038	H	Y		
Vesper	1854	American	2557	15129	H	Y		
Vesper	1861	American	2557	15133	H	Y		
Victoria	1858	Hawaiian			H	Y		
Victoria	1859	Hawaiian			H	Y		
Victoria	1860	Hawaiian			H	Y		
Victoria	1862	Hawaiian			H	Y		
Victoria	1863	Hawaiian			H	Y		
Victoria	1864	Hawaiian			O	Y		
Vigilant	1858	American	672	15162	H	Y		
Vineyard	1868	American	2564	15180	O	N		
Walter Clayton	1853	American			H	N		
Warren	1858	American	691	15326	O	Y		
Warsaw	1846	American	2583	15346	H	N		
Waverly	1865	American	688	15471	H	M		
Whampoa	1859	Undetermined			H	Y		
William C. Nye	1853	American	684	15626	H	N	0	L
William C. Nye	1863	American	684	15633	H	Y		
William C. Nye	1865	American	684	15633	H	Y		
William Gifford	1866	American	693	15636	H	Y		
William Gifford	1867	American	693	15636	H	Y		
William T. Wheaton	1852	American	2621	15717	O	M		
William T. Wheaton	1853	American	2621	15717	H	N		
William T. Wheaton	1855	American	2621	15717	H	M		
William Tell	1856	American	2622	15725	H	N		
Winslow	1854	French		30557	H	M		
Winslow	1865	French		30597	O	M		
Winslow	1866	French		30594	H	M		
Winslow	1867	French		30594	H	N		
Zone	1865	American			H	M		
Zoroaster	1853	American	700	15934	O	N		
Zuid Pool	1848	Dutch			O	Y		

Bycatch and ship strikes of gray whales in U.S. and Canadian waters, 2008-2012

JONATHAN J. SCORDINO[1]*, JIM CARRETTA[2], AND PAUL COTTRELL[3]

Contact email: jonathan.scordino@makah.com

ABSTRACT

The IWC held a workshop from 8 April to 11 April, 2014 to review the range-wide population structure and status of North Pacific gray whales. One of the objectives of the meeting was to develop a modelling framework to better assess the status of gray whales and the potential impact of human activities. The impacts of some human activities, such as hunting, are well documented whereas the impact of other human activities like shipping and fishing are not. In this paper we assessed the human-caused mortality, other than hunting, in Canada and US waters for 2008 through 2012. Whales observed alive with injuries from ship strikes or entanglement that likely had a compromised chance of survival were given a prorated level of mortality based on the observed known fate of North Atlantic right whales with similar distress following procedures established by NOAA (2012). We separated all observed incidents of human-caused mortality into regions defined as California (US border to 41°N), Pacific Coast Feeding Group (PCFG) Range (41°N to 52°N), Puget Sound, Southeast Alaska, Kodiak Island, and northern waters (>52°N) and by season to either migratory or feeding. We report three different models for apportioning the observed mortalities and injuries to the PCFG, Far North feeding group (FN), and Sakhalin Island feeding group (SI). We evaluated sighting data from the Cascadia Research Collective database of gray whale sightings to determine the availability of PCFG whales in each of the regions during the migratory and feeding seasons. The availability of PCFG and FN whales was used to proportion observed mortalities and serious injuries to these two feeding groups. To determine the possible proportion of whales that were from the SI group we multiplied migratory incidents by the median risk of 0.07 estimated by Moore and Weller (2013). During the 5-year period we observed 27.1 serious injuries and mortalities. We apportioned those mortalities and injures using three methods which resulted in a range of mortality of 7 to 13 for PCFG, 25.1 to 31.1 for FN, and 0.05 for SI over the five-year period resulting in an annual rate of 1.4-2.6, 5.0-6.2, and 0.01 respectively. These estimates are minimum estimates because it is not likely that all whales killed by human activities are reported or drift to shore where they can be examined and documented.

INTRODUCTION

From 8 April through 11 April the IWC held a workshop to review the range-wide population structure and status of North Pacific gray whales. One of the objectives of the meeting was to develop a modelling framework to better assess the status of gray whales and the potential impact of human activities. Some human activities that directly cause whale mortality, such as hunting, are well documented whereas the impact of other human activities like shipping and fishing are not. Mortalities due to ship strikes and entanglement in fisheries gear and other marine debris cause conservation concern for other cetacean populations (e.g. North Atlantic right whales: Knowlton and Kruas 2001 and vaquita: D'agrosa *et al.* 2000). It is our goal in this

[1]Marine Mammal Program, Makah Fisheries Management, Makah Tribe, Neah Bay, Washington
[2] Protected Resources Division, Southwest Fisheries Science Center, NOAA Fisheries, San Diego, California
[3] Pacific Region Marine Mammal Program, Pacific Region, Department of Fish and Oceans Canada, Vancouver, British Columbia

paper to estimate the rates of this non-hunting human-caused mortality in US and Canadian waters for modeling by the IWC Scientific Committee to determine if these sources of mortality are a conservation concern for Pacific Coast Feeding Group (PCFG), Far North feeding groups (FN), or the Sakhalin Island (SI) feeding group. It is not our intention for this paper to be used in domestic marine mammal management in Canada or the US.

METHODS

Gray whale mortalities and injuries were documented through fisheries observer programs, fisher and sailing captain self-reports, reports from the public, and through examination of dead whales on the beach. Every report was documented in a database by the Canadian or US government in their respective areas.

All whales in which human interactions were assumed to have caused the mortality were recorded as a 1 for mortality. We utilized methods developed by NOAA (2012) to account for the likelihood of mortality for whales injured due to a ship strike or entanglement. Each injured whale was classified according to the large whale injury criteria table in NOAA (2012; Appendix 1). NOAA (2012) utilized the known fate of whales monitored in the past with similar injuries to determine a prorated value of mortality between 0 and 1 for each of the classifications.

The goal of this study is to apportion the observed mortalities to the Far North (FN) feeding group, Pacific Coast Feeding Group (PCFG), or Sakhalin Island feeding group (SI). The first step of apportioning these mortalities is to determine the region and season in which the mortality occurred. We assigned all mortalities and serious injuries (hereafter mortality) to the regions of FN (north of 52°N) with Kodiak Island and Southeast Alaska accounted separately for one analysis, Puget Sound, PCFG (41 to 52°N), and California (north of US/Mexico border and south of 41°N). All observations from June through November with one exception were assigned to the feeding season and all observations from December through May were assigned to the migratory season. The one exception for the feeding season was a whale observed on 15 June 2012 at Nitinat, British Columbia anchored to the bottom with multiple ropes in very decomposed condition. We decided to count this whale as having died in the migratory season given that its state of decomposition suggested it most likely died prior to 1 June.

Much of the observed mortality occurred at times or locations where the three feeding groups are mixed or are potentially mixed. As a result, without more information than time and location, it is not possible to allocate mortalities among the three feeding groups with certainty. To address this challenge we developed three methods for apportioning the observed mortalities. In all methods we assigned mortality in the PCFG during the migratory season equal to the availability of PCFG whales in Northwest Washington. We chose to use Northwest Washington rather than the availability of gray whales at all research segments in the PCFG because in areas outside Northwest Washington researchers target whales they believe are PCFG whales during surveys. Availability of PCFG whales was calculated by number of sightings of PCFG whales divided by total sightings in Northwest Washington during the time period of December through May. The first method used the strict definition of PCFG whales as only feeding in the range of 41° to 52° N and mortalities outside that range during the feeding season were assigned 100% to the FN. The second method assumed that all mortalities in California during the feeding season were of PCFG whales since the feeding group is spatially much closer to this region than is the FN or SI. For both methods one and two, the availability of PCFG whales during the migration in California was assumed to be equal to the ratio of the two population sizes. The last method used empirical data from the sighting database maintained by Cascadia Research Collective to determine the availability of PCFG whales within all region and season combinations except for in the FN where data is too limited. Availability was calculated as the number of sightings of gray whales that met the IWC definition of PCFG whales divided by the total number of sightings within the region and season of interest for all sightings in the catalogue through 2012. Data for this analysis was accessed from the sighting database on 10 April 2014.

RESULTS

During the time period of 2008 through 2012 we observed 50 serious injuries and mortalities due to ship strikes or entanglements in US and Canadian waters (Appendix 2). To our knowledge, none of the whales were identified as PCFG whales in the Cascadia Research Collective catalog or were matched with the photo catalog for SI whales. Four whales were downgraded to a non-significant injury after being first documented as a serious injury because they were either successfully disentangled or disentangled themselves. The majority of human-caused injuries (70%) were due to entanglements in fishing gear or other marine debris. Five of the 35 entanglements occurred in Canada. We also recorded 15 ship strikes with one reported in Canada.

Availability of PCFG by region and season

Availability of PCFG whales by region and season was calculated from the sightings in the database maintained by Cascadia Research Collective and is reported in Table 1.

Table 1: Observed availability of PCFG whales by season and region with total numbers of observations reported.

	Feeding Season			Migratory Season		
Region	Observations of PCFG	Total Observations	Availability	Observations of PCFG	Total Observations	Availability
Kodiak	42	225	0.19	0	2	N/A
Southeast Alaska	21	37	0.57	0	0	N/A
Puget Sound	4	70	0.06	4	896	0.00
PCFG	16,321	17,316	0.94	97	270	0.36
California	13	43	0.30	3	35	0.09

Total observed mortality by region

Using method 1 we assigned whale mortalities during the feeding season using a strict application of the IWC definition of PCFG whales. During the migratory season we assigned whale mortalities in California and Puget Sound (PS) proportionally to the population size of the two groups (200 PCFG: 20,000 FN), resulting in an availability of 0.01. We assumed that no mortalities in the FN were PCFG whales. We assigned 0.2% of mortalities during the migration to SI whales based on the estimated risk to on an individual SI whale conducted by Moore and Weller (2013). This assessment concluded that the median estimate of the Makah hunt encountering a SI whale was 0.2% and assumed that there was zero probability of taking an SI whale during the feeding season. We estimated a total mortality of 7.0 PCFG, 31.1 FN, and 0.05 SI whales with an annual average of 1.4, 6.2, and 0.01 respectively from 2008 through 2012.

Table 2: Total observed non-hunting human-caused mortality for US and Canadian waters in 2008-2012 by region and season and apportionment of mortality to feeding group using a strict application of the IWC definition of PCFG whales.

	Feeding Group Proration						Observed Mortalities		Estimated mortalities		
Region	PCFG Feeding	PCFG Migrating	FN Feeding	FN Migrating	SI Feeding	SI Migrating	Feeding	Migrating	PCFG	FN	SI
Far North	0	0	1	1	0	0	2.75	1.5	0.0	4.3	0.00
Puget Sound	0	0.01	1	0.99	0	0.002	0	1	0.0	0.0	0.00
PCFG	1	0.359	0	0.641	0	0.002	4.02	7.75	6.8	5.0	0.02
California	0	0.01	1	0.99	0	0.002	6	16.05	0.2	21.9	0.03
Total							12.8	26.3	7.0	31.1	0.05
Average (2008-2012)									1.4	6.2	0.01

Method 2 used similar assumptions as method 1 with the exception that all mortalities in California during the feeding season were assigned to the PCFG because they are the closest feeding group spatially to where the mortality occurred. Using this method we estimated 13.0 PCFG, 25.1 FN, and 0.05 SI mortalities with an annual average of 2.6, 5.0 and 0.01 respectively for the 2008 through 2012 time period.

Table 3: Total observed non-hunting human-caused mortality for US and Canadian waters in 2008-2012 by region and season and apportionment of mortality to feeding group using the assumption that all mortalities in California during the feeding season were PCFG whales.

	Feeding Group Proration						Observed Mortalities		Estimated mortalities		
Region	PCFG Feeding	PCFG Migrating	FN Feeding	FN Migrating	SI Feeding	SI Migrating	Feeding	Migrating	PCFG	FN	SI
Far North	0	0	1	1	0	0	2.75	1.5	0.0	4.3	0.00
Puget Sound	0	0.01	1	0.99	0	0.002	0	1	0.0	0.0	0.00
PCFG	1	0.359	0	0.641	0	0.002	4.02	7.75	6.8	5.0	0.02
California	1	0.01	0	0.99	0	0.002	6	16.05	6.2	15.9	0.03
Total							12.8	26.3	13.0	25.1	0.05
Average (2008-2012)									2.6	5.0	0.01

Method 3 utilized the database of gray whale sightings maintained by Cascadia Research Collective to inform the availability of PCFG whales in each region by season. We added the regions of Southeast Alaska and Kodiak Island to provide better resolution to the availability estimates. Using this method we found 11.3 PCFG, 26.7 FN, and 0.05 SI mortalities with an annual average of 2.3, 5.3, and 0.01 respectively for the 2008 through 2012 time period.

Table 4: Total observed non-hunting human-caused mortalities for US and Canadian waters in 2008-2012 and apportionment by region and season using empirical data from the database of gray whale sightings maintained by Cascadia Research Collective.

	Feeding Group Proration						Observed Mortalities		Estimated mortalities		
Region	PCFG Feeding	PCFG Migrating	FN Feeding	FN Migrating	SI Feeding	SI Migrating	Feeding	Migrating	PCFG	FN	SI
Far North	0	0	1	1	0	0	0	0.75	0.0	0.8	0.00
Kodiak	0.185	0.01	0.815	0.99	0	0.007	0	0	0.0	0.0	0.00
SE Alaska	0.568	0.01	0.432	0.99	0	0.007	2.75	0.75	1.6	1.9	0.01
Puget Sound	0.06	0.004	0.94	0.996	0	0.007	0	1	0.0	0.0	0.00
PCFG	0.942	0.359	0.058	0.641	0	0.007	4.02	7.75	6.6	5.2	0.05
California	0.302	0.087	0.698	0.913	0	0.007	6	16.05	3.2	18.8	0.11
Total							12.8	26.3	11.3	26.7	0.17
Average (2008-2012)									2.3	5.3	0.03

DISCUSSION

We presented three methods for apportioning the total observed non-hunting human-caused mortality that occurs in US and Canadian waters to the PCFG, FN, and SI. All three methods count more mortalities than were documented because mortalities were 100% apportioned to the PCFG and FN before accounting for possible SI mortality. The risk of bycatch or ship strike of a SI whale is low enough that this weakness in the analysis is likely negligible. Of the three methods, method 3 is the strongest estimate because it uses observed values for the availability of PCFG whales by region and season rather than estimates based on the IWC-defined area and season of PCFG whales. Based on sighting data we know that some PCFG whales do feed in the FN during the summer but we felt that the available data was too limited to provide a meaningful estimate of the availability of PCFG whales in that region during the feeding season.

The methods used in this paper contrast strongly with the methods used in the US stock assessment report (SAR) for gray whales. In the SAR the IWC-defined area and season of PCFG whales is applied strictly and only mortalities from June to November in the range of 41°N to 52°N are included (Carretta *et al.* 2014a). At present the method employed by the US government may produce a stronger estimate than the methods in this paper because our methods assume that the likelihood of a whale being struck by a vessel or entangled in fishing gear or marine debris is equal to the proportion of times a whale observed by a research vessel was or was not a PCFG whale. Factors such as the whale's activity or sensitivity to boat noise will make it more or less available to be photographed by researchers. It is possible that the availabilities we used are biased high for PCFG whales during the migratory season because it is more likely that PCFG whales are feeding south of the Bering, Beaufort, and Chukchi seas feeding grounds and a feeding whale is easier to approach in a research vessel and easier to photograph. Accepting this potential bias in our methods, we calculated the availability of PCFG whales from sightings in the gray whale catalogue maintained by Cascadia Research Collective to make an informed assessment of how to apportion mortality based on the area and season in which the mortality was observed rather than making assumptions. In the future we recommend that photographs of whales recorded as dead or a serious injury be compared to the Cascadia

Research Collective's catalogue to determine if the apportionment estimates in this paper, particularly method 3, are accurate. As stated in the introduction, the purpose of this paper is inform the modeling associated with the range-wide workshop on gray whale stock structure and is not intended to replace domestic processes in the US or Canada for accounting of gray whale mortality.

Many of the mortality and serious injury reports used in this analysis were reports from the public. In most cases the reports are sound and very helpful but in many cases they lack sufficient detail to evaluate the nature of a whale's injury and to discern whether a single whale is reported on multiple occasions. Another limitation of reports from the public is that there are many PCFG gray whales known to have very visible, large, healed wounds (Figure 1). If these whales are reported by the public then they are included as a serious injury even though a trained observer would note that the injuries have healed.

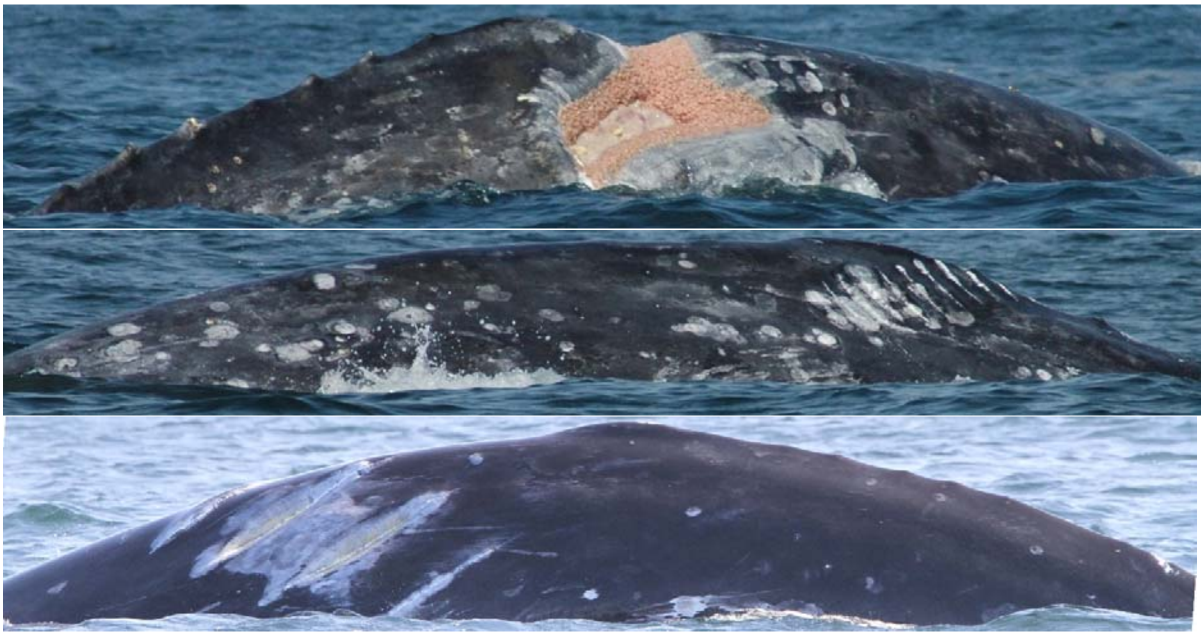

Figure 1: Large wound on CRC 204 (top) and propeller wounds on CRC 6 (middle) and CRC 144 (bottom) that may be reported by the public as a new injury despite the age of these wounds.

Scordino and Mate (2011) conducted a similar analysis of non-hunting human-caused mortality for California through British Columbia for 1990 through 2010. In that analysis they documented an annual PCFG mortality rate of 1.845 whales per year. This rate was 25% less than the estimate in this paper using method 3 (2.3 PCFG whales per year for 2008 through 2012). The difference in results may be due differences in methods such as the 2011 report not including Alaskan mortalities or the differences in how injuries were accounted as either a mortality or not. The different results may also show an increase in bycatch and ship strikes in recent years as compared to 1990 through 2010. Even with the greater estimates in this report, the total estimates of non-hunting human-caused mortality reported are minimum estimates because it is not likely that all whales killed by human activities are reported at-sea or drift to shore where they can be examined and documented and because this report does not report mortalities in Mexico.

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Appendix 1: Summary of Large Cetacean[1] Injury Categories and Criteria (Table 1 from NOAA 2012)

Instructions: Each large cetacean injury event is recorded to the appropriate injury/information category using all available information and scientific judgment, as described in the Procedural Directive. Criteria L10 - L12 accommodate events that lack details necessary for assignment to a more specific category. For a single injury event to which several categories apply, the injury determination with the highest level of severity is assigned. More detailed information or extended observation on an individual case/animal may justify a determination differing from the guidance of this table. An animal that is fully disentangled would generally be considered not seriously injured, unless there is additional evidence of a serious injury. Any injury leading to apparent significant health decline (e.g., skin discoloration, lesions near the nares, fat loss, increased cyamid loads) is a serious injury.

Category	**Injury/ Information**	**Injury Determination**	**Criteria**
L1	Ingested gear[2] or hook(s)	SI[3]	Swallowed, not simply draped through mouth
L2	Constricting wrap	SI	Tightly wrapped line anywhere on body that indents the skin or does not shift with whale's movement, or line that is likely to become constricting as the whale grows. Indication that a whale that is heavily weighted, anchored or has a discolored appendage is sufficient evidence of constricting gear
L3	Loose wrap, bridled or draped gear	NSI[4]	Loosely wrapped gear that moves or shifts freely with whale's movement. Absence of constricting gear must be confirmed
L4	External hook	NSI	Fishing hook of any size on any part of the body (i.e., not ingested)
L5a	Deep lacerations[5]	SI	Laceration with the potential to affect major artery (e.g., laceration or severing at insertion of flipper/fluke), penetrating body cavity, or cutting bone
L5b	Superficial laceration	NSI	Laceration not deeper than blubber layer, does not affect major artery, or cut bone
L6a	Vessel much greater in size than whale or vessel ≥65' and >10 knots	SI	Struck by vessel much greater in size than the whale and traveling greater than 10 knots, or struck by vessel equal or greater than 65' and traveling greater than 10 knots, and no information

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			on injury to the whale
L6b	Vessel smaller in size than whale or vessel <65' and >10 knots	Prorate[6]: 0.20	Struck by vessel smaller in size than the whale and traveling greater than 10 knots, or struck by vessel less than 65' and traveling greater than 10 knots, and no information on injury to the whale. A strike to a calf by a vessel of any size and traveling greater than 10 knots will be considered a serious injury
L6c	Vessel any size ≤10 knots	NSI	Struck by vessel of any size traveling at equal or less than 10 knots and no information on injury to the whale
L7a	Vessel much greater in size than whale or vessel ≥65' and speed unknown	Prorate: 0.56	Struck by vessel much greater in size than the whale traveling at an unknown speed, or struck by vessel equal or greater than 65' and traveling at unknown speed, and no information on injury to the whale. A strike to a calf by a vessel of any size when speed is unknown will be considered a serious injury
L7b	Vessel smaller in size than whale or vessel <65' and speed unknown	Prorate: 0.14	Struck by vessel smaller than the whale traveling at an unknown speed, or struck by vessel less than 65' and traveling at unknown speed, and no information on injury to the whale. A strike to a calf by a vessel of any size when speed is unknown will be considered a serious injury
L8	Dependent[7]	SI	Dependent calf of a dead or seriously injured mother
L9	Brought on deck	SI	Whale removed from water and brought on deck

L10	Evidence of entanglement	Prorate: 0.75	Confirmed entanglement but insufficient information available to place in any of the L1-L4 criteria with a high degree of certainty
L11	Vessel strike laceration	Prorate: 0.52	Whale confirmed with non-entanglement related laceration but lacking details to place in either criteria L5a or L5b with a high degree of certainty. Includes observation of blood in water
L12	Vessel strike observed	Prorate: 0.36	Confirmed vessel strike report where there is insufficient detail to assign event to criteriaL6a – L7b with a high degree of certainty. A strike to a calf by a vessel of unknown size traveling at an unknown speed will be considered a serious injury

Appendix 2: All observed mortalities and serious injuries in US and Canadian waters from 2008 through 2012.

DATE	INTERACTION TYPE	LOCATION	PROVINCE/ STATE	INITIAL INJURY ASSESSMENT	COMMENTS	FINAL INJURY ASSESSMENT	SI CODE	PRORATION	RANGE	SEASON
15-Oct-08	VESSEL STRIKE	TOFINO	BC	DEAD	CARCASS HAD PROPELLER LACERATION DORSAL SIDE	DEAD	NA	1	PCFG	FEEDING
17-May-09	MARINE DEBRIS	TOFINO	BC	SI	FREE SWIMMING ANIMAL HAD TAIL STOCK WRAP AND TRAILING ROPE	SI	L2	1	PCFG	MIGRATION
27-Aug-08	MARINE DEBRIS	NOOTKA	BC	SI	FREE SWIMMING ANIMAL HAD TAIL STOCK WRAP AND TRAILING ROPE (DO NOT HAVE PICTURES), NOT SURE IF THIS IS THE SAME ANIMAL FROM MAY 17, 2009)	SI	L2	1	PCFG	FEEDING
21-Mar-10	ROPE	MORSBY ISL	BC	SI	ANIMAL IS FREE SWIMMING AND HAS TAIL STOCK WRAP AND TRAILING ROPE, NOT ABLE TO RELOCATE	SI	L2	1	PCFG	MIGRATION
15-Jun-12	UNIDENTIFIED FISHERIES INTERACTION	NITINAT	BC	DEAD	ANIMAL DEAD (VERY DECOMPOSED) ANCHORED TO BOTTOM. MULTIPLE ROPES	DEAD	NA	1	PCFG	MIGRATION
2-Sep-12	UNIDENTIFIED FISHERIES INTERACTION	TOFINO	BC	SI	FREE SWIMMING WITH UNIDENTIFIED GEAR, ROPE AND TWO BUOYS, NOT RESIGHTED	SI	L10	0.75	PCFG	FEEDING
7-Feb-08	VESSEL STRIKE	ORANGE	CA	DEAD	CARCASS; PROPELLER-LIKE WOUNDS TO LEFT DORSUM FROM MID-BODY TO CAUDAL PEDUNCLE; DEEP EXTERNAL BRUISING ON RIGHT SIDE OF HEAD; FIELD NECROPSY REVEALED MULTIPLE CRANIAL FRACTURES	DEAD	NA	1	California	MIGRATION
1-Mar-08	VESSEL STRIKE	MEXICO	CA	DEAD	CARCASS BROUGHT INTO PORT ON BOW OF CRUISE SHIP; COLLISION OCCURRED BETWEEEN PORTS OF SAN DIEGO & CABO SAN LUCAS BETWEEN 5:00 P.M. ON 2/28 & 7:20 A.M. ON 3/1	DEAD	NA	1	California	MIGRATION
31-Jan-09	UNIDENTIFIED POT/TRAP FISHERY ENTANGLEMENT	SAN DIEGO	CA	SI (PRORATE)	FREE-SWIMMING ANIMAL TOWING UNIDENTIFIED POT/TRAP GEAR; USCG REPORTED GEAR AS 4 LOBSTER POTS; FINAL STATUS UNKNOWN	SI (PRORATE)	L10	0.75	California	MIGRATION
25-Mar-09	GILLNET FISHERY	ORANGE	CA	SI (PRORATE)	FREE-SWIMMING ANIMAL WITH PINK GILLNET WRAPPED AROUND HEAD, TRAILING 4 FEET OF VISIBLE NETTING; REPORT RECEIVED VIA NATURALIST ON LOCAL WHALEWATCH VESSEL; NO RESCUE EFFORT INITIATED; FINAL STATUS UNKNOWN	SI (PRORATE)	L10	0.75	California	MIGRATION
4-Apr-09	VESSEL STRIKE	PACIFIC	WA	DEAD	NECROPSIED, BROKEN BONES IN SKULL; EXTENSIVE HEMORRHAGE HEAD AND THORAX; SUB-ADULT MALE	DEAD	NA	1	PCFG	MIGRATION

5-Apr-09	VESSEL STRIKE	ORANGE	CA	DEAD	DEAD STRANDING; 3 DEEP PROPELLER-LIKE CUTS ON RIGHT SIDE, JUST ANTERIOR OF GENITAL OPENING; CARCASS TOWED OUT TO SEA ON 6-APR, RESTRANDED AT 29TH STREET IN DEL MAR ON 10-APR; CARCASS TOWED OUT & RESTRANDED AT TORREY PINES STATE BEACH ON 12-APR; CARCASS EXAMINED BY LACMNH & SWFSC PERSONNEL	DEAD	NA	1	California	MIGRATION
9-Apr-09	MARINE DEBRIS ENTANGLEMENT	SITKA	AK	SI	THICK BLACK LINE WRAPPED TWICE AROUND WHALE'S BODY POSTERIOR TO THE EYES. PRIVATE CITIZEN CUT AND PULLED AWAY THE LINES. ANIMAL SWAM AWAY AND DOVE.	SI	L10	0.75	SE Alaska	MIGRATION
27-Apr-09	VESSEL STRIKE	ISLAND	WA	DEAD	LARGE AMOUNT OF BLOOD IN BODY CAVITY, BRUISING IN SOME AREAS OF BLUBBER LAYER AND IN SOME INTERNAL ORGANS. FINDINGS SUGGESTIVE OF BLUNT FORCE TRAUMA LIKELY CAUSED BY COLLISION WITH A LARGE SHIP.	DEAD	NA	1	Puget Sound	MIGRATION
1-May-09	VESSEL STRIKE	LOS ANGELES	CA	SI	CATALINA ISLAND TRANSPORT VESSEL COLLIDED WITH FREE-SWIMMING CALF ACCOMPANIED BY ADULT ANIMAL; CALF WAS SUBMERGED AT TIME OF COLLISION; PIECES OF FLESH & BLOOD OBSERVED IN WATER; CALF NEVER SURFACED; PRESUMED MORTALITY. VESSEL SIZE = 85 FT. SPEED = 27 KTS.	SI	L6A	1	California	MIGRATION
24-Jun-09	GILLNET FISHERY, TRIBAL	CLALLAM	WA	SI	WHALE CAUGHT IN THE BAG SECTION OF A TRIBAL SET GILLNET. WHALE ENCOUNTERED IN MORNING, UNKNOWN ENTANGLEMENT DURATION. NET HAD BEEN SET 8PM PREVIOUS DAY. WHALE WAS ABLE TO BREATH, BUT COULD NOT FREELY SWIM AND WAS STATIONARY WITHIN NET. RIGHT PECTORAL FIN AND HEAD WERE WELL WRAPPED IN NET WEBBING. WHALE REACTED VIOLENTLY AND SWAM AWAY IN RESPONSE TO A DISENTANGLEMENT ATTEMPT. NET WAS RETRIEVED AND FOUND TO BE TORN IN TWO. NO CONFIRMATION THAT WHALE WAS COMPLETELY FREE OF NETTING. WHALE LAST SEEN AT 1030 AM. PRORATE L10 SERIOUS INJURY BECAUSE OF POSSIBLE EXISTING ENTANGLEMENT.	SI (PRORATE)	L10	0.75	PCFG	FEEDING
21-Jul-09	GILLNET FISHERY	HUMBOLDT	CA	SI	FREE-SWIMMING ANIMAL WITH GREEN GILLNET, ROPE & SMALL BLACK FLOATS WRAPPED AROUND CAUDAL PEDUNCLE. PHOTOS SHOW ROPE CUTTING INTO CAUDAL PEDUNCLE. REPORT RECEIVED VIA HSU RESEARCHER ON SCENE DURING RESEARCH CRUISE; ANIMAL RESIGHTED ON 3-AUG; NO RESCUE EFFORT INITIATED; WHALE IDENTIFIED BY J. CALAMBOKIDIS AS PCFG GRAY WHALE, RESIGHTED IN 2010 AND 2011, STILL ENTANGLED. In 2012 observed healthy with no entanglement.	NSI	L2	0	PCFG	FEEDING

9-Sep-09	VESSEL STRIKE	CLALLAM	WA	SI (PRORATE)	USCG VESSEL REPORTED TO BE TRAVELING AT 10 KNOTS WHEN THEY HIT A GRAY WHALE ON 9/9/2009. THE ANIMAL WAS HIT WITH THE PROP AND WAS REPORTED ALIVE AFTER BEING HIT, BLOOD OBSERVED IN WATER.	SI (PRORATE)	L11	0.52	PCFG	FEEDING
16-Feb-10	VESSEL STRIKE	SAN DIEGO	CA	SI (PRORATE)	FREE-SWIMMING ANIMAL WITH PROPELLER-LIKE WOUNDS TO DORSUM	SI (PRORATE)	L11	0.52	California	MIGRATION
5-Mar-10	UNIDENTIFIED FISHERY INTERACTION	SAN DIEGO	CA	SI	TOWING ORANGE/WHITE BUOY; UNIDENTIFIED FISHERY. NO RESCUE EFFORT INITIATED; NO RESIGHTINGS REPORTED; FINAL STATUS UNKNOWN	SI	L10	0.75	California	MIGRATION
12-Mar-10	VESSEL STRIKE	SANTA BARBARA	CA	SI	21 METER SAILBOAT UNDERWAY AT 13 KTS COLLIDED WITH FREE-SWIMMING ANIMAL; WHALE BREACHED SHORTLY AFTER COLLISION; NO BLOOD OBSERVED IN WATER; MINOR DAMAGE TO LOWER PORTION OF BOAT'S KEEL; FINAL STATUS UNKNOWN	SI	L6A	1	California	MIGRATION
16-Apr-10	CRAB POT FISHERY ENTANGLEMENT	CLATSOP	OR	DEAD	ENTANGLED IN CRAB POT LINES	DEAD	NA	1	PCFG	MIGRATION
7-May-10	CRAB POT FISHERY ENTANGLEMENT	LINCOLN	OR	SI (PRORATE)	ENTANGLED IN 3 CRAB POTS, WHALE NOT RELOCATED	SI (PRORATE)	L10	0.75	PCFG	MIGRATION
11-May-10	GILLNET FISHERY	ORANGE	CA	SI	FREE-SWIMMING ANIMAL ENTANGLED IN GILLNET; ANIMAL FIRST OBSERVED INSIDE DANA POINT HARBOR ON 5/11/10; ANIMAL SUCESSFULLY DISENTANGLED ON 5/12/10 & SWAM OUT OF HARBOR; ANIMAL OBSERVED ALIVE IN SURF ZONE FOR SEVERAL HOURS ON 5/14/10 OFF DOHENY STATE BEACH BEFORE WASHING UP DEAD ON BEACH.	DEAD	NA	1	California	MIGRATION
17-Aug-10	CRAB POT FISHERY ENTANGLEMENT	MENDOCINO	CA	SI	CRAB POT LINE SPIRALED AROUND ANIMAL FROM HEAD TO FLUKES, TRAILING 20 FEET OF LINE ATTACHED TO CRAB POT; PECTORAL FIN SEVERED, ONLY NECROTIC TISSUE REMAINING. FREE-SWIMMING, BREACHING, MAKING SHALLOW DIVES; SUCCESSFUL DISENTANGLEMENT	SI	L2	1	California	FEEDING
22-Jan-11	VESSEL STRIKE	SAN DIEGO	CA	SI (PRORATE)	PLEASURE SAILBOAT COLLIDED WITH FREE-SWIMMING ANIMAL; ANIMAL DOVE IMMEDIATELY FOLLOWING CONTACT & WAS NOT RESIGHTED; NO BLOOD OBSERVED IN WATER; FINAL STATUS UNKNOWN. VESSEL SIZE ASSUMED LESS THAN 65 FT. AND SPEED UNKNOWN.	SI (PRORATE)	L7B	0.14	California	MIGRATION

12-Feb-11	VESSEL STRIKE	LOS ANGELES	CA	SI (PRORATE)	PRIVATE RECREATIONAL VESSEL COLLIDED WITH FREE-SWIMMING ANIMAL; ANIMAL BREACHED JUST PRIOR TO CONTACT, BOUNCING OFF SIDE OF VESSEL; DOVE IMMEDIATELY FOLLOWING CONTACT & WAS NOT RESIGHTED; NO BLOOD OBSERVED IN WATER; FINAL STATUS UNKNOWN; SKIN SAMPLE COLLECTED FROM VESSEL AND GENETICALLY IDENTIFIED AS A FEMALE GRAY WHALE. VESSEL SIZE ASSUMED LESS THAN 65 FT AND SPEED UNKNOWN.	SI (PRORATE)	L7B	0.14	California	MIGRATION
18-Apr-11	VESSEL STRIKE	SAN FRANCISCO	CA	DEAD	CRUSHED MANDIBLE	DEAD	NA	1	California	MIGRATION
11-Jun-11	VESSEL STRIKE	SAN MATEO	CA	DEAD	MASSIVE HEMORRHAGE INTO THE THORAX, BLOOD CLOTS AROUND LUNGS. LESIONS INDICATE MASSIVE TRAUMA. DUE TO CARCASS POSITION, THE SKELETON COULD NOT BE COMPLETELY EXAMINED (LYING ON BACK, TOP OF SKULL IN SAND)	DEAD	NA	1	California	FEEDING
13-Jul-11	UNIDENTIFIED FISHERY INTERACTION	SAN LUIS OBISPO	CA	SI	ANIMAL HAS BEEN IN AREA FOR ~5 WEEKS, OBSERVED FEEDING; THIS WAS FIRST OBSERVATION OF ENTANGLEMENT; GRAY LINE WITH BLACK AND WHITE FLOAT WRAPPED AROUND FLUKE/PEDUNCLE AREA, TRAILING LINE, 2 LACERATIONS IN THE FLUKE AREA, ONE DEEP ONE AT THE BASE AND ONE ON ONE OF THE BLADES CAUSING THE TIP TO CURL; ANIMAL OBSERVED ENTANGLED IN THE MORNING BUT AT 1330 OBSERVED WITHOUT ENTANGLEMENT; SHED GEAR ON ITS OWN; GEAR-FREE BUT INJURED	SI	L2	1	California	FEEDING
27-Jul-11	UNIDENTIFIED FISHERY INTERACTION	KITSAP	WA	NSI	INDICATIONS OF OLD HEALED ENTANGLEMENT SCAR ON FLUKE. OPEN ULCER/ LESIONS ON ABDOMEN OF UNKNOWN ORIGIN.	NSI	L5B	0	PCFG	FEEDING
25-Aug-11	UNIDENTIFIED NET FISHERY ENTANGLEMENT	PETERSBURG	AK	SI	ENTANGLED IN 50 LBS. HEAVY MONOFILAMENT WEBBING, CORK LINE, AND LEAD LINE, AS WELL AS OVER 200 LBS. OF BULL KELP ATTACHED TO GEAR; COMPLETELY DISENTANGLED; LEADING EDGE OF FLUKES HAD SIGNIFICANT CUTS AND ABRASIONS; OVERALL BODY CONDITION WAS POOR; MASSIVE INFESTATION OF WHALE LICE AND BARNACLES; ANIMAL VERY EMACIATED AND LACKED ANY VISIBLE SIGNS OF RECENT FEEDING; OBSERVED THE DAY AFTER DISENTANGLEMENT SWIMMING VERY SLOWLY. (APPARENT HEALTH DECLINE DUE TO CONSTRICTING AND WEIGHTED ENTANGLEMENT)	SI	L2	1	SE Alaska	FEEDING

25-Aug-11	UNIDENTIFIED POT/TRAP FISHERY ENTANGLEMENT	SAN MATEO	CA	SI	ONE WHITE "CRAB POT" BUOY NEXT TO BODY BY LEFT PECTORAL FIN; FLOAT STAYED NEXT TO BODY AND DID NOT CHANGE POSITION; ANIMAL REMAINED IN SAME POSITION - POSSIBLY ANCHORED; ONLY OBSERVED FOR ~2 MIN; NOT RESIGHTED, NO RESCUE, OUTCOME UNKNOWN	SI	L2	1	California	FEEDING
27-Sep-11	COD POT FISHERY ENTANGLEMENT	KODIAK	AK	SI	ENTANGLED IN COD POT GEAR; 3-5 WRAPS OF LINE AROUND PEDUNCLE AND WHALE IMMOBILIZED; 2-3 WRAPS OF FLOATING POLY BUOY LINES WRAPPED CLOSE TO FLUKES, SINGLE WRAP OF POT LINE AROUND PEDUNCLE EXTENDED DOWN TO THE POT AT AN ANGLE; FLUKES IMMOBILIZED; COMPLETELY DISENTANGLED AFTER 2 HRS AND OBSERVED SWIMMING SLOWLY. NON-SERIOUS INJURY BECAUSE WHALE'S CONDITION WAS REPORTED AS GOOD AND ALL GEAR REMOVED.	NSI	L2	0	Kodiak Island	FEEDING
17-Jan-12	COD POT FISHERY ENTANGLEMENT	ALEUTIANS EAST	AK	SI (PRORATE)	A 40' WHALE WAS CAUGHT IN COD POT GEAR NEAR UNIMAK PASS. LINES WERE CUT BY BOAT CREW AND BUOYS WERE RECOVERED, HOWEVER, THE POT AND SOME LINE REMAINED IN THE WATER. ANY LINE POSSIBLY REMAINING ON ANIMAL THOUGHT TO BE MINIMAL. GRAY WHALE DETERMINATION MADE FOLLOWING EXTENSIVE QUESTIONING BY KATE WYNNE. DETERMINATION: PRORATE AT L10 BECAUSE GEAR POSSIBLY REMAINS ON ANIMAL.	SI	L10	0.75	Far North	MIGRATION
22-Jan-12	MARINE DEBRIS ENTANGLEMENT	PACIFIC	WA	DEAD	POSSIBLE ENTANGLEMENT,DEEP CABLE-LIKE INDENTATION AROUND GENITAL AREA.	DEAD	NA	1	PCFG	MIGRATION
28-Jan-12	UNIDENTIFIED POT/TRAP FISHERY ENTANGLEMENT	SAN DIEGO	CA	SI (PRORATE)	ENTANGLED ANIMAL REPORT; TOWING TWO ORANGE BUOYS AND AT LEAST 150 FT OF LINE; UNKNOWN FISHERY, REPORTED AS POSSIBLE GILLNET; NO RESPONSE EFFORT	SI (PRORATE)	L10	0.75	California	MIGRATION
24-Mar-12	GILLNET FISHERY	LOS ANGELES	CA	SI	ENTANGLED ANIMAL REPORT; GILLNET GEAR AROUND PEDUNCLE; RESPONSE EFFORT RESULTED IN SUCCESSFUL DISENTANGLEMENT WITH >100 FT OF PINK GILLNET REMOVED FROM ANIMAL, BUT ANIMAL SUBSEQUENTLY OBSERVED DEAD ON 03/27 (FLOATING, SKIN SAMPLE TAKEN, NO NECROPSY). NET REMOVED ON 03/24 FOUND TO CONTAIN ONE DEAD CA SEA LION AND THREE DEAD SHARKS.	DEAD	L2	1	California	MIGRATION

28-Mar-12	UNIDENTIFIED FISHERY INTERACTION	ORANGE	CA	SI	ENTANGLED ANIMAL REPORT; LINE DEEPLY EMBEDDED AROUND TAIL STOCK AND UNDER FLUKE; ~45 FEET OF ROPE WITH HAND CARVED BUOY; ANIMAL SUCCESSFULLY COMPLETELY DISENTANGLED ON 3/29. FINAL OUTCOME UNKNOWN. ANIMAL SUCCESSFULLY DISENTANGLED AND ALL GEAR RECOVERED. ENTANGLEMENT NO LONGER LIFE THREATENING. CONDITION OF ANIMAL INDICATED THAT ANIMAL IS LIKELY TO SURVIVE.	NSI	L2	0	California	MIGRATION
17-Apr-12	UNIDENTIFIED FISHERY INTERACTION	ORANGE	CA	SI (PRORATE)	40-FOOT GRAY WHALE REPORTED ENTANGLED WITH APPROXIMATELY 150 FEET OF LINE TRAILING. FOUR SPONGEX BULLET BUOYS LIE ALONG THE LEFT SIDE OF THE ANIMAL. ENTANGLEMENT INVOLVES THE MOUTH, A WRAP OVER THE HEAD, AND THE LEFT PECTORAL FLIPPER. ENTANGLEMENT APPEARS RECENT. PARTIALLY DISENTANGLED 5/3/12 BY FISHERMEN.	SI (PRORATE)	L10	0.75	California	MIGRATION
21-Apr-12	UNIDENTIFIED FISHERY INTERACTION	SAN LUIS OBISPO	CA	DEAD	ROPE LIKE MARKS ON CAUDAL PEDUNCLE. ROPE IMPRESSION ON PECTORAL FIN. PHOTOS TAKEN.	DEAD	NA	1	California	MIGRATION
28-Apr-12	UNIDENTIFIED FISHERY INTERACTION	MENDOCINO	CA	SI (PRORATE)	SMALL GRAY WHALE OFF FORT BRAGG CA, IN COMPANY OF TWO OTHER ANIMALS, TRAILING TWO BUOYS.	SI (PRORATE)	L10	0.75	California	MIGRATION
5-May-12	MARINE DEBRIS ENTANGLEMENT	MONTEREY	CA	SI (PRORATE)	WHALE WATCH VESSEL NOTICED FROM IMAGES TAKEN OF A 20 - 25 FOOT GRAY WHALE THEY HAD BEEN OBSERVING EARLIER IN THE DAY, THAT ANIMAL WAS ACTUALLY ENTANGLED. A SMALL GAUGE LINE, LIKELY FROM RIGHT SIDE OF MOUTH GOES OVER THE ANIMAL'S BACK, AND OVER BLOWHOLES, TO LEFT SIDE OF MOUTH. NO BUOYS OR TRAILING LINE WERE OBSERVED. ANIMAL IN FAIR CONDITION. ANIMAL SIGHTED NEXT DAY BY WHALE WATCH VESSEL. CONFIRMED MOUTH ENTANGLEMENT, APPEARS TO BE STRAPPING MATERIAL.	SI (PRORATE)	L10	0.75	California	MIGRATION
8-May-12	DUNGENESS CRAB POT FISHERY ENTANGLEMENT	HUMBOLDT	CA	SI	ENTANGLED ANIMAL REPORT; DEEP CUTS FROM ROPE AROUND PEDUNCLE AND LACERATIONS AT FLUKE NOTCH AND LATERAL EDGE OF FLUKE; SUCCESSFULLY DISENTANGLED BUT LONG-TERM SURVIVAL NOTED AS QUESTIONABLE. GEAR WAS COLLECTED AND IDENTIFIED AS DUNGENESS CRAB POT GEAR. ANIMAL ENTIRELY FREED OF GEAR. ANIMAL IN FAIR CONDITION AND SLIGHTLY EMACIATED. DEEP CUTS (~ 2 INCHES) FROM THE ROPE AROUND THE PEDUNCLE REMAINED. GEAR WAS RECOVERED. RESULTS OF ENTANGLEMENT MAY STILL BE LIFE THREATENING.	SI	L2	1	PCFG	MIGRATION

11-May-12	DUNGENESS CRAB POT FISHERY ENTANGLEMENT	MARIN	CA	SI	ENTANGLED ANIMAL REPORT; LOOP BETWEEN CRAB POTS AND WEIGHTED LINE CAUGHT IN WHALE'S MOUTH; ENTANGLING GEAR STUCK IN ROCKS; ANIMAL ANCHORED WITH SMALL RADIUS OF MOVEMENT FOR 4 DAYS; SUCCESSFULLY DISENTANGLED. GEAR WAS COLLECTED.	NSI	L2	0	California	MIGRATION
13-May-12	UNKNOWN FISHERY INTERACTION	MONTEREY	CA	SI	ANIMAL ENTANGLED THROUGH MOUTH IN AT LEAST TWO SETS OF SUSPECTED POT GEAR THAT THAT HANG BELOW. ANIMAL ANCHORED WITH A SHORT SCOPE IN 28 FEET OF WATER TO SUSPECTED POTS. BUNDLE OF GEAR, INCLUDING 4 BUOYS LIE UNDER ANIMAL. ANIMAL HAVING SOME DIFFICULTY GETTING TO SURFACE. ANIMAL EVENTUALLY DISENTANGLED, BUT RESULTS OF ENTANGLEMENT MAY STILL BE LIFE-THREATENING.	SI	L2	1	California	MIGRATION
16-Jun-12	GILLNET FISHERY	VALDEZ-CORDOVA	AK	SI	30' GRAY WHALE IN PRINCE WILLIAM SOUND ENTANGLED IN GEAR. THRASHING AT SURFACE AND MOVING AT 4-5 KNOTS. NO WOUNDS OR CHAFING WAS OBSERVED. GILLNET, CORKLINE (ATLEAST 12 FLOATS), AND LEADLINE OBSERVED OVER ANIMAL'S ROSTRUM, BODY, AND TAILSTOCK. BOTH PECTORAL FLIPPERS APPEARED PINNED TO BODY. ANIMAL LATER APPEARED TIRED AND WAS SWIMMING AT 2 KNOTS. IT WAS NOT RELOCATED. ASSIGNED L2 BECAUSE GEAR APPEARS TO BE CONSTRICTING MOVEMENT OF WHALE'S FLIPPERS.	SI	L2	1	SE Alaska	FEEDING
22-Aug-12	GILLNET FISHERY	VALDEZ-CORDOVA	AK	SI (PRORATE)	WHALE SIGHTED BY TOUR BOAT. FEW DETAILS, OTHER THAN PART OF A FISHING NET WAS OBSERVED BEING TRAILED FROM A GRAY WHALE'S FIN. PHOTOS APPARENTLY AVAILABLE, BUT HAVE NOT BEEN LOCATED. PRINCE WILLIAM SOUND. EXTENT AND SEVERITY OF ENTANGLEMENT UNKNOWN.	SI	L10	0.75	SE Alaska	FEEDING
31-Aug-12	UNKNOWN FISHERY INTERACTION	LOS ANGELES	CA	SI (PRORATE)	ANIMAL FIRST DETECTED NEAR SAN DIEGO. SUBADULT GRAY WHALE REPORTED ENTANGLED WITH SMALL GAUGE, DARK-COLORED LINE DEEPLY EMBEDDED AROUND ITS TAIL STOCK. LITTLE GEAR TRAILS. ENTANGLEMENT WAS ONCE MORE INVOLVED AS INDICATED BY SCARS ON THE ANIMAL'S BODY. ANIMAL IN VERY POOR CONDITION - EMACIATED, SCARRED AND A HEAVY LOAD OF CYAMID AMPHIPODS. BLACK LINE AROUND PEDUNCLE, 20 FT TRAILING; OBSERVED OFF SAN DIEGO ON 8/31, COMPLETELY DISENTANGLED OFF LOS ANGELES 9/6, STRANDED DEAD 9/14/12.	DEAD	L2	1	California	FEEDING

13-Oct-12	GILLNET FISHERY	MENDOCINO	CA	SI	ENTANGLED ANIMAL REPORT; ANIMAL REPORTED WITH ROPE AROUND THE PEDUNCLE WHICH WASN'T SEEN IN PHOTOGRAPHS BUT PHOTOS DID SHOW GREEN GILLNET WITH CUTS TO THE HEAD; ANIMAL DISAPPEARED AND FINAL STATUS IS UNKNOWN	SI	L2	1	California	FEEDING

Individual gray whale use of coastal waters off northwest Washington during the feeding season 1984–2011: Implications for management

JONATHAN J. SCORDINO[1], MERRILL GOSHO[2], PATRICK J. GEARIN[2], ADRIANNE AKMAJIAN[1], JOHN CALAMBOKIDIS[3] AND NANCY WRIGHT[4]

Contact e-mail: jonathan.scordino@makah.com

ABSTRACT

Gray whales (*Eschrichtius robustus*) in northwest Washington were studied, with the aims to: (1) increase understanding of gray whale use of the study area; (2) document the annual and seasonal fluctuations in the numbers of whales utilising the area; and (3) assess the fidelity of whales to the study area within and between years. Together these goals establish a baseline of gray whale behaviour during summer and autumn in the region of the Makah Tribe's proposed whale hunt. From 1984 to 2011, a total of 225 unique gray whales were observed, with 49% being observed again in a future year. There was significant variability in observation rates of gray whales by month and year. During the feeding season, the observation rate increased to a peak in August in the north research segment in the Pacific Ocean and to a peak in October in research segments in the Strait of Juan de Fuca and in the southern research segment in the Pacific Ocean. Gray whales were most commonly observed at depths of 5–15m over rocky substrates and often near kelp forests, although the locations where they fed were dynamic by both month and year. Some whales habitually returned to northwest Washington, however the average whale in the study area was observed in only 31.6% (SE = 1.6%) of the possible years in which they could have been observed. Gray whales in the study area had an average minimum tenure (residency time) of 24.8 days out of a possible 183 days of the feeding season. A discovery curve analysis did not reach an asymptote over the 27 years of this study showing that there is no population closure to the research area. Based on these findings, it can be concluded that even though northwest Washington is an important feeding area, most Pacific Coast Feeding Group (PCFG) gray whales do not have strong fidelity to this one region within the IWC defined PCFG range. The findings presented in this paper provide a baseline for evaluating the impact of Makah hunting activities on the behaviour of PCFG whales that utilise the Makah's traditional hunting area once hunting activities resume.

KEYWORDS: GRAY WHALE; PACIFIC OCEAN; FEEDING GROUND; MOVEMENTS; SITE FIDELITY; NORTHERN HEMISPHERE; SURVEY–VESSEL

INTRODUCTION

Most Eastern North Pacific (ENP) gray whales (*Eschrichtius robustus*) migrate from wintering grounds in Baja California, Mexico, to feeding grounds in the Bering, Chukchi and Beaufort seas. A small subset of the ENP gray whale population does not complete the migration to arctic feeding grounds and instead spends the summer and autumn at feeding grounds along the coast of the Pacific Ocean from California through Southeast Alaska (Calambokidis *et al.*, 2002). This group of whales has been referred to by many names since it was first studied in the 1970s and is currently recognised as the Pacific Coast Feeding Group (PCFG) by the International Whaling Commission (IWC, 2011) and the US Government (Carretta *et al.*, 2013). The IWC defines the PCFG as gray whales seen in more than one year in the months of June to November within the range of northern California to northern British Columbia (41°N–52°N), excluding gray whale sightings in Puget Sound, Washington (IWC, 2012). The range is restricted to 52°N even though PCFG whales are known to frequently occur as far north as Kodiak Island, Alaska (Gosho *et al.*, 2011) and have been observed in the Beaufort Sea (Calambokidis *et al.*, 2014). The IWC-defined range of the PCFG is narrower than previous definitions of this group. This is primarily because most photo-identification surveys have been focused on 41–52°N. Population estimates are therefore more reliable for this range. There are few historic or projected future catches of gray whales north of 52°N and south of the Bering Sea, making the more narrowly defined range more applicable to management (IWC, 2012). The abundance estimate for the PCFG in 2012 was 209 whales (Calambokidis *et al.*, 2014).

Recent genetic studies have found small but statistically significant differences in frequencies of mtDNA haplotypes between samples collected from PCFG whales and other ENP whales in other portions of their range (Frasier *et al.*, 2011; Lang *et al.*, 2014). No statistically significant differences have been found in the frequencies of nuclear DNA (D'Intino *et al.*, 2013; Lang *et al.*, 2014). Despite the significant difference in mtDNA haplotype frequency, PCFG and ENP whales had similar haplotype diversity which suggests that immigration into the PCFG could be occurring (Lang *et al.*, 2014). The results of a genetics simulations study (Lang *et al.*, 2012) and photo-identification work (Calambokidis *et al.*, 2014) were consistent with immigration from other portions of the ENP range into the PCFG having a significant role in the

[1] *Marine Mammal Program, Makah Fisheries Management, Makah Tribe, Neah Bay, Washington, USA.*
[2] *National Marine Mammal Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic Atmospheric Administration, Seattle, Washington, USA.*
[3] *Cascadia Research Collective, Olympia, Washington, USA.*
[4] *Olympic Coast National Marine Sanctuary, National Ocean Service, National Oceanic Atmospheric Administration, Port Angeles, Washington, USA.*

population dynamics of the group. Given that there is evidence both for the PCFG having open population dynamics and evidence for matrilineal recruitment, there is currently debate on whether or not the PCFG is a stock. NOAA Fisheries used a panel of experts to evaluate whether the PCFG is a stock; the panel could not agree whether the PCFG is a stock for US domestic purposes but did agree that more research is needed (Weller *et al.*, 2013).

Interest in PCFG whales has been inspired by concern regarding the possible impacts on the PCFG of the Makah Tribe resuming their treaty protected right to hunt whales. In 1855, the Makah Tribe protected its whaling rights in the Treaty of Neah Bay. In the 1920s, the Tribe voluntarily suspended whale hunting due to the impacts of commercial whaling on gray and humpback whale populations (Renker, 2012; Thompson, 2006). In 1994, when the gray whale was removed from the US Endangered Species List, the Makah Tribe informed the US Government of its intentions to resume traditional whale hunting. The US Government has obtained aboriginal whaling catch limits for the harvest of gray whales from the IWC to be used by the Makah Tribe since 1997. However, since that time the Makah Tribe has only landed one gray whale due to domestic court cases and regulatory processes suspending the hunt in 2000. The Tribe has submitted a proposed management plan to the US Government and the IWC for review. The management plan restricts the hunt to the migratory season in the Pacific Ocean portion of the Makah Usual and Accustomed (U&A) fishing grounds to minimise the risk that a hunt takes a PCFG whale. Nonetheless, it is recognised that the hunt may still take PCFG whales, so the management plan also has a provision to limit the number of PCFG whales landed through a conservative calculation based on the abundance of PCFG whales (IWC, 2013). The IWC evaluated the impact of Makah hunting on PCFG population dynamics and found that the Tribe's proposed management plan meets the conservation goals of the IWC of ensuring the PCFG will remain above 60% of its carrying capacity over a 100-year simulation (IWC, 2013).

Past studies have documented the behaviour of PCFG whales throughout their entire range (Calambokidis *et al.*, 2002; 2010; 2012; 2014). This paper reports on the behaviour of gray whales in the coastal waters of northwest Washington during the summer and autumn feeding season. Data were collected from 1984–2011 with the goals of: (1) increasing our understanding of gray whale use of the study area; (2) documenting the annual and seasonal fluctuations in the numbers of whales utilising the area; and (3) assessing the fidelity of whales observed within the study area within and between years. Together these three goals establish a baseline of gray whale behaviour in the region of the Makah Tribe's proposed whale hunt to evaluate (once the hunt is approved) whether the hunt impacts gray whale behaviour in the northwest Washington.

METHODS

Study area

Research effort was conducted along the northwest tip of Washington State, USA (Fig. 1). Northwest Washington is bounded by two bodies of water: the Strait of Juan de Fuca

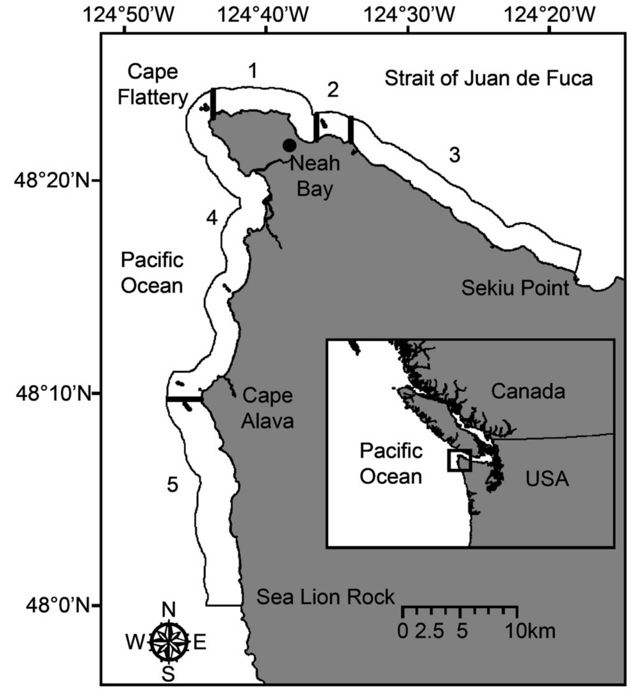

Fig. 1. Map of the gray whale survey region in northwest Washington with the focal survey area shown enclosed with a line. The numbered survey segments are: (1) West Strait; (2) Neah Bay Entrance; (3) East Strait; (4) North Ocean; and (5) South Ocean.

to the north and the Pacific Ocean to the west. The rocky shorelines are interspersed with sandy beaches, and rocky underwater habitats dominated by forests of bull kelp (*Nereocystis luetkeana*) and giant kelp (*Macrocystis spp.*) in waters 5–15m deep. The waters of northwest Washington have high biological productivity due to the confluence of currents from the California Current and the drainage of Puget Sound through the Strait of Juan de Fuca, and seasonal winds causing upwellings (Marchetti *et al.*, 2004). The study area encompasses most of the nearshore habitat of the Makah U&A and the entire area in which the Makah Tribe has proposed for hunting gray whales (Makah Tribal Council, 2011).

Survey methodology

The northwest Washington survey area is too large to be surveyed effectively in one day. One day of survey effort covered the area to the east of Neah Bay along the shores of the Strait of Juan de Fuca to Sekiu Point, approximately 25km from Neah Bay. The other survey day covered the area west along the shores of the Strait of Juan de Fuca to Cape Flattery and then south following the shoreline of the Pacific Ocean to Sea Lion Rock (47°59.58'N, 124°43.45'W). The total distance covered in the southbound leg is approximately 60km. Surveys for gray whales were generally conducted within 1–2km of shore because gray whales feeding in northwest Washington primarily congregate near shore. Portions of the survey in the Pacific Ocean, particularly south of Cape Alava, were conducted further from shore due to poorly charted submerged rocks.

Survey effort was variable by year. The early years of survey effort in northwest Washington were conducted opportunistically with three years of surveys in the 1980s (1984, 1986 and 1989) by Cascadia Research Collective

(CRC). Starting in 1992 surveys were conducted annually by the National Marine Mammal Laboratory (NMML) and CRC but effort was low and opportunistically conducted during studies of other marine mammal species. After 1996, surveys were standardised and were generally conducted on a bi-weekly basis from June through November as weather and ocean conditions allowed with NMML and the Makah Tribe as the primary research groups. The objective was to collect photo-identification of whales. Thus, if the researchers had good reason to suspect that survey effort in the Strait of Juan de Fuca would result in limited or no photographs of gray whales, then effort was focused on the Pacific Ocean and vice versa. The Pacific Ocean survey area was generally surveyed monthly regardless of anticipated opportunities to photograph gray whales because the surveys were also used for monthly California and Steller sea lion research. All research effort was conducted from small vessels of 6–9m in length.

During surveys, observers periodically recorded time and location and variables that could have influenced the probability of sighting a whale such as cloud cover and Beaufort sea state. When gray whales were sighted, their location, depth and activities were recorded. Observers then attempted to take photographs of the dorsal ridge along both flanks as well as the flukes. Photographs were taken using digital SLR cameras with a 70–300mm lens (35mm film cameras were used prior to 2004). The lens magnification allowed photo-documentation of unique colouration patterns on the lateral sides and flukes of the whales (Darling, 1984). The frame numbers from the photographs were recorded on the field data sheet with the sighting information.

Photo-identification methodology

All gray whale photographs of suitable quality were compared to a catalogue of gray whales previously seen in the PCFG as described in Calambokidis *et al.* (2012) by CRC. If a photographed whale was matched to a catalogued whale then the catalogue number of the whale was recorded. If a match could not be made, and the photograph was of sufficient quality, then the photographed whale was assigned a new catalogue number. All catalogue numbers of sighted gray whales were recorded in a database along with attributes of the sighting such as date, time, water depth, location and whale behaviour.

Data exploration

The three primary goals of this research were: (1) to increase understanding of gray whale use of the study area; (2) to document seasonal and annual fluctuations in the numbers of whales using the study area; and (3) to assess fidelity of whales to the study area. The analyses conducted could be interpreted as achieving one or more of these goals but for the purpose of explaining each method, and why it was conducted, each method is listed by research goal. For all analyses observations of uniquely identified whales were used instead of all gray whale observations to prevent pseudo-replication. Research effort and data collection was not consistent in all years (as described above) and as a result some analyses could not use all collected data whereas others could (Table 1).

To address the goal of increasing understanding of gray whale use of the study area four analyses were conducted. The first analysis was to characterise the depth range and habitat types where gray whales were observed. The second analysis was to document the occurrence of new whales in the study area. The purpose of this analysis was to determine the turnover of individuals in the study area. New whales were simply defined as whales not previously observed in the study area although they may have been observed within the PCFG in the past. For each year the number of new whales observed and the proportion of those that were observed to 'recruit' into the study area and be observed again in a subsequent year were determined. The third analysis documented how many calves were observed and calculated an estimate of proportion of newly observed whales that were calves (see Calf Analysis below). The last analysis determined if there is population closure to the study area. Calambokidis *et al.* (2010) concluded that gray whales who utilise northwest Washington have fidelity to a region at least as large as Oregon to Southern Vancouver Island. Despite the findings of Calambokidis *et al.* (2010), domestic processes for evaluating the impact of the proposed Makah whale hunt still question what the local area should be for analysis. To evaluate closure discovery curves were constructed both for all whales observed and for whales that were observed to have some fidelity to the area and were observed in more than one year.

Two analyses were used to document seasonal and annual fluctuations of whales in the study area. In the first analysis

Table 1

Years of data used and justification for each analysis.

Analysis	Years of data used	Justification
Depth	1984–2011	All depths recorded were used for the analysis.
Temporal and spatial distribution of sightings	1996–2011	Data prior to 1996 was not used for analysis because effort was opportunistic in nature and could not be quantified to research segment.
Mapping	2004–2011	We used 2004–11 only because during prior years whale locations were not recorded precisely leading to challenges in interpreting maps.
Fidelity to research area	1984–2011	All data was used.
Minimum tenure	1996–2011	Survey effort was standardised for 1996–2011 in all years but 2004 with effort throughout the summer and fall feeding season.
Occurrence of new whales	1996–2011	All years were used in the analysis. Some of the analysis focused on 1996–2011 to ensure that new whales were not whales that commonly use the study area but had not been 'discovered' yet.
Photo analysis of new whales	2004–2011	The analysis was performed at Makah Fisheries and only photographs after 2004 were available for analysis.
Population closure in study area	1984–2011	All data was used.

all sightings were divided into five research segments (Fig. 1). The five research segments were: (1) East Strait (Sekiu Point to Third Beach); (2) Neah Bay Entrance (Third Beach to Waadah Island); (3) West Strait (Waadah Island to Tatoosh Island); (4) North Ocean (Tatoosh Island to Cape Alava); and (5) South Ocean (Cape Alava to Sea Lion Rock). The number of sightings were divided by the number of surveys in the research segment and the length of the research segment in km to standardise the number whales observed per segment for comparison purposes, hereafter this standardised sighting rate will be referred to as 'observation rate'. Observation rates were compared by month and year within each research segment using ANOVA. The second analysis used was mapping and is described in more detail below. The purpose of these analyses was to provide a baseline of habitat use behaviour in the area.

To evaluate gray whale fidelity to the study area, two analyses on different temporal scales were used. Fidelity was evaluated on an annual basis by analysing sighting histories of individual whales to determine the proportion of individuals that were observed in a subsequent year after being first observed. The average percent of years whales were observed in the study area was determined by dividing the number of years each whale was seen in the study area by the number of possible years it could have been observed in the study area. Fidelity was also evaluated within each feeding season by calculating the average 'minimum residency time' for each identified individual by year. For this analysis, minimum residency time was defined as the number of days between the first and last day a whale was seen during the June through November survey time period. The residency time estimate is a minimum because it was possible that a whale was present before the first day (or after the last day) it was sighted during a given year. This estimate may also overestimate residency time because whales could have left the survey area for some unknown length of time between the first and last sighting of the year. Minimum residency time calculations are sensitive to the number of days of survey effort within a year and the temporal distribution of surveys within the survey season. Calambokidis *et al.* (2014) noted that whales observed in the PCFG range during the summer can generally be described as 'transient' whales who are only observed in one year and then not observed in the future and 'PCFG whales' who show some level of fidelity to the IWC defined PCFG range. Fidelity analyses were conducted both for all whales including transients and for whales that have been seen in more than one year. This analysis was conducted to determine a baseline of gray whale fidelity to the area where hunts were planned.

Mapping

To analyse trends in monthly and annual gray whale use of northwest Washington coastal water, the number of photo-identifications made during a whale survey were mapped onto a grid of 1km^2 cells that were aggregated into one of five regions: (1) East Strait; (2) Neah Bay Entrance; (3) West Strait; (4) North Ocean; and (5) South Ocean. Each of these regions extended 2km offshore except the South Ocean which extended 3km, and according to the survey protocol, any survey effort in one of these regions was counted as a full day of effort.

To develop spatial statistics for the survey effort, latitude/longitude coordinates from whale sightings were spatially joined to the 1km^2 grid in ArcGIS 10.1 and exported to MS Excel where total whale counts per 1km^2 grid cell were divided by the survey effort from the same monthly or yearly period to determine sighting density of whales corrected for effort. The sighting densities for each grid cell were re-imported to ArcGIS and plotted as estimates of areal use by gray whales. The grid cells with whale sighting density less than 0.1 were ranked as 'Rare'; cells with sighting density greater than 0.1 but less than 0.3 were ranked as 'Seldom'; cells with sighting densities greater than 0.3 but less than 0.6 were 'Common'; and cells with sighting density greater than 0.6 were ranked as 'Very Common'. This coding was standardised for monthly and annual maps.

The objective of mapping was to document what areas within the larger study area were most important to gray whales and to document how use of those sites changed by month and year.

Calf analysis

During the surveys a whale was recorded as a calf if it was in close association with a much larger individual and appeared to be less than 8m in length. It is possible that calves weaned prior to when they were first observed in the study area as cow-calf pairs in the PCFG have been observed separated as early as the beginning of July (Calambokidis *et al.*, 2012). To make an estimate of what proportion of new whales observed in the study area are calves, photographs were analysed following methods developed by Bradford *et al.* (2011). The analysis was limited to new whales in the study area that were also seen in the PCFG for the first time in that year. Only whales with suitable photo-quality of the

Table 2

Number of gray whale dedicated surveys tallied by year for each segment of research area and total opportunistic surveys by year.

	East Strait	West Strait	North Ocean	South Ocean	Neah Bay entrance	Opportunistic surveys
1984	–	–	–	–	–	3
1986	–	–	–	–	–	10
1989	–	–	–	–	–	2
1992	–	–	–	–	–	2
1993	–	–	–	–	–	5
1994	–	–	–	–	–	7
1995	–	–	–	–	–	5
1996	13	32	23	7	40	5
1997*	22	54	38	14	63	6
1998	28	37	29	13	55	4
1999	14	23	17	15	30	1
2000	13	19	13	8	26	4
2001	12	15	15	10	28	1
2002	10	12	8	6	21	0
2003	15	19	15	8	27	0
2004	4	2	1	1	6	0
2005	11	17	14	6	21	1
2006	15	22	15	9	30	0
2007	13	19	11	8	27	1
2008	25	19	10	5	35	3
2009	23	22	12	7	32	0
2010	18	28	22	14	40	0
2011	11	29	24	18	35	1
Total	**247**	**369**	**267**	**149**	**516**	**81**

*20 surveys were conducted during effort to monitor the Makah setnet fishery. All of these surveys transited the West Strait and into the Northern Ocean research segment.

head and postcranial region were used for the analysis. Whales with evidence of only recently attached barnacles, no old barnacle scars, and white pigmentation mottling the postcranial region were recorded as calves (Bradford *et al.*, 2011). The goal of this analysis was to determine how important northwest Washington was as a site for cow-calf pairs and for recently weaned calves.

RESULTS

Effort to photographically identify gray whales in northwest Washington was conducted between 1984 and 2011. From 1996–2011, surveys were conducted on a more dedicated and rigorous basis resulting in 516 surveys in the research area. Survey effort was greatest from 1996–1998 and 2008–11 (Table 2). By month, effort during dedicated surveys was greatest in the late summer and early autumn (Table 3). The majority of field effort during the autumn was conducted within the Strait of Juan de Fuca due to weather conditions in the Pacific Ocean and the distribution of gray whales. Research effort resulted in the collection of photographs from 225 gray whales that could be identified as unique individuals during the months of June through November from 1984 through 2011.

Gray whales were most often observed in water 5–15m deep, often associated with either kelp forests or emergent offshore rocks (Fig. 2). Sightings of gray whales in waters greater than 20m or less than 5m were rare and were not associated with any obvious habitat type (Fig. 2).

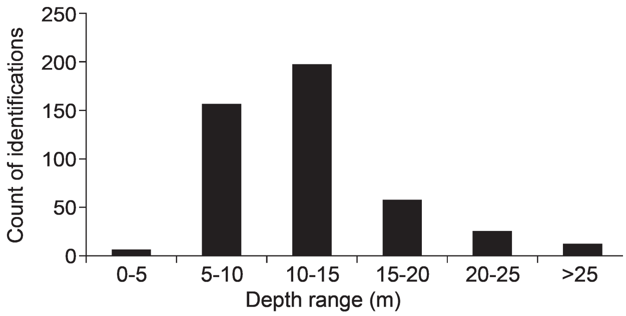

Fig. 2. Histogram of the count of gray whale identifications by depth binned in 5m increments.

Table 3

Number of surveys tallied by month for each segment of research area during gray whale dedicated survey effort from 1996 through 2011.

	East Strait	West Strait	North Ocean	South Ocean	Neah Bay entrance
Jun.	29	50	40	26	64
Jul.	43	78	59	34	99
Aug.	40	98	69	31	120
Sep.	56	79	57	31	114
Oct.	51	41	27	19	78
Nov.	28	23	15	8	41
Total	**247**	**369**	**267**	**149**	**516**

Temporal and spatial distributions of sightings

Gray whale distribution in the Strait of Juan de Fuca (hereafter Strait) varied widely by month and year. Gray whale use of feeding sites in the West Strait and East Strait

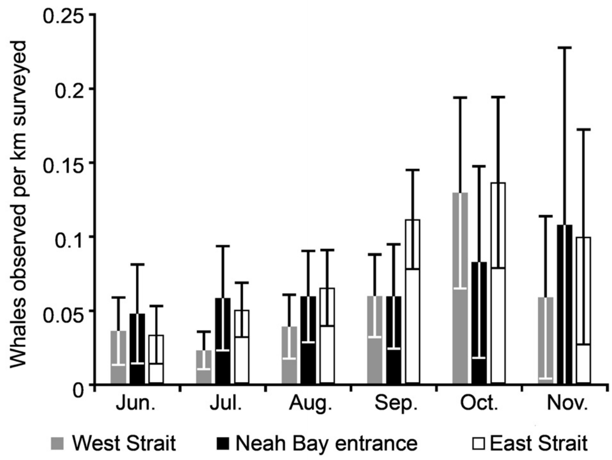

Fig. 3. Average observation rates in the three research segments in the Strait of Juan de Fuca by month for the years 1996 to 2011. Error bars are two times the SE.

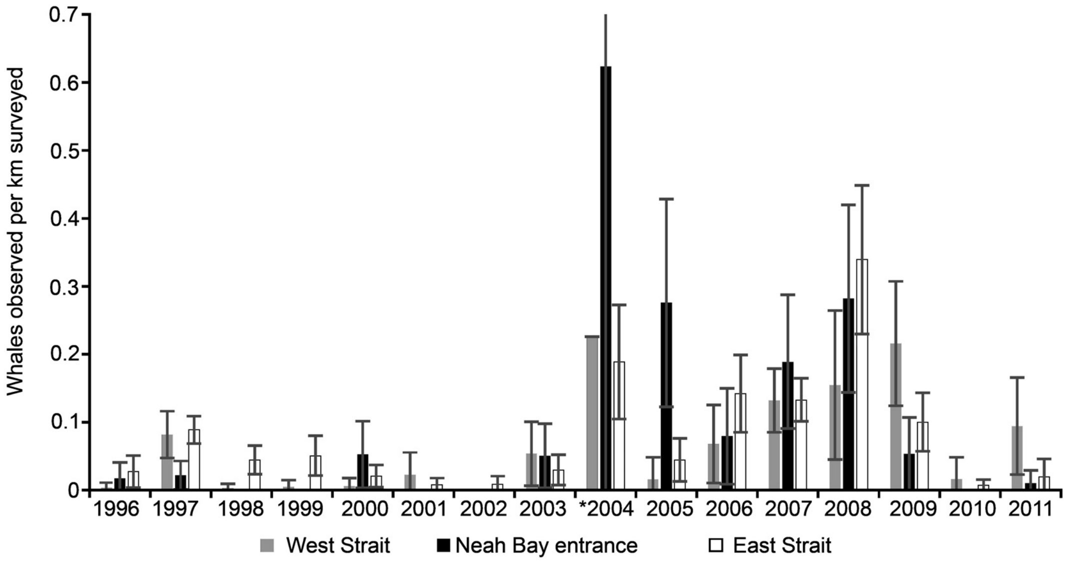

Fig. 4. Average observation rates in the three research segments of the Strait of Juan de Fuca by year with months of the feeding season, June to November, pooled. Error bars are 2 times standard error. * 2004 had much lower effort than other years of the study.

research segments increased through the summer and early autumn until use peaked in October (Fig. 3). The average observation rate varied significantly between months in both the West Strait (ANOVA, df = 368, $p < 0.001$) and the East Strait (ANOVA, df = 246, $p = 0.004$) as the observation rate increased from June to a peak in October. At the entrance to Neah Bay, no significant differences in observation rate by month were detected (ANOVA, df = 515, p = 0.73).

Significant differences in observation rate by year were observed in the Strait of Juan de Fuca in all three research segments (ANOVA: West Strait, df = 325, $p < 0.001$; Neah Bay, df = 514, $p < 0.001$; East Strait, df = 249, $p < 0.001$) (Fig. 4). From 1996 to 2003 (particularly 2000–03) and from 2010 through 2011, there were low observation rates in all three of the research segments (Fig. 4). In contrast, the time period 2004–09 had higher observation rates (Fig. 4).

Gray whale distribution in the Pacific Ocean (hereafter Ocean) also varied by month and year. Within the North Ocean survey area (Cape Flattery to Cape Alava), the observation rate varied significantly by month (ANOVA, df = 266, $p = 0.001$), peaking in August and with lows in June and November (Fig. 5). In the South Ocean research segment (Cape Alava to Sea Lion Rock), there were no significant differences in observation rate by month (ANOVA, df = 148, $p = 0.34$).

Similar to the Strait, significant year to year variability in observation rate was observed in both ocean survey segments (ANOVA: North Ocean, df = 266, $p < 0.001$; South Ocean, df = 148, $p < 0.001$) (Fig. 6). Years of high and low observation rates were not the same years as observed for the Strait (Fig. 4, Fig. 6). Like the Strait survey areas, the Ocean research segments had low observation rates during the early years of the time series from 1996 to 2001. Opposite the Strait, the observation rate increased in 2001 through 2003 and was also high in 2010 and 2011. The years with greatest observation rates were 2005–11. The South Ocean showed more year to year variability than the North Ocean.

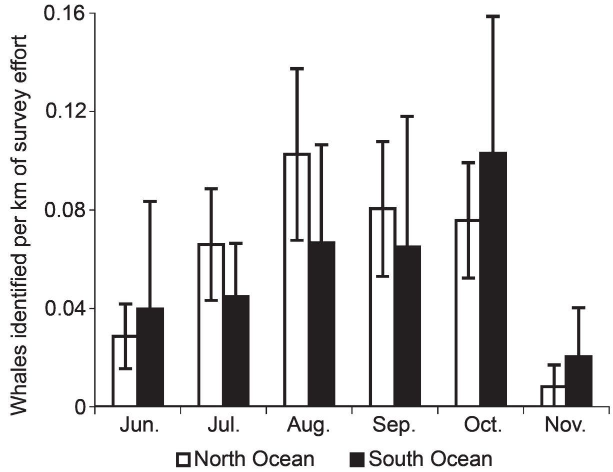

Fig. 5. Average observation rates in the two research segments of the Pacific Ocean by month for the years 1996 to 2011, error bars are two times standard error.

Maps were made using the average number of whales identified per km^2 of research area to examine finer scale trends in gray whale distributions in northwest Washington by month and year. Trends observed in whale densities by month reaffirm our findings that the number of gray whales identified per survey increased to greatest densities and greatest spatial coverage in September and October in the Strait and in August and September in the North Ocean (Fig. 7). Some sites were consistently used both in the Strait and in the Ocean each month; whale densities at these sites increased through the summer and into autumn in the Strait

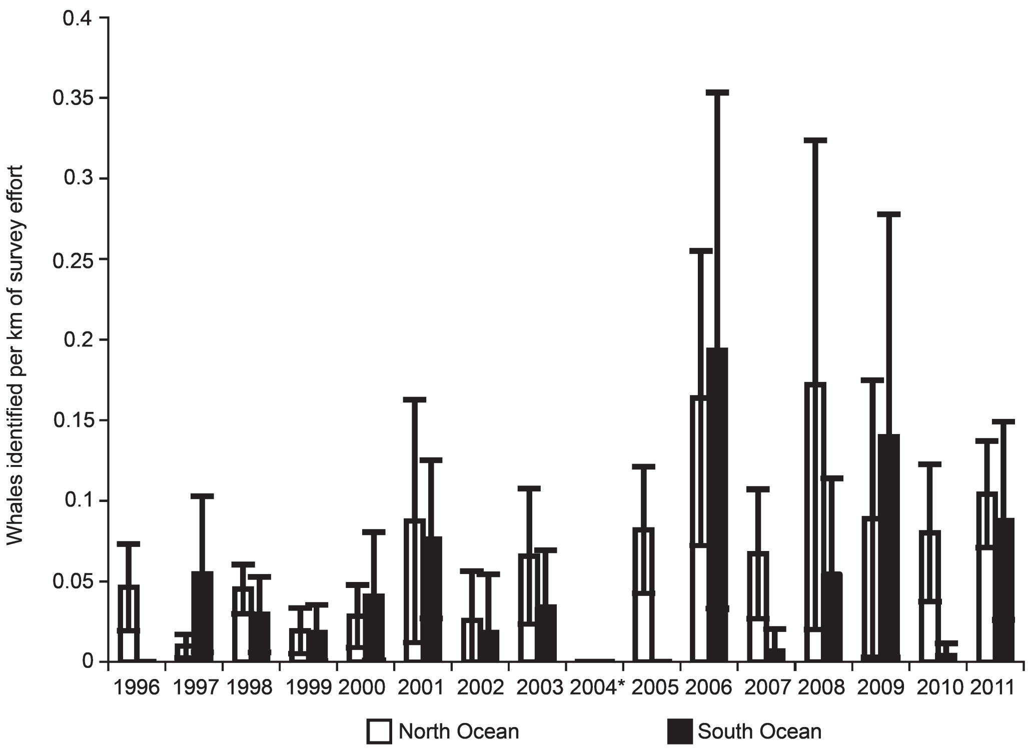

Fig. 6. Average observation rates in the two research segments of the Pacific Ocean by year for the months of the feeding season, June to November. Error bars are two times standard error. *No surveys were conducted in the ocean in 2004.

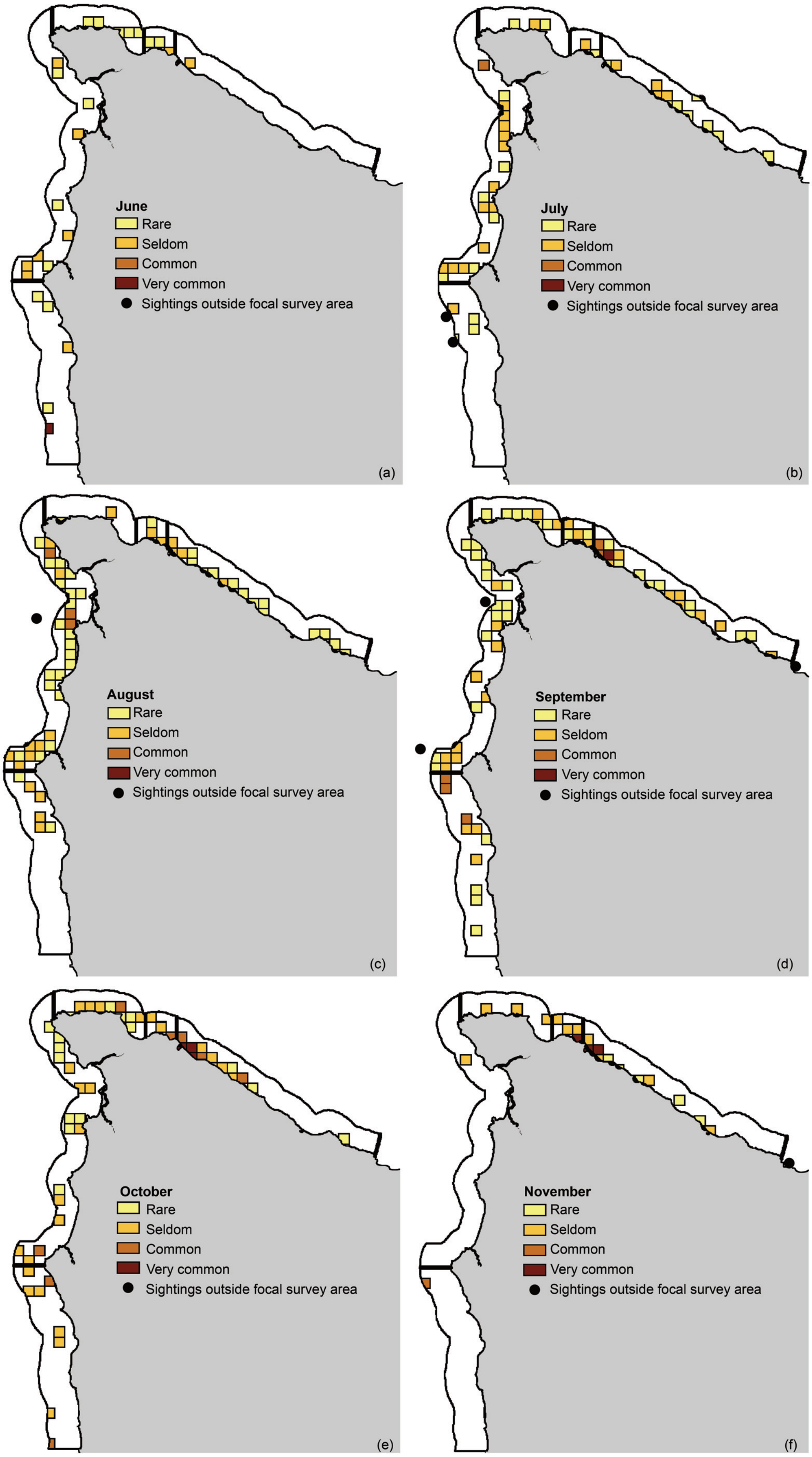

Fig. 7. Sighting density of gray whales identified per km^2 in northwest Washington per day of research effort in 2004 to 2011 by month: (a) June; (b) July; (c) August; (d) September; (e) October; and (f) November. Grid cells with sighting densities of less than 0.1 whales were ranked as 'Rare', cells with sighting density greater than 0.1 and less than 0.3 whales were ranked as 'Seldom', cells with sighting densities greater than 0.3 and less than 0.6 whales were ranked as "Common" and cells with sighting densities greater than 0.6 whales were ranked as 'Very Common'.

and increased until late summer/early autumn in the Ocean (Fig. 7). A review of nautical charts and knowledge of the area show that sites with high use were generally characterised by rocky bottoms and large kelp forests, whereas sites with low use were characterised by sandy bottoms. The maps do show sightings of whales in areas of sandy bottoms, however these sightings were primarily of whales that were presumed to be travelling or resting. The greater distance from shore of gray whale distributions in the ocean as compared to the Strait was likely due to the gradual slope of the bottom in the ocean as compared to the steep drop off in the Strait.

Maps of the yearly distribution of whales display greater variability in gray whale site use, where whales appeared to use some areas frequently for a number of years and then subsequently either abandon those areas or use them intermittently (Fig. 8). This phenomenon can be observed by examining the area just east of the Neah Bay research segment. From 2006 to 2009, high densities of whales were observed in this area and then were not observed using the site at all in 2010 and only rarely in 2011. Other areas appeared to be used intensively for one year and then not used again. This can be seen most easily by looking at the southern border of the South Ocean research segment and noting the changes in gray whale sighting density through the years.

Fidelity to the research area

Fidelity to the research area was examined by comparing the number of individual whales that returned to the northwest Washington research area after the first year observed and estimating how long individual whales used the research area within a given year. Some gray whales were observed to use the waters of northwest Washington consistently after they were first observed. Sixteen percent of whales were observed in six or more years in the study area, although not necessarily in consecutive years. Roughly half (51%) of the whales identified in this study were only observed in the area during one year (Fig. 9). The average whale was observed in 2.48 years (SE = 0.14). Removing the individuals that were only observed in one year, the average whale was seen in 4.01 years (SE = 0.20). Whales first observed in 2010 or earlier were observed in an average of 31.6% (SE = 1.6%) of possible years after they were first observed (number of years observed divided by total number of possible years to be observed for each whale); removing whales only seen in one year increased the average percentage to 38.7% (SE = 1.9%) of possible years. Among the whales that were first identified prior to 2010 and therefore have more than one year in which they could have been resighted, only two whales were seen in all possible years after the first observation; these whales were seen in every year after being first observed in 2004 and 2006, respectively.

The length of time a whale used the study area during the feeding season was estimated by calculating minimum tenure, in this case the minimum number of days an individual whale resided in the research area assumed to be equal to the difference in time between the date of first and last observation. The average minimum tenure calculated for whales observed in the northwest Washington research area

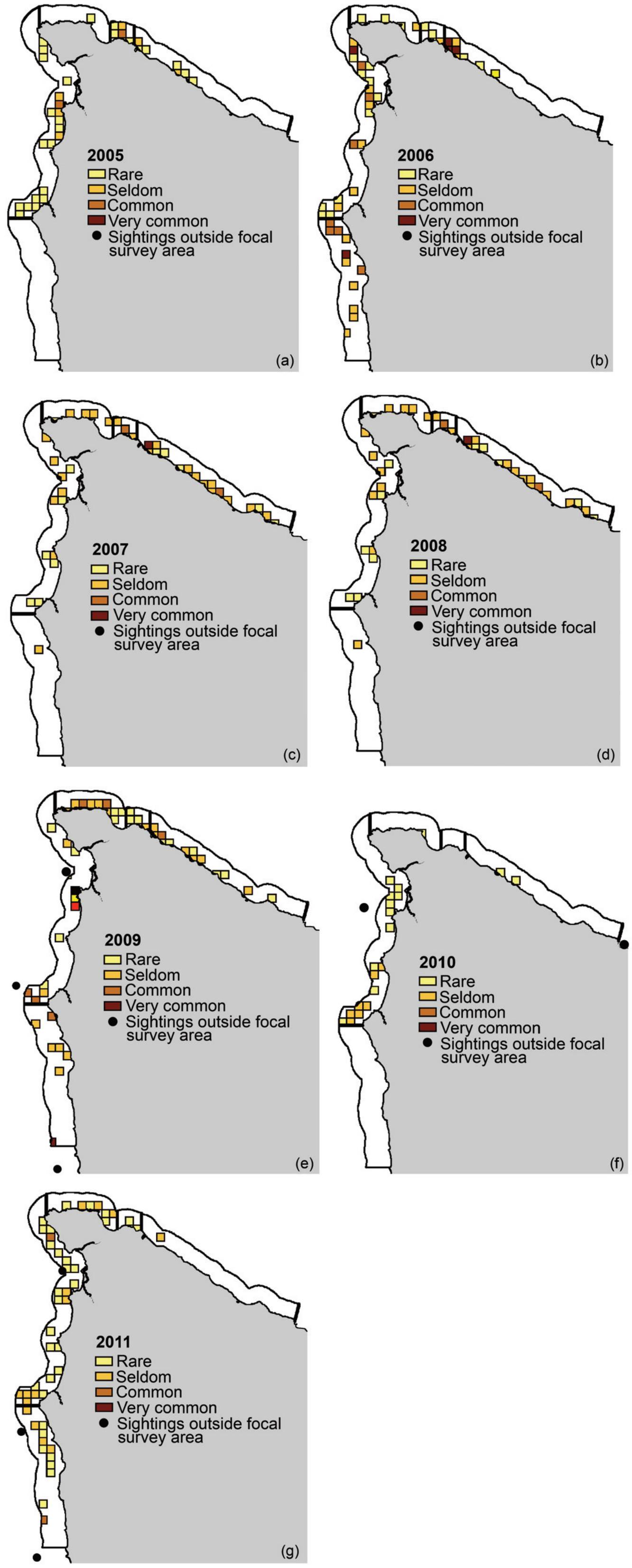

Fig. 8. Sighting density of gray whales identified per km^2 in northwest Washington per day of research effort in the feeding season, June through November by year: (a) 2005; (b) 2006; (c) 2007; (d) 2008; (e) 2009; (f) 2010; and (g) 2011. Grid cells with densities of less than 0.1 whales were ranked as 'Rare', cells with sighting density greater than 0.1 and less than 0.3 whales were ranked as 'Seldom', cells with sighting densities greater than 0.3 and less than 0.6 whales were ranked as 'Common' and cells with sighting densities greater than 0.6 whales were ranked as 'Very Common'. No map was provided for 2004 because data collection lacked spatial and temporal resolution.

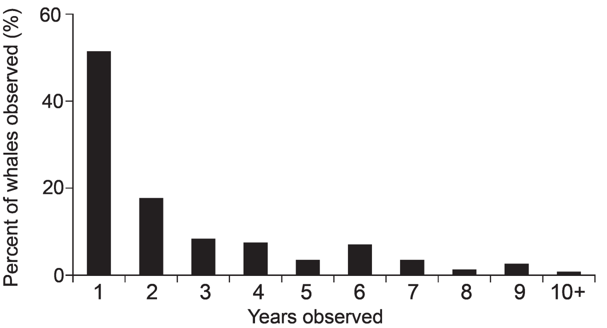

Fig. 9. Count of unique whales observed by the number of years a whale was observed.

was 24.8 days (range 1 to 151 days) out of a possible 183 days in the June to November feeding season. A large degree of variability in minimum tenure by year was observed in the research area (ANOVA, df = 493, $p < 0.01$) (Fig. 10).

No evidence was found that the number of years a whale has been observed in northwest Washington affected average minimum tenure during the study (ANOVA, df = 202, $p = 0.62$) (Fig. 11). However, it was found that average minimum tenure was a good predictor of whether a whale would be seen in the following year. Whales seen in year *Y* and in the following year (*Y*+1) had an average minimum tenure of 28.3 days, which was significantly greater than whales seen in year *Y* but not year *Y*+1 (19 days; Two-sample *t*-test, df = 506, $p = 0.002$).

Occurrence of new whales

From 1996 through to 2011, an average of 10.8 new whales were observed per year (SE = 1.8) in the northwest Washington study area. From 1996 through 2010 (excluding 2011 to allow a year for recruitment), an average of 5.6 new whales per year (SE = 1.1) were observed again in a future year. The number of new whales observed was not consistent between years. High numbers of new whales (> 15) were observed in 1993, 1995, 1998, 2001, 2006 and 2008 (Table 4). It is possible that the high numbers of new whales observed in 1993 and 1995 were not actually new whales to the research area; rather it is likely that some of these whales regularly used the area but had not been seen previously due to low research effort in the early years of the study. In a time series of population estimates, Calambokidis *et al.* (2014) found a large increase in PCFG gray whale abundance in the late 1990s and early 2000s that they postulated was caused, at least in part, by immigration from

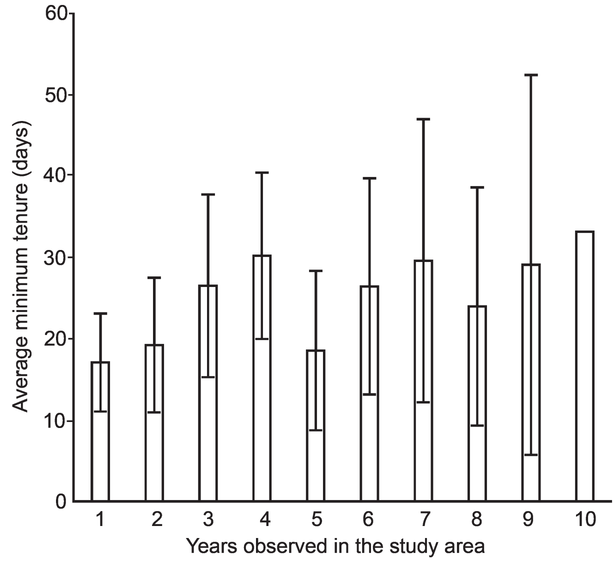

Fig. 11. Average minimum tenure of whales in days compared to the number of years they have been observed in northwest Washington.

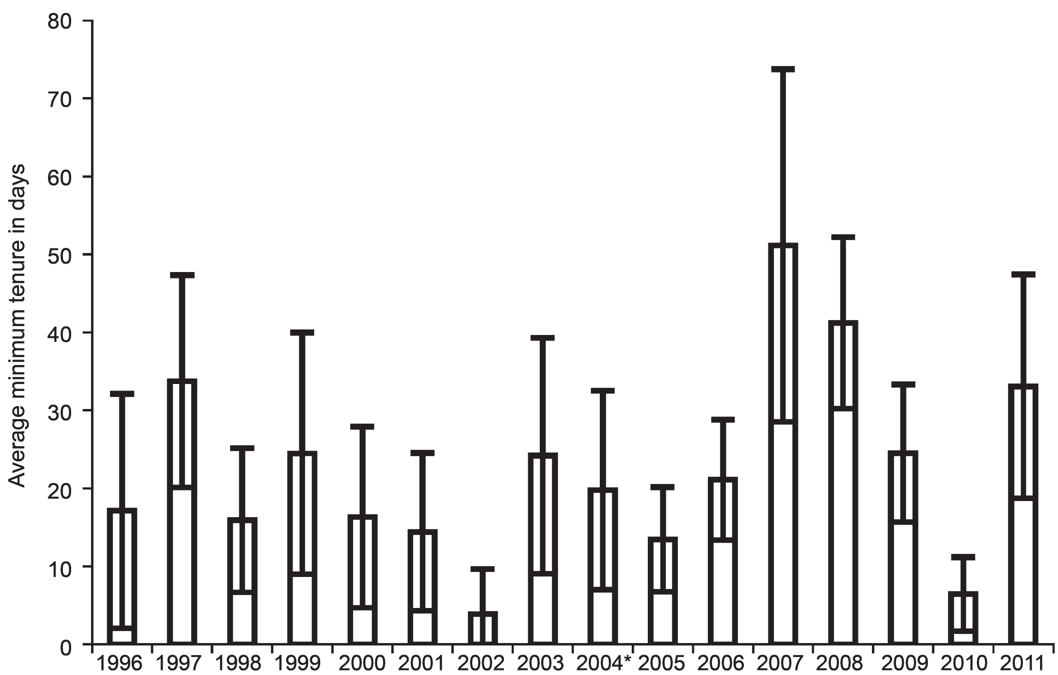

Fig. 10. Average minimum tenure (residency time) computed as the number of days between the first and last sighting of an individual in a given year. *2004 had lower total survey effort and lower temporal coverage of survey effort than other years, and the estimate of minimum tenure is likely underestimated.

Table 4

This table shows the sighting history of whales by the first year they were observed (row). Column totals report the number of uniquely identified whales from each cohort in each feeding season. The first value in each row is the number of new whales observed for that year.

Year	1984	1986	1989	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1984	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986		4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
1989			4	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0
1992				2	0	1	1	2	2	0	1	0	0	0	0	1	1	1	0	0	0	0	1
1993					21	4	4	4	4	10	4	1	3	1	3	1	4	4	2	6	5	1	2
1994						5	2	0	1	1	0	0	1	1	1	0	0	1	1	1	0	1	0
1995							15	5	7	2	1	0	2	0	0	0	3	2	2	3	1	0	0
1996								8	4	3	2	1	1	0	1	1	1	4	0	3	4	1	2
1997									8	1	1	0	1	0	1	1	2	1	1	1	1	0	0
1998										17	1	1	1	0	0	0	0	2	1	2	0	1	0
1999											1	0	0	0	0	0	0	0	0	0	0	0	0
2000												11	6	3	2	0	2	5	1	5	3	4	3
2001													16	2	2	1	0	1	0	1	1	0	0
2002														1	1	1	1	1	0	1	1	1	1
2003															11	3	2	3	0	1	1	2	1
2004																12	7	7	3	7	5	3	5
2005																	10	4	2	3	2	1	1
2006																		20	5	10	7	4	6
2007																			2	1	2	0	1
2008																				29	11	3	3
2009																					11	1	1
2010																						4	1
2011																							11
Total	**2**	**4**	**4**	**2**	**21**	**10**	**22**	**19**	**27**	**35**	**11**	**14**	**32**	**8**	**22**	**21**	**33**	**56**	**20**	**74**	**56**	**27**	**39**

northern feeding grounds during the 1999/2000 mortality event (Gulland *et al.*, 2005). Based on the findings of Calambokidis *et al.* (2014) a large increase in the number of new whales observed and of new whales observed in a future year during the time period of 1998–2002 was to be expected. Instead, the average number of new whales observed from 1998–2002 was lower than the 1996–2010 average, with 9.2 new whales (SE = 4.3) of which 4.3 whales (SE = 1.5) were seen in a future year. The percentage on average of new whales observed from 1998–2002 that were seen in a future year (44.3%, SE = 18.4%) was also lower than the 1996–2010 average.

Calf analysis

There were seven mother-calf pairs observed during surveys (Table 5), showing that some of the new whales observed in this study were internally recruited. One mother, CRC 67, was observed with three calves: a suspected calf (CRC 169) in 1995 and a confirmed calf in both 2004 (CRC 819) and 2011 (CRC 1350). Four other females were each observed with one calf (Table 5).

Some new whales were first observed later in the year (i.e. autumn) than when calves become independent of their mothers (Bradford *et al.*, 2011; Calambokidis *et al.*, 2012). To determine the proportion of new whales which are actually calves digital photographs taken between 2004 and 2011 were analysed. Only new whales for which photographs had already been obtained from the first year they were seen in the entire PCFG (i.e. not just the first year seen in northwest Washington) were analysed. Twenty one photographs of new whales for which the first year they were sighted in northwest Washington was also the first year they were sighted in the PCFG were available. Of those, 18 photographs showed the head and post-cranial region clearly in order to be able assess if they were calves. Of the 18 whales evaluated, 4 (22%) were either confirmed calves (CRC 819 and CRC 1350) or were most likely calves (CRC 1047 and CRC 1054) and the other 14, based primarily on observation of old barnacle scars, were not calves of that year. CRC 1047 and CRC 1054 were both first observed in 2008.

The occurrence of calves in northwest Washington shows that the site is used by cow-calf pairs and recently weaned calves. The number of calves observed during the study were low suggesting that the site is not a very important for cow-calf pairs for the PCFG as a whole although it does appear important for CRC 67.

Table 5

All known mother-calf pairs observed in northwest Washington from 1984–2011 with whales only suspected to be calves noted with an asterisk.

Mother	Calf	Dates observed together
105	104	09/07/94
43	107	09/07/94 to 04/08/94
67	169*	19/07/95 to 23/07/95
596	595	26/06/01
216	860*	26/07/03 to 28/07/03
67	819	27/08/04
67	1350	23/06/11 to 01/09/11

Population closure in the study area

If population closure exists within the study area (no immigration or emigration), one would expect that over the 17 years of research effort that all of the whales in the 'population' would have been photographed and identified and the best fit line would approach a horizontal asymptote. To test if there is closure a discovery curve was plotted with the number of new whales observed for 1984 through 2011 and the number of whales observed in more than one year for 1984 through 2010 (Fig. 12). The function best fitting the discovery curve was linear for all new whales ($y = 9.15x$–

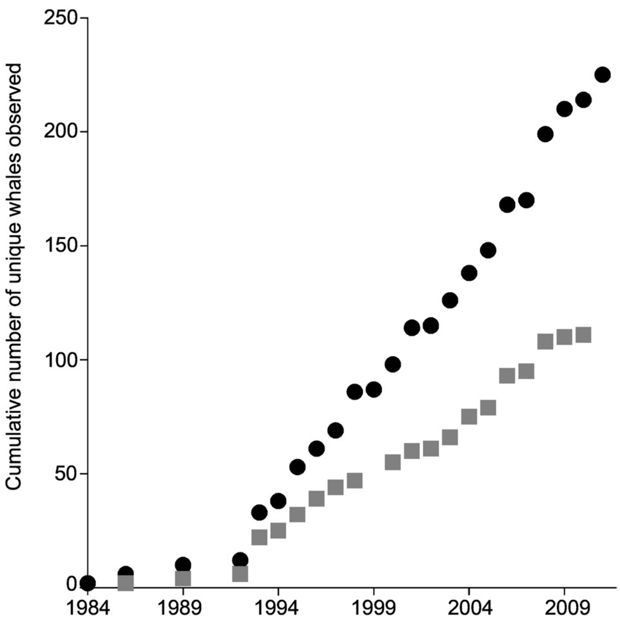

Fig. 12. Plot of the cumulative number of whales observed during the duration of this project for all whales (black dots) and whales observed in greater than one year (grey squares).

18,193, $r^2 = 0.95$) and whales observed in more than one year ($y = 5.07x–10,076$, $r^2 = 0.97$), suggesting that closure is not occurring for the northwest Washington survey area.

DISCUSSION

Temporal and spatial distribution of whales

There was large annual variability in the numbers of whales identified per survey in all research segments and large amounts of inter-year and intra-year variability in where whales were observed. Observation of variability is similar to Darling *et al.* (1998) who concluded that year-to-year variability in timing, prey type and feeding location is the key feature of gray whale observations from the central coast of Vancouver Island. Gray whale researchers of the PCFG have noted that the whales are commonly observed to exhibit benthic feeding behaviours (Avery and Hawkinson, 1992; Darling *et al.*, 1998; Dunham and Duffas, 2001; Kvitek and Oliver, 1986; Oliver *et al.*, 1984). However, in the present study mud plumes were rarely observed, suggesting that benthic feeding is uncommon in the northwest Washington area. Within the dynamic nature of site use it was found that more whales were observed per day of survey effort in the autumn in both the Strait of Juan de Fuca and the South Ocean research segment, whereas in the North Ocean research segment peak use was late summer. Also, the vast majority of gray whales were observed in waters between 5 and 15m of depth. This depth range coincides with the primary depth range of the mysid shrimp (small epibenthic and planktonic crustaceans of the family *mysidae*, suborder *pericarida*) (Nelson *et al.*, 2009). The primary mysid species consumed by gray whales off Vancouver Island were *Holmesimysis sculpta, Acanthomysis pseudomaropsis* and *A. anassa californiensis* (Murrison *et al.*, 1984; Darling *et al.*, 1998; Dunham and Duffus, 2002; Feyrer and Duffas, 2011) and they are also likely to be the primary prey species in northwest Washington. Feyrer and Duffus (2011) found that average mysid density was significantly correlated with the average number of whales in the survey area near Vancouver Island. We hypothesise that shifting mysid density and fluctuations in abundance caused the observed variability in gray whale counts in northwest Washington since most of the gray whale sightings occurred in optimal mysid habitat. Systematically monitoring prey at sites commonly used in northwest Washington would allow testing of this hypotheses on prey preference and specifically the influence of mysid abundance on whale distributions.

A consistent pattern observed through the years was lower observation rates in June compared to later in summer and autumn. This fits with the movements of migrating gray whales which generally reach Arctic feeding grounds from May to June (Swartz *et al.*, 2006). To date, there have been three publications on the movements of six satellite tagged PCFG whales, each of which had active tags between April and June; of these six whales, four were observed to migrate steadily north into southeast Alaska before their transmitters stopped transmitting (Calambokidis *et al.*, 2014; Ford *et al.*, 2013; Mate *et al.*, 2010). Given that 66% (4 out of 6) of the PCFG whales with documented spring movement patterns travelled north of the PCFG area, it is quite possible that other whales that feed in the PCFG also feed further north in the spring and early summer before returning south to the PCFG area later in the summer and autumn. It should be noted that the migratory behaviour of four of the six individuals may not be representative of all PCFG whales, as the three tags applied by Ford *et al.* (2013) targeted whales presumed to be migrating past Vancouver Island and one tag applied to a PCFG whale by Calambokidis *et al.* (2014) targeted a feeding whale.

Occurrence of new whales in northwest Washington

From 1996 to 2011, an average of 10.8 new whales were observed each year, of which 5.6 were observed in a future year. Many of the whales that were new to the northwest Washington study area had been seen previously in another research area of the PCFG. For whales that were photographed in northwest Washington during the first year they were seen in the PCFG, analysis of photographs using techniques described by Bradford *et al.* (2011) found that 22% of the whales were calves. Thus 78% of the new whales observed in our research area and to the PCFG were either born in a previous year in the PCFG and were not observed, or were non-calves who emigrated from another feeding area into the PCFG.

An analysis of the time series of population estimates of PCFG whales shows a large increase in the number of whales in the PCFG from 1998 through 2002 concurrent with the timing of the 1999 gray whale mortality event (Calambokidis *et al.*, 2014). Somewhat surprisingly, a smaller average of new whales (9.2) was observed from 1998 to 2002. The lower number of new whales observed in that time period could have been a result of poorer feeding conditions in Washington compared to later years in the data series. Of the new whales observed during those five years, a smaller portion was observed again in a subsequent year (44.3%) than the average for the whole data series. Based on the calculated population increase of the overall PCFG, we would have expected the average proportion of new whales and new whales seen in more than one year to be much greater from 1998 to 2002 than was observed in this study.

CONCLUSION

Northwest Washington is a small but important region within the summer and autumn feeding range of PCFG gray whales. Individual gray whale use of this region is variable, with some individuals observed regularly whereas most do not show strong site fidelity to this region. This study allowed examination of trends in site use over multiple decades within northwest Washington and it was found that rocky habitat in the 5–15m depth range is very important to gray whales and that gray whale use of these habitats is dynamic by year. The impacts of the Makah gray whale hunt are a debated issue, thus it is hoped that the baseline of gray whale behaviour provided here can be used to help evaluate if there are discernible effects on PCFG whale behaviour in the proposed hunt area when hunting resumes.

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Marine Mammal Commission

An independent agency of the U.S. Government

Review of the National Marine Fisheries Service's Marine Mammal Stock Assessment Reports

Range, Abundance, and Potential Biological Removal

June 2016

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PURPOSE

This report reviews the efforts by the National Marine Fisheries Service (NMFS) to assess marine mammal stocks as required by Section 117 of the Marine Mammal Protection Act of 1972 (MMPA, the Act, 16 U.S.C. et seq.).[1] Congress passed the MMPA in 1972 to conserve marine mammals and ecosystems. In the Act (16 U.S.C. 1361), Congress found that—

Humpback whale with calf in NOAA's Hawaiian Islands Humpback Whale National Marine Sanctuary. (NOAA)

> (1) certain species and population stocks of marine mammals are, or may be, in danger of extinction or depletion as a result of man' s activities; [and]
>
> (2) marine mammal species and population stocks should not be permitted to diminish beyond the point at which they cease to be a significant functioning element in the ecosystem of which they are a part, and, consistent with this major objective, they should not be permitted to diminish below their optimum sustainable population[2]...;

Importantly, Congress also found that—

> (3) there is inadequate knowledge of the ecology and population dynamics of such marine mammals and of the factors which bear upon their ability to reproduce themselves successfully….

To address these findings, Congress directed that a science-based approach be developed to manage marine mammals and the human-related risks that threaten their persistence. To assess marine mammal stocks, Section 117 of the Act (16 U.S.C. 1386, as amended in 1994) specifies that each stock in U.S. waters be assessed with regard to the following information—

(1) geographic range;

(2) minimum population estimate, current and maximum net productivity rates, and current population trend;

(3) human-caused mortality and serious injury rate;

(4) interactions with commercial fisheries;

(5) current status; and

(6) potential biological removal level (PBR).

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[1] The Service is responsible for assessing the status of all marine mammal stocks that occur in U.S. waters except the manatee, polar bear, sea otter, and walrus, which are studied and managed by the Fish and Wildlife Service (16 U.S.C. 1375a).

[2] With respect to any particular stock, the MMPA defines the "optimum sustainable population" to mean "the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element" (16 U.S.C. 1362(9)).

APPROACH

The Commission reviewed stock assessment reports available as of 2014[3] (the most recent reports available at the time of this review) to evaluate performance of NMFS in gathering, assessing, and reporting on some of the information required by section 117. The review starts by underscoring the importance of stock identification, a necessary precursor of stock assessment. The review then highlights NMFS's progress in obtaining information on three of the six requirements of Section 117 (requirements 1, 2, and 6). Those three requirements provide the foundational information necessary to manage any stock: where and when it occurs (requirement 1), the number of animals in the stock (requirement 2), and whether there is enough information to derive a management metric. In the case of marine mammals the management metric is potential biological removal (PBR) (6th requirement). Without this basic information the status of a stock cannot be confidently ascribed (requirement 5 of Section 117). Nor can the stocks be managed effectively even if commercial fisheries interactions (requirement 4) and other human caused mortality and serious injury (requirement 3) are well known and reported in the stock assessments. The review includes several recommendations intended to support NMFS in its efforts to improve stock assessments.

STOCK STRUCTURE

Congress identified the stock (or population stock) as the primary management unit for marine mammals (16 U.S.C. 1362.11). It defined a stock to mean "a group of marine mammals of the same species or smaller taxa in a common spatial arrangement, that interbreed when mature."

North Atlantic right whale off the coast of Florida. Photo taken under NOAA research permit #775-1875. (Florida Fish and Wildlife Conservation Commission)

An accurate understanding of stock structure is therefore the cornerstone for stock assessment, management, and conservation even though not explicitly listed among the Act's six specified information needs. Historically, marine mammal scientists identified stocks using morphologic, demographic, behavioral, and geographic range/distribution patterns (e.g., Dizon et al. 1992). However, detecting such patterns depends largely on field observations, which often are not sufficient to reveal the reproductive barriers indicative of stock structure. Stocks can be difficult to identify for a variety of reasons, such as remote distributions, cryptic behavior, and physical similarity to, and geographic overlap with, other stocks. More recently, scientists have relied heavily on genetic methods to identify and distinguish marine mammal stocks, as those methods provide important insights not always discernible through direct observations. NMFS scientists have excelled in the use of genetic tools, but inadequate resources often have undermined their efforts in this regard. Efforts to

3 The 2013 reports are available at http://www.nmfs. noaa.gov/pr/sars/region.htm.

identify marine mammal stocks would therefore be enhanced by funding for genetic studies (including both sampling and analyses). Beyond genetics NMFS scientists recently reviewed each of the various lines of evidence to judge their respective strengths in distinguishing stocks, and provided initial guidelines for the use of such evidence (Martien et al. 2015). The Commission acknowledges and applauds those efforts and supports NMFS's continued pursuit of improving stock structure determinations, using multiple lines of evidence.

GEOGRAPHIC RANGE

Adult male northern elephant seal. Picture taken under NMFS permit #87-1743. (Sam Simmons, Marine Mammal Commission)

The first requirement of a stock assessment according to section 117 of the MMPA is to describe "the geographic range of the affected stock, including any seasonal or temporal variation in such range."

IMPORTANCE

Understanding a marine mammal stock's geographic range is essential to conservation and management effort because that range provides information relevant to the—

- stock's potential habitat requirements; that is, the physical, chemical, biological, and ecological conditions necessary for the stock's persistence;
- human activities that may affect the stock; and
- areas where stock assessment, research, and conservation may be most useful.

CHALLENGES TO DESCRIBING THE RANGE OF STOCKS

The distribution and range of most marine mammals varies in accordance with multiple factors, such as—

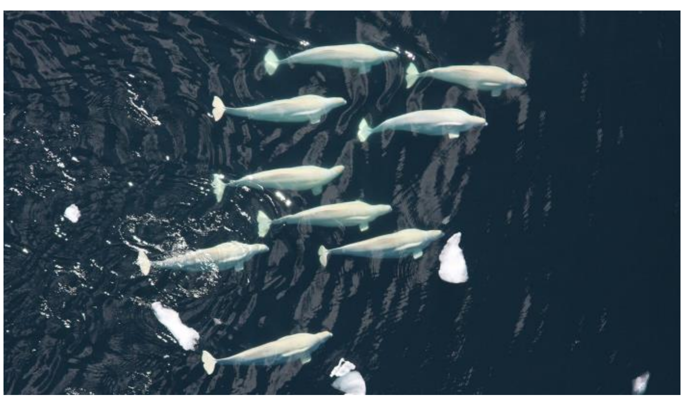
- season: annual migrations are examples of seasonal variation in habitat use. Winter ranges, in particular, often are poorly described or largely unknown (e.g., eastern population of North Pacific right whales, southern resident killer whales, North Atlantic right whales);
- year: marine mammal stocks may vary their distributions and use of habitat annually depending on oceanographic conditions, or the timing and extent of sea ice formation and breakup (e.g., bowhead whales, gray whales);
- age: mature individuals of some species may have larger ranges or occupy different latitudes than immature animals (e.g., northern fur seals, Steller sea lions), but juveniles often disperse widely and vary their habitat-use patterns;

- sex: females and males may have overlapping ranges during the breeding season, but have more-or-less distinct ranges during the remainder of the year (e.g., sperm whales);
- reproductive status: certain portions of a stock (e.g., individuals that are either sexually immature or senescent) may use habitat different from that used by reproductively active individuals (e.g., North Atlantic right whales);
- prey availability and predator avoidance: during and outside the reproductive season, variability in prey availability and predator distribution are likely major determinants of marine mammal habitat-use patterns; and
- human-caused disturbance: may cause marine mammals to abandon or alter optimal use of key habitat depending on sources of anthropogenic disturbance.

For all these reasons, describing a stock's range and associated use of habitat is not a simple, singular challenge, but rather one that requires frequent and ongoing assessment under variable conditions. The need for frequent and ongoing assessment of range is even greater in light of potential alterations to ranges driven by climate change, which may render long-standing stock boundaries of many stocks obsolete. Determining a stock's range can be especially challenging when two or more stocks of similar-appearing individuals have overlapping ranges. For example, the ranges of the genetically distinct coastal and offshore bottlenose dolphins along the U.S. Atlantic coast overlap and because the stock affiliations of individuals cannot be visually distinguished in the field it is difficult to determine their seaward or coastal stock boundaries, respectively.

Additionally, international cooperation is needed to determine stock ranges and habitat-use patterns for stocks that occur in both national and international waters.

POPULATION PARAMETERS



Beluga whale pod in the Chukchi sea. Photo taken under Marine Mammal Permit: 782-1719. (Laura Morse, NOAA)

Section 117's second requirement is to provide "… [a] minimum population estimate, the current and maximum net productivity rate, and current population trend, including … the information upon which these are based" for each stock.

MINIMUM POPULATION ESTIMATE

Abundance information is critical for determining a stock's status, trend, and vulnerability to human activities. Stocks with low abundance generally are more easily depleted and subject to a higher risk of extinction. Examples include the AT1 killer whale stock (7 individuals), eastern North Pacific right whale stock (~30), Gulf of Mexico Bryde's whale stock (~33), southern resident killer whale stock (~80), Hawaiian insular false killer whale stock (~130), Cook Inlet beluga whale stock (~350), and North Atlantic right whale stock (~450). However, low abundance is not the only factor that could raise concern. A strong negative trend in population size can also raise concerns. Stocks that once numbered in the hundreds of thousands (e.g., western Steller sea lion stock) or even millions (e.g., Arctic ringed seal stock) have declined or are expected to decline rapidly in the foreseeable future, increasing their risk of extinction.

Scientists are rarely able to determine the exact abundance of a marine mammal stock and must characterize the reliability of their estimates using associated measures of confidence. Reliability is measured by precision (random measurement or estimation error) and bias (a systematic tendency to over- or underestimate).

False killer whales, October 15, 2010. (Robin Baird, Cascadia Research)

The MMPA recognizes uncertainty in abundance estimates and addresses it in a precautionary manner by requiring use of a "minimum population estimate" to calculate a stock's PBR level. The MMPA defines minimum population estimate (N_{min}, 16 U.S.C. 1362.27) as an estimate of the number of animals in a stock that "(A) is based on the best available scientific information on abundance, incorporating the precision and variability associated with such information; and, (B) provides reasonable assurance that the stock size is equal to or greater than the estimate."

To review NMFS's assessment of stock abundances, the Commission tallied the stocks for which NMFS provided a minimum population estimate (N_{min}) and a best available estimate (N_{best}) with a coefficient of variation (CV; a measure of precision) less than or equal to 0.3 in the 2013 reports. A CV of 0.3 indicates about 95% confidence that the true abundance lies between 40 and 160 percent of the best estimate for an unbiased and normally distributed estimate. For example, if scientists estimated a stock's abundance as 10,000, a CV of 0.3 would indicate they could be 95% confident that the true abundance is between 4,000 and 16,000. A CV of 0.3 is considered a reasonable degree of precision for management purposes by NMFS.

Thoroughness. The 2013 stock assessments indicate that NMFS had N_{min} estimates for 138 of the 248 (56%) stocks assessed. NMFS provided an N_{min} estimate for 30 of the stocks along the Atlantic Coast (58%), 20 stocks in the Gulf of Mexico (35%), 44 stocks each along the Pacific Coast (i.e., Washington, Oregon, and California) and in the Pacific Islands (73%), 24 stocks in Alaska (53%), and none in the Caribbean (0%) (Figure 1). The 73% figure for the Pacific Islands (including Hawaii and the Pacific Territories) is misleading because it is estimated that over 100 stocks exist in the central and western Pacific but have yet to be assessed and a stock assessment drafted.

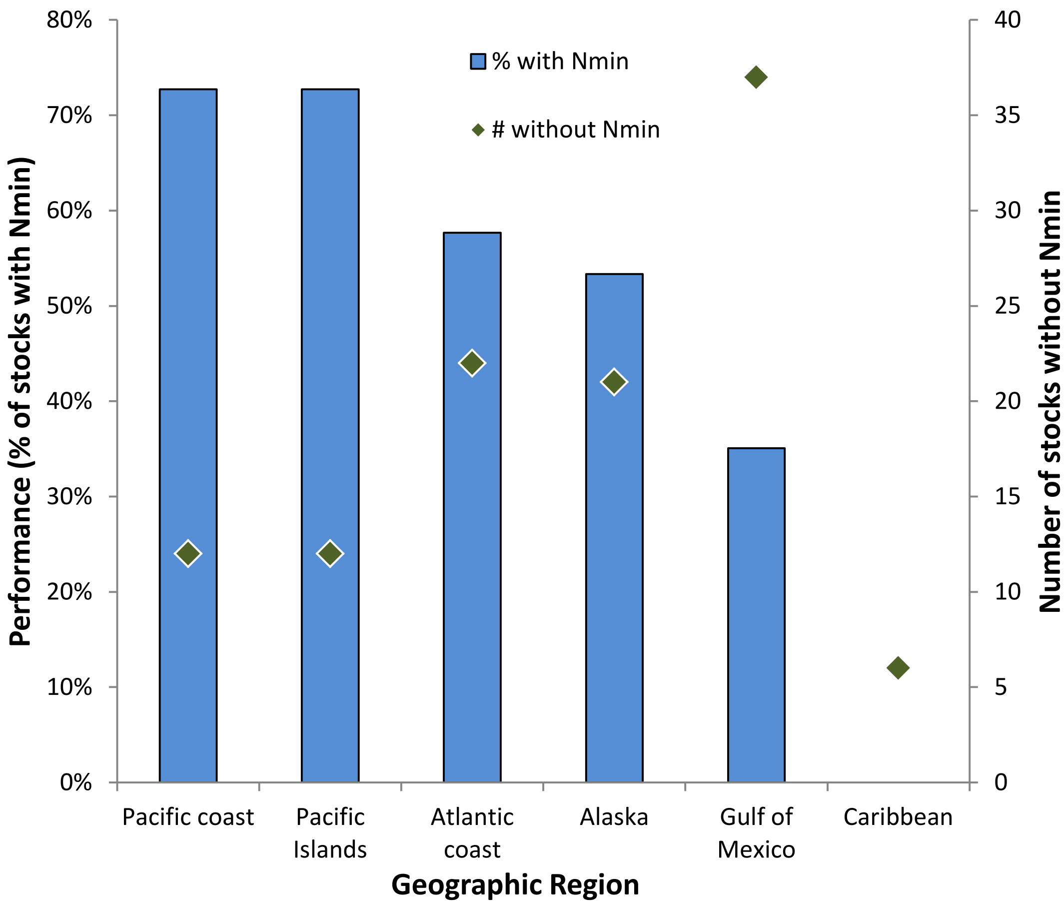


Figure 1: Performance of NMFS in the 2013 assessment reports by geographic region, with regard to % of stocks for which an Nmin was provided. The number of stocks without an Nmin is also presented (right axis) to illustrate what is required to reach 100% in each region. For example along the Pacific coast an Nmin for an additional 12 stocks would result in a 100% performance.

Precision. The 2013 stock assessments indicate that NMFS had N_{best} estimates with an associated CV less than or equal to 0.3 for 50 of the 248 stocks reported (20%). This includes 9 stocks along the Atlantic Coast (17%), 6 in the Gulf of Mexico (11%), 9 along the Pacific coast (20%), 10 in the Pacific Islands (23%), 16 in Alaska (36%), and none in the Caribbean (0%) (Figure 2).

Bias. The 2013 stock assessments reveal several sources of systematic error in N_{best} estimates.

- No estimates: NMFS scientists were not able to estimate abundances for a substantial number of stocks. Some stocks have long been neglected (e.g., Caribbean), others have only recently been recognized (e.g., spinner dolphin stocks in the Northwestern Hawaiian Islands), and still others have yet to be identified (e.g., in the central and western Pacific Ocean and Caribbean).

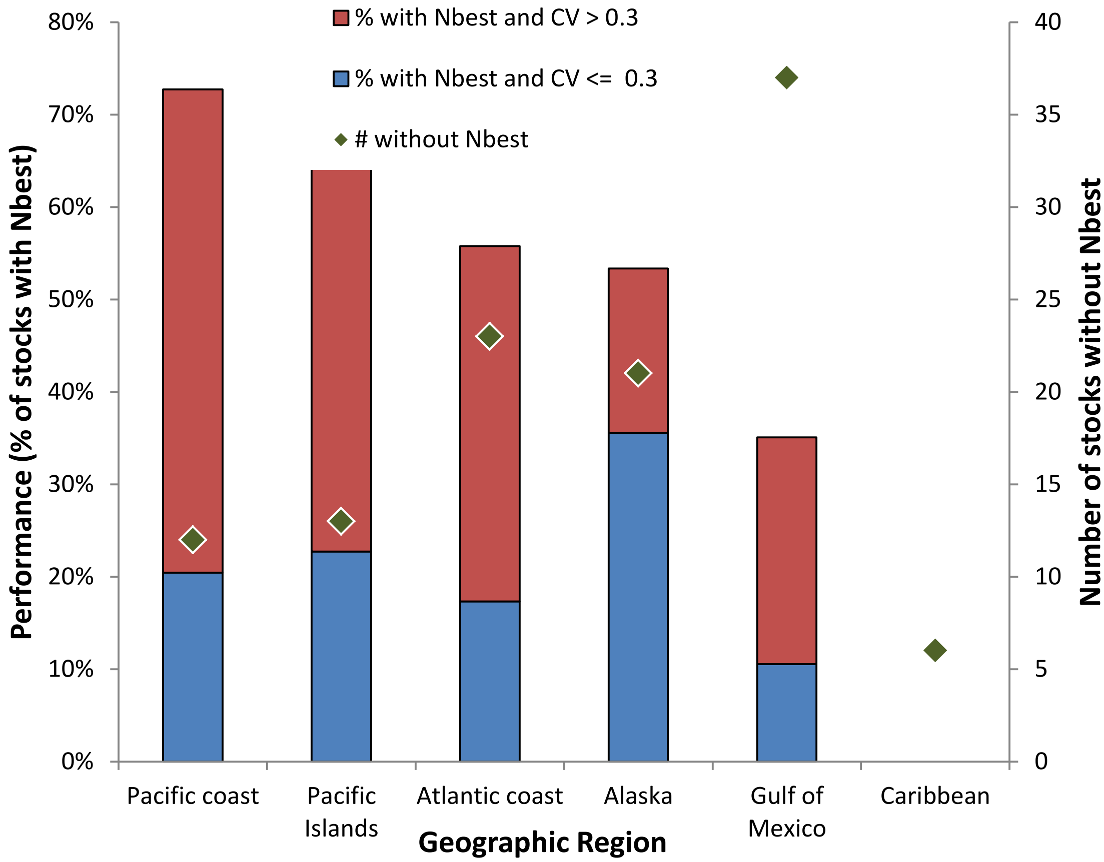


Figure 2: Performance in the 2013 assessment reports by geographic region, with regard to % of stocks for which an Nbest was provided, either with a CV(N) <= 0.3 (and therefore of reasonable precision for management purposes) or with a CV(N) > 0.3. The number of stocks without an estimate of Nbest is also presented (right axis) to illustrate what is required to reach 100% in each region, e.g., along the Atlantic coast an Nbest for another 23 stocks would result in a 100% performance.

- Stock pooling: NMFS scientists occasionally have provided a single, pooled estimate for groups of stocks of similar appearance, behavior, or natural history (e.g. beaked whales in the Atlantic, Gulf of Mexico, and Pacific regions and pygmy and dwarf sperm whales in the Atlantic and Gulf of Mexico). Pooling does not mean those stocks are of equal abundance. Indeed, this is almost certainly not the case and therefore adds a degree of bias.
- Temporal bias: Stock abundance estimates are available for many stocks but are considered by NMFS to be outdated if they are based on data that are more than eight years old—a cutoff supported by the Commission. Older data are useful for determining trends, but they are not considered reliable indicators of current abundance. The fact that abundance estimates are outdated for a number of stocks generally reflects insufficient research resources, including funding and infrastructure (e.g., vessels, aircraft), which prevents repeating surveys before eight years have elapsed. The lack of up-to-date data

for several Gulf of Mexico stocks was a major obstacle to assessing the impact to marine mammals of the 2010 Deepwater Horizon oil spill.

- Spatial bias: Abundance estimates for many stocks are based on surveys that cover only portions of their respective ranges, a form of spatial bias. If the unsurveyed areas are not representative of the surveyed areas, then abundance estimates will be systematically too high or low. Typical examples include Arctic stocks (e.g., bearded, ringed, ribbon seals), stocks that may occur in waters relatively close to shore but also occur in oceanic (pelagic or offshore) habitat, making comprehensive surveys particularly challenging (e.g., pantropical spotted, striped, rough-toothed, Clymene, Fraser's, Pacific white-sided, and Risso's dolphin), and transboundary stocks.
- Availability and perception biases: Abundance estimates also may be distorted if they are not corrected for availability or perception biases. Availability biases (not available to be seen) are more common for stocks or species with poorly understood natural history traits (e.g., diving or haulout patterns), whereas perception biases (difficult to see when available) are most severe for stocks or species that are difficult to detect at the surface (e.g., beaked whales, pygmy and dwarf sperm whales because of a low surface profile).

Current and maximum net productivity rate

A stock's current net productivity rate is a measure of its observed rate of increase under current conditions. Its maximum net productivity rate is a measure of its maximum potential for growth, which—in accordance with density-dependence theory—is expected to occur when a stock is at relatively low abundance. Both rates are determined by the stock's rates of reproduction and survival.

The MMPA allows NMFS scientists to use either a theoretical or an empirically estimated maximum net productivity rate for purposes of estimating a stock's tolerance for human impacts. In the 2013 assessments, empirically estimated rates were used for only 5% of stocks and theoretical (default) rates for 95%. That is to be expected for the most part because scientists rarely have an opportunity to observe a stock growing from a low abundance without impediment.

Current population trend

Marine mammals are large-bodied with low rates of reproduction and growth, many invest in extended parental care of their young, and have the capacity to live long lives. Those qualities help them cope with environmental variation but also mean that their populations are slow-growing and—depending on risk factors—can decline much faster than they can recover.

Whereas measures of a stock's abundance provide a snapshot of its status at a point in time, a stock's trend indicates changes in status over time. Whether growing, stable, or declining, a stock's trend reflects its inherent capacity for growth as affected by any relevant risk factors. Even when risk factors cannot be identified and evaluated with confidence, a declining trend in abundance may be the first indication that a stock is being exposed to one or more risk factors. Similarly, information on trends can be helpful for determining whether management efforts are achieving their conservation objectives. Some recovery plans (e.g., Steller sea lions) use positive growth over a set period, rather than achieving a target stock abundance, as a measure of recovery.

For any given stock, the value of trend analysis depends on the length of the time series involved and the quality of the data. To evaluate NMFS efforts to assess stock trends, the Commission counted the number of 2013 stock assessment reports that provided quantitative or qualitative trend analyses. The number of quantitative trends that spanned at least 15 years and included at least some data that were not more than 8 years old was also tallied.

Of the 248 stock assessment reports, 76 (31%) contained some trend information, including 33 (13%) with a quantitative trend analysis and 43 (17%) with a qualitative description. Of the 33 quantitative analyses, 27 (11% of the total) spanned at least 15 years and included at least some data that were not more than eight years old. Results are summarized in Table 1.

Table 1. Number of stocks with quantitative trend analysis, qualitative trend analysis, or no trend analysis. Numbers in parentheses indicate the number of stocks with at least 15 years of trend data, at least some of which were less than or equal to 8 years old in 2013.

Region	Stocks	Quantitative analysis (high quality)	Qualitative analysis	No trend data
Atlantic coast	52	1 (1)	6	45
Gulf of Mexico	57	0 (0)	2	55
Pacific coast	44	16 (10)	20	8
Pacific Islands	44	2 (2)	0	42
Alaska	45	14 (14)	15	16
Caribbean	6	0 (0)	0	6
Total	**248**	**33 (27)**	**43**	**172**

Taylor et al. (2007) illustrated how inadequate trend information undermines NMFS's ability to detect stocks in trouble. Among other things, those authors—

- defined a decrease in abundance of 50% or more in 15 years as a precipitous decline;
- noted that a stock experiencing such a decline could be designated as depleted under the MMPA;
- assessed three categories of cetaceans, two categories of pinnipeds, and a category consisting of polar bears and sea otter stocks; and
- found that given information available, declines would be detected statistically for 28% of large whales, only 10% of beaked whales, 22% of dolphins/porpoises, 0% of pinnipeds breeding on ice, 95% of pinnipeds breeding on land, and 45% of polar bear/sea otter stocks.

The stock assessment reports and the results of Taylor et al. (2007) indicate that, given the best scientific information currently available, the majority of marine mammal stocks could decline significantly without detection. Clearly, the ability of scientists to assess trends is influenced by marine mammal natural history (e.g., land-breeding versus ice-breeding pinnipeds; long, deep-divers such as beaked whales versus rapidly surfacing and relatively shallow divers such as harbor porpoises), but it also is determined by the availability (or current lack thereof) of the research infrastructure (e.g., vessels, aircraft) and the resources required for field surveys/studies.

POTENTIAL BIOLOGICAL REMOVAL LEVEL

The sixth requirement of Section 117 is to estimate each stock's tolerance for human-caused mortality and serious injury, using the potential biological removal level (or PBR) metric.

IMPORTANCE

Harbor seal ready to be released. (Dave Withrow, Alaska Fisheries Science Center, NOAA Fisheries)

The MMPA established the objective of maintaining each marine mammal stock within, or returning it to, its optimum sustainable population range (OSP).[4] With that objective in mind, Congress directed NMFS to develop a stock-specific reference value for judging when direct human-caused mortality or serious injury poses an unacceptable risk of stock depletion. That threshold is called the stock's potential biological removal (PBR) level, defined as "the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population" (16 U.S.C. §1362.20). PBR is calculated as the product of—

(a) the minimum population estimate of the stock (N_{min});

(b) one-half the maximum theoretical or estimated net productivity rate of the stock at a small population size (R_{max}); and

(c) a recovery factor of between 0.1 and 1.0 (F_r).

Hence, PBR = N_{min} x 0.5 R_{max} x F_r.

APPLYING THE PBR CONCEPT

The PBR formulation accounts for uncertainty in a stock's abundance by using N_{min} (rather than N_{best}). It accounts for variability in the stock's tolerance of human impacts by allowing the Service to vary the recovery factor based on a stock's status (i.e., threatened, endangered, depleted), trend (i.e., increasing, stable, decreasing), and abundance relative to its optimum

[4] NMFS's implementing regulations define OSP to be the range between a stock's maximum net productivity level and its environmental carrying capacity (50 C.F.R. § 216.3).

sustainable population level (NMFS 2005). The maximum net productivity rate can be based on an empirical estimate or a theoretical value.[5]

Although the PBR concept may appear straightforward, applying it has been compromised by insufficient abundance data to calculate reliable, up-to-date PBR estimates. Of the 248 stocks evaluated, 134 (54%) had PBR estimates, 51 (21%) had outdated PBR estimates, 59 (24%) had no estimates, and the reports for 4 stocks (2%) were described as having population dynamics inconsistent with application of the PBR concept (Figures 3a and b).

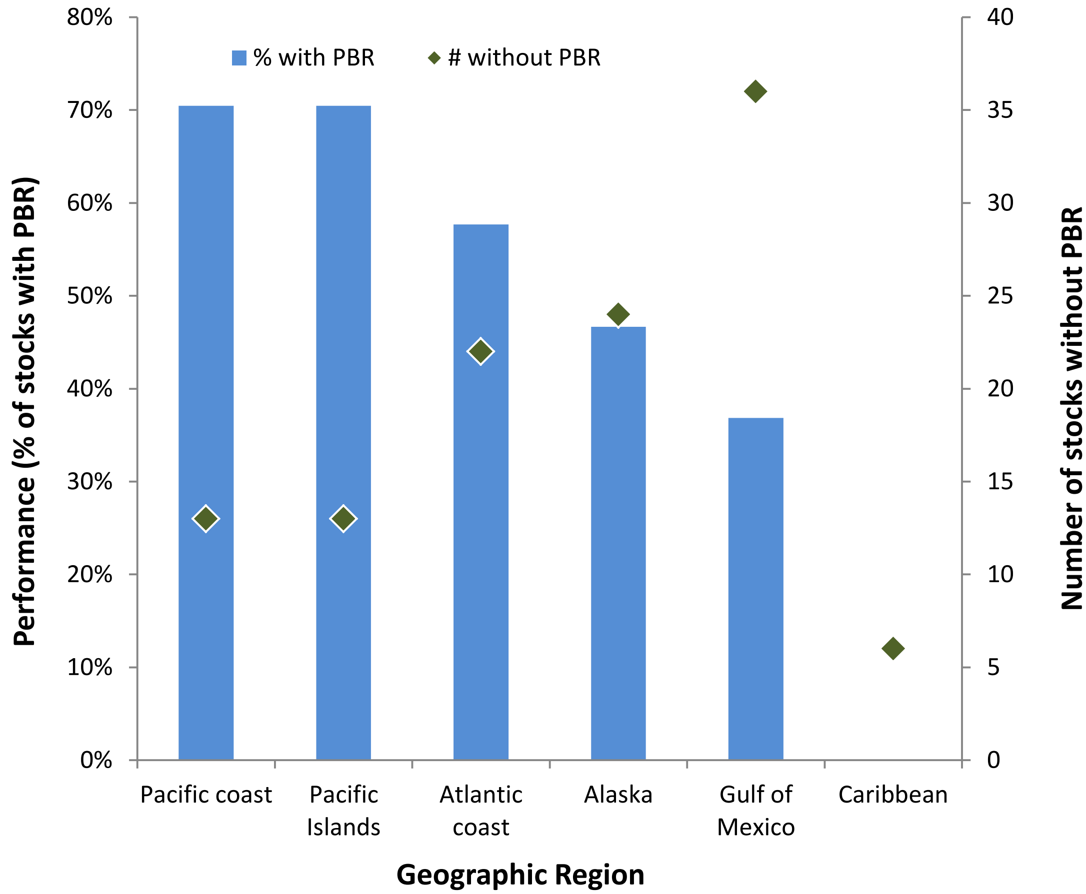


Figure 3a: Performance of NMFS in the 2013 assessment reports by geographic region, with regard to % of stocks for which a PBR estimate was provided. The number of stocks without a PBR is also presented to illustrate what is required to reach 100% in each region. For example, in the Gulf of Mexico to reach 100% performance a PBR must be estimated for an additional 36 stocks.

[5] In practice a default theoretical value that is specific to species group (cetaceans or pinnipeds) was used for most stocks in the 2013 assessments

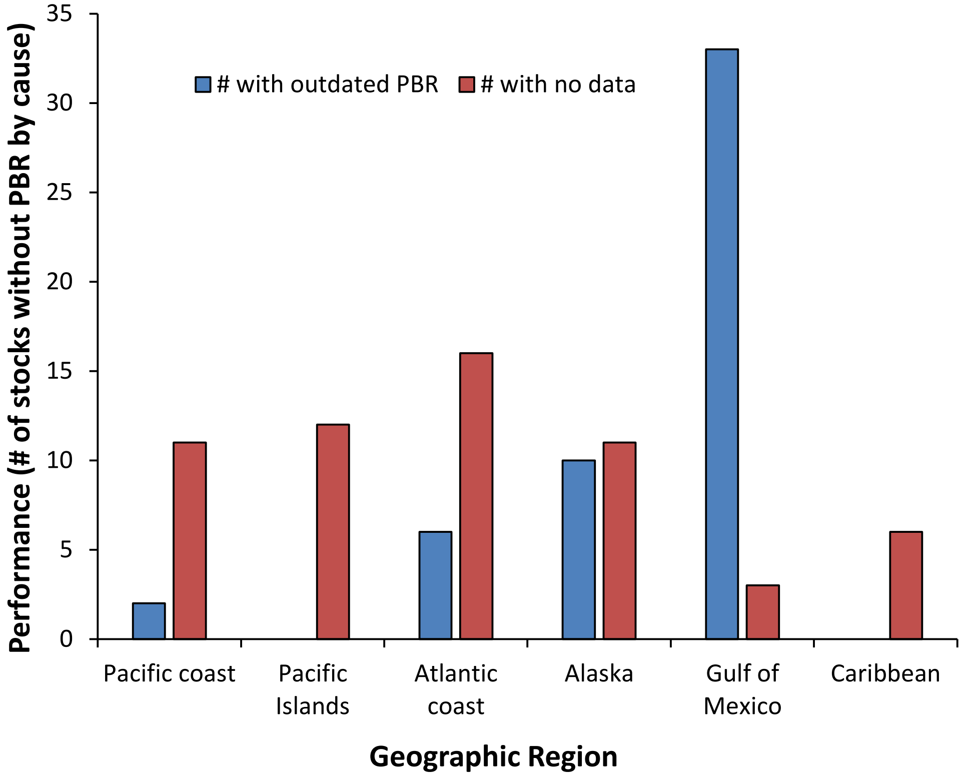


Figure 3b: Reason for the lack of a PBR estimate by geographic region. "Outdated PBR" indicates stocks that had some survey effort but those surveys are now more than eight years old and considered outdated. "No data" indicates stocks on which no significant survey effort has been focused. For example, in the Gulf of Mexico of the 36 stocks without a PBR in the 2013 assessments 33 are due to outdated survey data and 3 are due to no data.

CHALLENGES APPLYING THE PBR CONCEPT

The 2013 stock assessments indicate a number of problems that undermine the PBR approach or its application under current conditions.

1. As noted above, calculation of PBR requires an estimate of N_{min} and 110 (44%) of the 248 stocks in the 2013 stock assessments do not report an N_{min} estimate; therefore, the Service could not estimate a PBR for those stocks.
2. If NMFS has an N_{min} estimate for a stock, but the estimate is based on data older than eight years, then any PBR calculated using that N_{min} is deemed unreliable. In the next two years, ten abundance estimates will become outdated if NMFS does not have the resources to collect new abundance data.
3. Recovery factors strongly influence PBR estimates and are based in part on stock trend, but trend information is not available for 172 (69%) of the stocks.
4. A single PBR estimate for a pooled group of stocks will overestimate the tolerance for human-related effects of at least one stock in each pooled group. If this approach is to be used at all, it should be used sparingly and on a temporary basis only because such

pooling poses greater risk to pooled stocks with relatively smaller abundances, slower growth rates, greater vulnerability to human-related risk factors, or less resilience to those factors.

DISCUSSION AND RECOMMENDATIONS

The MMPA is a statement of conservation responsibility by Congress on society's behalf. It establishes a science-based framework for conserving marine mammals and the ecosystems upon which they depend. When they are complete, stock assessment reports provide a valuable basis for managing the adverse effects of human activities on marine mammals. This review indicates that although considerable progress has been made, on the whole, existing stock assessment reports fall far short of meeting the objectives set forth in the MMPA.

Three humpback whales dive together.

Of the 248 stocks in the 2013 reports NMFS provided—

- minimum estimates of abundance for only 138 stocks (56%);
- estimates of maximum productivity rates (i.e. not use a default value) for only 12 stocks (5%);
- population trend information for 76 stocks (31%), including quantitative analysis in 33 stocks(13%) and qualitative analysis in 43 stocks (17%); and
- a current potential biological removal level for only 134 stocks (54%). Of the remaining stocks 51 (21%) had outdated PBRs, 59 stocks (24%) had no PBR, and the reports for 4 stocks (2%) were described as having population dynamics inconsistent with application of the PBR concept.

Based on discussions with NMFS in regard to the shortcomings, the most obvious and prevalent problem appears to be lack of resources (funding and logistical) to support the science needed for management purposes. NMFS's staff have demonstrated that they have the capacity to do excellent scientific work, but they cannot do so if they do not have the resources needed.

Inadequate information in the stock assessment reports compromises NMFS's ability to prioritize its management and recovery actions in any meaningful or effective way. It also impedes the accurate evaluation of impacts from permitted sectors such as fisheries, energy, and defense, as well as impacts of catastrophic events such as the Deepwater Horizon Gulf Oil Spill, exposing marine mammal stocks to unnecessary risks.

The Commission therefore recommends that Congress support NMFS in its efforts to—

- improve understanding of stock structure, particularly for marine mammals in the Gulf of Mexico, central and western Pacific, and Arctic regions;
- identify and survey the ranges of marine mammal stocks to more accurately estimate abundance and distribution of stocks and hence better manage human interactions, risks of injury and mortality, and detect changes in stock status;
- implement a national stock assessment strategy that describes the infrastructure and resources needed to adequately conduct required stock assessments coordinated across regions, incorporates efforts to identify new stocks, and follows a schedule that ensures that NMFS has the status and trend information needed to identify, manage, and conserve depleted, threatened, or endangered stocks. NMFS currently undertakes some of these activities as part of its "Protected Resources Science Investment and Planning Process (PRSIPP);" [6] and
- identify and prioritize, on a national rather than regional basis and as part of the PRSIPP, those stocks for which an estimated PBR level cannot be calculated.

Specifically, the Commission recommends that Congress—

- work with leadership in NOAA, the Department of Commerce, and other Administration officials, to identify and secure the resources necessary to implement Section 117 of the MMPA and produce high quality, thorough, stock assessment reports nationally.

To improve stock assessments particular focus should be placed on vessel, ground, and aircraft surveys of the U.S. EEZ and adjacent waters conducted with consistent methodology at least twice in an eight-year period (to estimate the abundance and trends of all marine mammal stocks in U.S. waters), development of alternative survey technologies, and genetic analyses to better identify and define discrete marine mammal stocks in U.S. waters

The Commission would welcome the opportunity to discuss the results of its review with NMFS, NOAA, the Department of Commerce, the Administration, and Congress. The Commission believes that, with adequate resources, NMFS can fulfill the vision and mandates set forth in the MMPA for stock assessment.

ACKNOWLEDGMENTS

The Marine Mammal Commission would like to thank Timothy Ragen, Tiffini Brookens, Kristine Lynch, Robert Gisiner, Nina Young, and Dennis Heinemann. This report would not have been completed without your ideas, discussions, and contributions.

[6] NMFS has a proposal for conducting rotational surveys on a predictable schedule to increase efficient use of resources nationally but lacks the funding to support this initiative.

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IMPLICATIONS OF NON-LINEAR DENSITY DEPENDENCE

BARBARA L. TAYLOR

DOUGLAS P. DEMASTER[1]
Southwest Fisheries Science Center, P.O. Box 271,
La Jolla, California 92038-0271

ABSTRACT

Ranges of the ratio of maximum net productivity level (MNPL) to carrying capacity (K) are explored in general models for pinnipeds and odontocetes. MNPL/K is used in management of marine mammals but no empirical evidence exists to limit the range of values expected. Density dependent changes in age-specific birth and death rates have been used to infer MNPL/K. Non-linearities in these rates do not translate directly to population growth curves. The simple models demonstrate: (1) density dependence is likely to involve more than a single parameter (such as birth rate), (2) MNPL/K can be greatly reduced from that inferred from one strongly non-linear parameter when changes in other parameters are linear, (3) ranges of MNPL/K depend on biological limits on ranges of fecundity and survival rates, and (4) the magnitude and sign of bias incurred by inferring MNPL/K from functional forms of single parameters cannot be determined. Given current empirical evidence the range of MNPL/K for marine mammals as a group is large. Although MNPL/K should not be inferred from single parameter non-linearities, distributions of MNPL/K values can be generated through models which account for single species ranges for birth and death rates and maximum population growth rate.

Key words: demography, density dependence, logistic, marine mammal, non-linear dynamics, odontocete, pinniped, population dynamics.

Density dependent population dynamic models are used routinely in the management of marine mammals (Gerrodette and DeMaster 1990). Populations are typically managed relative to the population level where the maximum sustainable yield is realized (Donovan 1989) or the population level where net productivity is maximized. Maximum net productivity level (MNPL) is defined as (Gehringer 1976), "... the greatest net annual increment in population numbers or biomass resulting from additions to the population due to reproduction and/or growth less losses due to natural mortality." Empirical data

[1] Present address: National Marine Mammal Laboratory, 7600 Sand Point Way, N.E. Bldg. 4, Seattle, WA 98115.

concerning population growth rates at different population sizes for marine mammals are limited. Population growth is usually represented by deterministic models which describe the future state of a population given the current state. The state is given in terms of numbers of individuals. These population growth models, such as the logistic or various modified logistic models, consider all individuals to be equal with respect to future prospects of birth and death, that is, age structure is not explicitly used in the models.

Although the data for the relationship between population growth and population size are sparse for marine mammals, data on some age-specific birth and death rates are available for a few species. Based on these data, MNPL has been inferred to be above $0.5K$ (Fowler *et al.* 1980, Fowler 1987). From a model using an evolutionary argument, Fowler *et al.* (1980) state: "We would expect a whale population with a maximum specific productivity of 0.04 to show its greatest productivity levels between 88 and 92 percent of its equilibrium level." However, using the relationship from Fowler (1987), with a generation time of 20 yr and a maximum specific productivity of 0.04, would result in MNPL/K of 0.67. The purpose of this paper will be to explore the range of MNPL/K values possible for different combinations of density dependent age-specific changes in birth and death rates. Special attention will be given to biases which could result from inferring MNPL/K from density dependent changes in a single age-specific parameter. Two simple models will be used to explore whether what is known about non-linearities in age-specific birth and death rates justifies acceptance of any particular range of MNPL/K values. The first model is a generalized pinniped model which represents the marine mammal life history with the fastest population growth rate. At the other end of the spectrum, a generalized odontocete model is used to represent life history strategies with slow growth rates.

Empirical evidence—General reviews of empirical evidence for density dependence in large mammals, with separate sections on marine mammals, are presented in Fowler (1987) and Fowler *et al.* (1980). The intent of this paper is not to focus on any particular species but rather to present what general forms may pertain to specific demographic parameters. Fowler (1984) reviews density dependence in marine mammals and finds evidence of regulation for fecundity in nine species, age of first reproduction (AFR) in ten species, juvenile survival in five species and adult survival in one species. These frequencies may reflect ease of gathering data. For example, although adult survival may be density dependent, estimation is difficult and power to detect a change would be low for the amount of change required to affect population growth rates. The lack of empirical evidence makes the form of density dependence for adult survival purely speculative.

A recent reanalysis (de la Mare 1992) of some data reviewed by Fowler *et al.* (1980) shows the inability to draw general conclusions about the shape of recruitment functions. The following statements can be made based on empirical data (Fowler *et al.* 1980, de la Mare 1992): (1) marine mammals show density dependent responses, (2) for species for which data are available over a range of population sizes, density dependent responses are not abrupt (knife-edge),

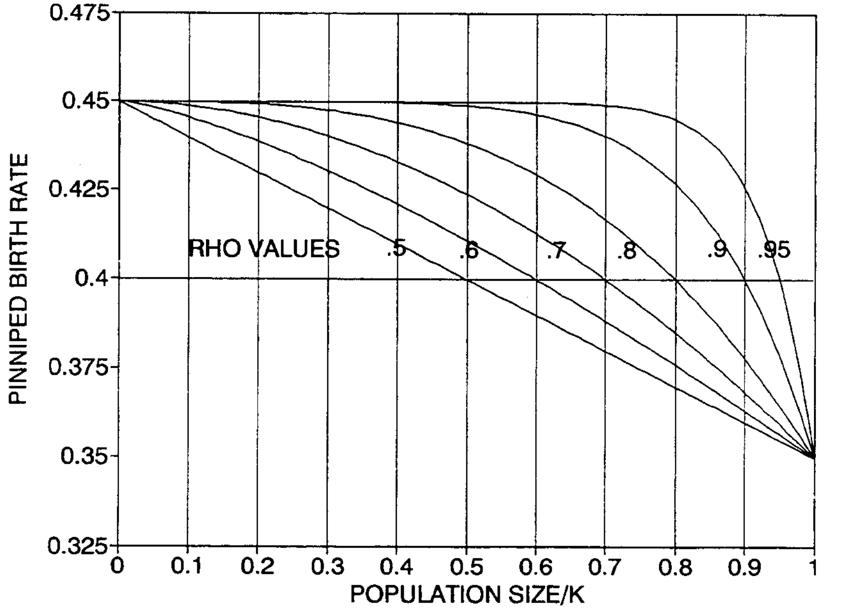

Figure 1. Curves for the Allen equation (Equation 3) for different ρ-values for birth rates for pinnipeds. The horizontal line indicates the point of 50% change in the parameter range. Note the intersections of the functions for different ρ-values with this line.

and (3) density dependent responses have not been shown to be concave (higher rates of change at low density), though the power is low. In this paper, a concave curve is one in which the value for any point between two endpoints is less than the value which would be a linear interpolation. Given the endpoints (0, 1) and (1, 0), a linear relation would yield a y-value of 0.5 when $x = 0.5$. A curve passing through any y-value <0.5 at $x = 0.5$ would be concave. None of the curves in Figure 1 are concave. A theoretical argument has been given by de la Mare and Cooke (1992) that concave responses are possible by allowing spatial variation in the environment. For the purposes of this paper, responses are limited to range from linear to strongly convex (most density dependent response at levels very close to K). Given current quantities and qualities of empirical data, it is not possible to further limit functional forms of age-specific density dependent responses for marine mammals as a group.

Theoretical arguments—Although MNPL is defined in population terms, empirical data exist primarily for age-specific demographic rates. We now consider how each approach is represented theoretically. Density dependent population growth is commonly represented by the generalized logistic equation (Pella and Tomlinson 1969, Gilpin *et al.* 1976) (altered below for discrete growth).

$$N_{t+1} = N_t + (\lambda_{\max} - 1)N_t\left[1 - \left(\frac{N_t}{K}\right)^{\theta}\right] \quad (1)$$

where N = population size, t = time, K = carrying capacity, λ_{max} = maximum discrete rate of population growth, and θ = shape parameter. Goodman (1980) showed distortion in the population growth curve caused by age structure: a linear change in birth rate caused the population growth curve to be convex. The convex shape of density dependent birth and survival functions argues generally for a maximum growth rate which is greater than $K/2$ ($\theta > 1$).

The θ-logistic equation does not include age-specific mortality or fecundity, but rather uses a single parameter, discrete population growth rate (λ, where $\lambda_{Nt} = N_{t+1}/N_t$), to predict the next population size given the current population size. For any given set of age-specific birth and death parameters there is a unique population growth rate which satisfies the equation:

$$1 = \sum_{x=AFR}^{\omega} l_x m_x \lambda^{-x} \tag{2}$$

where x = age, AFR = age of first reproduction, ω = oldest age, l = survivorship, m = fecundity, and λ = discrete rate of growth. Population growth is sensitive to different parameters in varying strengths. For example, equal proportional changes (called elasticity, Caswell 1989) in adult and juvenile survival rates will result in different changes to λ. For long-lived animals which have high adult survival rates and typically relatively low maximum population growth rates, λ is most sensitive to changes in adult survival rate (Goodman 1981). Relatively large changes in birth and juvenile survival rates result in rather small changes in λ. For example, consider a case where the survival rate for the first year is 0.50 and is 0.95 thereafter. Let $AFR = 1$, $\omega = 20$, and $m = 0.5$ giving $\lambda = 1.051$. A 10% reduction in adult survival, juvenile survival, and birth rate results in λ values of 0.972, 1.026, and 1.038 or changes of −7.5%, −2.4%, and −1.2% respectively. For this reason it is difficult to intuit how non-linear changes in birth or juvenile survival rates will affect λ and the MNPL. Therefore, simple models will be used to investigate the translation of density dependent changes in birth and death rates into population growth rates.

Methods

Introduction to the life history models—The translation of several age-specific density dependent functions into a single population growth function is best illustrated with simplified population models. The following parameters characterize the demography: mean fecundity (m), annual adult survival rate (p_a), annual juvenile survival rate (p_j—from age zero to one), AFR, oldest age (ω) and maximum discrete rate of growth (λ_{max}). We chose parameter values based loosely on the life history of fur seals (*Callorhinus ursinus*) for the pinniped model (Ragen 1990), and the bottlenose dolphin (*Tursiops truncatus*) for the odontocete model (Scott *et al.* 1990, Wells and Scott 1990). Default values for each parameter were selected to give the growth rate expected at $K/2$ within known ranges for pinnipeds (Ragen 1990) and odontocetes (Scott *et al.* 1990,

Table 1. Default parameters to yield λ at K/2 assuming a linear decrease in per capita growth.

Model	$\lambda(N = K/2)$	m	AFR	p_j	p_a	ω
Pinniped	1.05	0.40	5	0.423	0.960	20
Odontocete	1.02	0.12	10	0.593	0.980	50

Brault and Caswell 1993) (Table 1). Density dependent population growth was achieved by adjusting one or more of the above parameters.

Changes in single parameters—We begin examining the effect of changes in age-specific parameters on population growth rate by changing only a single parameter. The required single parameter changes needed to obtain growth rates from $\lambda = \lambda_{max}$ to $\lambda = 1$ could then be solved given equation 1. Change between the minimum and maximum parameter values was governed by:

$$X_N = X_{N=K} + (X_{N=0} - X_{N=K})\left[1 - \left(\frac{N}{K}\right)^z\right] \tag{3}$$

where N = population size, K = carrying capacity ($\lambda = 1$), $X_{N=0}$ = the value of the parameter when $N = 0$, $X_{N=K}$ = the value of the parameter at K, and z = shaping parameter. Because z-values are difficult to interpret, we have used a different scale. Let ρ be the N/K value reached when the z-value has changed half its range. Equation 3 can be rearranged to solve for z given the desired ρ-value.

$$z = \frac{\ln(0.5)}{\ln(\rho)} \tag{4}$$

Using Equation 4, we find that if we want a given parameter to have changed 50% of its range when $N/K = 0.9$ then $z = 6.58$. We investigated ρ-values between 0.50 ($z = 1$) and 0.95 ($z = 13.5$). The knife-edge limitation is therefore defined as $\rho = 0.95$, when the parameter has changed 50% of its range in 0.95 (N/K). Equation 3 (Allen 1976) is shown for different ρ-values in Figure 1 for birth rate for pinnipeds.

Changes in multiple parameters—In order to reduce the number of permutations of multiple parameters, changes were allowed which met two criteria: (1) parameter values must be biologically reasonable, and (2) changes in z must

Table 2. Minimum and maximum values allowed to maintain biological realism. Birth rate parameters assume a sex ratio of 0.5 and a maximum pregnancy rate of 90%. For the odontocete model calving interval is three years when $N = 0$ and five years when $N = K$.

Model	λ $X_{N=0}$	AFR $X_{N=0}$	AFR $X_{N=K}$	m $X_{N=0}$	m $X_{N=K}$	p_j $X_{N=0}$	p_j $X_{N=K}$
Pinniped	1.10	4	6	0.45	0.35	0.67	0.24
Odontocete	1.04	8	12	0.15	0.09	0.66	0.51

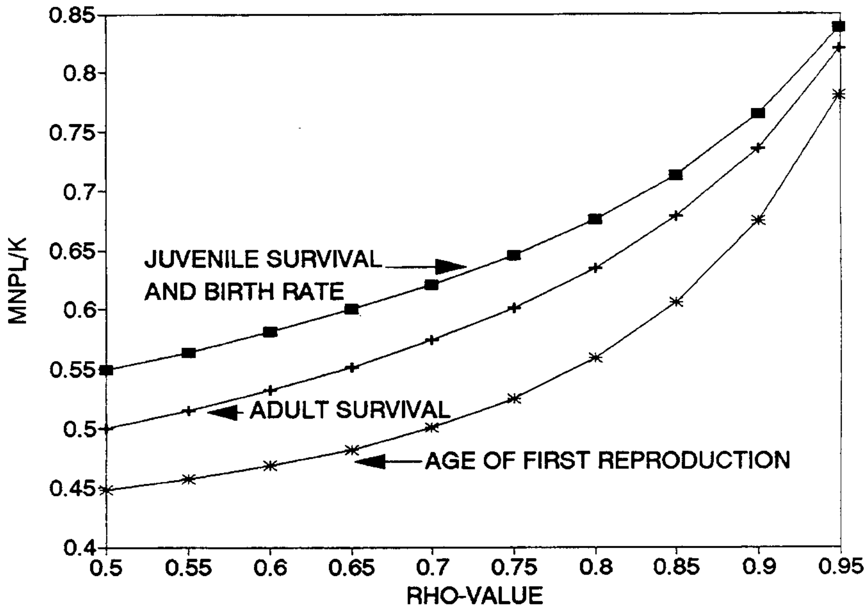

Figure 2. Single parameter changes (Table 1) resulting in a decrease in growth rate from $\lambda = \lambda_{max}$ to $\lambda = 1.0$. Values shown are for the odontocete model. Values for the pinniped model differed by less than 1%.

follow known empirical evidence (*i.e.*, density dependent changes are not knife-edge in form: $0.5 \leq \rho \leq 0.95$). Minimum and maximum values are given in Table 2.

Results

Single parameter changes—Figure 2 shows MNPL for different ρ-values for changes in single parameters as shown in Table 3. Results are shown for the odontocete model as values from the pinniped model never differed by greater than 1%. There are several items to note from this figure. First, as shown by Goodman (1980), not all linear density dependent changes ($z = 1$) produce a MNPL/K at $K/2$ (MNPL/K = 0.5). In particular, juvenile survival and birth rate produce a MNPL/K of 0.55. These two rates are the same because the

Table 3. Demographic parameter values required to achieve specified λ by changing a single parameter from the default values in Table 1, for use in Equation 3.

Model	λ	m	AFR	p_j	p_a
Pinniped ($X_{N=K}$)	1.00	0.232	10.510	0.245	0.914
Pinniped ($X_{N=0}$)	1.10	0.643	1.840	0.680	1.000
Odontocete ($X_{N=K}$)	1.00	0.072	22.681	0.355	0.961
Odontocete ($X_{N=0}$)	1.04	0.189	2.875	0.935	0.999

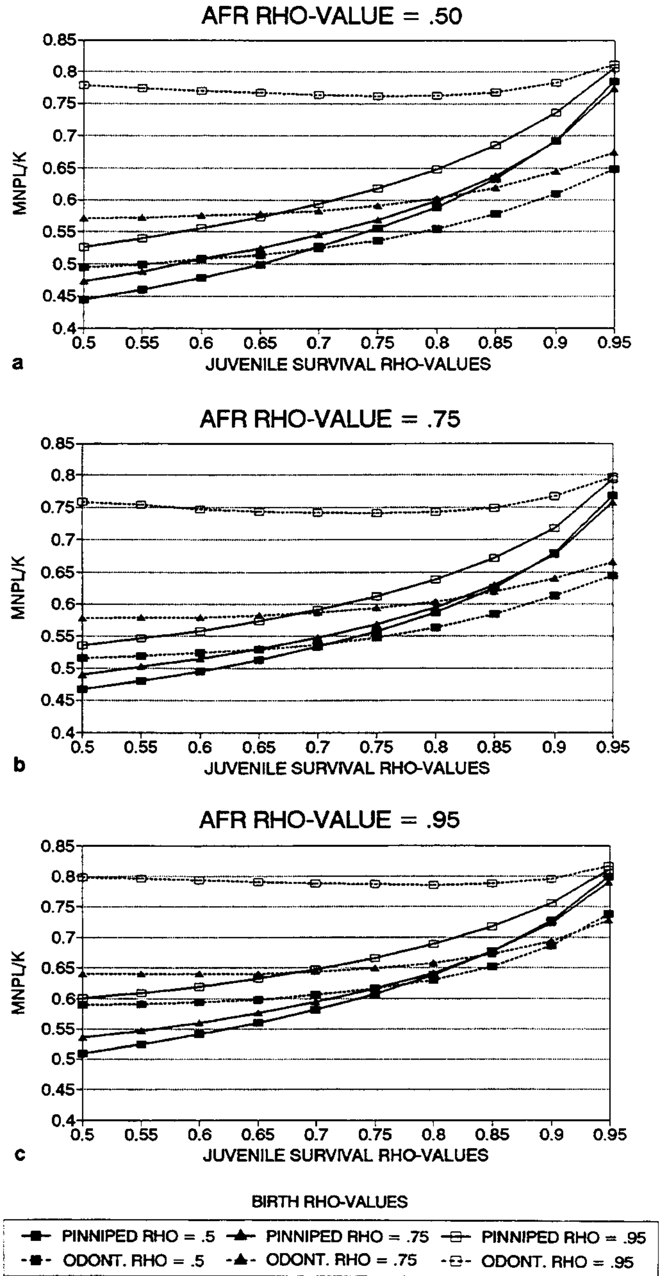

Figure 3. Multiple parameter changes resulting in a reduction in growth rate from $\lambda = \lambda_{max}$ to $\lambda = 1.0$. Figures a, b, and c correspond to *AFR* ρ-values of 0.50, 0.75, and 0.95 respectively. Pinnipeds (solid lines) and odontocetes (dashed lines) are shown for birth ρ-values of 0.50, 0.75, and 0.95. Lines between symbols are given for visual clarity.

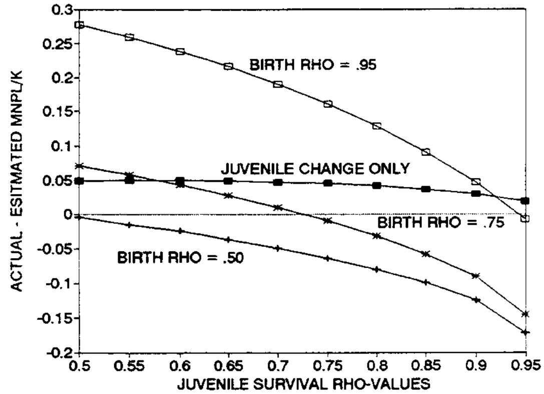

Figure 4. Bias in estimates of MNPL/K from assuming that $\theta = z$-value for juvenile survival. To obtain the actual MNPL/K value, the bias must be added to the value estimated from the z-value. The case shown is for odontocetes where juvenile survival is the only regulating mechanism and for three cases where AFR changes linearly ($z = 1$) and birth ρ-values are 0.50, 0.75, and 0.95.

elasticities are the same for these parameters. Recall that elasticity is the response in λ to a proportional change in the parameter. With only one year of juvenile survival, a reduction in juvenile survival or a reduction in birth rate cause the same reduction in the number of individuals recruited into the population. The small range of MNPL/K values for a given ρ-value irrespective of which parameter is being altered is not surprising. Even though λ is more sensitive to p_a, Table 3 reveals that much smaller proportional changes in p_a are required to produce the growth rate change. It may be surprising to note that even strong non-linearities ($\rho = 0.95$) do not produce MNPL/K >0.85. Higher ρ-values will, of course, yield MNPL/K values >0.85, but such highly concave functions imply no density dependent response until the population is very close to K. There are no empirical data to support such a knife-edge density dependent response. The final item to note is that the change required for a single parameter to accomplish all the density dependent change is often biologically unreasonable and sometimes (in the case of birth rate and AFR) biologically impossible. For example, in the pinniped model, AFR ranges from a minimum age (1.84) which is physically impossible to a maximum age (10.51) which is unlikely and was not observed when fur seals were thought to be near K in the 1950s (Scheffer 1955). Because marine mammals produce a single offspring and have a sex ratio of 0.5, values for birth rates cannot exceed 0.5. The maximum value in Table 3 for pinnipeds ($m = 0.643$) is therefore impossible. Similar arguments can be made for the same parameters in the odontocete model.

Changes in multiple parameters—All combinations of AFR, juvenile survival and birth rates for $\rho = 0.50$–0.95 were investigated. Results are shown in Figure 3. Note that changes in more than one parameter yield MNPL/K values which are less than those for equal ρ-values for changes in only a single parameter (also found in Fowler *et al.* 1980). The combination of three linear changes for the pinniped model ($\rho = 0.5$ ($z = 1$) for AFR, juvenile survival, and birth rate) actually yields an MNPL/K that is less than 0.5. Comparison of the pinniped model to the odontocete model shows that MNPL/K of the former to be more sensitive to changes in juvenile survival rate ρ-values and the latter to birth rate ρ-values. This is due to the differing magnitude of allowed change in these parameters (Table 2): birth rates vary more for odontocetes and juvenile survival rates vary more for pinnipeds. Thus, the models are sensitive to the minimum and maximum values. Changes in *AFR* ρ-values affect both models similarly when other ρ-values are low but have almost no effect on either when other ρ-values are high.

Consider the scenario where only data concerning juvenile survival were available. If we were to use the z-value from a fit of juvenile survival as the θ in Equation 1 how would our estimated MNPL/K compare to the actual MNPL/K when all birth and death functions are known? Figure 4 gives one example of bias for odontocetes. It can be seen that for a given ρ-value, even the sign of the bias cannot be inferred. The magnitude of the bias depends on the ρ-values of both the juvenile survival and birth rates. Therefore, it is not valid to infer MNPL/K from the functional form of a single demographic parameter. MNPL/K can be estimated either from population size estimates or from complete demographic models.

Discussion

Although it is likely that MNPL is found at values greater than $K/2$, the argument that MNPL should be very close to K (MNPL/$K > 0.8$) is unsupported. The only parameter for which empirical evidence lends credence to strong non-linearities is for juvenile survival in fur seals (Ragen 1990). Even here, many deterministic models have been used to fit the data with values for MNPL/K ranging from 0.43 to 0.93 (Ragen 1990). It is clear that when data are available for marine mammals, one of the primary density dependent regulating mechanisms is age of first reproduction (Fowler 1984). There is no evidence for non-linear change for this parameter (Fowler 1984, Lett *et al.* 1981), though power is undoubtedly low. As shown in Table 3, biological constraints make the likelihood of this parameter being the sole regulatory mechanism unlikely. It is therefore likely that population growth is regulated by several mechanisms, only some of which may be non-linear (Smith and Polacheck 1981). When several parameters change in a density dependent fashion, the result is that MNPL/K is less than that achieved by only a single non-linear growth rate regulating mechanism. If z-values for all parameters are high, MNPL/K values differ very little from values estimated for MNPL/K assuming $\theta = z$. On the other hand, disparities can be large if some parameter changes are linear.

The generalized pinniped and odontocete models were chosen to bracket the range of population growth rates observed in marine mammals. It may be argued, however, that these choices do not bracket the range of possible MNPL/K

values. Fowler (1988) argues that MNPL/K is related to rate of increase per generation. The generalized models have similar rates of increase per generation. To investigate the influence of rate of increase per generation on the conclusions of this paper, we chose the most extreme outlier in Fowler's work: *Stenella.* This genus has a similar rate of increase to the odontocete model but a shorter generation time. Choice of parameter ranges were from Chivers (1992). Results were very close to the odontocete model and did not compromise the conclusions from the generalized models.

Non-linearities in population regulation mechanisms which lead to linear decreases in per capita growth rates (MNPL/K = 0.5) have been noted in several laboratory systems (Barlow 1992, Kerfoot *et al.* 1985). Further, Barlow's experiment with guppies (*Poecilia reticulata*) (1992) showed highest sensitivity to density dependent somatic growth. Although mammals express determinate growth, AFR seems to be an important regulatory mechanism which may link body growth rate to population growth (Lett *et al.* 1981).

Unfortunately, we are only a little closer to defining likely ranges of MNPL/K. It seems likely that $0.5 < \text{MNPL}/K < 0.85$. For a given species, the range may be able to be reduced. For example, if we know that for fur seals z-values were $z = 1$, $1 \leq z \leq 3$, and $3 \leq z \leq 9$ for *AFR,* birth and juvenile survival rates respectively, then $0.58 < \text{MNPL}/K < 0.73$. A much more realistic fur seal model (Ragen 1990) calculated a distribution of MNPL/K from simulations using permutations of possible ranges of demographic values and z-values. MNPL/K occurred at highest frequency between 0.60 and 0.65 (corrected values; Ragen, personal communication). Unfortunately, there are few species for which we have the quantity of data available as for the fur seal.

Eberhardt (1977) proposed a general model for self-regulation in long-lived species which gave an order for age-specific density dependent responses. Such rigidity in growth regulation was questioned by a comparison of population dynamics of three species of Antarctic seals (Siniff 1984). These species, living in proximity to one another, showed varied responses which were attributed to different reactions to environmental variance. Thus, even within the Antarctic ecosystem and among closely related species, marked differences in density dependent age-specific birth and death rate responses exist. The deterministic equations discussed in this paper assume no environmental variance. Clearly, populations must evolve to respond to the stress caused by environmental changes. Marine environments change markedly over short time periods (El Niño events, fluctuations in prey availability in cold water regimes, *etc.*). Some marine mammal species are relatively fixed in space due to breeding or feeding requirements while others may be free to move over large distances to locate resources. It seems an act of faith to believe that all the likely different density dependent age-specific regulatory mechanisms would result in a narrow range of MNPL/K values. The exercise in this paper has demonstrated that even if dynamics were deterministic, without knowledge about all the density dependent age-specific birth and death rates, a single value of MNPL/K cannot be inferred. Distributions of MNPL/K for each species given a range of parameter estimates may be more appropriate considering the current amount and quality of data.

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CALCULATING LIMITS TO THE ALLOWABLE HUMAN-CAUSED MORTALITY OF CETACEANS AND PINNIPEDS

PAUL R. WADE
Office of Protected Resources,
National Marine Fisheries Service,
%National Marine Mammal Laboratory,
Alaska Fisheries Science Center,
7600 Sand Point Way NE, Seattle, WA 98115, U.S.A.
E-mail: paul.wade@noaa.gov

ABSTRACT

A simulation method was developed for identifying populations with levels of human-caused mortality that could lead to depletion, taking into account the uncertainty of available information. A mortality limit (termed the Potential Biological Removal, *PBR*, under the U.S. Marine Mammal Protection Act) was calculated as the product of a minimum population estimate (N_{MIN}), one-half of the maximum net productivity rate (R_{MAX}), and a recovery factor (F_R). Mortality limits were evaluated based on whether at least 95% of the simulated populations met two criteria: (1) that populations starting at the maximum net productivity level (*MNPL*) stayed there or above after 20 yr, and (2) that populations starting at 30% of carrying-capacity (*K*) recovered to at least *MNPL* after 100 yr. Simulations of populations that experienced mortality equal to the *PBR* indicated that using approximately the 20th percentile (the lower 60% log-normal confidence limit) of the abundance estimate for N_{MIN} met the criteria for both cetaceans (assuming $R_{MAX} = 0.04$) and pinnipeds (assuming $R_{MAX} = 0.12$). Additional simulations that included plausible levels of bias in the available information indicated that using a value of 0.5 for F_R would meet both criteria during these "bias trials." It is concluded that any marine mammal population with an estimate of human-caused mortality that is greater than its *PBR* has a level of mortality that could lead to the depletion of the population. The simulation methods were also used to show how mortality limits could be calculated to meet conservation goals other than the U.S. goal of maintaining populations above *MNPL*.

Key words: bycatch, cetacean, conservation, incidental fisheries mortality, management, mortality limit, *PBR*, population modeling, pinniped, U.S. MMPA.

Human activities sometimes cause the mortality of marine mammals. This mortality ranges from the obvious, such as intentional takes by commercial or subsistence harvesters, to the not-so-obvious, such as incidental mortality in fishing operations. Correctly assessing the significance of incidental mortality to marine mammal populations can be difficult. In cases where the incidental fisheries mortality is perceived to be high, such as for the well-known 1960s case of eastern tropical Pacific dolphins killed in the tuna purse seine fishery (Perrin 1969, Wade 1995), it can seem obvious that the mortality should be reduced. However, when human-caused mortality is more moderate, it becomes less obvious whether that mortality should be of concern from the standpoint of preventing the depletion of a population. Of course, some may argue that no mortality should be tolerated, but even some of the least-harmful fisheries still have the potential to cause the death of a marine mammal. Other human activities that are apparently innocuous can also cause incidental mortality, such as ships colliding with large whales (*e.g.,* Kraus 1990), yet it would be impractical to stop all ship traffic. Most people would probably agree that an activity could be considered acceptable if it only rarely caused the incidental mortality of a marine mammal (*e.g.,* one animal in 20 yr). The difficulty is how to decide when a level of mortality is no longer acceptable. This paper describes a method for setting a limit in mortality for identifying marine mammal populations with levels of human-caused mortality that may be too high.

Before a management scheme can be designed, the management goal must be defined. The management goal of the U.S. Marine Mammal Protection Act (MMPA) is to prevent populations from "depletion." The U.S. National Marine Fisheries Service (NMFS) considers a population depleted if it falls below its maximum net productivity level (*MNPL*) (Fig. 1). For marine mammals, this level is thought to be between 50% and 85% of carrying capacity and is more likely to be in the lower portion of that range (Taylor and DeMaster 1993). Therefore, populations are considered depleted by the U.S. Government if they are directly estimated to be below their *MNPL,* or if they are estimated to be below 50%–70% of a historic population size which is thought to represent carrying capacity (Gerrodette and DeMaster 1990). Although maintaining populations above *MNPL* is an excellent management goal, basing management decisions entirely on assessing status relative to *MNPL* has proven inadequate. Assessment methods such as *dynamic response* (Goodman 1988) or *back calculation* (Smith 1983) require a quantity of data unavailable for most species and cannot always be applied (Gerrodette and DeMaster 1990).

Alternatively, management actions could be triggered by criteria using trends in abundance. In fact, a series of abundance surveys were planned to monitor spotted dolphins (*Stenella attenuata*) in the eastern tropical Pacific (Holt *et al.* 1987). The goal was to detect a 10% annual decline over five years (six surveys) with 90% assurance, assuming a coefficient of variation (CV) of 12% for each annual abundance estimate. In reality, the estimated CV averaged 30% over the five surveys actually performed (Wade and Gerrodette 1992). Given that level of precision, it would take nine years (10 surveys) to detect a 10% annual decline, assuming a survey was done every year (Gerrodette 1987). Thus, the time required to estimate the trend implies that a management scheme based on detecting a significant decline in abundance would not initiate any management action until a previously unexploited population became depleted; a population declining at 10% per year would be at only 39%

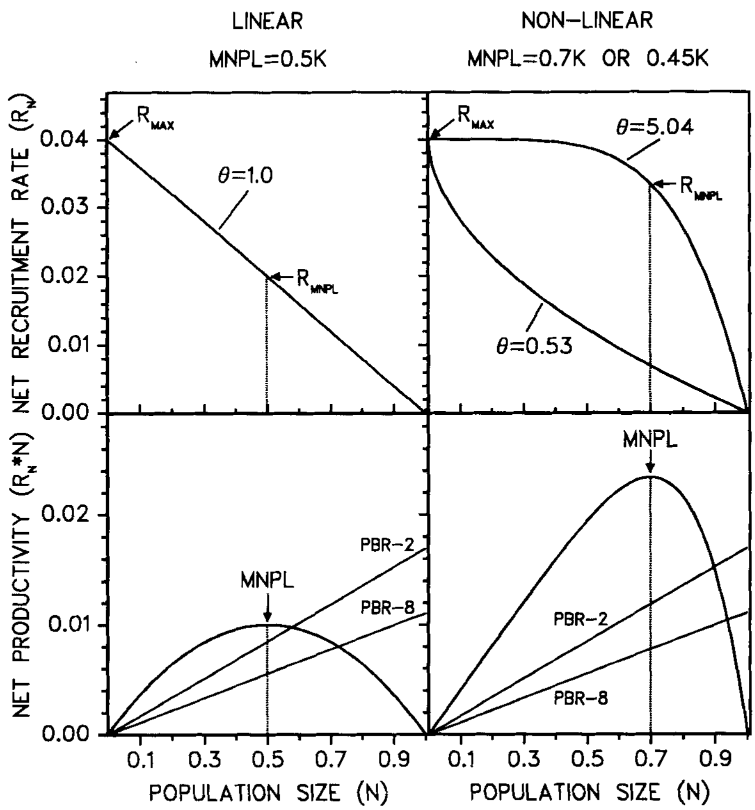

Figure 1. Illustration of density-dependent response specified by generalized logistic model (Equation 2), showing relationship between quantities discussed in text. Two panels on the left show linear model ($\theta = 1.0$). Top panel shows linear decline of net recruitment rate (*per capita* population growth rate) with population size (expressed as fraction of carrying capacity [K]). Bottom panel shows net productivity curve, which is product of net recruitment rate and population size. For linear model, net productivity curve is symmetric, with maximum (*MNPL*) at 0.5K. Net recruitment rate at *MNPL* (R_{MNPL}) is ½ the maximum rate (R_{MAX}). Two straight lines in bottom panel represent expected *PBR* (Equation 1) calculated as product of 20th percentile of abundance estimate, ½ R_{MAX}, and value of 1.0 for recovery factor (F_R), assuming CV of abundance estimate of 0.2 (*PBR*-2) or 0.8 (*PBR*-8). Top panel on right shows two types of possible non-linear density-dependent responses of net recruitment rate. Higher curve represents example of convex density dependence ($\theta = 5.04$), where net recruitment rate declines slowly at low population size but declines more rapidly at higher population size. Bottom panel on right shows net productivity curve associated with this value of θ, which is not symmetric and has maximum at 0.7K. If $\theta > 1.0$, then $MNPL > 0.5K$, and $R_{MNPL} > ½ R_{MAX}$. Lower curve in top panel represents example of concave density-dependent response ($\theta = 0.53$), where net recruitment rate declines more rapidly at lower population sizes than at higher population sizes. Associated net productivity curve not shown in lower panel, but *MNPL* is 0.45K for this value of θ. If $\theta < 1.0$, then $MNPL < 0.5K$, and $R_{MNPL} < ½ R_{MAX}$.

of its initial population size after nine years. This problem becomes even more acute for small populations because the precision of abundance estimates decreases as abundance decreases (Taylor and Gerrodette 1993), and thus conceivably a small declining population could become extinct before it could be found to be significantly declining.

Thus, management which is dependent on detecting a trend in abundance is unlikely to maintain above *MNPL* all populations which have high levels of human-caused mortality. Gathering trend data for management would also require frequent surveys, which would be costly for the 153 defined stocks of marine mammals in U.S. waters, most of which have been subject to some form of human-caused mortality (Barlow *et al.* 1995*b*). If a decline in abundance is detected, this should, of course, initiate management response, but it may often be appropriate to take action well before it is possible to prove that a decline in abundance is occurring.

A better management scheme would use data that can be dependably gathered to initiate management actions before populations become depleted. Fortuitously, it is easier to detect the circumstances that will lead to a decline in abundance than it is to detect the actual decline itself. We can often estimate the level of human-caused mortality of marine mammals when the source of the mortality is known. Therefore, a management scheme can be based on calculating a mortality limit. Mortality above the limit would trigger management actions beyond basic monitoring.

It is obvious that such a limit has to be unique and scaled to each population and therefore must be based on mortality relative to population size, not on an absolute level of mortality. For example, it is unlikely that the kill of a single common dolphin (*Delphinus delphis*) off the coast of California would have any significance to a population recently estimated at 225,821 (Barlow 1995). However, the kill of a single individual may be of importance to a very small population such as that of the western North Atlantic right whale (*Eubalaena glacialis*), currently estimated to number only about 295 animals (Knowlton *et al.* 1994).

If we had perfect knowledge of a population's human-caused mortality, abundance (N) and dynamics, including its growth rate at the maximum net productivity level (R_{MNPL}) (Fig. 1), we could exactly determine a mortality limit that would prevent depletion to below the *MNPL*, as the product of N and R_{MNPL}. Instead, we usually have only estimates of abundance and mortality and a plausible range of growth rates based on life-history information (*e.g.*, Reilly and Barlow 1986). We also have empirical estimates of rate of increase for a few populations, such as recovering populations of pinnipeds (*e.g.*, Cooper and Stewart 1983) or baleen whales (*e.g.*, Best 1993). To ensure a robust management strategy, a mortality limit that is calculated from such information should explicitly account for the precision and bias of the available estimates of abundance and mortality, as well as for the uncertainty of the population growth rate.

Several years ago, NMFS scientists with experience in the management of marine mammals recognized the deficiencies of previous management schemes, as discussed above, and proposed a management strategy based on calculating a mortality limit (Proposed regime to govern interactions between marine mammals and commercial fishing operations, National Marine Fisheries Service Legislative Proposal, November 1992, available from the Office of Protected Resources, National Marine Fisheries Service, Silver Spring, MD). This proposal was the initial basis for what became the 1994 amendments to the MMPA, which introduced the concept of a mortality limit, termed the "potential biological removal level" or *PBR*. The proposal and the subsequent amendments attempted to implement several principles that have been developed to promote better conservation of wild, living resources, particularly that assessment should precede the use of resources and that managers should recognize the possible consequences of uncertainty and act accordingly (Mangel *et al.* 1996). Therefore, the *PBR* management scheme implemented by the 1994 amendments, and the methods I present here for calculating *PBR*s, may have value beyond the narrow focus of management of marine mammals in U.S. waters. For convenience, however, I use the (admittedly idiosyncratic) terminology of the MMPA.

The relevant specific rules, as modified by the 1994 amendments, are stated as follows in the Definitions (Section 3) of the MMPA:

> "(19) The term 'strategic stock' means a marine mammal stock—(A) for which the level of direct human-caused mortality exceeds the potential biological removal level; . . . ."
>
> "(20) The term 'potential biological removal level' means the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. The potential biological removal level is the product of the following factors:
>
> (A) The minimum population estimate of the stock.
>
> (B) One-half the maximum theoretical or estimated net productivity rate of the stock at a small population size [see Fig. 1].
>
> (C) A recovery factor of between 0.1 and 1.0."
>
> "(26) The term 'net productivity rate' means the annual *per capita* rate of increase in a stock resulting from additions due to reproduction, less losses due to mortality."
>
> "(27) The term 'minimum population estimate' means an estimate of the number of animals in a stock that—(A) is based on the best available scientific information on abundance, incorporating the precision and variability associated with such information; and (B) provides reasonable assurance that the stock size is equal to or greater than the estimate."

Therefore, from the definitions it follows that the *PBR* is calculated as:

$$PBR = N_{\text{MIN}} \frac{1}{2} R_{\text{MAX}} F_R \tag{1}$$

where:

N_{MIN} = the minimum population estimate of the stock,

$\frac{1}{2}R_{MAX}$ = one-half the maximum theoretical or estimated net productivity rate of the stock at a small population size,

F_R = a recovery factor between 0.1 and 1.

Note that the goal of the *PBR* is to allow each stock to reach or maintain its "optimum sustainable population" (*OSP*):

> "(9) The term 'optimum sustainable population' means, with respect to any population stock, the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element."

To make that definition more specific, NMFS has defined *OSP* as a population level between carrying capacity and the population size at maximum net productivity (Federal Register, 21 December 1976, 41 FR 55536). Therefore, the specific goal of the *PBR* is to allow each stock to reach or maintain a population level above the maximum net productivity level (*MNPL*). This has long been the goal of the MMPA; the key difference instituted by the 1994 amendments is that management actions related to direct human-caused mortality no longer rely on detecting depletion, but on simply detecting a mortality level that will lead to depletion.

Although the MMPA specifies the three components of the *PBR*, it does not define them in quantitative terms. The purpose of this paper is to propose specific quantitative definitions for N_{MIN}, R_{MAX}, and F_R that can be used to calculate a mortality limit which can be used to evaluate the impact of known levels of human-caused mortality of marine mammals.

With perfect knowledge, a mortality limit of the product of N and R_{MNPL} would exactly maintain populations at *MNPL*. Thus, conceptually the *PBR* specifies the use of N_{MIN} to account for imprecision in the abundance estimate. Additionally, $\frac{1}{2}R_{MAX}$ is a conservative surrogate for R_{MNPL}, because $\frac{1}{2}R_{MAX}$ will always be less than or equal to R_{MNPL} if *MNPL* is greater than or equal to 50% of K (carrying capacity) (Fig. 1). Finally, F_R can be seen as both an additional factor to hasten the recovery of depleted populations and as a "safety" factor to account for additional uncertainties other than the precision of the abundance estimate. In statistical terms, using N_{MIN} addresses uncertainty due to imprecision which can be estimated. F_R, on the other hand, can be used to address potential biases caused by our ignorance of some important factors, such as stock boundaries.

Taylor (1993) used population simulations to compare the results of using two alternative definitions of N_{MIN}. She estimated PBR using mean abundance for N_{MIN} and using a lower, 2-tailed 95% confidence limit for N_{MIN}. Using the mean estimate of abundance for N_{MIN} (along with $F_R = 1.0$) resulted in many of the simulated populations being depleted (below *MNPL*) after 100 yr. In contrast, using the 95% lower confidence limit resulted in all populations being far above *MNPL* under the same conditions. Taylor (1993) also followed the structure used by the International Whaling Commission to test its Revised Management Plan (Donovan 1989) by performing "robustness" trials. In these trials, the performance of calculating the *PBR* in various ways was evaluated under simulations involving plausible flaws in the data or assumptions, such as substantial biases in the abundance or mortality estimates. In these robustness trials, a *PBR* calculated using the 95% lower confidence limit for N_{MIN} and an F_R of 0.5 also resulted in all simulated populations being far above *MNPL* after 100 yr.

It is worth considering whether other ways of estimating N_{MIN} are sufficient to maintain populations above *MNPL,* and whether other values of F_R are sufficient to account for potential bias or other problems with the data. The lower 95% confidence limit represents the 2.5th percentile of the sampling distribution of the abundance estimate, whereas the point estimate represents the 50th percentile. If the 2.5th percentile more than achieves the desired goal, but the 50th percentile does not, clearly some intermediate percentile could be found that would be just sufficient to result in a high probability that populations would be above *MNPL.* Similarly, various values of F_R could be tested to solve for a value that was just sufficient to account for "worst-case" scenarios of problems with the data or other information.

The intent of the proposed management scheme is to provide an appropriately conservative level for the *PBR* that will allow populations to recover to or remain above *MNPL* in spite of uncertainty, whether in the form of imprecise or biased information. R_{MAX} is unknown for most marine mammals, and only a moderate number of populations have available observed rates of increase. Gaining knowledge about the true value of R_{MAX} for any population of marine mammal is probably harder than estimating its abundance or human-caused mortality. I present a strategy that is based on assuming plausible default values for R_{MAX} for pinnipeds and for cetaceans (I will not consider what are appropriate values of R_{MAX} for other marine mammals). If population or species-specific information indicates that a value different from the default is appropriate, this specific value can and should be substituted for the default value. Thus, I proceed assuming a reasonable estimate for R_{MAX} is available (although significant bias in R_{MAX} will be addressed in the bias trials) and propose a scheme for estimating a mortality limit by ensuring that the product of N_{MIN} and F_R is less than the point estimate of abundance by a sufficient amount to achieve the management goal. The selection of an appropriate default R_{MAX} for cetaceans and for pinnipeds is discussed in the Appendix.

It is also worth considering how to set mortality limits for management objectives other than the specific U.S. MMPA goal of maintaining populations above *MNPL.* For example, one might be interested in a management goal of maintaining populations close to their pre-exploitation population level (*i.e.,* *K*). Another type of management goal might be to allow populations to grow at a rate close to what their population growth rate would be in the complete absence of human-caused mortality. This type of criterion might be useful for calculating a mortality limit that would promote the recovery of a population that is known to have declined to a very low fraction of its pre-exploitation size, such as 5%–20% of *K.* Therefore, I will briefly illustrate a method for calculating mortality limits to achieve these other management goals, again using Equation 1. However, for clarity, the product of such calculations will be referred to as a mortality limit (*ML*) rather than as a *PBR*, because the term *PBR* refers to a specific mortality limit intended to meet the objectives of the U.S. MMPA.

METHODS

Conservation Goals and Performance Criteria

Here I describe three specific conservation goals along with criteria designed to evaluate (by simulation) whether a mortality limit will achieve the desired goal. The first goal is that of the U.S. MMPA. I propose the second and third as other possible conservation goals.

MNPL goal—maintain populations above their maximum net productivity level (*MNPL*). This is the primary management goal of the U.S. MMPA. *PBR* is calculated using values of the two parameters N_{MIN} and F_R set according to these criteria:

(1) Base case criteria—find a value for N_{MIN} (as a percentile of a point estimate of abundance) such that (a) any population in the base case of an absence of significant biases in the data will be above *MNPL* with 95% probability after 100 yr (to measure long-term performance), under mortality equal to a *PBR* calculated with an F_R equal to 1.0, and (b) a population starting at *MNPL* will still be at or above *MNPL* in 20 yr (to measure short-term performance) with 95% probability.
(2) Bias criteria—find a value for F_R such that the above criteria (1(a) and 1(b)) are also met during bias trials in which the data are assumed to have plausible unknown problems, such as significant bias.

Carrying-capacity goal—allow a population to recover to a level close to its carrying capacity, or pre-exploitation population level.

Carrying-capacity criterion—find the value of F_R such that a population which then experiences that level of human-caused mortality will equilibrate above a specified fraction of its carrying capacity, with 95% probability. To distinguish this from a *PBR* calculated to meet the *MNPL* goal of the U.S. MMPA, a mortality limit calculated with this value of F_R will be called ML_K (mortality limit to achieve a population level close to K, the carrying-capacity).

Recovery-rate goal—allow a population known to be at a low level relative to its pre-exploitation level recover at a rate close to its maximum possible.

Recovery-rate criterion—find the value of F_R such that a population starting at just 5% of its pre-exploitation level will not be delayed by more than a specified percent in the time it takes to recover to its maximum net productivity level when it experiences that level of human-caused mortality (relative to the recovery-rate of a population with no human-caused mortality), with 95% probability. A mortality limit calculated with this value of F_R will be called ML_{Rec} (mortality limit to promote recovery).

Simulation Methods

Methods nearly identical to those of Taylor (1993) were used for the simulations. The underlying population dynamics model was a discrete form of the generalized logistic equation,

$$N_{t+1} = N_t + N_t R_{\text{MAX}}\left[1 - \left(\frac{N_t}{K}\right)^{\theta}\right] \tag{2}$$

where:

N_t = population size at time t,

R_{MAX} = the maximum net recruitment rate,

K = the pre-exploitation population size or carrying capacity,

θ = the shape parameter, which controls the amount of non-linearity in the density-dependent response of the net recruitment rate and thus sets the *MNPL* (see Fig. 1).

The procedure and sequence of each simulation were:

(1) The population was projected from year t to year $t + 1$ using Equation 2, with R_{MAX} equal to either 0.04 (typical of cetaceans) or 0.12 (typical of pinnipeds). In each simulation, $K = 10{,}000$, and $\theta = 1.0$, for a *MNPL* of $0.5K$, or 5,000.

(2) Every ith year (starting in year 1), an estimate of abundance was "surveyed" by randomly drawing from a log-normal distribution with a specified coefficient of variation CV(N).

(3) A *PBR* (or mortality limit) was then calculated from Equation 1, using the most recent survey.

(4) Incidental fisheries mortality was simulated by subtracting from the current population a Gaussian random deviate from a distribution with a mean equal to the *PBR* (or *ML*) and a coefficient of variation, CV(M), of 0.30.

(5) This sequence was repeated until the population was projected from year 0 to year 20, 100, or 200, depending upon the simulation. Each trajectory was initiated in year 0 at a population size equal to a specified fraction of K. The first survey occurred in year 1.

(6) For each trial, 2,000 trajectories were simulated, and the distribution of ending population sizes was stored. The mean and the 5th and 95th percentiles of this distribution were calculated. Thus, for example, if the lower percentile (representing the lower bound of a two-tailed 90% confidence limit) value was above *MNPL*, it could be concluded that more than 95% of the trajectories were above *MNPL*.

The sampling error of the survey was assumed to follow a log-normal distribution with a mean equal to the true population size, with a specified CV of either 0.2 or 0.8. Each abundance estimate, or "survey," was therefore generated by

Table 1. Specifications for the maximum population growth rate (R_{MAX}) and the coefficient of variation for each survey-based abundance estimate (CV(N)) for the four base case trials in the simulations.

Base cases	R_{MAX}	CV(N)
A. Cetacean, low CV	0.04	0.2
B. Cetacean, high CV	0.04	0.8
C. Pinniped, low CV	0.12	0.2
D. Pinniped, high CV	0.12	0.8

$$\hat{N}_t = \exp\left[\ln\left(\frac{N_t}{\sqrt{(1 + CV^2)}}\right) + x\sqrt{\ln(1 + CV^2)}\right] \tag{3}$$

where

x = a Gaussian random deviate with a mean of zero and a variance of 1.

N_{MIN} was calculated as the lower percentile of a log-normal distribution as

$$N_{MIN} = \frac{\hat{N}}{\exp(z\sqrt{\ln(1 + CV(N)^2)})} \tag{4}$$

where

z = a standard normal variate and thus equals 1.96 for the 2.5th percentile, 1.645 for the 5th, 1.282 for the 10th, 0.842 for the 20th, and so on.

MNPL Goal

Base case trials—A total of four "base cases" were considered (Table 1). To represent cetacean life history, two cases used an R_{MAX} of 0.04 for the *PBR* calculation (Eq. 1). One case used a CV(N) of 0.2 and the second used a value of 0.8. To represent pinniped life history, another two base cases used an R_{MAX} of 0.12 for the *PBR* calculation with the same combinations of CV(N). In all four base cases the "true" R_{MAX} in the population model (Eq. 2) was the same as the R_{MAX} used to calculate *PBR.*

Bias trials—A total of eight "bias trials" and the base case (trial 0) were considered (Table 2). Trials 1, 2, and 3 represented bias in the estimates of mortality, abundance, and R_{MAX}, respectively. Trials 4 and 5 represented situations where the variance of an estimate is severely underestimated. Trial 6 explored the result of surveying every eight years rather than every four years. Trial 7 had the true *MNPL* set to 0.45K rather than the assumed 0.5K. Trial 8 repeated trial 1 (bias in the estimate of mortality) but also had the true *MNPL* set to 0.7K rather than the assumed 0.5K. The magnitude of the assumed biases are given in Table 2. They were generally set to a level that was considered a plausible "worst-case scenario." However, deciding what level of unknown bias is plausible is an uncertain task. Some guidance can be gained

Table 2. Specifications for the bias trials for the simulation.

Trial	Description
0	Base case.
1	Estimated mortality equal to one-half the actual mortality.
2	Estimated N twice actual N.
3	Estimated R_{MAX} twice actual R_{MAX}. If estimated to be 0.04, actual R_{MAX} is set to 0.02. For estimated R_{MAX} of 0.12, actual R_{MAX} is set to 0.06.
4	Estimated abundance CV < actual CV (estimated CV of 0.2 actually 0.8, estimated CV of 0.8 actually 1.6).
5	Estimated mortality CV = one-quarter actual CV. CV(M) is set to 1.20 rather than 0.30.
6	Abundance estimated every 8 yr rather than every 4 yr.
7	True $MNPL$ equal to $0.45K$ ($\theta = 0.53$) rather than assumed $0.50K$ ($\theta = 1.0$).
8	Mortality bias as in trial 1 with true $MNPL$ equal to $0.70K$ ($\theta = 5.04$) rather than assumed $0.50K$ ($\theta = 1.0$).

from populations that have been studied more thoroughly than others. Justification for the plausibility of the specified magnitudes of bias is considered in the Appendix.

Carrying-Capacity Goal

The same four "base cases" were considered as above. The final population level after 200 yr (to allow time to equilibrate) was stored for simulated populations which started at $0.05K$ and experienced human-caused mortality at a level equal to ML_K, calculated with N_{MIN} equal to the 20th percentile for a range of values for F_R. It should be noted that the equilibrium level will be independent of the starting population level as long as the populations are projected for enough years, which was the case here.

Recovery-Rate Goal

The same four "base cases" were considered as above. First, a population was projected with no human-caused mortality from an initial population size of $0.05K$ to calculate how many years it took the population to reach $0.5K$. Then simulations which experienced human-caused mortality equal to ML_{Rec}, calculated with N_{MIN} equal to the 20th percentile and for a range of values for F_R, were performed, and again the year in which the population reached $0.5K$ was stored. For each simulation, the percent increase in time to recover to $0.5K$ was calculated.

Results

MNPL Goal

Base case trials—Using the best estimate of abundance (the 50th percentile) for N_{MIN} resulted in the majority of the trajectories ending up below 50% of

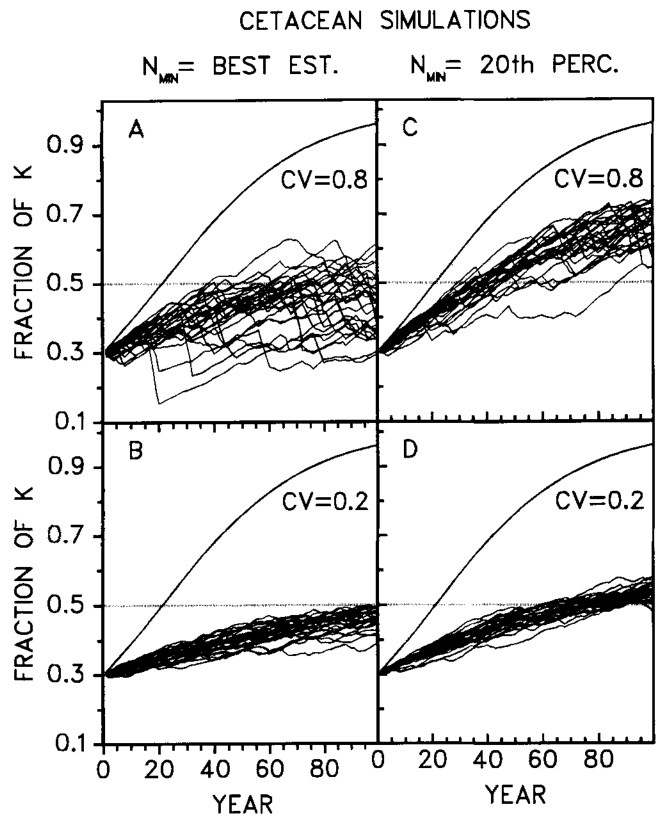

Figure 2. Simulated cetacean population trajectories (R_{MAX} = 0.04) with mean human-caused mortality equal to estimated *PBR*, showing 30 sample trajectories out of total of 2,000. Horizontal line represents maximum net productivity level (0.5*K*). Medium curved line represents a population trajectory with no human-caused mortality. The four panels differ in whether best estimate of abundance or 20th percentile of the abundance estimate was used for N_{MIN} and in whether abundance estimate has coefficient of variation (CV) of 0.2 or 0.8. (A) Using best estimate for N_{MIN} when CV = 0.8. (B) Using best estimate for N_{MIN} when CV = 0.2. (C) Using 20th percentile for N_{MIN} when CV = 0.8. (D) Using 20th percentile for N_{MIN} when CV = 0.2.

K, the *MNPL* (Fig. 2A, B; Fig. 3A, B). This replicated the results of Taylor (1993). In fact, in the pinniped simulations with poor precision of the abundance estimates (CV = 0.8), more than 5% of the trajectories went extinct (Fig. 3A; Fig. 4D). Using the 2.5th percentile (equivalent to the lower bound of a 2-tailed 95% confidence limit) for N_{MIN} resulted in all trajectories ending above *MNPL* for each case (Fig. 4), again replicating the results of Taylor (1993).

The percentile that just achieved the 100-yr performance criterion (95% of the trajectories above *MNPL* after starting at 0.3 of *K*) was close to the 20th percentile in all four base cases (Fig. 2C, D; Fig 3C, D; Fig. 4). A slightly

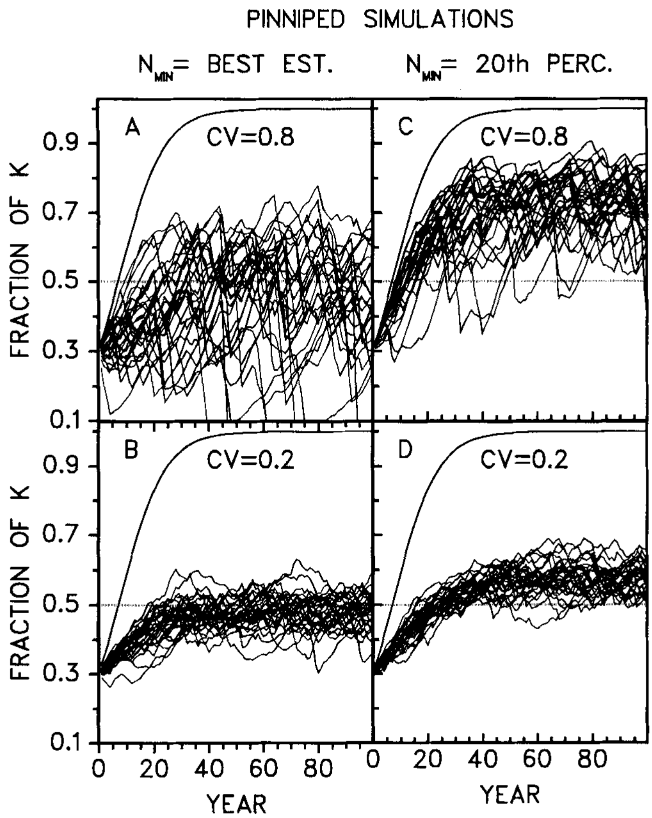

Figure 3. Simulated pinniped population trajectories ($R_{MAX} = 0.12$) with mean human-caused mortality equal to the estimated *PBR*, showing 30 sample trajectories out of a total of 2,000. Horizontal line represents maximum net productivity level (0.5*K*). Medium curved line represents population trajectory with no human-caused mortality. The four panels differ in whether best estimate of abundance or 20th percentile of abundance estimate was used for N_{MIN}, and in whether abundance estimate has coefficient of variation (CV) of 0.2 or 0.8. (A) Using best estimate for N_{MIN} when CV = 0.8. (B) Using best estimate for N_{MIN} when CV = 0.2. (C) Using 20th percentile for N_{MIN} when CV = 0.8. (D) Using 20th percentile for N_{MIN} when CV = 0.2.

higher value, the 25th percentile, was sufficient only for cetaceans with a high CV. Similar results were found for the 20-yr performance criterion (95% of the trajectories above *MNPL* 20 yr after starting at *MNPL*); the 20th percentile was sufficient or nearly sufficient in each case (Fig. 5). Therefore, using the 20th percentile for N_{MIN} achieved or nearly achieved both the 100- and 20-yr performance criteria.

Bias trials—After setting N_{MIN} equal to the 20th percentile of the abundance estimate, bias trial 1 (true mortality twice the estimated mortality) was run for a range of values of F_R. This type and magnitude of bias was considered a reasonable worst-case scenario, given the available information (Appendix).

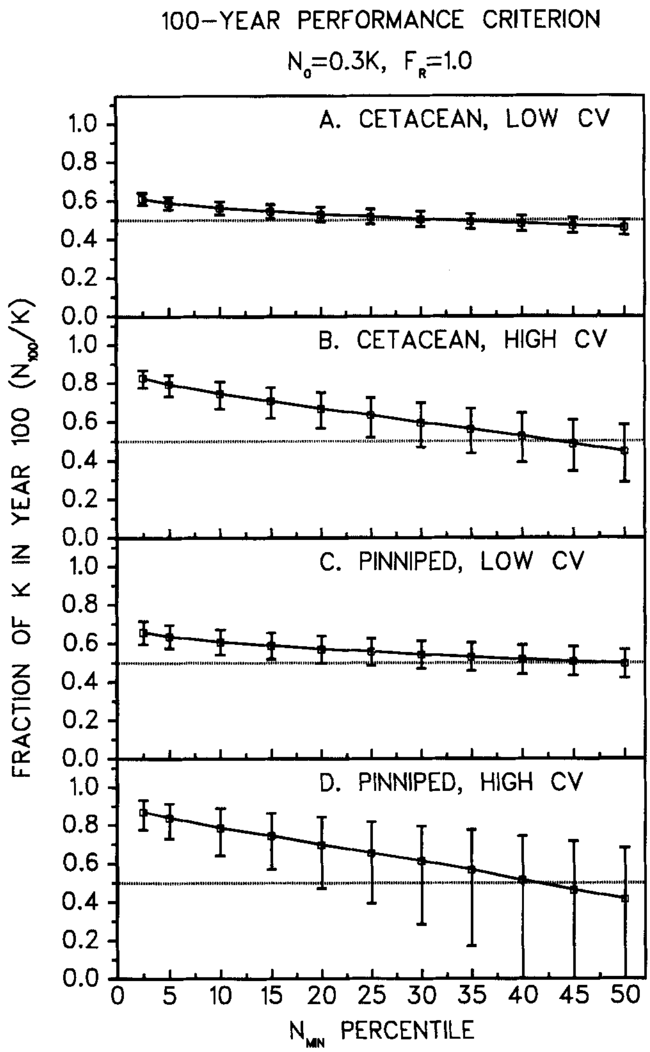

Figure 4. *MNPL* goal (100-yr performance criterion): population size after 100 yr *versus* percentile of abundance estimate used to calculate N_{MIN}, with F_R = 1.0 and initial population size equal to 0.3*K*. Boxes represent median value of simulations. Confidence limits capture 90% of simulations. Dotted line represents *MNPL* (0.5*K*). If lower confidence limit is above *MNPL*, simulation meets 100-yr performance criterion of 95% of trajectories ending above *MNPL*. (A) Cetacean (R_{MAX} = 0.04) with low CV (0.2). (B) Cetacean (R_{MAX} = 0.04) with high CV (0.8). (C) Pinniped (R_{MAX} = 0.12) with low CV (0.2). (D) Pinniped (R_{MAX} = 0.04) with high CV (0.8).

A value of 0.50 for F_R was sufficient or nearly sufficient for both pinnipeds and cetaceans to meet the 100-yr criterion, with 95% of the simulated trajectories above *MNPL* (Fig. 6). This is a consequence of the change in *PBR* being equivalent to the change in the mortality estimate due to the bias.

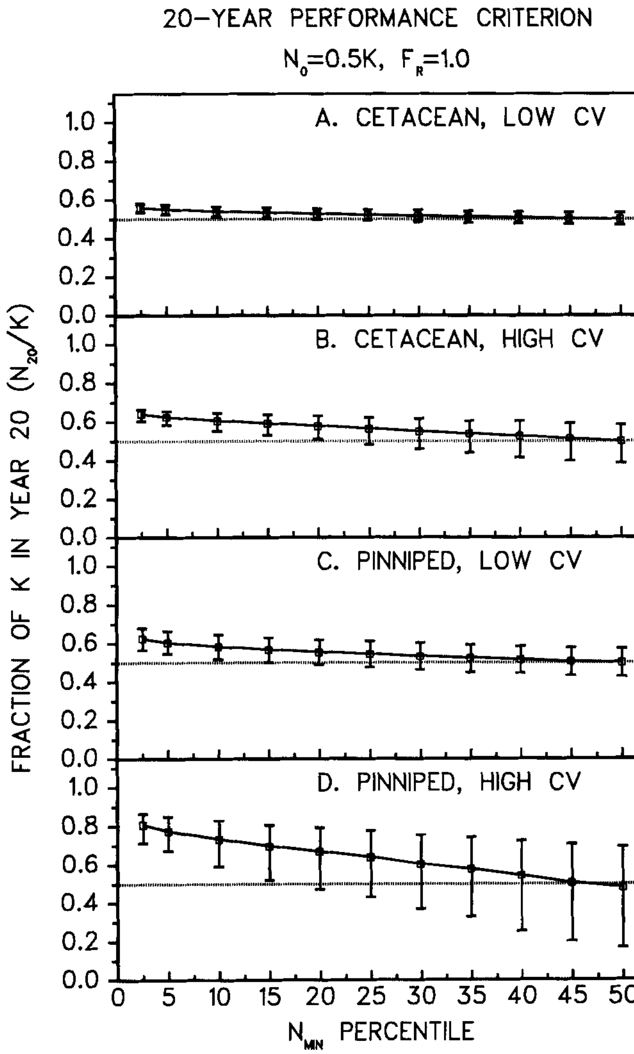

Figure 5. *MNPL* goal (20-yr performance criterion): population size after 20 yr versus percentile of abundance estimate used to calculate N_{MIN}, with F_R = 1.0 and initial population size equal to 0.5*K*. Boxes represent median value of simulations. confidence limits capture 90% of simulations. Dotted line represents *MNPL* (0.5*K*). If lower confidence limit above *MNPL*, simulation meets 20-yr performance criterion of 95% of trajectories ending above *MNPL*. (A) Cetacean (R_{MAX} = 0.04) with low CV (0.2). (B) Cetacean (R_{MAX} = 0.04) with high CV (0.8). (C) Pinniped (R_{MAX} = 0.12) with low CV (0.2). (D) Pinniped (R_{MAX} = 0.04) with high CV (0.8).

Setting F_R equal to 0.5 compensated for accidentally halving the mortality estimate and yielded the correct comparison between *PBR* and mortality.

The full bias trials confirmed that the combination of the 20th percentile for N_{MIN} and an F_R of 0.50 would meet or nearly meet the 100-yr criterion in all cases and trials (Fig. 7). Not surprisingly, bias trials 2 and 3 (overesti-

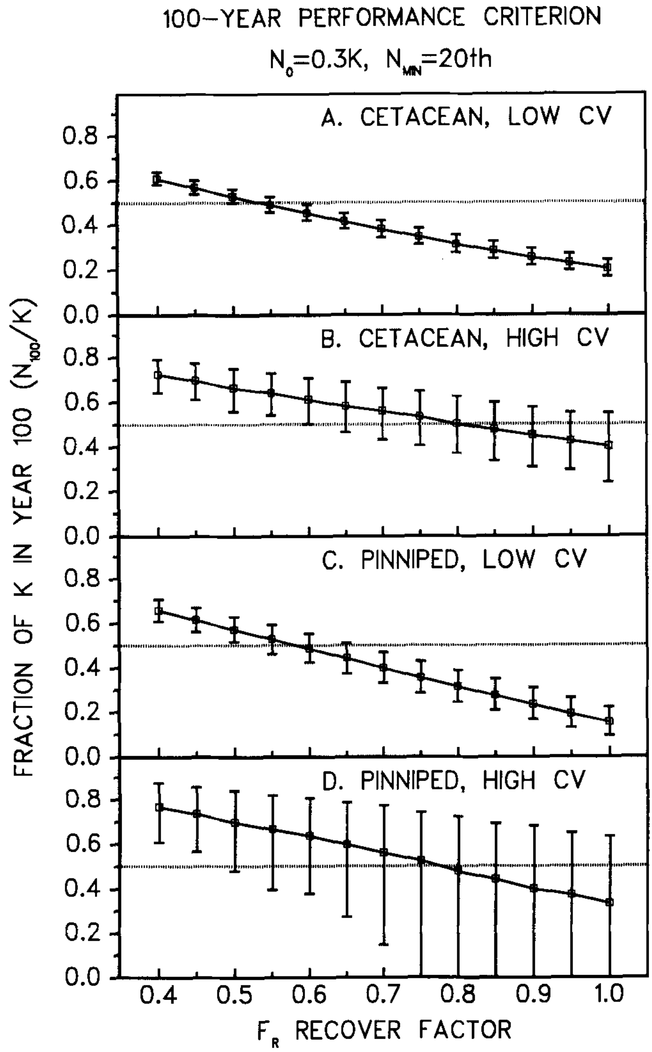

Figure 6. *MNPL* goal: bias trial 1 (true mortality twice estimated mortality), showing population size after 100 yr *versus* recovery factor (F_R) used to calculate *PBR*, with initial population size = 0.3*K*. Boxes represent median value of simulations. Confidence limits capture 90% of simulations. Dotted line represents *MNPL* (0.5*K*). If lower confidence limit is above *MNPL*, simulation meets 100-yr performance criterion of 95% of the trajectories ending above *MNPL*. (A) Cetacean (R_{MAX} = 0.04) with low CV (0.2). (B) Cetacean (R_{MAX} = 0.04) with high CV (0.8). (C) Pinniped (R_{MAX} = 0.12) with low CV (0.2). (D) Pinniped (R_{MAX} = 0.04) with high CV (0.8).

mating population size or R_{MAX} by a factor of 2) had similar results. Trials 2 and 3 both involved direct elements of the *PBR* equation and thus doubled the size of the *PBR*, whereas trial 1 effectively halved the mortality estimate. Bias trials 1, 2, and 3 had the greatest effect in terms of reducing the final population level after 100 yr relative to bias trial 0 (no bias).

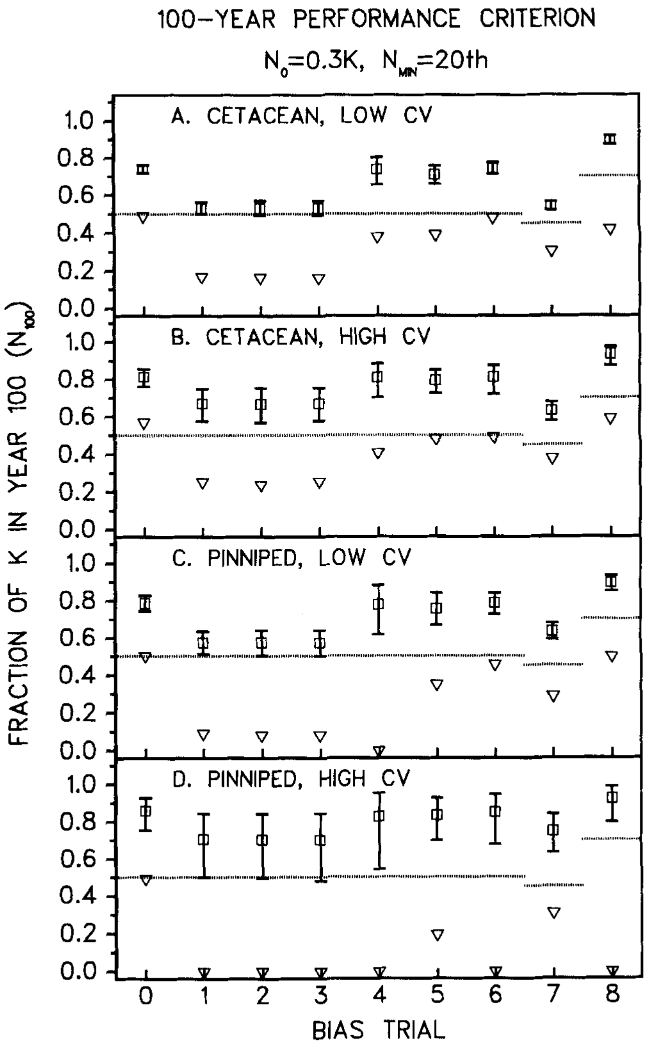

Figure 7. *MNPL* goal: population size after 100 yr for all bias trials, using 20th percentile for N_{MIN} and 0.5 for F_R, with initial population size = 0.3*K*. Boxes represent median value of simulations. Confidence limits capture 90% of simulations. Dotted line represents *MNPL*. If lower confidence limit is above *MNPL*, simulation meets 100-yr performance criterion of 95% of trajectories ending above *MNPL*. Triangles are lower confidence limits from simulations using F_R = 1.0 and thus represent effect of not accounting for unknown bias. (A) Cetacean (R_{MAX} = 0.04) with low CV (0.2). (B) Cetacean (R_{MAX} = 0.04) with high CV (0.8). (C) Pinniped (R_{MAX} = 0.12) with low CV (0.2). (D) Pinniped (R_{MAX} = 0.04) with high CV (0.8). Bias trials are (0) base case (no bias), (1) mortality, (2) abundance, (3) R_{MAX}, (4) abundance CV, (5) mortality CV, (6) survey frequency, (7) true *MNPL* = 0.45*K*, (8) mortality bias with true *MNPL* = 0.70*K*.

Severely underestimating the CV of the abundance estimate (trial 4) did not have as much effect in reducing the final population size except for the pinniped high-CV case. A value of 0.5 for F_R was sufficient to prevent depletion in that case and was more than sufficient in all the other cases. When the variance of the mortality estimates was severely underestimated (trial 5), there was less of an effect on the final population size, and an F_R of 0.5 was more than sufficient to prevent depletion. Doing abundance surveys every eight years instead of every four years (trial 6) had a strong effect only on the final population size of the pinniped, high-CV case, and again the value of 0.5 was sufficient to prevent depletion.

The effect on the final population size of an *MNPL* lower than the assumed $0.5K$ (trial 7) was moderately strong and was enough to cause depletion in each case (note that depletion here is defined as being below the different *MNPL* of $0.45K$). A value of 0.5 for F_R was more than sufficient to prevent depletion in most cases, but only by a small margin in the cetacean low-CV case. As expected, when the true *MNPL* was $0.7K$ (trial 8) in combination with biased mortality estimates, the population did relatively better than when the true *MNPL* was $0.5K$ (trial 1), although the effect of the bias in mortality was still enough to cause the populations to be depleted. Using F_R equal to 0.5 was then more than sufficient to prevent depletion.

In all cases the results from the bias trials for the 20-yr performance criterion were very similar to the results for the 100-yr criterion and thus are not shown. A recovery factor of 0.5 was just sufficient to meet the 20-yr performance criterion for trials 1–3 and more than sufficient for the other trials.

Carrying-Capacity Goal

The resulting distributions of population levels after 200 yr are shown for various values of F_R (Fig. 8). To achieve a goal of allowing a population to recover to at least a specific fraction of K, the lower confidence limit has to be above that level. For example, a limit of ML_K calculated with a value for F_R of 0.15 would be required for 95% of the simulations to be above $0.9K$ in all four cases. Alternatively a limit of ML_K calculated with a value for F_R of about 0.1 would be required for 95% of the simulations to be above $0.95K$ in all four cases.

Recovery-Rate Goal

The resulting distributions of percent increases in recovery time to *MNPL* are also shown for various values of F_R (Fig. 9). To achieve a goal of not delaying the time to recovery with 95% probability, the upper confidence limit has to be less than or equal to the specified percent increase in recovery time. For example, to not delay the time to recovery by more than 10%, the upper confidence limit has to be below the line shown in Fig. 9. Therefore, a limit of ML_{Rec} calculated with a value for F_R of 0.15 should accomplish

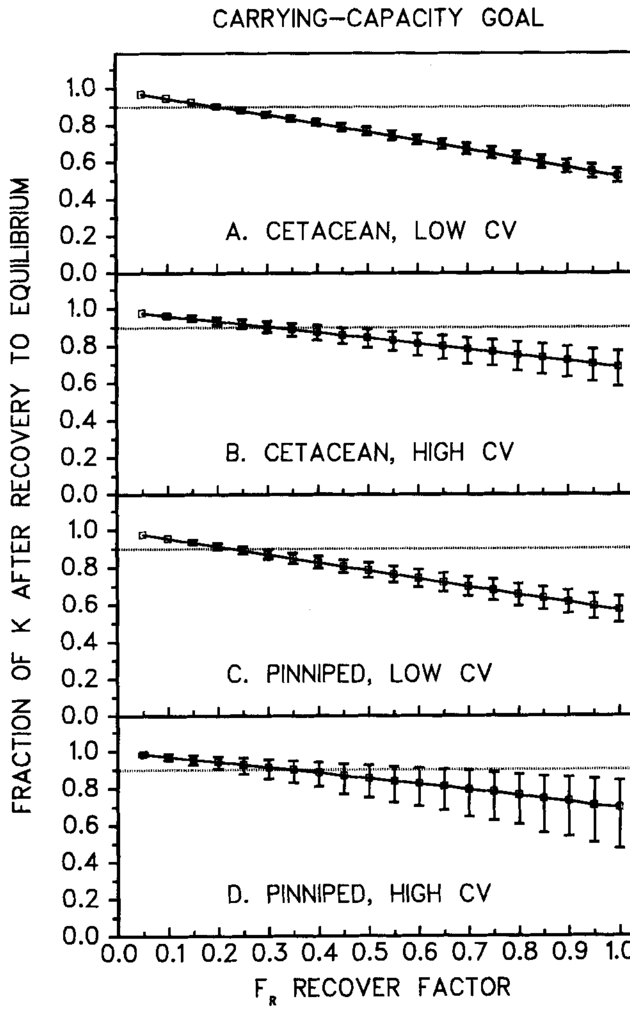

Figure 8. Carrying-capacity goal: population size after 200 yr *versus* value of recovery factor (F_R) used to calculate mortality limit ML_K, using 20th percentile for N_{MIN}. Initial population size = 0.05K but does not influence results as 200 yr is sufficient time for population trajectories to reach equilibrium. Boxes represent median value of simulations. Confidence limits capture 90% of the simulations. Dotted line represents example of possible conservation goal of maintaining populations at greater than specified fraction of K. If lower confidence limit is above line, 95% of trajectories would be at level greater than 0.9K. (A) Cetacean (R_{MAX} = 0.04) with low CV (0.2). (B) Cetacean (R_{MAX} = 0.04) with high CV (0.8). (C) Pinniped (R_{MAX} = 0.12) with low CV (0.2). (D) Pinniped (R_{MAX} = 0.04) with high CV (0.8).

this goal in all cases. Alternatively, a limit of ML_{Rec} calculated with a value for F_R of 0.25 would accomplish a goal of not delaying recovery by more than 20% for a cetacean population with a low CV (Fig. 9A), whereas a higher value of F_R would be sufficient in the other cases (Fig. 9B, C, D).

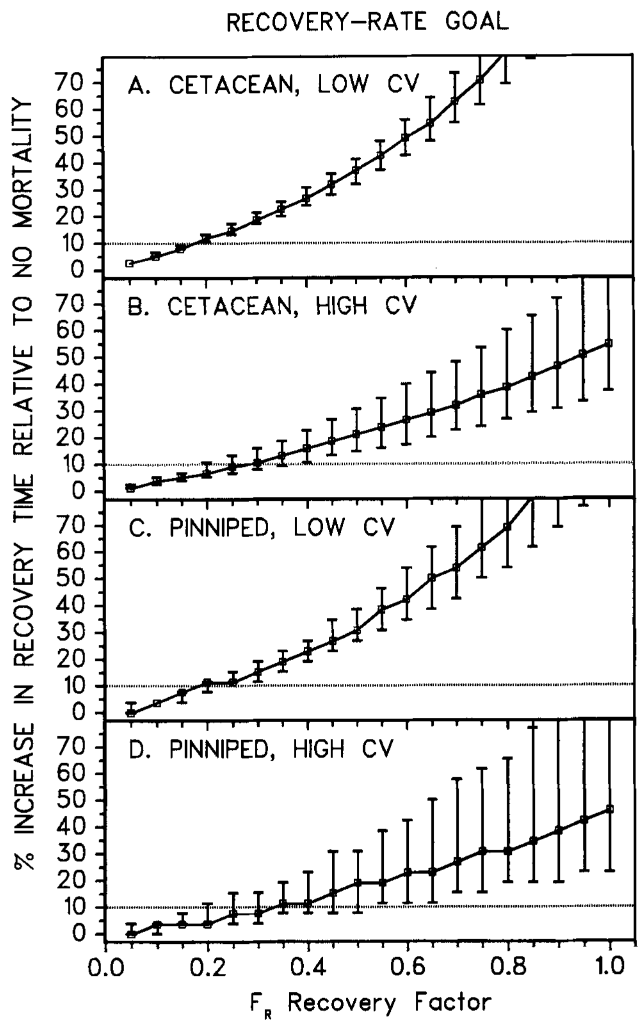

Figure 9. Recovery-rate goal: percent increase in time to recovery relative to population with no human-caused mortality, *versus* various values for recovery factor (F_R) used to calculate the mortality limit ML_{Rec}. Recovery is defined as achieving *MNPL,* although recovery to any specified population level will be delayed by approximately same percentage. Boxes represent median value of simulations. Confidence limits capture 90% of simulations. Dotted line represents 10% increase in recovery time. If upper confidence limit below 10% line, simulation meets example recovery-rate goal of 95% of trajectories not being delayed in their time to recovery by more than 10%. (A) Cetacean (R_{MAX}= 0.04) with low CV (0.2). (B) Cetacean (R_{MAX} = 0.04) with high CV (0.8). (C) Pinniped (R_{MAX} = 0.12) with low CV (0.2). (D) Pinniped (R_{MAX} = 0.04) with high CV (0.8).

DISCUSSION

MNPL Goal

Base-case trials—A sample of 30 of the simulation trajectories gives a visual representation of the performance of the chosen value of the 20th percentile for N_{MIN} (Fig. 2, 3; panels C and D). The desired properties of the management scheme are evident; depleted populations steadily recovered to a population level above *MNPL* and stayed there, in spite of uncertainty in the estimates of abundance and mortality. Additionally, motivation exists to improve the precision of the estimates of abundance, because for a given population level the *PBR* will be higher when the CV of the abundance estimate is lower (*e.g.,* in Fig. 1, lower panels, the expected *PBR* with a CV = 0.2 would be higher than the expected *PBR* with CV = 0.8). The *PBR* successfully allowed depleted populations to recover to above *MNPL* over 100 yr (the 100-yr criterion, Fig. 4) and also successfully maintained populations above *MNPL* over 20 yr (the 20-yr criterion, Fig. 5).

Although model simulations were used here to select specific values, one good characteristic of the *PBR*-based management approach is that all three components of the *PBR* have intuitive meaning by themselves and in how they are put together to calculate *PBR.* In other words, they have meaning apart from the specific population dynamics model used in the simulations. The *PBR* can be thought of as an appropriately conservative estimate of what the current net production of the population would be if it were currently at a true *MNPL* of 0.5*K.*

One half of R_{MAX} should be a conservative estimate of the current net production rate of a depleted population (*i.e.,* a depleted population should achieve more than $\frac{1}{2}R_{MAX}$ if there are no Allee effects), thus reserving part of the net production of the population for recovery. It will not be a conservative estimate if the population is not depleted. The 20th percentile of the abundance estimate represents a population level that should be smaller than the true population size and is based on the familiar concept of a lower confidence limit of the abundance estimate. Thus, current production is calculated from appropriately conservative values of the current production rate and the current population size. Using a recovery factor of less than 1.0, such as 0.5, provides a safety factor to account for levels of unknown bias or estimation problems that have been observed in some populations of marine mammals and would also account for less severe biases co-occurring, such as overestimating R_{MAX} while underestimating mortality.

It would be possible to perform simulations tailored to the specific information available for a particular stock. In other words, a *PBR* for each stock could be calculated from a unique simulation determined by the stock's specific estimates of abundance, mortality, and their associated CVs. However, a panel of scientists convened to review this issue recommended a simpler approach (Barlow *et al.* 1995*b*). That is, there is utility in having the *PBR* calculated from familiar quantities (such as a predetermined confidence limit) so that the process of calculating a mortality limit can be more transparent and intuitive to the casual observer rather than being a quantity that just emerges from a complex computer simulation.

Setting N_{MIN} equal to the 20th percentile of an abundance estimate maintained about 95% of the simulated populations above *MNPL* for all four base cases. It would be possible to calculate for each specific base case an exact percentile (that would be close to but different from the 20th percentile) that would meet the 100-yr performance criterion exactly for that particular base case. However, it is likely that a different percentile would result from meeting the 20-yr performance criterion exactly, and then it would be uncertain which percentile should be used. Additionally, as reasonable as the base-case simulations are, no one can be confident that they exactly represent the true dynamics of any real marine mammal population. Therefore, there is no strong reason to calculate an exact percentile for each case. Thus, the 20th percentile serves as a generic standard that can be expected to work reasonably well in a variety of real world situations.

Some examples illustrate the use of the *PBR*. Harbor porpoises (*Phocoena phocoena*) are killed incidentally in gillnet fisheries throughout their range. The Gulf of Maine population of harbor porpoises is impacted by the sink gillnet fishery. Abundance surveys in 1991 and 1992 led to a combined estimate of 47,200 (CV = 0.19) (Palka 1995). The 20th percentile of the abundance estimate is 40,297. Using the default R_{MAX} of 0.04 and a value of 0.5 for F_R means that the *PBR* is equal to $0.01N_{MIN}$, and is thus 403. Total fisheries mortality in 1993 was estimated to be 1,876, which is more than four times the *PBR* (Blaylock *et al.* 1995). In this case, the *PBR* calculation identified a population for which the mortality may not be sustainable.

Similarly, harbor porpoises in central California have been killed in the set gillnet fishery for Pacific halibut for many years, which may have caused the population to decline (Forney 1995). The most recent abundance estimate for this stock is 4,120 (CV = 0.31) from surveys from 1988 to 1993 (Barlow and Forney 1994), which results in an N_{MIN} of 3,431 and a *PBR* of 34. Fisheries mortality was greater than 100 per year for every year from 1979 to 1987, with a peak of 303 in 1984 (Barlow and Forney 1994). Fisheries mortality has decreased since the peak but was still equal to or greater than the *PBR* in every recent year through 1992. A substantial drop in fishing effort led to an estimated mortality in 1993 of only 11 animals. Thus, for this stock, human-caused mortality was greater than the *PBR* and may have caused a decline in the population, but the 1993 level of mortality was probably sustainable.

As a final example, harbor seals (*Phoca vitulina richardsi*) in Oregon and Washington coastal waters have been incidentally killed in several gillnet fisheries. In 1991–1992, the estimated mortality in the Washington and Oregon lower Columbia River drift gillnet fishery for salmon was an average of 213 harbor seals a year, with total mortality (including two other fisheries) estimated at 233 per year. The abundance of this population in 1992 was estimated to be 29,939 (CV = 0.062), which results in an N_{MIN} of 28,322 (Barlow *et al.* 1995*a*). A *PBR* calculated as the product of N_{MIN}, 0.06 (½ of the R_{MAX} of 0.12), and 0.5 (F_R) would be 849. The estimated human-caused mortality is well below this hypothetical conservative *PBR*[1], and therefore it can be concluded that this level of mortality is sustainable. Corroborating this conclusion is the evidence that this population is currently increasing in size (Barlow *et al.* 1995*a*).

Bias trials—The bias trials involve levels of bias that should be relevant to a variety of marine mammal populations, as most of the specified magnitudes of bias have been noted at least one time in real situations (Appendix). Past experiences with potential biases in estimates of mortality, abundance, and R_{MAX} (trials 1–3), as well as the definition of stock structure, lend justification to the concept of using a safety factor to guard against unknown biases when potential problems cannot be ruled out. Trials 4 and 5 indicate that biases in the estimated variances of mortality and abundance are less worrisome. In situations where it is known there is no bias in the parameters, and where the stock structure is accurately identified, a *PBR* calculated with an F_R of 1.0 should be a sufficient limit for human-caused mortality. However, the question remains as to when one will be sufficiently confident that no bias exists and that the stock structure is correctly identified. Only the most well-studied marine mammal populations will meet such high standards. Therefore, the default case should be to use a value of F_R less than 1.0, such as the value of 0.5 that was shown here to pass the specified bias trials. This will ensure a robust management procedure that will work for populations of unknown status, even under conditions of fairly severe bias in the collection of data. Populations meeting specified criteria regarding available information could have F_R increased from the default value. This potential would encourage the collection of better information when the effect of a certain level of human-caused mortality on a population is in question. One possible criterion for increasing F_R could be if a population increases while experiencing a known level of incidental mortality, which provides confirmation that such a level of mortality is sustainable. However, before such action is taken to raise the F_R value from the default value, reasonable assurance in the form of scientific justification should be provided to ensure that the estimates of abundance, mortality, and R_{MAX} are not severely biased and that the coefficients of variation of the abundance and mortality estimates are within the range used in these simulations (< 0.8 for the abundance estimate, < 0.30 for the mortality estimates).

The simulations were run assuming *MNPL* was 0.5*K*. If *MNPL* is actually higher than 0.5*K*, populations will achieve higher population levels than they would have with *MNPL* equal to 0.5*K*. For example, in bias trial 8, which is identical to trial 1 except for having an *MNPL* of 0.7*K* rather than 0.5*K*, the simulated trajectories reach both a greater population level and a greater level relative to *MNPL* (Fig. 7). This occurs because the *PBR* is calculated assuming a growth rate of $\frac{1}{2}R_{MAX}$ at 0.5*K*, but populations with an *MNPL* greater than

[1] Note that the actual *PBR* for this stock was 1,699; $F_R = 1.0$ was used because the population is significantly increasing (Barlow *et al.* 1995*a*).

$0.5K$ will actually be growing at a rate higher than $\frac{1}{2}R_{MAX}$ when they are at $0.5K$ (Fig. 1). The inability to precisely estimate *MNPL* for any marine mammal population, even some of the best studied (Ragen 1995), is part of the motivation for moving to a management scheme that does not require knowing what the *MNPL* actually is. The proposed management scheme is robust to higher values of *MNPL*. In such cases a population with human-caused mortality as great as the *PBR* would exceed the performance criteria specified here (*i.e.*, the *PBR* would be conservative relative to the goal of having 95% of the trials meet the short-term and 100-yr performance goals).

Bias trial 8 indicated by how much the population might exceed the performance criterion. Under the condition of true mortality twice the estimated mortality, with F_R equal to 1.0, it can be seen that populations with *MNPL* equal to $0.7K$ would still become depleted. The additional benefit to the population of the higher *MNPL* level was not enough to compensate for the biased mortality estimates. When F_R is set to 0.5, all of the simulated populations recover (as expected) to higher population levels than those of trial 1, where *MNPL* was equal to $0.5K$ (Fig. 7). Such populations exceed the performance criterion by a moderate to large amount, whereas when the true *MNPL* was $0.5K$, the populations just met the performance criterion (trial 1). This amount of potential extra conservatism seems a reasonable trade-off, *versus* the possibility of depletion given the complete lack of information regarding specific *MNPL* levels.

Note that in each bias trial only one parameter was assumed biased (except trial 8). In real situations, consideration needs to be given to the possibility of multiple biases.

The Carrying-Capacity and Recovery-Rate Goals

The goals of the U.S. MMPA are reasonable but, of course, are not the only goals which could be considered for managing the human-caused mortality of marine mammals. For example, one possible conservation goal could be to maintain populations at or near their pre-exploitation level (*i.e.*, their population level in the absence of human-caused mortality). Under the U.S. MMPA, a population previously unexploited would be allowed to decline to a level just above *MNPL*, which could be a level as low as 50% of *K*. However, such a decline would be unacceptable if one had the goal of maintaining populations close to their pre-exploitation levels. Conservation goals are rarely stated in specific quantitative terms. However, if a specific goal can be stated, such as maintaining populations at a level above 90% of *K*, then a limit of ML_K can be set by choosing the appropriate value for F_R from Figure 8.

The second type of alternative goal considers the population growth rate rather than the final population level; this might be most appropriate for managing the human-caused mortality of populations that are at a small fraction of their pre-exploitation level. Ensuring that the time to recovery is not substantially delayed is a way of ensuring that the population growth rate is not substantially reduced, thus promoting recovery. Like the use of the *PBR*, setting a mortality limit in this way allows a management scheme to work without requiring one to be able to estimate precisely the exact level of the population relative to its pre-exploitation size, as the limit ML_{Rec} is based on an abundance estimate and is calculated in the same way regardless of the current population level. In other words, this scheme can be applied to populations which are thought to be at a low level even if it is impossible to know precisely where they are relative to *K*.

The mortality limit ML_{Rec} may be useful for species given special protection status because they are at a low level. For example, in the U.S., most large whales were listed as "Endangered" under the U.S. Endangered Species Act because they were thought to have been reduced to low population levels by commercial whaling. Therefore, the U.S. in calculating *PBR*s chose to use a value of 0.1 for F_R for these species, based partly on the rationale that this would not cause more than a 10% increase in the time to recovery (Barlow *et al.* 1995*b*). Such a mortality limit should allow a large fraction of the net production of the population to go to population increase and eventual recovery and should thus have a relatively insignificant negative impact upon the population.

However, managing the human-caused mortality of endangered species involves some special considerations. A mortality level that is not thought to have much of an impact on the population growth rate would appear to be insignificant. However, for populations of extremely low abundance, any human-caused mortality may be significant. For such populations, the effect of human-caused mortality needs to be evaluated in the context of how much it might increase the risk of extinction for the population, which is beyond the scope of this paper. In other words, the goal of not delaying recovery time does not substitute for a proper population viability analysis (Gilpin and Soule 1986) that considers other factors, such as environmental and demographic stochasticity, that is most appropriate for evaluating the human-caused mortality of a small population that is at risk of extinction.

Additionally, situations where a population is declining for unknown reasons makes the evaluation of known human-caused mortality difficult. A mortality limit may still be useful in evaluating the role of various known sources of human-caused mortality. For example, if a declining population has an incidental fisheries mortality that is less than the *PBR*, one can then fairly reliably conclude that the fisheries mortality is not solely responsible for the decline. This allows managers to set research priorities; in this case they would need to investigate other possible causes of the decline besides the fisheries mortality.

Model Assumptions

The generalized logistic model used in these simulations is admittedly one that oversimplifies nature. However, it should accurately represent the main features of marine mammal population dynamics that are important to setting limits for human-caused mortality, with certain caveats discussed below.

The base trials assumed that *MNPL* was at least 0.5*K*. Eberhardt (1977) suggested that *MNPL* might be well above 0.5*K* for marine mammals, which corresponds to a convex non-linear response of the net recruitment rate to population size (*e.g.*, Fig. 1 with *MNPL* = 0.7*K*). Fowler (1981) used a model based on an evolutionary argument to infer that cetaceans would have an *MNPL* level well above 0.5*K*. Empirical evidence that is available for large, long-lived mammals has shown convex non-linear density dependence in life history parameters such as age-specific birth and mortality rates (Fowler *et al.* 1980; Fowler 1987, 1994), which would again indicate *MNPL* > 0.5*K*. Similarly, the data sets available for marine mammals, though fewer in number (Fowler 1984), are generally consistent with those found for large terrestrial mammals. Goodman (1980) showed that a linear density-dependent change in only the birth rate (which implies *MNPL* = 0.5*K*) would actually cause the population growth curve to be convex (*MNPL* > 0.5*K*). Taylor and DeMaster (1993) reviewed the available empirical data and concluded that (1) marine mammals show density-dependent responses, (2) these responses are not abrupt changes close to *K* (*i.e.*, knife-edge), and (3) these responses have not been shown to be concave, though the statistical power to detect concavity is low. Their analyses showed that combinations of even highly convex density-dependence in more than one life history parameter translates into a population level response where the inflection point of the growth curve (*i.e.*, *MNPL*) occurred at a population level that was less than 0.8*K*. Further, a concave population response could be produced only by the combination of linear responses in several life-history parameters. This, in combination with the lack of evidence for concave responses in life history parameters, led them to conclude that *MNPL* > 0.5*K* (Taylor and DeMaster 1993).

As shown and discussed above, the *PBR* scheme is robust to population dynamics which have a value for *MNPL* greater than 0.5*K*. Bias trial 7 showed that a value for F_R of 0.5 would be sufficient to make the scheme robust to values of *MNPL* as low as 0.45*K*. At some lower value for *MNPL* the scheme would no longer be robust, but there is little evidence to suggest such dynamics in large mammals. Such a low *MNPL* implies that individual animals feel the effects of the addition of another animal to the population much more strongly at very low densities than at high densities. In Figure 1 it can be seen that a value of less than 0.45*K* for *MNPL* would imply that a population can achieve a *per capita* growth rate of more than half its maximum possible value only when it is reduced to less than about 25% of its carrying capacity. Although such strongly concave dynamics in a single life-history parameter of a large mammal are not known to occur, it should be recognized that MacCall and Tatsukawa (1994) provided a theoretical mechanism for producing such dynamics from strong density-dependent habitat selection combined with certain types of habitat gradients (see the Appendix for further discussion of this point).

The generalized logistic model does not have what is referred to as the Allee effect, where at some point the net production rate declines as population size gets lower, rather than continuing to increase. Fowler and Baker (1991) concluded that the Allee effect was likely to be a common phenomenon in animal population dynamics, especially populations at a level less than $0.1K$. Therefore, the Allee effect is an important consideration for assessing the risk of extinction (Fowler and Baker 1991) but would likely not be of significance to the *MNPL* goal simulations performed here, as those simulations all start at $0.3K$ or higher. However, the Allee effect could influence the recovery time of populations reduced to lower levels and thus warrant further attention for calculations of ML_{Rec}.

The generalized logistic model also does not explicitly take into account the age and sex structures of the population. This should not make a difference in estimates of N_{MIN} or F_R as long as the human-caused mortality is relatively random with respect to age and sex. However, if the human-caused mortality is highly selective, it could be a cause for concern. Higher mortality of females relative to males would likely cause a population to decline to a lower level than if the mortality were random. Similarly, selective mortality of animals close to the age of sexual maturity would also have a greater impact, as these are the animals with the greatest reproductive value to the population. Where possible, data on the age and sex distributions of the animals killed should be collected. If such data indicate that the mortality is highly selective, a case-specific simulation could be used to calculate a *PBR* in a way similar to the approach used here, but using an age- and sex-structured model to account for selective mortality.

The model used is deterministic rather than stochastic, meaning that there is no variability in the population growth rate at a particular population size due to environmental variance. Simulations using a stochastic model would be possible, but specifying the amount of environmental variance to simulate for cetaceans may be difficult because such data are difficult to obtain. For pinnipeds, it is often possible to see environmental effects upon populations, such as large changes in the number of pups produced from one year to the next. The simulation results presented here may be relatively robust to environmental variance, as the *PBR* will be self-correcting in one sense; a sudden decline in a population due to unfavorable environmental conditions will be reflected in a lower subsequent abundance estimate and thus result in a lower *PBR*. However, it would still be useful to investigate the effects of stochastic dynamics through simulations which incorporated plausible levels of environmental variance.

Alternatives

There are other ways that N_{MIN} and F_R could be adjusted to meet the same performance criteria specified here. For example, F_R could be set to 1.0 and then the N_{MIN} percentile could be found that would have passed the bias trials. Alternatively, a point estimate of abundance could be used for N_{MIN}, and the value of F_R could be found that would have passed the bias trials. However, the two-part procedure suggested here has some desirable qualities. First, using a lower confidence limit for N_{MIN} is an intuitively reasonable method of accounting for the uncertainty of an abundance estimate. For management in the U.S., it also meets the intent of the 1994 amendments to the MMPA, which state that N_{MIN} "(A) is based on the best available scientific information on abundance, incorporating the precision and variability associated with such information; and (B) provides reasonable assurance that the stock size is equal to or greater than the estimate." Second, using a lower confidence limit encourages improving the precision of abundance estimates, as lower CVs result in higher *PBR*s. Third, separating the factors that account for precision (N_{MIN}) and other uncertainties such as bias (F_R) allows for flexibility in management. Finally, as discussed before, a *PBR* calculated this way has some biological meaning, as the product of N_{MIN} and R_{MAX} represents a conservative estimate of what the current net production would be if the population were at *MNPL,* and the recovery factor accounts for possible unknown biases and problems.

Another area that could be explored would be how to combine abundance estimates to improve precision. The simulations used here ignored previous abundance estimates once a new "survey" was performed. Use of previous estimates would involve a trade-off between improving precision by using more data and increasing potential bias from using abundance estimates made when the population was possibly at a different size. The performance of various methods of combining abundance estimates over a specified time period could easily be investigated, using the same simulation framework presented in this paper.

Conclusions

Adjusting the values of N_{MIN} and F_R to meet specific criteria should allow for a robust management procedure that will prevent the depletion of marine mammal populations by known human-caused mortality. This can be accomplished without being unnecessarily conservative or restrictive on the sources of human-caused mortality, such as commercial fisheries. If an estimate of human-caused mortality exceeds the calculated *PBR* for a population, it should serve as a warning that the mortality could lead to the depletion of the population.

It is important to note the distinction between estimating mortality to be greater than the *PBR versus* detecting a significant decline in abundance. Where mortality exceeds the *PBR,* it may be sufficient to cause a decline in abundance and subsequent depletion. This situation can be identified with only a single abundance estimate. This is not the same as directly detecting a significant decline in abundance, which generally takes many years of data (Gerrodette 1987). Initially, some populations with sustainable levels of human-caused mortality may, by chance alone, have estimated mortality greater than *PBR.* However, if the level of mortality is truly sustainable, subsequent estimates will show mortality to be less than or equal to the calculated *PBR.* The simulations performed here must be interpreted to mean that if mortality is consistently estimated to be greater than the *PBR* over many years, then the population will become depleted with a probability estimated to be > 0.05. Estimating incidental mortality in one year to be greater than the *PBR* calculated from a single abundance survey does not prove the mortality will lead to depletion; it identifies a population worthy of careful future monitoring and possibly indicates that mortality-mitigation efforts should be initiated.

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APPENDIX

Plausibility of the Specified Bias Trials

The specified types and magnitudes of bias were chosen because they were thought to represent real possibilities. Justification for the selected levels of bias is presented here. Because the bias trials represent simulations under conditions of unknown bias, there is no definitive way to objectively determine what the magnitude of an unknown bias might be. However, it is possible to examine known biases to gain some insight into what plausible unknown biases might be.

Trial 1: Mortality Estimates

There are several ways in which estimates of incidental fisheries mortality can be biased. Usually, only a small fraction of all fishing trips are observed in a fishery, and mortality rates from those observed fishing trips are extrapolated to the total effort of the fishery. This standard method will give an unbiased estimate of marine mammal mortality only if the observed trips are representative of all trips. One way in which this assumption can be violated is if there are "observer effects" in which the behavior of the fishermen is different when they carry an observer aboard than when they do not. For example, a statistical analysis concluded that significant observer effects occurred in the eastern tropical Pacific tuna purse-seine fishery (Wahlen and Smith 1985). However, this fishery probably represents a special case in that the rate of marine mammal mortality is very much dependent upon the expertise of the crew and the amounts of time and energy expended to release dolphins from the net.

A more general source of potential bias from observer effects can occur if marine mammal mortality rates vary predictably depending upon when and where the fishermen fish. For example, harbor porpoise mortality rates in the Gulf of Maine sink gillnet fishery have been seen to vary by location and time of year, which has led to the implementation of time-area closures to attempt to reduce the mortality (NMFS 1994*a*). Where such variation in mortality rates exists (without time-area closures being implemented) the potential exists for fishing vessels with observers to stay away from areas where they have experienced high incidental takes of marine mammals in the past. This could lead to overall mortality being underestimated.

Mortality estimates for gillnet or other fisheries can also be biased because animals fall out of the gear while the gear is being hauled in and thus are not counted by an observer. Net fallout which could be observed from the vessel was found to be a potential problem in observing the Gulf of Maine sink gillnet fishery, where it was determined that many incidentally caught porpoises did not come aboard the vessel, and thus it was important for the observers to watch the net as it came out of the water (NMFS 1994*b*). Of course, in any gillnet fishery the possibility also exists that caught animals may fall out of the net or swim away entangled in a portion of the net before the net is retrieved and so may never be observed. Quantifying this kind of bias would be very difficult, as it would involve inspecting the net while it is still in the water in its fishing position just prior to being hauled in.

There are other potential sources of bias in mortality estimates that are common. Often, due to logistical or practical difficulties, it is not possible to place observers on vessels in a completely representative way. For example, it may be possible to place observers only on vessels in the larger ports, so vessels fishing out of smaller ports (and their mortality rates) may be under-represented. Also, fishing effort is often estimated using surrogate measures, such as the quantity of fish landed, and such conversions introduce the possibility of other kinds of bias. In conclusion, unless observer coverage approaches 100%, in many fisheries it will be difficult to exclude the possibility of bias in mortality estimates. It is plausible that mortality could be underestimated by one-half. For example, this could occur if mortality rates differed by a factor of 2 spatially, and if observed boats always went to known low-mortality locations.

Trial 2: Abundance Estimates

This trial used a twofold positive bias in abundance. Most estimates of abundance for cetaceans are from line-transect data. Most potential biases of line-transect data are negative, and sources of positive bias are limited. One known source for some species is attraction to vessels, which is often a problem with Dall's porpoise (*Phocoenoides dalli*), for example, and can introduce more than a twofold positive bias. Such a bias would be more than is accounted for by this bias trial, but it should be recognizable and not remain unknown (and thus be corrected for).

Another possible positive bias, especially for dolphins, comes from overestimating mean group size because of the easier detection of large groups. However, such a bias is unlikely to result in a greater than twofold overestimate of abundance. This type of bias is also identifiable and correctable.

Abundance might be overestimated by a factor of two very easily from incorrectly identifying the stock structure of the population in question, such as in a situation where two stocks with limited movement between them were considered one stock. Abundance would essentially be overestimated by a factor of 2 in a case where the stocks were of equal size and all human-caused mortality was in the region of just one stock. This is a plausible unknown bias because examples exist of just such scenarios. For example, the two stocks of harbor porpoise in California waters have estimated abundances of 4,120 for the central stock and 9,250 for the northern stock, but incidental fisheries mortality in the coastal set gillnet fishery occurred only within the range of the central stock (Barlow and Forney 1994). If the two stocks were treated as one stock, the lumped abundance would essentially overestimate, by a factor of more than 3, the estimated abundance of the population experiencing the mortality.

Trial 3: R_{MAX}

The *PBR* calculations assume that R_{MAX} is 0.04 for cetaceans and 0.12 for pinnipeds. Where species-specific information is available, it should be used rather than these defaults. However, it is difficult to estimate R_{MAX} because of the difficulty in estimating all of the life history parameters for marine mammals. In particular, survival rates are difficult to estimate, as to do so requires following the fate of individual animals within an increasing population over long periods of time. Alternatively, observed rates of increase may or may not serve as a good surrogate for R_{MAX}, depending on whether or not the population is at a low level relative to carrying capacity. Observed rates of increase should at least provide a lower bound for R_{MAX}. Therefore, a brief review of what data are available for some species may provide some guidance for setting default values when no data are available for a species. If the true value of R_{MAX} is higher than the default, then the *PBR* as calculated is too conservative. The issue here for the bias trial is what the appropriate value to use as a default is when no data are available. Most important is to choose a reasonable value for R_{MAX} for most species, while minimizing the possibility that this value is much higher than the true unknown value of any particular species. Such species could become depleted if their human-caused mortality were as high as a *PBR* calculated using the default value.

There are several estimates of rates of increase greater than 4% for mysticetes, especially southern hemisphere right whales (*Eubalaena australis*) (Best 1993). However, the northwest Atlantic population of right whales, *E. glacialis*, has been estimated to be growing at only 2.5% per year (Knowlton *et al.* 1994). Because that population is estimated to number only a few hundred animals, it should be growing at a maximum rate unless some form of depensation is taking place. The estimated net productivity (increase plus harvest) of gray whales, *Eschrichtius robustus*, was about 4% per year from 1968–1988 (Reilly 1992). An estimate of 3.4% per year was made for bowhead whales, *Balaena mysticetus* (Zeh *et al.* 1991). Although some mysticete populations apparently have an R_{MAX} greater than 4%, in unknown situations 4% is a reasonable default. Given the apparent observed rate of the northwest Atlantic right whale, 2% is a reasonable worst-case scenario.

Modeling of the life history of some odontocetes indicated that R_{MAX} could be as high as 0.06 if survival rates were very high (Reilly and Barlow 1986). However, such a high rate of increase has never actually been observed in an odontocete, although few observations of any kind exist. The rate of increase for a population of resident killer whales (*Orcinus orca*) has been estimated at 2.9% (Olesiuk et al. 1990*a*) and 2.5% (Brault and Caswell 1993) per year, but the maximum rate for this population could be higher. The eastern spinner dolphin (*Stenella longirostris orientalis*) was estimated to have an R_{MAX} of only 2%, although the 95% confidence limit on that estimate did not exclude 4% as a possible value (Wade 1994). In the same study the northeastern stock of offshore spotted dolphins (*Stenella attenuata*) was estimated to have an R_{MAX} of about 4% (Wade 1994). The lack of evidence of higher rates suggests that 4% is probably a suitable default value for odontocetes and that 2% represents a reasonable worst-case scenario. However, some caution is required, as so few data exist on observed rates of increase of odontocetes. Also, although several odontocete populations have apparently declined from human-caused mortality, none have been observed to recover. Although this may be due to the difficulty in monitoring odontocete populations, it also suggests that maximum rates of increase for some odontocetes could be even lower than 2%.

Some observed rates of increase are available for recovering phocid populations. The highest estimated rate of increase for the total northern elephant seal (*Mirounga angustirostris*) population is 8.3% per year (Cooper and Stewart 1983). Harbor seals (*Phoca vitulina*) in British Columbia increased at 12.5% per year from 1974 to 1988 (Olesiuk *et al.* 1990*b*). A preliminary estimate of the rate of increase of harbor seals in California was 9.7% per year from 1982 to 1992 (Barlow *et al.* 1995*a*). The Oregon and Washington coastal-waters stock of harbor seals increased 11% per year from 1977 to 1982 (Barlow *et al.* 1995*a*). The pup production of three undisturbed populations of grey seals (*Halichoerus grypus*) in the Outer Hebrides (1970–1976), Orkney (1964–1968), and the Farne Islands (1956–1971) increased at 6%–7% per year (Summers 1978); these populations were not at extremely low population sizes and they have likely increased at least since being partly protected in 1914, so the maximum growth rate for gray seals is possibly higher. The highest observed rate of increase at a breeding site for the Hawaiian monk seal (*Monachus schauinslandi*) is only 5%–6% per year (Gilmartin and Eberhardt 1995).

Several rates of increase are available for recovering otariid populations, especially in the Southern Hemisphere. Antarctic fur seal (*Arctocephalus gazella*) pup counts on South Georgia were estimated to have increased at 16.8% per year from 1958 to 1972 (Payne 1977), but a correction factor for undercounting was applied only to the last data point. An analysis of the uncorrected counts gives an estimate of 13.1% per year (York 1987). The total population of subantarctic fur seals (*Arctocephalus tropicalis*) increased 12.9% per year from 1951 to 1988 on Marion Island and 9.7% per year from 1982 to 1988 on Prince Edward Island, and the antarctic fur seal (*Arctocephalus gazella*) increased 10.9% per year from 1981 to 1988 on Marion Island (Wilkinson and Bester 1990).

However, for the Northern Hemisphere, York (1987) pointed out the great difference observed between *Arctocephalus* spp. and the northern fur seal (*Callorhinus ursinus*), which has been well studied and whose maximum observed rate of increase in pups was only 8% per year from 1911 to 1924 (Kenyon *et al.* 1954). A preliminary estimate of the net productivity rate of California sea lions (*Zalophus californianus*) from 1980 to 1994 was 11.7% per year (Barlow *et al.* 1995*a*).

In conclusion, 12% is a reasonable default value for R_{MAX} for both phocids and otariids. The information available regarding the monk seal suggests 6% may be a plausible worst-case scenario for phocids, although it is debatable how relevant the life history of monk seals is to other phocids. Six percent is likely a conservative worst-case scenario for otariids. The relatively low observed rate for the well-studied northern fur seal (8%) indicates that although many otariids have been observed to increase at rates of around 12% per year, it is not safe to assume that any otariid will necessarily increase at a rate that high.

Trial 4: CV of the Abundance Estimate

Although there is often much discussion of potential biases in abundance estimates, there has not been as much consideration given to potential biases in estimates of the variance of those abundance estimates. However, long-time series of abundance have occasionally resulted in more interannual variation in abundance estimates than expected from the estimated variance. For example, annual estimates of abundance for the southern stock of common dolphin (*Delphinus delphis*) in the eastern tropical Pacific showed a significant decline from 1986 to 1987 and then a significant increase to 1988 (Wade and Gerrodette 1992), changes which could not be due solely to mortality and reproduction of the population. The explanation was likely a low estimate in 1987 caused by a distributional shift of the population to the south, out of the study area, creating additional interannual variability not accounted for by the CV of the estimated abundance. Another example comes from the long series of abundance estimates available for gray whales, in which adjacent abundance estimates have non-overlapping confidence limits, indicating some component of the variance has not been accounted for (Reilly 1992).

Although this kind of bias is clearly possible, there is not much guidance for defining a worst-case scenario. The specified bias trials (CV actually 0.8 when estimated to be 0.2, and CV 1.6 when estimated to be 0.8) were not based on experience with actual situations. They were somewhat arbitrarily chosen to be magnitudes of bias greater than what one might imagine was reasonable.

Trial 5: CV of the Mortality Estimate

Bias trial 5 (CV of the mortality estimated to be 0.3 but actually 1.2) was similarly chosen in an arbitrary fashion, with perhaps less information available, indicating its potential to be a problem. However, it is possible to imagine situations which would lead to bias in the estimated variance of the mortality estimates. One example would be an observer effect that resulted in vessels fishing in areas with lower variability in their bycatch rates when an observer was on the vessel.

Trial 6: Survey Frequency

Although not strictly addressing a bias, it seemed appropriate to explore the consequences of doing surveys less frequently than was assumed during the simulations.

Violation of this assumption will be known, of course, so the implications of doing surveys less frequently than every eight years can be investigated, if necessary, at a later time.

Trial 7: MNPL *Less Than 0.5*K

As noted in the Discussion, Taylor and DeMaster (1993) reviewed the available empirical data and concluded that density-dependent responses in marine mammals have not been shown to be concave, although statistical power to detect this is low. Taylor and DeMaster (1993) also noted that a linear response in several life-history parameters simultaneously could generate a population-level response that was concave and thus had a maximum net productivity level of less than 0.5*K*, but there was likewise no known example of such a population. Concave dynamics have not often been suggested for marine mammals. Such dynamics imply that adding an individual to the population at a low population size has a greater effect on the other individuals in the population than does adding an individual at a high population size. For example, in the case used here, if R_{MAX} is 0.04 and *MNPL* is 0.45K, the *per capita* growth rate has already fallen to 0.02 (half the maximum rate assumed to exist at a very low population size) by the time the population is at only 0.27*K* (Fig. 1). In other words, the potential of the population to grow has been substantially reduced at a small fraction of its carrying capacity. If *MNPL* is equal to 0.5*K*, a linear decline in *per capita* growth rate results, which implies that adding an individual to the population has an effect independent of the population size, and thus the *per capita* growth rate declines to 0.02 at 0.5*K*. A more-than-linear decline is not seen in life-history parameters (Fowler 1987), and a decline more severe than implied by an *MNPL* of 0.45*K* seems unlikely given the available life-history data.

The exception to the above conclusion is the density-dependent habitat selection hypothesis of MacCall and Tatsukawa (1994). Under this hypothesis, selection can generate a population response that is concave even if local dynamics are convex. However, the hypothesis relies on strong habitat selection by the animals and on a constant gradient in habitat quality within the environment. For example, this assumes that there exists a small piece of habitat (such as 1% of the total habitat area) that is "best," and that any animals outside this best area will have a lower population growth rate irrespective of animal density. Furthermore, in applying this mechanism it is necessary to assume that if such best habitat is available, any animal not in such habitat will find it. MacCall and Tatsukawa (1994) recognized that it is unknown whether the assumptions of their model hold true for any whale population but cautioned that such a possibility would mean that local population dynamics would not provide an accurate account of overall population behavior.

Trial 8: MNPL *More than 0.5*K *with Biased Mortality Estimates*

It is thought that *MNPL* is somewhere between 0.50 and 0.85 of *K* for marine mammals (Eberhardt 1977, Fowler 1987). Although Taylor and DeMaster (1993) recognized that some range is plausible, they suggested that *MNPL* is probably not greater than 80%. Their reasoning was based on their analyses which indicated that non-linear dynamics in a single life-history parameter translate into more linear dynamics in the population response, if the other life-history parameters have a linear response themselves. Thus, for the population-level response to have an *MNPL* of 0.85*K*, either (1) all of the life-history parameters would have to have that extreme a non-linear response simultaneously, or (2) some of the single life-history parameters would have to have an even more extreme non-linear response, close to knife-edge, for which they concluded there was little evidence. The level of $0.7K$ used in this trial is therefore towards the high end of the probable range for marine mammals, but there is admittedly still much uncertainty in this conclusion.

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FEATURE ARTICLE

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Movements of gray whales between the western and eastern North Pacific

David W. Weller[1,]*, Amber Klimek[2], Amanda L. Bradford[3], John Calambokidis[2], Aimee R. Lang[1], Brian Gisborne[4], Alexander M. Burdin[5], Wendy Szaniszlo[6], Jorge Urbán[7], Alejandro Gómez-Gallardo Unzueta [7], Steven Swartz[8], Robert L. Brownell Jr.[1]

[1]Protected Resources Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 3333 North Torrey Pines Court, La Jolla, California 92037-1022, USA
[2]Cascadia Research Collective, Olympia, Washington 98501, USA
[3]Protected Species Division, Pacific Islands Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Honolulu, Hawaii 96814, USA
[4]Juan de Fuca Express, Victoria, British Columbia, Canada
[5]Kamchatka Branch of Pacific Institute of Geography, Far East Branch - Russian Academy of Sciences, Petropavlovsk, Kamchatka, Russia
[6]PO Box 486, Ucluelet, British Columbia, Canada
[7]Programa de Investigación de Mamíferos Marinos, Universidad Autónoma de Baja California Sur, La Paz, B.C.S., Mexico
[8]Cetacean Research Associates, Darnestown, Maryland 20874, USA

ABSTRACT: The western North Pacific (WNP) population of gray whales *Eschrichtius robustus* is redlisted by the IUCN as Critically Endangered. As part of a long-term study on whales off Sakhalin Island, Russia, photo-catalog comparisons of gray whales in the western and eastern North Pacific (ENP) were undertaken to assess population mixing. These comparisons involved 2 approaches: (1) a systematic comparison of the WNP 'Sakhalin Catalog' to an ENP 'Pacific Northwest Catalog' that consisted of images from the northwest coast of North America and (2) a non-systematic comparison of the WNP 'Sakhalin Catalog' to an ENP 'Laguna San Ignacio Catalog' that consisted of images from central Baja California, Mexico. The Sakhalin to Pacific Northwest comparison consisted of 181 and 1064 whales, respectively, and resulted in 6 matches (3 males, 2 females, and 1 whale of unknown sex). All sightings of 'Sakhalin whales' in the Pacific Northwest occurred off southern Vancouver Island, British Columbia, Canada. The Sakhalin to Laguna San Ignacio comparison consisted of 181 and 2514 whales, respectively, and resulted in 4 matches (2 males and 2 females). As the Pacific Northwest and Laguna San Ignacio catalogs represent only a small fraction of the total estimated number of individuals in the ENP population (~19 000), it is likely that more WNP/ENP exchange has occurred than was detected by these photo-catalog comparisons. Although these matches provide new records of movements between the WNP and ENP, recent observations of gray whales off Japan and China suggest that not all gray whales identified in the WNP share a common wintering ground.

Once thought to be extinct, an endangered western North Pacific gray whale breaches off Sakhalin Island, Russia.
Image: David W. Weller

KEY WORDS: Gray whale · Pacific Ocean · Movement patterns · Conservation

INTRODUCTION

Gray whales *Eschrichtius robustus* are presently recognized as 2 populations in the North Pacific Ocean. Recent genetic studies using both mitochondrial and nuclear markers have demonstrated significant differentiation between the western North

*Email: dave.weller@noaa.gov

Pacific (WNP) and eastern North Pacific (ENP) populations (LeDuc et al. 2002, Lang 2010, Lang et al. 2011). The ENP population ranges from calving areas off Baja California, Mexico, to feeding areas in the Bering, Beaufort, and Chukchi Seas. The WNP population feeds in the Okhotsk Sea off Sakhalin Island, Russia, and in nearshore waters of the southeastern Kamchatka Peninsula (southwestern Bering Sea). Little is known about the current migratory routes and wintering areas of the WNP population, but historic evidence indicates that the coastal waters of eastern Russia, the Korean Peninsula, and Japan were part of the migratory route and that areas in the South China Sea were used as wintering grounds (see review by Weller et al. 2002).

Both populations were dramatically reduced by commercial whaling during the 19th and 20th centuries (Henderson 1984, Weller et al. 2002, Reeves et al. 2010). The ENP population was removed from the U.S. List of Endangered and Threatened Wildlife in 1994 and is currently estimated to number approximately 19 000 individuals (Laake et al. 2009). At the single species-level unit, gray whales are redlisted by the International Union for Conservation of Nature (IUCN) as being of Least Concern (Reilly et al. 2008). The WNP subpopulation, however, is redlisted by the IUCN as Critically Endangered (Reilly et al. 2008). The most recent assessment of the Sakhalin population, using a Bayesian individual-based stage-structured model, resulted in a median 1+ (non-calf) estimate of 130 individuals (90% Bayesian CI = 120–142) in 2008 (Cooke et al. 2008).

Research on gray whales in the WNP has been ongoing since 1995, predominantly on the primary feeding ground off northeastern Sakhalin Island (Weller et al. 1999, Bradford et al. 2008, Lang et al. 2011), and more recently off southeastern Kamchatka (Vertyankin et al. 2004, Tyurneva et al. 2010, Burdin et al. 2011). These studies monitor gray whales using photo-identification methods, as gray whales are individually identifiable based on unique, permanent pigmentation features (Darling 1984). Such monitoring on the Sakhalin feeding ground has documented (1) pronounced seasonal site fidelity and inter-annual return of known individuals, (2) consistent use of the area by adult females when pregnant, resting (i.e. when not pregnant or lactating), and accompanied by calves, and (3) annual return by many individuals that were first identified there as young-of-the-year (Weller et al. 1999, 2002, Bradford et al. 2008, Bradford 2011).

Whales associated with the Sakhalin feeding area can be absent for all or part of a given feeding season (Bradford et al. 2008), indicating that they probably use other areas during the summer and fall feeding period. Some of the whales identified feeding in the coastal waters off Sakhalin, including reproductive females and calves, have also been documented off the southern and eastern coast of Kamchatka (Tyurneva et al. 2010, Burdin et al. 2011). Further, whales observed off Sakhalin have been sighted off the northern Kuril Islands in the eastern Okhotsk Sea and Bering Island in the western Bering Sea (Weller et al. 2003). Finally, Lang (2010) reported that 2 adult individuals from the WNP, sampled off Sakhalin in 1998 and 2004, matched the microsatellite genotypes, mtDNA haplotypes, and sexes (1 male, 1 female) of 2 whales sampled off Santa Barbara, California, USA (Area 3 in Fig. 1) on 20 and 23 March 1995. The study by Lang (2010) was the first to suggest that some level of interchange might be occurring between the WNP and ENP.

While information regarding the summer feeding areas of gray whales in the WNP has become increasingly available in the past decade, current data from the historic migratory corridor(s) are limited and data from the presumed wintering area(s) are essentially unavailable. There have been only 13 known sightings or strandings in Japanese waters since 1990 (Nambu et al. 2010). Between 2005 and 2007, 4 female gray whales were fatally entrapped in set nets along the Pacific coast of Honshu, Japan. One of these females, entrapped in January 2007, was matched to earlier photographs of it as a calf (with its mother) while on the Sakhalin feeding ground in July and August 2006 (Weller et al. 2008). This match provided the most contemporary link between the summer feeding ground off Sakhalin and a winter location along the coast of Asia.

In an effort to obtain more information about the southern migration route(s) and wintering area(s) of gray whales in the WNP, a satellite telemetry project was undertaken in 2010 by a team of Russian and American scientists (Mate et al. 2011). While the objective of that study was to document gray whale movements in the WNP, the only whale tagged was tracked from the WNP to the ENP. The result of this telemetry study, together with the genetic matches reported by Lang (2010), provided the impetus for WNP/ENP photo-identification catalog comparisons, which we conducted to further assess population mixing.

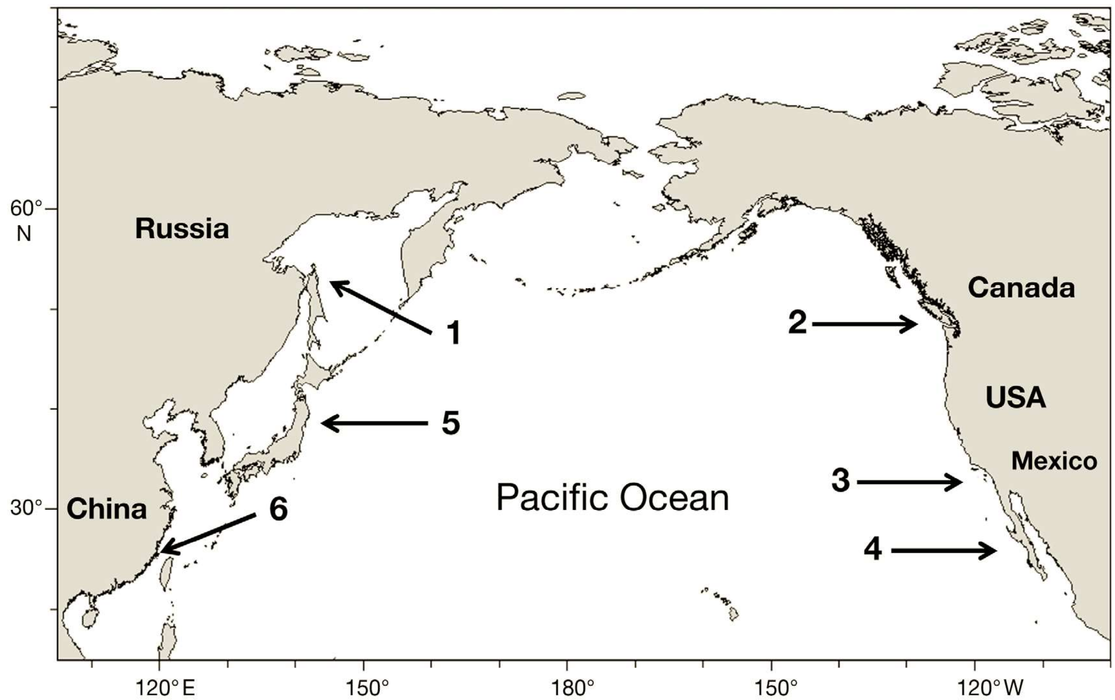

Fig. 1. *Eschrichtius robustus.* North Pacific Ocean, showing: (1) Western North Pacific (WNP) feeding ground off Sakhalin Island, (2) Eastern North Pacific (ENP) region off Vancouver Island where 6 photographic matches to Sakhalin individuals were found, (3) ENP region off California where 2 genetic matches were found (Lang 2010), (4) ENP region off Baja California where 4 photographic matches to Sakhalin individuals were found, (5) WNP region of Japan where a photographic match was found (Weller et al. 2008), and (6) WNP region of China where a gray whale stranded in November 2011 (Zhu 2012)

MATERIALS AND METHODS

Photo-identification images of 181 Sakhalin gray whales (the Sakhalin catalog, hereafter SAK catalog) collected off Sakhalin Island (Area 1 in Fig. 1) between 1994 and 2009 by a joint Russia-U.S. research program (Weller et al. 1999, 2002) were compared to a catalog of 1064 'Pacific Northwest gray whales' (hereafter, PNW catalog) identified by Cascadia Research Collective and collaborators working in U.S. and Canadian waters from California to Alaska (Area 2 in Fig. 1) primarily between 1998 and 2009 (Calambokidis et al. 2002, 2010). The PNW catalog focuses on gray whales that feed during summer and fall in coastal waters between northern California and the Gulf of Alaska, referred to as the Pacific Coast Feeding Group (PCFG), but also includes some migrating whales identified in the spring (March to May) during their northward passage to high-latitude feeding grounds.

Of the 181 whales in the SAK catalog, all were represented by a right-side dorsal flank image, and 179 were associated with a left-side dorsal flank image. Of the 1064 whales in the PNW catalog, 845 were represented by a right-side dorsal flank image, and 898 were associated with a left-side dorsal flank image. Each individual in the SAK catalog was compared in numerical order to all individuals in the PNW catalog as follows. First, the left-side dorsal flank of each individual in the SAK catalog was compared to the left-side dorsal flank of all individuals in the PNW catalog. This process was then repeated using the right-side dorsal flank and ventral aspect of the tail flukes. Comparisons were made by a single analyst (A.K.), but resulting matches were confirmed by 3 independent researchers skilled in gray whale photo-identification (including A.L.B. and J.C.).

Similarly, photo-identification images of 181 whales in the SAK catalog were compared to an online catalog of 2514 'Laguna San Ignacio gray whales' (hereafter, the LSI catalog) identified between 2006 and 2010 in Baja California, Mexico (Area 4 in Fig. 1). This assessment was not comprehensive or systematic, as was the case for the PNW catalog, because the LSI catalog represented a collection of 'annual working catalogs' rather than a single multi-year catalog of known individuals. Thus, the comparison to the SAK catalog reported herein was undertaken opportunistically. A single analyst (A.L.B.) conducted the appraisal, with identified matches confirmed by 2 additional observers (including D.W.W.).

RESULTS

The comparison of the SAK catalog to the PNW catalog resulted in a total of 6 confirmed matches of individuals, including 3 males, 2 females, and 1 whale of unknown sex (Table 1). None of these 6 whales is a known PCFG animal, and, to date, each one has only ever been photographed a single time during either April or May.

Remarkably, all 6 of the matches were from only 2 days of effort, with 3 whales identified on 2 May 2004 and 3 on 25 April 2008. The 3 whales identified on 2 May 2004 were together in a single group, while the 3 whales recorded on 25 April 2008 were in 2 separate groups but in close proximity. All of the sightings of Sakhalin whales in the Pacific Northwest occurred near Barkley Sound off the west coast of southern Vancouver Island, British Columbia, Canada.

Three of the 6 whales were first identified as calves (with their mothers) on the Sakhalin feeding ground during 1997 (no. RUS-U.S. 032/CRC 1045), 2003 (no. RUS-U.S. 119/CRC 1040), and 2004 (no. RUS-U.S. 135/CRC 1042; Table 1). Interestingly, a genetic analysis of paternity classified one of the matched males (no. RUS-U.S. 035/CRC 0809) as the putative father of 2, or possibly 4, calves identified off Sakhalin (Lang 2010). All 6 whales had sightings off Sakhalin prior to their respective sightings off Vancouver Island, and 5 (83%) had sightings off Sakhalin subsequent to their Vancouver sightings. Four whales were sighted off Vancouver Island and Sakhalin in the same year: 3 in 2004 and 1 in 2008. Of the 3 whales identified off Vancouver Island on 2 May 2004, 2 were resighted off Sakhalin on 31 July 2004, while the third was first resighted on 6 August 2004. Whale no. RUS-U.S. 032/CRC 1045 was sighted off Sakhalin in 2007 during July (29), August (4, 18, 25), and September (7, 8, 9), off southern Vancouver Island on 25 April 2008, and then back off Sakhalin on 19 July 2008. This whale is the same individual satellite-tracked from Sakhalin to the ENP in 2010/2011 (Mate et al. 2011).

The comparison of the SAK catalog to the LSI catalog resulted in a total of 4 confirmed matches of individuals, including 2 males and 2 females (Table 2). Three of these 4 whales were photographed in Laguna San Ignacio in only 1 year, while whale no. RUS-U.S. 052 was identified in both 2007 and 2010. All 4 whales had sightings off Sakhalin prior to their respective sightings in Laguna San Ignacio, and 3 (75%) had sightings off Sakhalin subsequent to their lagoon sightings. Two whales were sighted in Laguna San Ignacio and Sakhalin in the same year: one in 2008 (no. RUS-U.S. 063) and one in 2010 (no. RUS-U.S. 052).

One of the 4 whales (no. RUS-U.S. 020) was first identified as a calf on the Sakhalin feeding ground

Table 2. *Eschrichtius robustus.* Sighting summary information for 4 gray whales matched between Sakhalin Island, Russia (SAK), and Laguna San Ignacio (LSI), Baja California, Mexico. Years shown with a dash (–) are inclusive. RUS-U.S.: joint Russia-U.S. research program; M: male; F: female

Whale ID	Sex	Years sighted in SAK	Years sighted in LSI
RUS-U.S. 020[a]	M	97, 02–04, 07–09	2006
RUS-U.S. 042[b]	F	97–00, 03–05	2009
RUS-U.S. 052[c]	M	98–03, 05–06, 08–10	2007, 2010
RUS-U.S. 063[d]	F	97–98, 00–02, 05, 07, 08, 10	2008

[a]First identified off Sakhalin in 1997 as a calf. Photo-matched to Bering Island in June 2000 (Weller et al. 2003). [b]Identified as a mother with calf in LSI 2009. Never seen with calf off Sakhalin. [c]Putative father of a 1998 Sakhalin calf (Lang 2010). [d]Identified as a mother with calf in LSI 2008. Known mother from Sakhalin in 1998

Table 1. *Eschrichtius robustus.* Sighting summary information for 6 gray whales matched between Sakhalin Island, Russia (SAK), and the Pacific Northwest coast of North America (PNW). Years shown with a dash (–) are inclusive. RUS-U.S.: joint Russia-U.S. research programm; CRC: Cascadia Research Collective; M: male; U: unknown; F: female

Whale ID	Sex	Years sighted in SAK	PNW sighting	PNW sighting coordinates
RUS-U.S. 002 / CRC 0817	M	94–95, 97, 99–01, 04–09	02 May 2004	48° 41.41′ N, 124° 58.06′ W
RUS-U.S. 032 / CRC 1045[a]	M	97–98, 01–05, 07–10	25 April 2008	48° 53.81′ N, 125° 24.54′ W
RUS-U.S. 035 / CRC 0809[b]	M	95, 97, 98–07, 09–10	02 May 2004	48° 41.41′ N, 124° 58.06′ W
RUS-U.S. 078 / CRC 0825	U	97, 99, 02–04, 06–10	02 May 2004	48° 41.41′ N, 124° 58.06′ W
RUS-U.S. 119 / CRC 1040[c]	F	03, 10	25 April 2008	48° 44.01′ N, 125° 07.70′ W
RUS-U.S. 135 / CRC 1042[d]	F	04	25 April 2008	48° 44.01′ N, 125° 07.70′ W

[a]Same whale satellite-tagged in 2010 (Mate et al. 2011). First identified off Sakhalin as a calf in 1997. [b]Putative father of 2 (strict criterion) or 4 (relaxed criterion) Sakhalin calves (for definitions see Lang 2010). Years that these calves were first identified are: 1998, 2001, 2002, and 2003. [c]First identified off Sakhalin in 2003 as a calf. [d]First identified off Sakhalin in 2004 as a calf

during 1997 (Table 2) and photographically matched to the Commander Islands in June 2000 (Weller et al. 2003). A genetic analysis of paternity classified 1 of the matched males (no. RUS-U.S. 052) as the putative father of a calf identified in 1998 off Sakhalin (Lang 2010). Both of the matched females were identified as mothers with calves while in Laguna San Ignacio. Whale no. RUS-U.S. 042 was identified as a mother with a calf in 2009 but has never been seen with a calf off Sakhalin. Whale no. RUS-U.S. 063 was identified as a mother with a calf in 2008 and was also observed with a calf off Sakhalin (in 1998).

DISCUSSION

The photographic matches reported here provide new information that is of broad significance to understanding the migration patterns and mixing of gray whales in the North Pacific. The high number of matches made between the SAK and PNW catalogs is particularly intriguing given that the PNW catalog used for comparison focuses on PCFG whales and thus greatly underrepresents individuals that pass off the Pacific Northwest during the spring migration. Limited numbers of whales in the PNW catalog have been photographed during the spring off the coast of Vancouver Island where the 6 matched whales were observed (n = 26 for southern Vancouver Island; n = 48 for all of western Vancouver Island). Thus, 6 of the 74 (8.1%) whales identified off Vancouver Island in the PNW catalog were known Sakhalin individuals. Given that the PNW catalog contains only a small fraction (1064) of the estimated total number of individuals (~19000) in the ENP population, it is likely that more WNP/ENP exchange has occurred than was detected during this comparison.

The high match rate observed between the SAK and PNW catalogs suggests a spatio-temporal behavioral factor that makes Sakhalin whales more likely to have been identified in the small PNW spring sample. The fact that all the matches came from sightings made on only 2 days, mostly in the same groups and in localized areas, indicates that whales from the Sakhalin feeding ground associate, at least to some degree, even when utilizing migratory routes in the ENP. These 6 whales were sighted in an area where some whales tend to linger and feed during the northbound migration (Darling et al. 1998). Feeding whales are often found in more nearshore waters and over extended periods of time, potentially making them more likely to be photographed than animals rapidly migrating past the area (Darling et al. 1998, Calambokidis et al. 2010). The long distance and potential open water crossing required for transit from the ENP to the WNP may make it advantageous for whales to spend time feeding in the Pacific Northwest (e.g. Vancouver Island) prior to undertaking a westerly passage to Sakhalin.

The preliminary comparison of the SAK and LSI catalogs revealed 4 additional matches. Since the SAK to LSI catalog comparison was conducted in a non-comprehensive manner, relying on long-term familiarity with whales in the WNP catalog, it is probable that additional matches exist. Given the importance of conducting further comparisons to the wintering lagoons of Baja California, Mexico, a systematic and comprehensive comparison of the SAK catalog to a recently compiled multi-year catalog from LSI and Laguna Ojo de Liebre (Scammon's Lagoon) is presently underway (see IWC 2011).

When the 10 WNP/ENP photo-identification matches reported here are combined with the 2 genetic matches noted by Lang (2010), a total of 12 gray whales (6 males, 5 females and 1 whale of unknown sex) identified in the WNP off Sakhalin Island have been matched to 3 locations in the ENP (Vancouver Island, Southern California, Laguna San Ignacio), providing evidence that both sexes, in approximately equal numbers, move between the WNP and the ENP. Despite this level of mixing, significant mtDNA and nuclear genetic differences between whales utilizing the Sakhalin feeding ground and those summering in the ENP support the continued recognition of Sakhalin animals as a distinct genetic unit (Lang et al. 2011).

Adding to the complexity of mixing between the WNP and ENP are contemporary records of gray whales off Japan and, to a lesser degree, China. As previously mentioned, there have been only 13 records of gray whales in Japanese waters since 1990 (Nambu et al. 2010). One of these reports includes a whale first identified as a calf accompanied by her mother on the Sakhalin Island feeding ground in July and August 2006 that was later fatally entrapped in a set net off the Pacific coast of Honshu (Area 5 in Fig. 1) in January 2007 (Weller et al. 2008). While observations of gray whales in Japan have been made between November and August, most of these records are concentrated between March and May. This March to May period coincides with the sightings in the ENP of the 10 matched whales described here. Observations of gray whales in China are exceptionally rare. Only 24 sightings and/or strandings have been recorded since 1933, including observations of 2 mother–calf pairs (Wang 1984, Zhu 2002). However, a 13 m female gray whale stranded in the Taiwan Strait near the town of Baiqingxiang (Pingtan County), China (Area 6 in Fig. 1), in November 2011 (Zhu 2012). These findings, in combination, suggest that not all gray whales identified in the WNP share a common wintering ground.

The use of photo-identification methods, together with genetic and telemetry techniques, is essential to furthering our understanding of gray whale population structure. We recommend that other existing photo collections and tissue samples of gray whales in the WNP and ENP (e.g. those from Sakhalin, Kamchatka, Chukotka, Mexico, and Japan) be used to further examine gray whale movement patterns and population mixing within the Pacific. Ideally, a collaborative Pacific-wide study should be undertaken, similar in scope to those conducted for humpback whales in the Atlantic and Pacific (Smith et al. 1999, Calambokidis et al. 2008).

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David W. Weller [1], Shannon Bettridge [2], Robert L. Brownell [1], Jr., Jeffrey L. Laake [3], Jeffrey E. Moore [1], Patricia E. Rosel [4], Barbara L. Taylor [1], Paul R. Wade [3]

[1] NOAA National Marine Fisheries Service
Southwest Fisheries Science Center
8901 La Jolla Shores Drive
La Jolla, CA 92037

[2] NOAA National Marine Fisheries Service
Office of Protected Resources
1315 East-West Highway, 13th Floor
Silver Spring, MD 20910

[3] NOAA National Marine Fisheries Service
Alaska Fisheries Science Center
7600 Sand Point Way Northeast
Seattle, WA 98115

[4] NOAA National Marine Fisheries Service
Southeast Fisheries Science Center
646 Cajundome Blvd.
Lafyette, LA 70506

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NOAA Technical Memorandum NMFS

The National Oceanic and Atmospheric Administration (NOAA), organized in 1970, has evolved into an agency that establishes national policies and manages and conserves our oceanic, coastal, and atmospheric resources. An organizational element within NOAA, the Office of Fisheries is responsible for fisheries policy and the direction of the National Marine Fisheries Service (NMFS).

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Executive Summary

The Marine Mammal Protection Act of 1972 (MMPA) requires that the National Marine Fisheries Service (NMFS) and the Fish and Wildlife Service develop stock assessment reports for all marine mammal stocks in waters under U.S. jurisdiction. NMFS considers stock structure as part of these assessments and has developed guidance for delineating separate population stocks under the MMPA. A single population stock of gray whales (*Eschrichtius robustus*), referred to as the eastern North Pacific (ENP) stock, is presently recognized in U.S. waters (Carretta *et al*. 2013). New information, however, suggests the possibility of recognizing two additional stocks of gray whales in U.S. waters: the Pacific Coast Feeding Group (PCFG) and the western North Pacific (WNP) stock. To evaluate the currently recognized and potentially emerging characterization of gray whale stock structure, NMFS established a scientific Task Force (TF). The overarching objective of this TF was to provide an objective scientific evaluation of gray whale stock structure as defined under the MMPA and implemented through the NMFS Guidelines for Assessing Marine Mammal Stocks (GAMMS; NMFS 2005). More specifically, the TF was convened to provide advice on the primary question – "*Is the PCFG a "population stock" under the MMPA and GAMMS guidelines"?* In addition, the TF was asked to provide advice on a question of developing importance – "*Is the WNP stock a "population stock" under the MMPA and GAMMS guidelines"?*

Both of these questions have immediate management implications, including: (1) how future NMFS stock assessment reports will address gray whale stock structure in the North Pacific, and (2) how to interpret any new information in the context of the Makah Indian Tribe's MMPA waiver request to resume hunting gray whales off Washington State, USA.

As the agency lead for gray whale science, the Southwest Fisheries Science Center convened a meeting of the aforementioned TF from 31 July to 2 August 2012. Using the best scientific information available at the time of the workshop, the TF worked to: (1) review new information relevant to gray whale stock structure, and (2) provide advice on revisions to stock structure so as to be available for management consideration. The TF conducted its work as an advisory rather than prescriptive body and therefore its conclusions should viewed as scientific advice based on review and discussion of the available science.

The implications of new data pertinent to stock structure, including considerable information related to the PCFG and WNP gray whales, were thoroughly reviewed during the workshop. Evaluating the new findings relevant to the status of the PCFG proved particularly complex. After review of results from photo-identification, genetics, tagging, and other studies within the context of the GAMMS guidelines (NMFS 2005) there remains a substantial level of uncertainty in the strength of the lines of evidence supporting demographic independence of the PCFG. Consequently, the TF was unable to provide definitive advice as to whether the PCFG is a population stock under the MMPA and the GAMMS guidelines. Members of the TF ranged in their opinions from strongly agreeing to strongly disagreeing about whether the PCFG should be recognized as a separate stock.

In the case of WNP gray whales, the work of the TF was more straightforward. The mitochondrial DNA and nuclear DNA genetic differentiation found between the WNP and ENP stocks provided convincing evidence that resulted in the TF providing unambiguous advice that the WNP stock should be recognized as a population stock pursuant to the GAMMS guidelines and the MMPA.

Additional research may narrow the uncertainty associated with the question of whether the PCFG should be recognized as a population stock. To work towards this objective, the TF recommended further investigation of recruitment into the PCFG. Presently, both the photo-identification and genetics data indicate that the levels of internal versus external recruitment are comparable, but these are not quantified well enough to determine if the population dynamics of the PCFG are more a consequence of births and deaths within the group (internal dynamics) rather than related to immigration and/or emigration (external dynamics). The TF offered a number of research recommendations, using the existing photo-identification and genetics datasets, that could provide increased resolution on the issue of recruitment and, in turn, the question of stock identification.

While the need for additional data collection was apparent, especially with regard to recruitment into the PCFG, the purpose of the workshop was for the TF to determine whether the *existing* best available science was sufficient to advise that the PCFG be recognized as a population stock under the language of the MMPA and GAMMS guidelines. Therefore, the advice of the TF offered in this report should be viewed as a contemporary "snapshot" taken from an emerging and ever-changing body of knowledge regarding the PCFG.

The TF emphasizes that the PCFG is relatively small in number and utilizes a largely different ecosystem from that of the main ENP stock. While the status of the PCFG as a population stock has yet to be resolved, continued research on these whales should be undertaken with particular attention dedicated to collecting data relevant to the question of stock identification.

Table of Contents

List of Acronyms

AFSC	Alaska Fisheries Science Center
ALJ	Administrative Law Judge
AWMP	Aboriginal Whaling Management Procedure
BRT	Biological Review Team
DIPs	Demographically Independent Units
DPSs	Distinct Population Segments
EIS	Environmental Impact Statement
ENP	Eastern North Pacific
ESA	Endangered Species Act
FEMAT	Forest Ecosystem Management Assessment Team
GAMMS	Guidelines for Assessing Marine Mammal Stocks
HCM	Human Caused Mortality
HWE	Hardy-Weinberg equilibrium
IR	Implementation Review
IUCN	International Union for Conservation of Nature
IWC	International Whaling Commission
K	Carrying Capacity
Makah U&A	Makah Usual and Accustomed (Fishing Ground)
MMC	Marine Mammal Commission
MMPA	Marine Mammal Protection Act
MNPL	Maximum Net Productivity Level
MSA	Magnuson-Stevens Act
MSYR	Maximum Sustained Yield Rate
mtDNA	Mitochondrial DNA
nDNA	Nuclear DNA
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NPS	Northern Puget Sound
NWR	Northwest Regional Office
OPR	Office of Protected Resources
OSP	Optimum Sustainable Population
PBR	Potential Biological Removal
PCFG	Pacific Coast Feeding Group
SAR	Stock Assessment Report(s)
SEFSC	Southeast Fisheries Science Center
SJF	Strait of Juan de Fuca
SRG	Scientific Review Group
SWFSC	Southwest Fisheries Science Center
SVI	Southern Vancouver Island
TF	Task Force
UME	Unusual Mortality Event
WNP	Western North Pacific

1. Introductory Remarks

Dr. Lisa Ballance, Director of the Marine Mammal and Turtle Division at Southwest Fisheries Science Center (SWFSC), welcomed the workshop participants. She noted that this workshop represented a significant event, in that it: (1) brings agency scientists together to review research that continues to evolve and reveal unexpected patterns, (2) provides results that will be relevant to management activities for the National Marine Fisheries Service (NMFS), and (3) typifies the ideal model for how NMFS works, illustrating science addressing management actions and highlighting the collaboration between NMFS scientists, regional offices, and headquarters.

The technical and scientific expertise required on the Task Force (TF) was determined by SWFSC in consultation with the NMFS Northwest Regional Office (NWR) and the NMFS Office of Protected Resources (OPR). TF members were experts in their respective fields with ample experience and ability to bridge scientific and policy issues related to marine mammal stock structure. Members of the TF included the following eight NMFS scientists:

Dr. Shannon Bettridge	NMFS – Office of Protected Resources
Dr. Robert L. Brownell, Jr.	NMFS – Southwest Fisheries Science Center
Dr. Jeffrey L. Laake	NMFS – Alaska Fisheries Science Center
Dr. Jeffrey E. Moore	NMFS – Southwest Fisheries Science Center
Dr. Patricia E. Rosel	NMFS – Southeast Fisheries Science Center
Dr. Barbara L. Taylor	NMFS – Southwest Fisheries Science Center
Dr. Paul R. Wade	NMFS – Alaska Fisheries Science Center
Dr. David W. Weller (Chairman)	NMFS – Southwest Fisheries Science Center

In addition to the TF, a number of agency scientists and NMFS affiliates (e.g., post-docs, contractors, etc.) attended the workshop to observe and provide information. These participants included: Eric Archer (SWFSC), Lisa Ballance (SWFSC), Laurie Beale (NOAA General Counsel), Jim Carretta (SWFSC), Donna Darm (NWR), Kirsten Erickson (NOAA General Counsel - by phone), Jason Foreman (NOAA General Counsel), Annette Henry (SWFSC), Aimee Lang (SWFSC), Karen Martien (SWFSC), Sarah Mesnick (SWFSC), Phil Morin (SWFSC), Vicki Pease (SWFSC), Bill Perrin (SWFSC), Wayne Perryman (SWFSC) and Steve Stone (NWR). At the request of the TF, several of these participants provided valuable information to the workshop in the form of expert knowledge, presentations and/or written documents. Aimee Lang and Annette Henry generously agreed to serve as workshop rapporteurs.

The agenda for the workshop was circulated amongst the TF for input in advance of the meeting (Appendix 1). It was agreed, however, that the agenda would serve to guide the workshop proceedings but be viewed as flexible so as not to constrain discussion. Documents for the workshop were made available on a file sharing website. Appendix 2 provides a list of the workshop documents available for review and consideration by the TF in preparation for the workshop.

1.1 Workshop objectives

NMFS presently recognizes a single stock of gray whales (*Eschrichtius robustus*) in U.S. waters that is referred to as the eastern North Pacific (ENP) stock (Carretta *et al*. 2013). New information, however, suggests the possibility of recognizing two additional stocks of gray whales in U.S. waters, including: (1) the Pacific Coast Feeding Group (PCFG) - defined as whales observed between 1 June to 30 November within the region between northern California and northern Vancouver Island (from 41°N to 52°N) and photo-identified within this area during two or more years (see section 3.3), and (2) western North Pacific (WNP) gray whales - defined as whales observed feeding during summer and fall off Sakhalin Island, Russia, and other areas in the WNP (see section 3.2). The main objective of the TF was to provide scientific advice regarding gray whale stock structure using the definitions given in the GAMMS guidelines (NMFS 2005; see also Moore and Merrick 2011). More specifically, the TF was convened to provide advice on two questions: (1) *Is the PCFG a "population stock" under the MMPA and GAMMS guidelines?*, and (2) *Is the WNP stock a "population stock" under the MMPA and GAMMS guidelines?* Both of these questions have immediate management implications, including: (1) how future NMFS stock assessment reports (SAR) will address gray whale stock structure in the North Pacific, and (2) how to interpret any new information in the context of the Makah Indian Tribe's MMPA waiver request to resume hunting gray whales off Washington State, USA.

1.2 Workshop relationship to stock assessment reports

At the request of the TF, Carretta (SWFSC) summarized the relationship of the workshop to future gray whale stock assessment reports (SARs). The current eastern North Pacific gray whale SAR (Carretta *et al*. 2013) provides a summary of present knowledge but is expected to evolve based on the input received at this workshop as well as from input from the scientific review groups (SRG)[1], NWR and OPR. The TF expected that the outcome of the workshop would influence how the SAR is structured in the future, including how various data sources (i.e., genetics, movements, distribution) are evaluated for future stock designation. The workshop report will also serve as a useful SRG background document on gray whale stock structure.

1.3 Workshop relationship to Makah waiver request

Newly available information from genetic, photo-identification and tagging studies suggests that more than one stock of gray whales may occur in U.S. waters (Lang *et al*. 2010; Frasier *et al.* 2011; Lang *et al.* 2011a; Lang *et al*. 2011b; Mate *et al*. 2011; Calambokidis *et al.* 2012; Weller *et al*. 2012). With that in mind, the TF requested that Darm (NWR) present a summary of the Makah Indian Tribe's request to hunt gray whales off northwest Washington State, USA.

The Makah's right to hunt whales is secured by the 1855 Treaty of Neah Bay, where the Makah ceded lands to the U.S. government but reserved the right to hunt, fish, seal and whale. The Ninth Circuit Court of Appeals decision in 2004 (Anderson v. Evans) held that for the Makah to exercise their right to hunt whales they must comply with the requirements of the MMPA. In 2005, the Makah requested authorization from NOAA/NMFS, under the MMPA and the Whaling Convention Act, to resume limited hunting of gray whales for ceremonial and subsistence purposes in the coastal portion of their usual and accustomed (U&A) fishing grounds off the coast of Washington State (NMFS 2008). The spatial overlap of the Makah U&A with the summer distribution of PCFG whales has management implications. The proposal by the Makah Tribe includes time/area restrictions designed to reduce the probability of killing a PCFG whale and to focus the hunt on whales migrating to/from feeding areas to the north.

The NWR was assigned responsibility for evaluating the Tribe's request under the MMPA and National Environmental Policy Act (NEPA) process. Section 101(a) of the MMPA imposes a

[1] Pursuant to Sec. 117 of the MMPA, independent scientific review groups, representing Alaska, and the Pacific and Atlantic coasts, were established in 1994. These groups consist of individuals with expertise in marine mammal biology and ecology, population dynamics and modeling, commercial fishing technology and practices, and stocks taken under section 101(b).

moratorium on the take of all marine mammals, although the statute provides for certain exemptions allowing the take of marine mammals. Section 101(a)(3)(A) allows for a waiver of the take prohibition; this exemption applies to a specific stock and is only authorized to the extent provided for in the waiver. Determination of whether the waiver will be granted must be made based on the best scientific information, in consultation with the Marine Mammal Commission, and with due regard to the distribution, abundance, breeding habits, and movements of the stock in question. For the waiver to be granted there must also be a finding that the requested take is in accord with sound principles of resources protection and conservation as provided for in the MMPA.

Unlike most rulemaking by the agency, this determination will entail a formal rulemaking process in which the agency presents evidence before an administrative law judge (ALJ) to support the rule. This process may involve presenting evidence on the status of relevant stocks, including their optimum sustainable population level (OSP)[2], and whether the stocks are at or below that level (i.e., depleted).

Although the NWR made substantial progress in evaluating the waiver request during the past few years, this progress had been slowed by: (1) new information pertinent to the question of whether the PCFG is a separate stock, and (2) the potential implications of movements of whales between the WNP and ENP. Therefore, the advice of the TF will provide a collective "best professional judgment" useful to the ongoing evaluation of the waiver by the NWR.

In discussion, the TF asked Darm if there would be a potential need to get more than one waiver to the MMPA if it was determined that three stocks of gray whales occur in U.S. waters (i.e., ENP, PCFG and WNP stocks). In that case, Darm replied that there would be some possibility of needing to request multiple exemptions (waivers). However, the need for a waiver would be informed by the likelihood of take and obtaining a waiver for WNP gray whales (if the group is recognized as a stock) is highly unlikely given that they are listed as endangered under the Endangered Species Act (ESA) and as such, would be considered depleted under the MMPA.

2. Overview of MMPA Language, GAMMS Guidelines and Related Key Concepts

From the outset of the workshop, the TF concurred that it was important to review the existing language of the MMPA and GAMMS with regard to the definition of "population stock". In addition, it was also agreed important to discuss three key concepts inherent to defining a population stock, including: (1) "demographic independence", (2) "interbreed when mature", and (3) "functioning element of the ecosystem".

Under the MMPA, population stock (used interchangeably with "stock" and "population" hereafter) is the fundamental conservation unit. The MMPA (Sec. 3) defines population stock as: "*a group of marine mammals of the same species or smaller taxa in a common spatial arrangement, that interbreed when mature.*" The purposes and polices underlying the stated definition, as follows, are found in Sec. 2(2) and Sec. 2(6) of the MMPA:

[2] The maximum net productivity level is described in the National Marine Fisheries Service's definition of "optimum sustainable population" (OSP) (50 CFR 216.3) as the abundance level that results in the greatest net annual increment in population numbers or biomass resulting from additions to the population due to reproduction and/or growth less losses due to natural mortality. Under the U.S. Marine Mammal Protection Act, populations above MNPL are considered to be at OSP; populations below MNPL can be designated as 'depleted' and are afforded a greater level of protection.

(1) *"[marine mammal] species and population stocks should not be permitted to diminish beyond the point at which they cease to be a significant functioning element in the ecosystem of which they are a part, and, consistent with this major objective, they should not be permitted to diminish below their optimum sustainable population."*

(2) *"… the primary objective of their management should be to maintain the health and stability of the marine ecosystem."*

Acknowledging the above definitions and objectives of the MMPA, the TF then considered the related guidelines contained in the "Definition of Stock" section of the GAMMS guidelines (NMFS 2005):

(1) *"For the purposes of management under the MMPA, a stock is recognized as being a management unit that identifies a demographically isolated biological population."*

(2) *"Demographic isolation means that the population dynamics of the affected group is more a consequence of births and deaths within the group (internal dynamics) rather than immigration or emigration (external dynamics). Thus, the exchange of individuals between population stocks is not great enough to prevent the depletion of one of the populations as a result of increased mortality or lower birth rates."*

The TF noted that within the broader field of population biology, the term "isolation" generally implies little or no exchange (emigration or immigration of individuals) between stocks and is a criterion commonly used to distinguish taxonomic units higher than that of a population (e.g., species, subspecies). In contrast, the GAMMS guidelines and definition of stock clearly allow for the "*exchange of individuals between population stocks"* (NMFS 2005), a distinction more in line with use of the term "demographic independence" rather than "demographic isolation". The use of the term "independence" as opposed to "isolation" is potentially confusing and has been noted by a number of NMFS reviewers and workshops (Eagle *et al*. 2008). To avoid this confusion, Eagle *et al*. (2008) suggested that the term "demographic isolation" be replaced by "demographic independence".

Moore (SWFSC) provided the TF with an overview of the GAMMS III workshop, convened by NMFS in February 2011, which also noted the potential confusion over the use of "isolation" as opposed to "independence". The GAMMS III workshop recommended revising the SAR guidelines to reflect that the intent of the GAMMS II guidelines (NMFS 2005) was to base stock identification on demographic independence as noted in Eagle *et al.* (2008) and proposed that the term demographic isolation be replaced with "demographic independence" as follows:

(1) *"For the purposes of management under the MMPA, a stock is recognized as being a management unit that identifies a demographically independent biological population."*

(2) *"Demographic independence means that the population dynamics of the affected group is more a consequence of births and deaths within the group (internal dynamics) rather than immigration or emigration (external dynamics). Thus, the exchange of individuals between population stocks is not great enough to prevent the depletion of one of the populations as a result of increased mortality or lower birth rates."*

In other words, the participants at the GAMMS III workshop viewed this as a semantic issue where the term demographic independence is a better description for the current GAMMS guidelines definition than is the term demographic isolation.

2.1 Discussion of "demographic independence"

This interpretation of "isolation" differs substantively from how it is used within the GAMMS guidelines definition above, wherein allowance is made for some level of exchange of individuals between stocks. The TF concurred that in spite of using the term "isolation", the actual definitions under the current GAMMS guidelines (see above) are more consistent with MMPA objectives to protect population stocks than with the objective of protecting just subspecies and species.

Given that the draft GAMMS guideline revisions from the GAMMS III workshop have not yet been formally approved, the TF agreed to use the current GAMMS guidelines definition (NMFS 2005) for the purposes of their discussions and deliberations but noted that the actual definition used in the two versions (for demographic isolation and demographic independence) is essentially the same in that neither implies true "isolation" within the context of the MMPA.

2.2 Discussion of "interbreed when mature"

Bettridge (OPR) presented a brief overview of relevant language under the MMPA and GAMMS guidelines pertaining to NMFS interpretation of "interbreed when mature". She explained that the draft second revision to the SAR guidelines (from the GAMMS II workshop held in Seattle in 2003) included a definition of interbreed when mature. This term was interpreted to mean cases in which either:

(1) "*mating occurs primarily among members of the same demographically isolated group*"

or

(2) "*the group migrates seasonally to a breeding ground where its members breed with members of the same group as well as with members of other demographically distinct groups which have migrated to the same breeding ground from a different feeding ground."*

When comments were solicited on the draft GAMMS II guidelines (69 FR 67541, 18 November 2004), the Marine Mammal Commission (MMC) supported the aforementioned interpretations, but suggested that a more rigorous analysis was needed of how the revisions fit with the language of the MMPA. Additionally, the MMC stated that NMFS should develop criteria for applying the modified guidelines to determine when a population is demographically isolated to an extent that it is a discrete group that warrants recognition as a separate stock.

In its response to comments on this issue (70 FR 35397, 20 June 2005), NMFS stated that public comments were sufficient to raise questions about the proposed interpretation, and the agency removed the proposed text pertaining to "interbreed when mature" from the final GAMMS II guidelines.

Subsequent NMFS review and consultation with MMC staff and NOAA General Counsel suggest that the GAMMS II workshop definition of "interbreed when mature" is consistent with NMFS GAMMS guidelines and the review undertaken in Eagle *et al.* (2008, see below). In those forums NMFS has consistently interpreted a population stock not as one that is completely reproductively isolated but rather as something less restrictive.

Regarding the MMC request for scientific criteria for how much interbreeding would be consistent with the proposed GAMMS II guidelines definition, the TF noted that specific quantitative criteria would be impractical to apply consistently across all contexts of uncertain stock definition and that determining whether a population is demographically independent or an isolated unit would likely have to be conducted on a case-specific basis. Some TF members felt that the “interbreed when mature” component of the MMPA definition of stock should merely be viewed as a necessary but not sufficient criterion for defining a stock. In other words, individuals “in a common spatial arrangement” would not constitute a stock unless there is some interbreeding (satisfying the need criterion), but this would not preclude individuals of a stock from also breeding with members of other stocks.

For the purposes of the workshop, the TF agreed they would continue to interpret “interbreed when mature” consistent with “demographic independence” as suggested by Eagle *et al*. (2008) and GAMMS II (NMFS 2005), with the minor change of “isolation” being replaced with “independence”.

2.3 Discussion of “functioning element of the ecosystem”

Sec. 2 of the MMPA states that marine mammals are “resources of great international significance, esthetic and recreational as well as economic” and “that the primary objective of their management should be to maintain the health and stability of the marine ecosystem”. The TF therefore considered whether the functioning element of the ecosystem criteria is aesthetically or ecologically based (or both) but no clear resolution on how to best define functioning element of the ecosystem was reached by the TF.

The TF then focused its discussion on defining the ecosystem and appropriate scale of management with respect to gray whales. The TF agreed the matter was complex given the species’ seasonal use of different ecosystems. In general, the TF agreed that the Chukotka Peninsula/Bering Strait feeding areas were not part of the same ecosystem as that found off the Pacific Northwest and used by the PCFG. In discussion of this concept, it was noted by some TF members that even for the largest-scale classification system for marine ecosystems (Longhurst 1998, discussed in Moore and Merrick 2011), it could be argued that the PCFG is in a different ecosystem than other gray whales. Other TF members pointed out, however, that this was only true for part of the year, and that the interpretation was complicated because non-PCFG animals migrate through the area defined for PCFG whales and, in some cases, may feed there in a given year but not return in a subsequent year.

2.4 Additional information on the definition of “population” for marine mammals

In addition to applying the MMPA language and GAMMS guidelines definitions, the TF considered two documents relevant to the question of stock definition under the MMPA. In the first (Taylor 1997), simulation analyses were used to explore the potential consequences, in terms of the risk of violating MMPA ecosystem function objectives, of defining a population stock as a unit akin to an evolutionarily significant unit or reproductively isolated group. Briefly, this analysis considered scenarios in which a single reproductively isolated population was distributed as a network of discrete groups occupying distinct habitat areas throughout its range, with some level of dispersal between discrete groups. The major analytical finding was that, if allowable human caused mortality (HCM) for the entire population (i.e., sum of all discrete groups) were to act disproportionately on certain groups, those groups could be extirpated, depending on whether the amount of immigration from other groups was below a certain dispersal rate threshold (which varied with simulation conditions). In conclusion, to achieve MMPA objectives of maintaining marine mammals as “functioning elements of their ecosystem”, distinct groups should be managed as separate stocks if their connectivity to other groups via dispersal is low, although how low is context specific.

Taylor (1997) provides several examples (Figure 1) where localized removals lead to local extirpation which arguably violates the ecosystem goals of the MMPA. For all of the models tested, when dispersal fell below a few percentage of the population per year, recruitment into the population with HCM was insufficient to compensate for removal, and population levels declined below those sought by management objectives. Therefore, populations should be managed separately if dispersal between them is less than several percent per year.

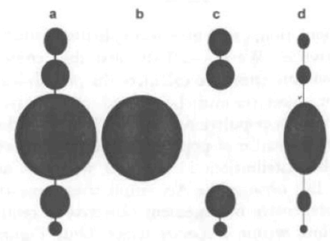

Figure 1. Distribution of pristine populations (a), versus potential distributions after 50% of the total abundance is removed (b–d). Width represents abundance; length represents distance.

Figure 1. Original figure from Taylor (1997).

Taylor (SWFSC) cautioned the TF, however, that it is impossible to have a "one number fits all" criterion and that a better approach would be to have an objective that states what is important in terms of maintaining the extent and connectivity of the range. There are some cases where it is obvious that a stock is no longer a functioning element of its ecosystem, such as example C in Figure 1 where the large central group is extirpated. Extirpation of the PCFG would be more analogous to removing one of the smaller groups outside of the main group (e.g., example B). Further discussion is needed to better define the intent of the MMPA with respect to maintaining marine mammals within different parts of their range.

The second document discussed by the TF, as pertains to the agency's definition of population stock, was the report of a 2006 workshop entitled "Conservation Units of Managed Fish, Threatened or Endangered Species, and Marine Mammals" (Eagle *et al.* 2008). This workshop was convened by NMFS with the objective of bringing together scientists, managers and policy advisers to discuss differences and recommend revisions to how NMFS defines units to conserve under three statutes – the MMPA, ESA and Magnuson-Stevens Act (MSA). The workshop sought to address two overarching questions: (1) why are conservation units different under the three statutes? and (2) is there a biological paradigm that can be used to explain the differences?

In brief, it was agreed by the participants of the 2006 workshop that the differences in how NMFS defines conservation units under the three statutes are appropriate given the differing objectives of the three laws. Under the ESA, major objectives are to prevent *species* extinction and preserve evolutionary potential. Thus, conservation units under this Act should be substantially reproductively isolated. Under the MMPA, objectives correspond to maintaining population and ecosystem goals. Therefore, conservation units align with demographically independent units (DIPs), which are demographically discrete from other populations but not necessarily genetically discrete due to a low but sufficient degree of interbreeding between them. Participants of the 2006 workshop concluded that while the GAMMS guidelines "…*clearly support the use of DIPs as stocks of marine mammals […] the MMPA does not indicate to what extent breeding should occur within a stock instead of among stocks*" and that future revisions to the GAMMS guidelines "*should, therefore, include a rationalization for recognizing DIPs as stocks in cases where males from one stock may breed with females from the same and other stocks*".

There was discussion amongst the TF regarding where to reasonably draw the line in defining small stocks, given that for some marine mammal species very small groups of animals could be considered DIPs. For example, individual pods of killer whales (*Orcinus orca*) could potentially be considered demographically independent. However, other TF members noted that the intent of the GAMMS guidelines was not to recognize very small population units – such as individual killer whale pods or a small group of animals occupying a small habitat fragment – as population stocks. It was similarly suggested that other criteria besides demographic independence, such as whether the unit can be considered a significant functioning element of the ecosystem, should also be considered in defining stocks. The TF understood that most biological "populations" and "stocks" do not exist as truly distinct groups, nor are individuals within the same population typically part of a truly panmictic group (Waples and Gaggiotti 2006). Rather, population differentiation occurs along a continuum, and placing discrete boundaries along this continuum for management purposes is a challenge. The TF acknowledged that marine mammal social structure can further complicate determining whether a unit should be considered demographically independent. In these areas of uncertainty, decisions will likely be case specific, and ultimately rely on scientific judgment and the factors identified for consideration in the MMPA and GAMMS guidelines.

The TF considered the report by Eagle *et al.* (2008) and the recommendations from that workshop as support for the NMFS interpretation of "interbreed when mature" as one that includes cases where individuals interbreed primarily within their stock but occasional interbreeding amongst stocks may occur and agreed to use such as the operational definition for the purposes of their work.

3. Overview of Eastern, Western and Pacific Coast Feeding Group Gray Whales

Like many species of baleen whales, gray whales exhibit seasonal movements between high-latitude summer feeding grounds and low- latitude wintering areas. The current distribution of this species is limited to the North Pacific, where a small western population (<150 individuals) and a much larger eastern population (~19,000 individuals) are recognized.(Reilly *et al.* 2008).

Lang (SWFSC) presented a brief overview of information on the biology of ENP, WNP, and PCFG gray whales. The purpose of this overview was not to discuss gray whale stock structure in detail but rather to provide a summary of relevant background information.

3.1 Eastern North Pacific (ENP) gray whales

During summer and fall most ENP whales feed in the Chukchi, Beaufort and northwestern Bering Seas (Figure 2). An exception is the relatively small number (100s) of whales that summer and feed along the Pacific coast between Kodiak Island, Alaska and northern California (Darling 1984; Calambokidis *et al.* 2002; 2012; Gosho *et al.* 2011). By late November, the southbound migration of the ENP stock is underway as whales begin to travel from summer feeding areas to winter calving areas off the west coast of Baja California, Mexico (Rugh *et al.* 2001; Swartz *et al.* 2006). The southbound migration is segregated by age, sex and reproductive condition (Rice and Wolman 1971). The northbound migration begins about mid-February and is also segregated by age, sex and reproductive condition.

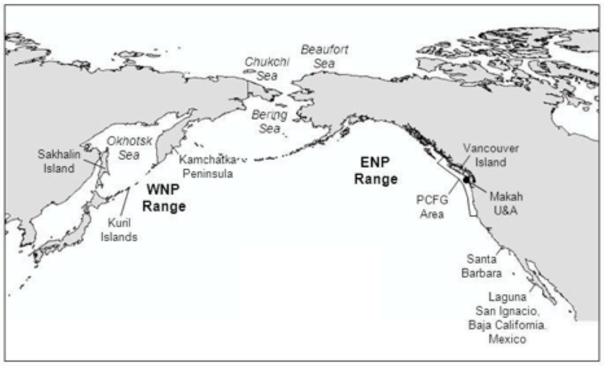

Figure 2. Geographic range of ENP, WNP and PCFG whales. In summer, WNP whales are typically found in feeding areas off the coasts of Sakhalin Island and the Kamchatka Peninsula, in Russia. Most ENP whales are typically found in summer north of St. Lawrence Island (in the northern Bering Sea), including the Bering Strait, the Chukotka Peninsula in Russia, the Chukchi Sea, and along the Beaufort Sea coast (north slope) of Alaska. Additional summer ENP feeding areas include Kodiak, AK, and areas between Southeast Alaska and Northern California. ENP whales migrate to the Baja Peninsula, Mexico in the autumn and return to feeding areas in the spring. The region used by the PCFG is defined to be the area between northern California and northern Vancouver Island (from 41°N to 52°N).

Gray whale breeding and calving are seasonal and closely synchronized with migratory timing. Sexual maturity is attained between 6 and 12 years of age (Rice 1990; Rice and Wolman 1971). Gestation is estimated to be 13 months, with calving beginning in late December and continuing to early February (Rice and Wolman 1971). Some calves are born during the southbound migration while others are born near or on the wintering grounds (Shelden *et al.* 2004). Females produce a single calf, on average, every 2 years (Jones 1990). Calves are weaned and become independent by six to eight months of age while on the summer feeding ground (Rice and Wolman 1971). Three primary calving lagoons in the ENP are utilized during winter, and some females are known to make repeated returns to specific lagoons (Jones 1990).

The abundance of the ENP population, which includes the PCFG, is presently estimated to be about 19,000 whales (Laake *et al.* 2012). The potential biological removal (PBR) level for the ENP stock of gray whales is calculated as the minimum (20^{th} percentile) estimate of population size, times one-half of the maximum theoretical net population growth rate (½ x 6.2% = 3.1%), times a recovery factor of 1.0 for a stock above its maximum net productivity level (MNPL) (Punt and Wade 2012). The minimum population estimate (N_{MIN}) for the ENP stock is calculated from Equation 1 from the PBR Guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{1/2})$. Using the 2006/07 abundance estimate of 19,126 and its associated CV of 0.071, N_{MIN} for this stock is 18,017. Therefore, PBR is 558 animals. A recent analysis conducted by Punt and Wade (2012) estimated a probability of 0.884 that the ENP gray whale stock is above its MNPL, which means there is a 0.884 probability that it is at its OSP as defined by the MMPA.

Genetic studies suggest some sub-structuring may occur on the wintering grounds, with significant differences in mitochondrial DNA (mtDNA) haplotype frequencies found between females (mothers with calves) utilizing two of the primary calving lagoons and females sampled in other areas (Goerlitz *et al.* 2003). Other research, employing both mtDNA and microsatellites, identified significant departure from panmixia between two of the lagoons using nuclear data, although no significant differences using mtDNA were observed (Alter *et al.* 2009). Significant mtDNA and nuclear (nDNA) genetic differences have been found between whales in the WNP and those in the ENP (LeDuc *et al*. 2002; Lang *et al.*, 2011b).

In discussion, the TF agreed that the information presented by Lang represented an up to date overview of the ENP population and had no follow up questions.

3.2 Western North Pacific (WNP) gray whales

Information on the distribution and migration patterns of gray whales in the WNP is incomplete. There is no doubt that the historical distribution of gray whales in the Okhotsk Sea once greatly exceeded what is found at present (Reeves *et al*. 2008). Today, the main feeding ground is in the Okhotsk Sea off the northeastern coast of Sakhalin Island, Russia (Figure 2) but some animals also occur off eastern Kamchatka and in other coastal waters of the northern Okhotsk Sea (Weller *et al.* 2002; Vertyankin *et al.* 2004; Tyurneva *et al.* 2010). Whales associated with the Sakhalin feeding area can be absent for all or part of a given feeding season (Bradford *et al*. 2008), indicating they probably use other areas during the summer and fall feeding period. For example, some whales observed off Sakhalin have been sighted off the northern Kuril Islands in the eastern Okhotsk Sea and Bering Island in the western Bering Sea (Weller *et al*. 2003).

The WNP migration route(s) and winter breeding ground(s) are poorly known (Weller *et al*. 2002; Weller and Brownell 2012). Information collected over the past century indicates that whales migrated along the coasts of Japan and South Korea (Andrews 1914; Mizue 1951; Omura 1984) to wintering areas somewhere in the South China Sea, possibly near Hainan Island (Wang 1984). At present, observations of gray whales off Japan are rare. Nambu *et al*. (2010) reported 13 known sighting or stranding records in Japanese waters between 1990 and 2007. Between 2005 and 2007, four female gray whales were fatally entrapped in set nets along the Pacific coast of Honshu, Japan. One of these females, entrapped in January 2007, was matched to earlier photographs of it as a calf (with its mother) while on the Sakhalin feeding ground in July and August 2006 (Weller *et al*. 2008). This match provided the most contemporary link between the summer feeding ground off Sakhalin and a winter location along the coast of Asia. More recently, in March 2012 a gray whale was sighted and photographed in Mikawa Bay (Aichi Prefecture), east of Ise Bay near Nagoya on the Pacific coast of Honshu (Japan Times, 3 May 2012).

Observations of gray whales in China are also exceptionally rare. Although 24 capture, sighting or stranding records exist since 1933 (Wang 1984; Zhu 2002), including observations of two mother-calf pairs, some of these (especially the sightings) have not been reported in sufficient detail to validate species identification. More recently, an 11.5 m female stranded live at Zhuanghe (Bohai Sea ca. 39˚N) in December 1996 (Zhao 1997) and a 13 m female gray whale was taken in fishing gear offshore of Baiqingxiang (Pingtan County), in the Taiwan Strait in November 2011 (Zhu 2012). The last known sighting of a gray whale off Korea was in 1977 (Park 1995).

The WNP gray whale population is redlisted by the IUCN as Critically Endangered. The most recent population assessment (for 2012), using a Bayesian individually-based stage- structured model, resulted in a median 1+ (non-calf) estimate of 155 individuals, with 95% CI = 142-165 (IUCN 2012). A collaborative Russia-U.S. research program on WNP gray whales summering off northeastern Sakhalin Island, Russia, has been ongoing since the mid-1990s. When data collected between 1994-2011 are combined, a catalog of 200 photo-identified individuals has been compiled. Beginning in 2002, photo-identification studies off Sakhalin have also been conducted by Russia scientists working with oil and gas companies (Tyurneva *et al*. 2010). This research largely corroborates the work of the Russia-U.S. team and in some cases collaborative analyses utilizing combined datasets have been conducted.

Recently, results from photo-identification (Urbán *et al.* 2012; Weller *et al.* 2012), genetic (Lang 2010; Lang *et al.* 2011b), and telemetry studies (Mate *et al.* 2011) have documented spatial and temporal overlap between WNP and ENP gray whales. Observations of such overlap include: (1) six whales photographically matched from Sakhalin Island to southern Vancouver Island, (2) two whales genetically matched from Sakhalin to Santa Barbara, California, (3) 13 whales photographically matched from Sakhalin Island to San Ignacio Lagoon, Mexico, and (4) 2 satellite tagged whales that migrated from Sakhalin Island to the west coast of North America. In combination, these studies have recorded a total of 23 gray whales observed in both the WNP and ENP. Despite this overlap, significant mtDNA and nDNA differences are found between whales in the WNP and those summering in the ENP (Lang *et al.* 2011b). Although it is clear that some whales feeding off Sakhalin Island during the summer/fall migrate to the west coast of North America during the winter/spring, past and present observations of gray whales in the WNP off Japan, Korea and China during the winter/spring suggest that not all gray whales in the WNP share a common wintering ground (Weller and Brownell 2012).

In discussion, the TF agreed that the occurrence of WNP gray whales in U.S. waters presented previously unexpected implications with respect to the SAR process and the Makah waiver request. More specifically, two questions were discussed at length, including: (1) given the occurrence of WNP gray whales in U.S. waters, is a WNP gray whale SAR required? and (2) given the potential occurrence of WNP gray whales in the proposed Makah hunt area, what are the implications regarding the existing wavier request?

TF members also noted that these new findings of gray whales moving between Sakhalin Island and the ENP had significance to our understanding of the status of gray whales in the WNP. That is, given that some of the whales sighted off Sakhalin appear to overwinter in the ENP, the number of animals remaining in the WNP year-round may be much smaller and of greater conservation concern than is currently recognized (Weller and Brownell 2012).

3.3 Pacific Coast Feeding Group (PCFG)

Gray whales using the Pacific Northwest area during summer and autumn include two components: (1) whales that return frequently and account for most of the sightings between 1 June and 30 November, and (2) whales that are sighted only in one year, tend to be seen for shorter time periods in that year, and are encountered in more limited areas. For the purposes of their work to evaluate the proposed Makah Indian Tribe gray whale hunt, the International Whaling Commission (IWC) defined PCFG gray whales as: whales observed between 1 June to 30 November within the region between northern California and northern Vancouver Island (from 41°N to 52°N) and photo-identified within this area during two or more years (IWC 2011; IWC 2012a). This same definition has been adopted in the analyses of Calambokidis *et al.* (2012). In this report, the TF defines "PCFG whales" following the IWC definition.

Recent research has provided new information on movements and habitat utilization of PCFG whales (for example Frasier *et al.* 2011; Lang *et al.* 2011a; Calambokidis *et al.* 2012). While PCFG whales are known to feed during summer and fall off the Pacific coast between northern California and southeastern Alaska, they also occasionally occur as far north as Kodiak (Gosho *et al.* 2011) and Barrow, Alaska (Calambokidis *et al.* 2012). The sighting from Barrow suggests that some PCFG whales (meaning whales seen in summer in the defined area used by the PCFG and in more than one year), at least occasionally occur in one of the most northern gray whale feeding areas in the ENP (Calambokidis *et al.* 2012). Similarly, of the 121 whales identified off Kodiak from 1998-2010, there have been 30 sightings of 17 individuals between June-November in areas extending from northern California to northern British Columbia (Table 9, Calambokidis *et al.* 2012). These observations indicate that at least some PCFG whales have used both the Kodiak feeding area in addition to the 41°N to 52°N area defined for the PCFG.

Satellite tagging studies between 3 September and 4 December 2009 off Oregon and California provide additional movement data for whales considered to be part of the PCFG (Mate *et al.* 2010). While duration of tag attachment differed between individuals, some whales remained in relatively small areas within the larger PCFG seasonal range while others traveled more widely. All six individuals whose tags continued to transmit through the southbound migration utilized the wintering area within and adjacent to Laguna Ojo de Liebre (Scammon´s lagoon). Three whales were tracked north from Ojo de Liebre and displayed the following movement patterns: (1) one whale traveled at least as far as Icy Bay, Alaska, and (2) two whales were tracked to coastal waters off Washington (Olympic Peninsula) and California (Cape Mendocino). In combination, satellite tag and photo-identification data suggest that the range of the PCFG may, at least for some individuals, exceed the pre-defined 41°N to 52°N boundaries that have been used in a number of PCFG-related analyses (e.g., abundance estimation).

Further support of the PCFG range extending beyond the pre-defined 41°N to 52°N boundaries comes from a study of six whales satellite tagged off the central west coast of Vancouver Island in March. This study was designed to determine northern migration routes in the greater Vancouver Island area (Ford *et al.* 2012). Three of the tagged whales had been previously sighted within the seasonal range used by PCFG whales (41°N to 52°N) and two had multi-year sighting histories there. These three whales moved north to between ~55°N to 57° N before their tags stopped transmitting. One of these whales was later observed in the seasonal range of the PCFG off southern Vancouver Island. These findings suggest that in the spring at least some PCFG whales may migrate northward, past the defined seasonal range used by the PCFG, along with the larger ENP stock before "circling back" to within the range of the PCFG summer feeding area.

It is unknown how long gray whales have used the PCFG area in summer and autumn; it may have been colonized as recently as the last century or during the Little Ice Age (~1540-1850) or other glacial periods when it was difficult or impossible for gray whales to feed further north. Records of gray whales feeding between northern California and Alaska during summer/fall date back to at least 1926 (Howell and Huey 1930), including reports of whales feeding on the southern feeding ground during the 1940s, 1950s, and 1960s (Gilmore 1960; Pike and MacAskie 1969; Rice and Wolman 1971). The consistent return of individuals to the southwestern coast of Vancouver Island, British Columbia, was first documented in the early 1970s (Hatler and Darling 1974).

A unique characteristic of PCFG whales is an apparent flexibility in their feeding habits. That is, whales summering in the seasonal range of the PCFG consume a varied diet including mysids, amphipods, crab larvae, and herring eggs/larvae. This is in contrast (generally speaking) to gray whales feeding in the arctic where they seem to be more focused on an amphipod food base (Nerini 1984). That being said, whales that utilize the seasonal range of the PCFG in only a single year (i.e., non-PCFG whales) must also be flexible, at least to some degree, in their feeding habits.

Abundance estimates of PCFG gray whales reported by Calambokidis *et al.* (2012) show a high rate of increase in the late 1990s and early 2000s, but have been relatively stable, albeit with some decline, since about 2003. No statistical analysis of trends in abundance is currently available for this population. The PCFG is estimated to contain about 200 individuals (Calambokidis *et al*. 2012). As stated in the 2012 gray whale SAR "because the PCFG appears to be a distinct feeding aggregation and may warrant consideration as a distinct stock in the future, a separate PBR was calculated" (Carretta *et al*. 2013). Calculation of a PBR for the PCFG allows NMFS to assess whether levels of HCM are likely to cause local depletion of this group. In keeping with that management objective, NMFS used the 2008 abundance estimate of 194 (SE = 17.0)[3] from Calambokidis *et al*. (2010) and the range of the PCFG (between 41°N to 52°N) as defined by the IWC to calculate a potential PBR for PCFG whales (Carretta *et al*. 2013). This calculation used the minimum population size (180 animals), times one half the maximum theoretical net population growth rate (½ x 6.2% = 3.1%), times a recovery factor of 0.5 (for a population of unknown status), resulting in a PBR of 2.8 animals (NMFS 2012). Further, a review of annual HCM in the PCFG between 2006 and 2010 was estimated and averaged 0.6 animals/year known deaths (Carretta *et al*. 2013).

In discussion, the TF asked Lang if there was any evidence that oceanographic changes have influenced the abundance or recruitment of whales into the PCFG. Lang replied that Calambokidis *et al.* (2012) reported a higher than usual "pulse" of animals recruited into the PCFG in the years following the 1999-2000 gray whale Unusual Mortality Event (UME). This UME has been theorized to be the result of limited food resources on the northern feeding grounds (see Gulland *et al.* 2005), and as such, this "pulse" of gray whale immigration[4] into the PCFG could potentially be considered a response to oceanographic changes. Given that the photo-identification effort on PCFG whales expanded greatly in 1998 (data from years prior to 1998 exist but not at the same level of effort), coinciding closely in time with the UME, it makes it impossible to resolve with certainty the occurrence or magnitude of the hypothesized pulse recruitment.

In response to the observations of PCFG whales in northern areas such as Kodiak and Barrow, Alaska, some members of the TF asked why the boundaries of the PCFG area defined by the IWC were not extended further north? The TF noted that the IWC definition was not intended to define the stock but rather to provide a conservative basis on which to evaluate the gray whale hunt proposed by the Makah Indian Tribe. With respect to low survey effort north of 52°N, the TF agreed that the PCFG could have a higher abundance than currently estimated and that this might affect a number of analyses including determination of annual sighting patterns of individual whales (e.g., a PCFG whale may have been present in a larger area but not photographed because it was located in an region not surveyed). The TF concurred that these issues are important to assignments of PCFG whales (i.e., those seen in two or more years between 41°N and 52°N) and highlighted the importance of expanding the spatial and temporal coverage of the photo-identification effort. In addition, further satellite tagging of known PCFG whales would also help to better define habitat use and delineate the seasonal feeding range.

Additional discussion was devoted to addressing the possibility that HCM (e.g., ship strikes and commercial fisheries bycatch) for whales in the PCFG area could be higher than for whales that migrate through the area. That is, PCFG whales spend more time near shore where ship traffic and fishing gear are concentrated. Despite this concern, little information is available on where

[3] This estimate will be updated in the 2013 SAR to include the now available 1999-2010 time series presented in Calambokidis *et al*. (2012).

[4] Immigration, as used here, means a permanent change of feeding ground fidelity and is considered interchangeable with "external recruitment".

HCM actually occurs. The TF asked Carretta how whales were classified as being PCFG in his analysis. He replied that the estimate was based on NMFS stranding data for the most recent 5-year period and included whales that stranded within the defined PCFG time period (1 June and 30 November) and range (41°N to 52°N). Carretta noted that his estimate of 0.6 animals/year, based on only the most current 5-year period (as per protocol of the SAR guidelines), is lower than the 20-year average of 1.5 animals/year reported elsewhere (IWC 2012a). The TF agreed that both of these estimates of HCM for the PCFG were likely to represent minimum estimates because there is no correction for incidents that go unobserved or unreported.

Related to the issue of HCM, the TF also discussed the results presented in Connor *et al.* (2011), which found that PCFG whales had higher rates of scarring than other gray whales. It was noted that crab pots are common off the Washington and Oregon coasts and as such may pose an increased threat in some parts of the PCFG range. Carretta noted that when looking through the HCM records, a fair number of southern California crab pot interactions were reported, which suggests that fisheries interactions of this nature could be a pervasive issue along the coast. The TF noted that PCFG animals could have more interactions (compared to non-PCFG whales) with crab pots and coastal fishing gear given their extended residency in nearshore areas. Therefore, the TF recommended that the existing photo-identification time series be used to examine scarring patterns of PCFG whales to possibly provide a better assessment of their interactions with fishing gear.

4. Population Dynamics of the Pacific Coast Feeding Group

Laake (AFSC) provided a summary of information regarding the PCFG (following the IWC definition) based on photo-identification research as described in Calambokidis *et al.* (2012). Photo-identification studies from 1998 to 2010 between northern California and northern British Columbia have categorized gray whales using that region during summer and autumn in two components: (1) whales that frequently return to the area, are seen in more than one year between 1 June and 30 November, and account for most of the sightings during that time period, and (2) whales that are sighted only in one year, tend to be seen for shorter time periods in that year, and are encountered in more limited areas.

4.1 Definition of Pacific Coast Feeding Group whales based on timing and area

Defining the PCFG involves analysis that spans both time and space. The temporal component of the PCFG range is better defined than the spatial component, but neither can be considered absolute. As mentioned previously, the IWC defines the PCFG as: gray whales observed between 1 June to 30 November within the region between northern California and northern Vancouver Island (from 41°N to 52°N) and photo-identified within this area during two or more years (IWC 2012a). The spatial boundaries of the PCFG range under the IWC definition were chosen for the following reasons: (1) samples used for the genetic analyses were taken from whales across this range, (2) the work of Calambokidis *et al.* (2012) showed movements of whales throughout the area (Figure 3), (3) only a small number of PCFG whales have been observed north or south of the area during the 1 June to 30 November time period, and (4) few if any whales are still migrating north through the 41°N to 52° N region from 1 June to 30 November. The temporal definition (1 June to 30 November) was based, in part, on the disparity in sighting rates across months. Whales observed after 1 June were more likely to be sighted (i.e., photographed) more than one time, in more than one year, and in more than one region (Figure 4).

In discussion, the TF asked whether the results presented in Figure 3 were effort-corrected. Laake explained that the proportions are only dependent on the effort in the region from the Makah U&A to Southern Vancouver Island (SVI) and not in the other areas. Variation in effort in areas outside of the Makah U&A-SVI region will change the sample size that could be detected in the Makah U&A-SVI but not the proportion of individuals resighted in the Makah U&A-SVI.

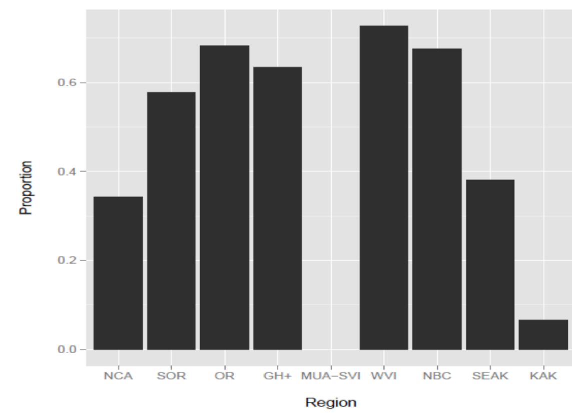

Figure 3. Proportion of whales sighted in the MUA-SVI region of whales seen in the identified areas. MUA and SVI were collapsed due to their proximity and high exchange rate. NCA = Northern California, SOR = Southern Oregon, OR = Central Oregon, GH+ = Gray's Harbor and surrounding coastal waters, MUA-SVI – Makah Usual and Accustomed Area to Southern Vancouver Island, WVI = West Vancouver Island, NBC = Northen Vancouver Island and coastal areas of British Columbia, SEAK = Southeast Alaska, KAK = Kodiak, Alaska.

The spatial range of PCFG whales was then discussed by the TF, including apparent gaps in survey coverage. Surveys in the seasonal range of the PCFG tend to focus on regions where gray whales have been seen and so the surveys are not randomly designed to cover the entire possible range. There is a large gap in survey effort north of 52° N (i.e., between northern Vancouver Island and Kodiak, Alaska). Because only a limited amount of gray whale survey effort has been undertaken in this region, it is unknown whether this area represents a true distributional gap. Even with this limitation, it is nevertheless possible to document observed movements of known individuals and estimate a related minimum range. Figure 5 presents the observed range of maximum distances between sighting locations for individual whales. Overall, approximately 40% of PCFG whales are known to have utilized areas spanning at least one degree of latitude. Further, there are documented movements of PCFG whales to Kodiak (Gosho *et al.* 2011) and Point Barrow, Alaska (Calambokidis *et al.* 2012), in years they were not seen in the PCFG area. Finally, information from tagging (see section above) also supports the idea that the range of some PCFG whales extends outside of the presently defined boundaries.

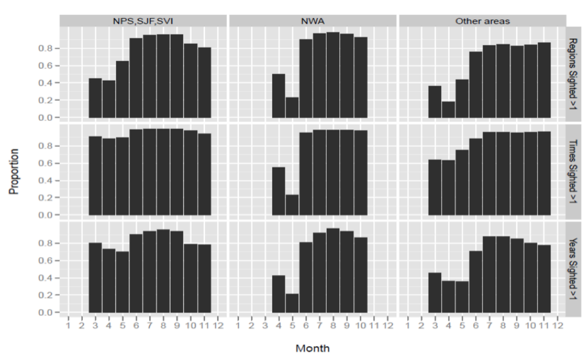

Figure 4. Proportion of whales sighted in more than one region (top), on more than one day (center) and in more than one year (bottom) as defined by the region and month they were seen. NPS = Northern Puget Sound, SJF = Strait of Juan de Fuca, SVI = Southern Vancouver Island, NWA = Northern Washington Coast.

It was noted by the TF that site fidelity of known reproductive mothers to the WNP Sakhalin Island feeding area is very strong (Weller *et al.* 2002). The TF therefore recommended that the existing PCFG photo-identification data be examined to see if moms/calves demonstrate higher levels of fidelity than other whales.

4.2 Pacific Coast Feeding Group abundance and survival

The photo-identification data collected annually in the seasonal range of PCFG whales (following the IWC definition) between 1998 and 2010 have been used to estimate abundance. In these analyses, the term "transient whale" was used to refer to whales seen in only one year and never seen again in any other year, and "non-transient whale" was used to refer to whales seen in at least two years, such that an estimate of the number of non-transient whales would be equivalent to an estimate of the number of whales defined to be in the area used by the PCFG. The total number of gray whales in the area used by the PCFG in summer would include both transient and non-transient whales, and is therefore higher than the number of defined PCFG whales in the area. In the following discussion of abundance estimates, whether an estimate is biased or not is relative to the true number of defined PCFG whales (not to the total number of gray whales in the area).

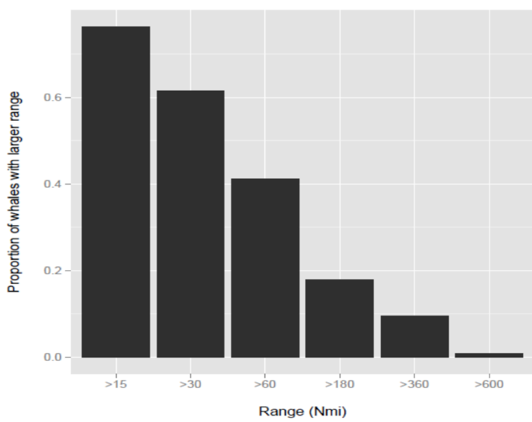

Figure 5. Distribution of maximum distance, in nautical miles, between photo-id locations for PCFG gray whales during 1 June – 30 November 1998-2010. The distance for 40% of the whales exceeded 1 degree latitude (60 nautical miles).

A number of different estimators were used including: (1) Lincoln-Peterson (LP), (2) Limited Lincoln-Peterson (LLP), and (3) Modified Jolly-Seber (JS1). The first two estimators constructed estimates from consecutive years of data. The LP estimator assumes a closed population and is unbiased if there are only losses or only gains. There are both losses and gains to the PCFG due to transient whales and therefore induces a positive bias. The LLP estimator removes the positive bias of the LP estimator by restricting the data to whales seen during the 2-year period but also in another year prior or after the 2-year period. This restriction eliminates whales that were transients in either of the years. The JS1 estimator is an open population model that estimates the abundance of non-transient whales. A fourth estimator, JS2, is an alternate JS modification that produced similar results except at the end of the time series (Calambokidis *et al*. 2012).

Calambokidis *et al.* (2012) considered the JS1 estimator to be the best suited for analysis of the PCFG (Figure 6). The Jolly Seber 1 (JS1) estimator assumes that any gray whale joining the PCFG is seen the first year it enters. The assumption is made to model the data adequately with the strong relationship between minimum tenure (time between first and last sighting in the year) and the probability it remains in the PCFG. The magnitude and trend of the LP abundance estimates do not match up well with the limited LP and the JS1 estimates; this is due to the fact that the LP

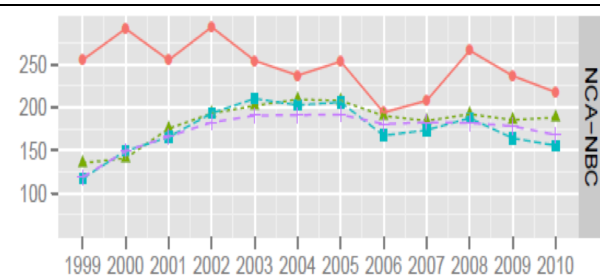

Figure 6. Estimates of the abundance of PCFG gray whales between northern California and northern British Columbia (NCA – NBC) using four different estimators based on photo-id data collected annually between 1998 and 2010. LP = Red Circle, JS1=Green Triangle, LLP=Blue Square, JS2=Purple Dotted Line

estimator was positively biased and the bias was greater at the beginning of the time series when there was more immigration and emigration into and out of the area used by the PCFG.

In discussion, the TF focused on whether the increase in the JS1 abundance estimates from 1999-2002 (Figure 6) was real or a reflection of the discovery of "new" whales that were present in the area used by the PCFG but not observed (i.e., photographed). Some of that discussion also focused on the related topic of recruitment described below. Laake responded that there were 13 whales not sighted in 1998 that were seen after 1998 (most of them were sighted in 1999) and were in the catalog for sightings prior to 1998. These results indicate that the assumption of JS1 (i.e., that any gray whale joining the PCFG is seen the first year it enters) was not met entirely. That being said, Laake argued that the bias was small or negligible after 1999 for the following reasons: (1) values from the JS1 estimator correspond closely to the value from the limited LP estimator which does not make the same assumption, (2) simulation results using similar values for capture probability estimated from the data showed a minimal amount of bias after 1999, and (3) the UME in 1999-2000 provides a plausible explanation for the coincident increase in PCFG abundance.

4.3 Pacific Coast Feeding Group IWC implementation review

Wade (AFSC) presented a brief overview of the status of the Implementation Review (IR) process conducted by the IWC. The IR includes trials based on three hypotheses: (1) Hypothesis P (Pulse) assumes that there is no bias in the PCFG abundance estimates (but dropping 1998) and that a pulse of immigration occurred in 1999 and 2000; (B) Hypothesis B (Bias) assumes a strong time-varying bias in the abundance estimate but no pulse of immigration; and (3) Hypothesis I (Intermediate) includes a moderate time-varying bias in the abundance estimates and a pulse of 10 immigrants into the PCFG in both 1999 and 2000. These hypotheses were evaluated because the model used in the IWC IR trials could not produce simulated abundance trajectories that fit the abundance estimates without incorporating a pulse or a bias into their model. For these trials the IWC Scientific Committee agreed that a sufficient fit to the data could be achieved with maximum annual immigration of up to six animals.

Wade noted that for the most part there was broad similarity between the population trajectories in the IWC trials and the population trajectories in the OSP determinations performed by Moore and Punt (pers. comm.), which only use Hypothesis P (a pulse of immigrants in 1999 and 2000, see related item below). The IWC implementation trials produce final statistics related to conservation status and catches.

There was some discussion about the need to evaluate trials that produced worrying conservation statistics and that it would be valuable to look at what the depletion level could be in those trials. Wade noted that the trials incorporating a low growth rate with little immigration or the trials in which the probability of taking a PCFG whale were doubled were the trials which do not do well with respect to conservation statistics such as final depletion level. Note that "final depletion level" is defined by the IWC to be the final population level as a percent of K. This is related to, but can be slightly different from, the U.S. MMPA definition of "depletion", which is defined to be a population level below the Maximum Net Productivity Level (MNPL). In U.S. MMPA depletion determinations, MNPL is generally assumed to either be a range from 50-70% of K, or a single value such as 50% or 60% of K. The only practical difference occurs when a range is used in MMPA determinations, where one calculates the probability a population is below MNPL over a range of percentages of K. If a single value is used for MNPL (e.g., 60%), than the IWC final depletion level is identical.

Some of the simulations conducted by the IWC with worrisome conservation performance (with respect to final depletion below 60%) are those using Maximum Sustained Yield Rate (MSYR) of 1% or 2%, implying a relatively low maximum population growth rate (Annex E, IWC 2012b). Note that the IWC Scientific Committee parameterizes population models with MSYR rather than Rmax (used in U.S. MMPA calculations). MSYR is the population growth rate at the Maximum Sustained Yield level, which is equivalent to MNPL if human-caused removals are unbiased with respect to age. Therefore, if MNPL is 50% of K, a population with an MSYR of 2% has an Rmax of 4%, and a population with an MSYR of 1% has an Rmax of 2%. Taylor noted that although she would have initially thought population growth rates that low were unlikely, after seeing some of the results presented she felt that relatively low population growth rates cannot be ruled out. She also noted that all trials in the table (which was a summary of trials that performed poorly with respect to conservation statistics) have annual immigration = 0 to 2, at the low end of the range considered. It appears that rates of annual immigration higher than 2 provide just enough of an offset to low MSYR rates of 1 or 2%.

The TF asked how the rescaled final depletion level was related to final depletion level in the IWC results. The rescaled final depletion statistic is used by IWC in trials whose specifications cause the population to decline even in the absence of catches. To evaluate those trials, the final population level for the trial (with catches) is compared to the final population level that would have been obtained in the absence of catches. That ratio is termed the rescaled final depletion, and represents the fraction of the population size that would have been obtained in the absence of catches. Since a low MSYR rate results in low population growth, the IWC found it is useful to compare depletion levels both with and without catches. The rescaled final depletion results for the PCFG only differ from the final depletion statistic for trials with a low value for MSYR, where the PCFG would decline and become depleted regardless of whether a hunt occurred due to the combination of a low population growth rate and bycatch.

4.4 Pacific Coast Feeding Group recruitment

Although new whales are identified each year in the range of the PCFG, about 50% of these individuals are seen in only one year and considered "transients" or "visitors" (Figure 7). Other whales are resighted in subsequent years and are considered "recruits" into the PCFG. Whales with a longer minimum tenure in the first year they were sighted have higher first year apparent survival and higher probability of return (i.e., do not permanently emigrate). This relationship might be expected given a hypothesis that whales are more likely to return if they find a suitable prey base during their first year in the seasonal range of the PCFG.

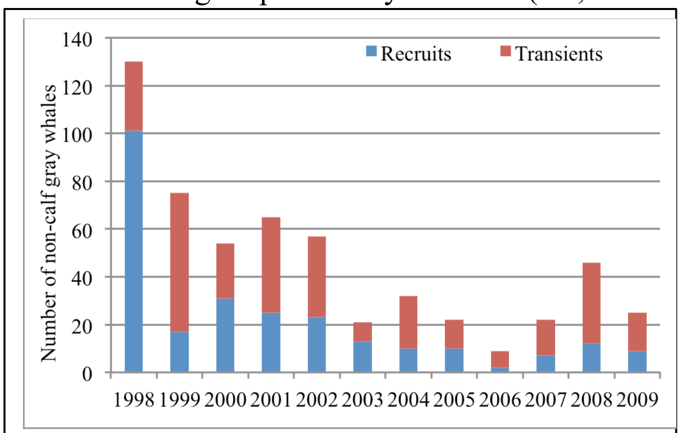

Figure 7. Number of "new" whales seen each year in the PCFG area that are transients (only seen in one year) and recruits (seen in more than one year).

Whales that recruited into the PCFG in 1999 or a subsequent year had lower first year apparent survival than whales that were first identified in 1998. Approximately 75% of the whales whose minimum tenure was 100 days or more in 1999 or later were resighted in a following year. For whales identified in 1998 (the first year of the study) whose minimum tenure was 100 days, nearly 100% were

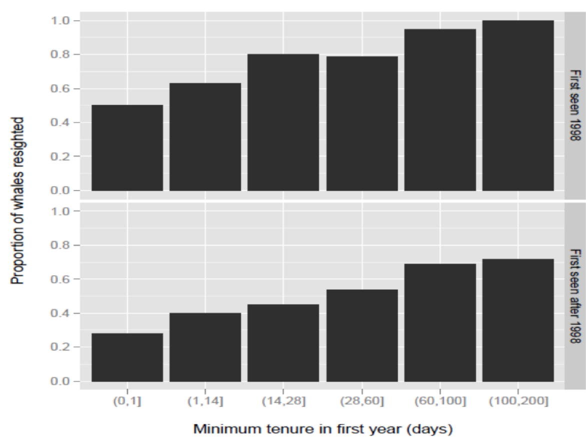

Figure 8. Relationship between minimum tenure in first year (# of days between first and last sighting plus 1) and the proportion resighted in at least one following year. The data series starts in 1998 so all whales are "new" so while the pattern is similar, the proportions are higher for 1998 because most whales are not truly new to the PCFG.

resighted in a following year (Figure 8). This suggests that some of the animals that recruited into the PCFG in 1999 or later may have subsequently emigrated out; this could explain why the abundance has declined somewhat in the later years (Figure 6). The high number of new whales identified in the seasonal range of the PCFG between 1999 and 2002 is hypothesized to have been in response to the 1999-2000 UME.

The TF discussed several alternative explanations for the relatively high numbers of recruits into the PCFG in the early part of the time series (1999-2002). For example, whether the increase in abundance during early years could be due to a "discovery" effect, such that it took a number of years for all the whales which were part of the PCFG to be photographed and "discovered". Alternatively, the heterogeneity in survey coverage over time and space could lead to some animals being considered "new" in a given year even if they had been utilizing areas with limited or no survey coverage in previous years. However, overall capture probabilities are high, suggesting it is unlikely a whale would be in the area for several years and not photographed. The TF concurred that on an annual basis, whales observed in the area used by the PCFG could be characterized as a collection of individuals whose residence patterns vary along a continuum such that some whales use the area for a single year (e.g., transients), some for a few years, and others on a consistent long-term basis.

By way of an analogy, Laake characterized the PCFG as a "leaky bucket", in that some whales are immigrating in while others are emigrating out. The "leaky bucket" phenomenon is not a random process, however, because a "core group" of whales appear to stay in the bucket over time. The dataset cannot discriminate between PCFG whales that die versus those that emigrate. Animals that recruit into the PCFG as non-calves may be more likely to emigrate out of the area than calves recruited to the PCFG in the year they were born. That is, calves of the year have been taught to feed on prey types common to the PCFG area (various swarming prey for instance) by their mothers and may obtain "local knowledge" that allows them to be successful long-term inhabitants of the PCFG area. To evaluate this, the TF recommended that the existing PCFG photo-identification time series be examined to see if moms/calves demonstrate higher degrees of fidelity than other whales.

In thinking about the "core group" of PCFG whales that return to the area on a consistent basis, the TF questioned if biopsy efforts in the area could be potentially biased towards these whales. If sampling efforts are unintentionally concentrating on the "core group" of PCFG whales, then the results of genetic comparisons may be driven by matrilineal fidelity of this "core group". In addition, the biopsy efforts are not spread evenly over time and space (more heterogeneity than the photo-identification survey efforts). If "core group" animals predominantly use the areas with high biopsy effort, then this potential bias could be magnified.

Some newly seen whales are calves with their mothers (Figure 9). As described in Calambokidis *et al.* (2012), much of the sighting effort occurs in August and later when many calves are likely to already be weaned and thereby more difficult to identify as a calf (versus a yearling). The TF noted that many of the whales identified as calves off Sakhalin Island in the WNP are not resighted for many years subsequent to their birth year but eventually they are again resighted in the area. This pattern suggests that young animals (1+ years old) may use other areas to feed during their first several years. Therefore, in the case of the PCFG, if a whale was not seen as a calf but returned in a later year it would appear to be an external rather than internal recruit. With that in mind, the TF recommended that the existing PCFG photo-identification time series be examined following a protocol developed by Bradford et al. (2011) that uses barnacle and pigmentation characteristics on young gray whales to reliably distinguish calves of the year from yearlings.

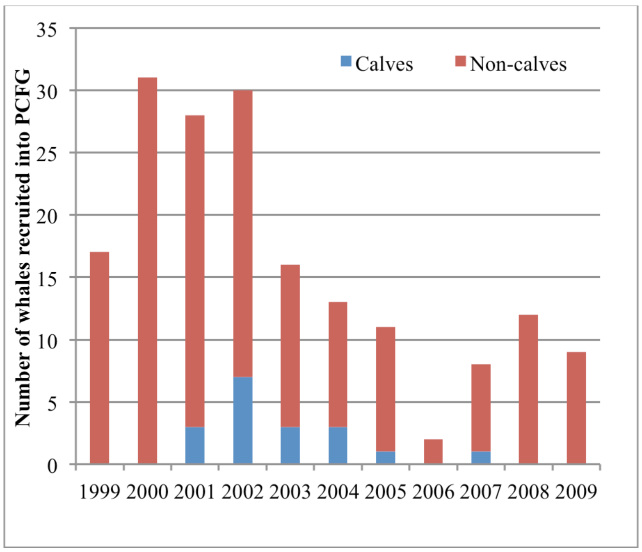

Figure 9. Number of whales first seen and recruited (seen in a following year) by year and calf and non-calf designation.

In summary, the TF discussion about the magnitude and source of recruitment into the PCFG focused on: (1) incomplete survey coverage of the entire seasonal range used by the PCFG and the potential for whales to be missed and then "recruited" in a subsequent year, (2) the proportion of "recruited" whales that were calves of mothers from the PCFG that may have been missed as a calf or misidentified as an external recruit, (3) the potential of the 1999/2000 UME to create a pulse of immigration into the PCFG, (4) to what degree gray whales recruited in 1999 or later were either emigrating back to the northern feeding areas or experiencing higher mortality, and (5) whether the biopsy sampling effort was prone to sample whales that spent more time in the range used by the PCFG.

All of these issues are relevant to assessing the amount of external recruitment into the PCFG and thereby especially pertinent to determining if it should be recognized as a population stock under the MMPA and GAMMS guidelines. That is, if the PCFG experiences little external recruitment then it would be considered demographically independent and should be recognized as a stock. If most of the recruitment into the PCFG were external, however, then it would not be considered demographically independent and would not be recognized as a stock. The TF concurred that the resolution of the existing photo-identification data in combination with uncertainly surrounding the accuracy of assigning whales as external or internal recruits prevent this question from being fully resolved. Increased genetic sampling in tandem with increased photo-id effort over both space and time may be the only way to better address this question.

4.5 Pacific Coast Feeding Group trend and optimum sustainable population determination

Moore presented an update on work he conducted in collaboration with Andre Punt (University of Washington) to determine if the PCFG, as a putative stock, is at OSP. The OSP assessment is based on the two-stock population model that has been developed as part of the IWC gray whale

Implementation Review (see section 4.3). Both assessments use the same definition for a PCFG whale. There are some differences, however, between the IWC model framework and the one used for the OSP assessment. First, in the OSP analysis, a Bayesian approach is used in which prior distributions are specified for input parameters and the time series of abundance estimates (for the ENP and PCFG) are used to the update priors and output posterior distributions. This contrasts with the IWC approach of generating outputs for many models each based on alternative fixed combinations of values for some parameters. Second, the IWC trials consider several hypotheses that attempt to explain the rapid increase in abundance estimates in the first few years of the time series; these include bias in the early abundance estimates, a pulse of immigration, and a combination of these two factors. In the OSP assessment, only the pulse immigration hypothesis is considered, based on work by Calambokidis *et al.* (2012) which suggested that the most recent abundance estimates should be fairly unbiased apart from the first estimate in 1998, which is not used in the OSP analysis.

At the time of the workshop, the OSP analysis considered two hypotheses pertaining to the regular annual immigration rate: one in which there is no immigration (PCFG is closed) and one in which the annual immigration rate is estimated, given a uniform prior distributed between 0 and 6 individuals per year. Different versions of the model allow the density-dependent (or inflection point) parameter θ to be estimated separately for each putative stock (PCFG vs. rest of the ENP) or to be constrained so that the two groups share a common θ. Outputs from both versions and immigration rate considerations (none vs. U[0, 6]) are similar in models run thus far. The primary parameter of interest in the OSP assessment is the probability that PCFG abundance is above MNPL (MSYL in IWC terms).

The analysis was not able to generate useful assessment results because, apart from the rapid population increase in the late 1990s attributed to an immigration pulse, the abundance time series is fairly flat and therefore not very informative for estimating *in situ* population growth parameters. The data have also not been informative for estimating population carrying capacity (K), a parameter necessary to determine whether current abundance is above MNPL. Posterior distributions for K have been strongly dependent on the upper bound used for the prior. Given that the abundance has been stable throughout most of the 2000s, it appears to be regulated at this level (of around 200 - 250 animals) by some factor, and thus it is somewhat puzzling that the data do not seem more informative with respect to estimating K. Moore suggested that annual levels of incidental take included in the model (about 2 animals per year) could be making it difficult to estimate whether the population is being regulated at K or some level below K, given that the data do not inform the estimates of MSYR (the population growth parameter in IWC models). For example, given annual bycatch mortality of 1%, a combination of being well below K and having a low MSYR may describe the data equally well as being close to K and having a high MSYR, since in both cases, the realized value for population growth would be low and potentially balanced by the additive mortality. It was also suggested that the population might be regulated at its current level as a result of emigration and bycatch offsetting the combination of immigration and *in situ* growth.

Moore and Punt were continuing to troubleshoot the problem by running alternative models that, for example, exclude incidental take from the model or constrain estimates of MSYR for the PCFG to be equal to those of the ENP. The goal of this troubleshooting is to explain why estimates of K and hence probability of being at OSP are elusive, which in turn may enable a decision as to whether an OSP assessment may be possible.

The TF thanked Moore and Punt for their work on this complicated matter and raised several points for clarification. It was asked where the estimates of incidental mortality for the model had come from. Moore reported that the bycatch estimate being used is based on a summary compiled at the 2011 IWC Aboriginal Whaling Management Procedure (AWMP) intersessional workshop (IWC 2012a). Carretta clarified that those estimates included data from over a 20-year period that tried to assign animals as being part of the PCFG (or not) based on time and space. Carretta also noted that the bycatch values used in the OSP analysis (as well as the SARs) account for only observed bycatch, which is likely to be an underestimate of actual bycatch.

It was also noted that emigration is a possible explanation for the difficulty in estimating K in spite of apparent PCFG population size stability. That is, all recruits are assumed in the model to have the same annual survival rate but as discussed above, whales that recruited into the PCFG in 1999 or later had lower first year survival than whales that were first identified in 1998. Not including this extra survival parameter may explain some of the lack of fit of the model to the abundance time series (plots show that the model underestimates abundance in the first half of the time series and overestimates abundance in the second half of the series).

The TF asked if the model assumed immigration was constant across years in the assessment given that in reality immigration into the PCFG is thought to vary across years. In the model, immigration to the PCFG occurs at a constant rate, with the number of immigrants being proportional to the northern stock (non-calf) abundance. The rate is equal to the estimated immigration parameter (*I*, specified with the uniform [0,6] prior) divided by 20,000. In other words, for recent abundance levels of the northern stock, annual immigration to the PCFG is approximately *I* individuals. Emigration from the PCFG group is similarly assumed to occur at a constant rate, specified by an additional survival parameter ($1 - S$), with the number of emigrants proportional to PCFG abundance. *S* is set so that when both stocks (northern and PCFG) are at carrying capacity, immigration and emigration to the PCFG is balanced, i.e., $IK_{\text{north}}/20000 = (1 - S)K_{\text{PCFG}}$.

Some members of the TF commented that based on this model it seems plausible that the pulse of immigration into the PCFG is larger than what the IWC is modeling or what the genetic simulations have modeled. If that were the case, then the estimates of regular annual immigration would be lower than estimated in the genetic simulations. In the light of this discussion, the TF noted that the genetic simulations should try pulses of 30 animals to see if that is consistent with the empirical genetic data. This line of thinking led to additional discussion as to how common pulse immigration events might be, and whether, for the purposes of the workshop and deliberations on internal versus external recruitment, the TF should be considering the pulse as part of the average level of immigration or if the pulse should be considered a one-time event and only annual immigration should be considered (in assessing how demographically independent the PCFG is).

It was further noted that if a UME event the size of the one in 1999-2000 had occurred previously, some record of it would be expected. Wade noted that it was due to this reasoning that they did not incorporate additional mortality events in the northern stock OSP analysis conducted by Punt and Wade (2012). Wade also noted, however, that there had been a drop in the northern stock abundance in earlier years of the time series but these were not accompanied by a record of increased strandings. The TF suggested that pulses could occur regularly on decadal time scales or as a result of a variety of other environmental or anthropogenic factors.

The TF discussed if the genetic data may reflect a sampling bias toward "core" PCFG animals. This follows other lines of evidence showing that there is a relationship between minimum tenure and probability of photographically capturing animals in the PCFG area (see section 4.4 above). If "core" PCFG whales are more approachable, then they are potentially more likely to be biopsied, meaning that these whales may be disproportionately selected for in the biopsy process.

Lang noted that she had looked at the current genetic sample set to see if the rare haplotypes found in the PCFG sample set came from animals that were sighted in 1999 or later, which might suggest that they were immigrants as the expectation would be that immigrants would be likely to bring in rare haplotypes. The results were mixed, with some rare haplotypes found in long-term PCFG whales while others were found in animals that came into the PCFG in 1999 or later.

This led to a discussion about what additional information might help the PCFG OSP assessment and improve inference generally about the level of internal versus external recruitment to the PCFG. The TF agreed that additional genetic sampling to improve estimates of immigration and residency times (emigration), and improved estimates of incidental mortality would be useful.

5. Probability of a Western North Pacific Gray Whale Being Taken by the Makah

Mixing of whales identified in the WNP and ENP has recently been reported (Weller *et al.* 2012). Lang (2010) reported that two adult individuals from the WNP, sampled off Sakhalin in 1998 and 2004, matched the microsatellite genotypes, mtDNA haplotypes, and sexes (one male, one female) of two whales sampled off Santa Barbara, California in March 1995. In 2010 and 2011, Mate and colleagues (Mate *et al.* 2011) satellite-tracked three whales from the WNP to the ENP (Mate *et al.* 2011; IWC 2012a; IWC 2012b). Finally, photographic matches between the WNP and ENP, including resightings between Sakhalin and Vancouver Island and Laguna San Ignacio, have further confirmed use of areas in the ENP by whales identified in the WNP (Urbán *et al.* 2012; Weller *et al.* 2012). Despite this level of mixing, significant mtDNA and nuclear genetic differences between whales in the WNP and ENP have been found (Lang *et al.* 2011b).

Observations of gray whales identified in the WNP migrating to areas off the coast of North America raise concern about placing the WNP population at potential risk of incurring mortality incidental to the ENP gray whale hunt proposed by the Makah Indian Tribe off northern Washington, USA (see IWC 2012a; IWC 2012b). Given the ongoing concern about conservation of the WNP population, in 2011 the Scientific Committee of the IWC emphasized the need to estimate the probability of a western gray whale being killed during aboriginal gray whale hunts (IWC 2012a). Additionally, NOAA is required by NEPA to prepare an Environmental Impact Statement (EIS) pertaining to the Makah's waiver request. The EIS will need to include an analysis of the likelihood of a western gray whale being killed during the proposed Makah gray whale hunt.

Moore summarized the work that he and Weller (SWFSC) have done to estimate the probability that a WNP whale might be taken during the proposed gray whale hunt (Moore and Weller 2013). Four alternative models were evaluated; these models made different assumptions about the proportion of WNP whales that would be available for the hunt or utilized different types of data to inform the probability of a WNP whale being taken. The probability of striking at least one WNP whale over the course of five years was estimated to range from 0.034 – 0.058 across different scenarios of the preferred model, with upper 95% CI estimates ranging from 0.107 –

0.170. This result may be compared to an estimate of PBR. If the recovery factor for calculating PBR is set to 0.1, and discounting the estimate for the proportion of the population that may be migrating through U.S. waters and the proportion of time (months out of a year) they are in U.S waters, then the 5-year PBR estimate is between 0.1 and 0.6 animals, depending on different assumptions about the amount of mixing between the WNP and ENP. Thus, if a WNP whale were to be struck during the 5-year period, PBR would be exceeded.

6. Status of Gray Whale Stocks as Defined by, MMPA, ESA and IUCN

At the request of the TF, Stone (NWR) provided a review of the status of ENP, WNP and PCFG gray whales under the MMPA, ESA, and the International Union for Conservation of Nature (IUCN) redlist.

(1) ENP – The ENP stock is not considered *"strategic/depleted"* under the MMPA and is listed as "*Least Concern*" by the IUCN. Gray whales in the ENP were delisted from the ESA in 1994. Although there have been two petitions (2001 and 2010) to relist the ENP stock under the ESA, both petitions were denied.

(2) WNP – The WNP stock is considered "*strategic/depleted*" under the MMPA and is redlisted as "*Critically Endangered*" by the IUCN. WNP whales are considered "*Endangered*" under the ESA, although there is no stand-alone SAR for WNP whales. Given that ENP whales were delisted in 1994, gray whales in the WNP would be considered a Distinct Population Segment (DPS) under the ESA. Use of the DPS terminology was not common at the time of the delisting and thus the listing documents do not describe the WNP as a DPS.

(3) PCFG - The PCFG does not have a formal status under the MMPA, IUCN nor ESA.

In addition to the above, the TF discussed the status of gray whale stocks as defined by the IWC. Under the IWC implementation review (IR) process, the IWC considers all plausible hypotheses of stock structure, and then determines which hypotheses have high or medium plausibility. Those stock hypotheses with high or medium plausibility are used to evaluate the management variants proposed by hunters. In the case of gray whales, the IWC traditionally considered only the hypothesis of a single ENP stock. New information presented to the IWC in 2010 (Frasier *et al.* 2011) suggesting that the PCFG could be a separate stock resulted in the IWC evaluating a two-stock hypothesis. Members of the TF reminded the group that the IWC does not have to decide if there are one or two gray whale stocks, but only if it is plausible that there is one stock and if it is plausible that there are two stocks (or three stocks). The objective of the IWC is to make sure that the stock or stocks are robust to the proposed hunt under all plausible scenarios. Thus, the IWC process is currently considering both stock hypotheses (1-stock and 2-stock). Future work by the IWC may need to incorporate a third stock (i.e., WNP) but for now the calculation of the probability of a WNP whale being killed during the Makah hunt (see section 5 above) is a stand-alone calculation.

7. Overview of Evidence Used in Recently Defined Population Stocks

Stone provided an overview of the lines of evidence used by NMFS to delineate stocks as inferred from the text of each SAR. It became clear during discussion of the summary that many of the SARs do not explicitly lay out the lines of evidence and justifications for originally delineating a stock but instead only present recent information. The killer whale SARs, for example, do not describe the acoustics data and other lines of evidence that were originally used to identify the stocks. There was general agreement that an updated summary, in spreadsheet form, would be useful as it could capture the history and provide a long-term record of how each stock was delineated, but this would not be a trivial task. In the end, the TF concurred that agency practices for delineating stocks were not based on a set standard but were more variable and fact-specific so as to use the best available information.

8. Review of Stock Definition Cases Relevant to the Pacific Coast Feeding Group

The TF reviewed several examples of stock delineations for other species exhibiting some similar characteristics to the PCFG. Similar characteristics included: (1) use of mtDNA as the sole genetic marker necessary for stock structure determination and (2) mixing with individuals from other stocks during parts of the year.

8.1 Atlantic harbor porpoises

Rosel (SEFSC) presented an overview of stock structure in Atlantic harbor porpoises (*Phocoena phocoena*) with a focus on the Gulf of Maine/Bay of Fundy stock. A single stock was designated in U.S. waters of the Northwest Atlantic based on published literature of Gaskin (1984) who hypothesized four populations in the Northwest Atlantic (three in Canadian waters and one in U.S. waters). While following Gaskin (1984), the first SAR for U.S. Gulf of Maine/Bay of Fundy harbor porpoises stated "*Presently there is insufficient evidence to accept or reject this hypothesis*" (Blaylock *et al*. 1995). In subsequent years, mtDNA evidence supported four stocks in the Northwest Atlantic, including the Gulf of Maine stock, but nuclear microsatellite data did not (Rosel *et al.* 1999). Organopollutant levels (Westgate *et al.* 1997, Westgate and Tolley 1999) and life history characteristics (Read and Hohn 1995) also differed between the Gulf of Maine/Bay of Fundy and other populations in the Northwest Atlantic. The weight of evidence supported delineation of the Gulf of Maine/Bay of Fundy stock and the lack of nDNA differentiation between this stock and others in the Northwest Atlantic was taken to indicate female philopatry coupled with male-mediated gene flow. Microsatellite data indicated that porpoises from the Gulf of Maine/Bay of Fundy probably overlap in winter in the mid-Atlantic with porpoises from other regions of the Northwest Atlantic (Hiltunen 2006), but this is outside the breeding season.

8.2 Alaska harbor seals

Taylor summarized the history of recognizing stocks of harbor seals in Alaska. Harbor seals (*Phoca vitulina*) are continuously distributed throughout Alaskan waters, but mtDNA indicates that genetic differentiation among sampled sites increases with increasing geographic distance (O'Corry-Crowe *et al.* 2003). The continuous distribution implies that there will be movement of animals across stock boundaries drawn on a map, but if no stock boundaries are designated, there is the risk of local depletion and loss of portions of the species' range. The first SARs for Alaska harbor seals comprised three stocks- Bering Sea, Gulf of Alaska and Southeast Alaska (Hill and DeMaster 1998). In 2011, the three stocks were changed to twelve (Allen and Angliss 2012). MtDNA, satellite telemetry, trend and distributional data were used to delineate these 12 stocks. At that time, nDNA data were not available and mtDNA analyses were considered sufficient to meet the criteria of demographic independence under the GAMMS guidelines.

8.3 Humpback whales

Lang presented a review of humpback whale (*Megaptera novaeangliae*) stocks, with a focus on the North Atlantic. There are multiple humpback whale feeding grounds in the Northwest Atlantic, but individuals from these different feeding grounds share one breeding ground in the

West Indies. Humpback whales throughout the Northwest Atlantic were originally classified as a single stock (Waring *et al.* 1999). However, genetic studies have revealed small but significant differences in mtDNA between animals sampled on different feeding grounds (Palsbøll *et al.* 2001) and photo-identification studies have documented strong site fidelity of individuals to the Gulf of Maine feeding area (Clapham *et al.* 1993). The 2000 SAR recognized whales utilizing the Gulf of Maine feeding area as a separate stock (Waring *et al.* 2000). Although this SAR covers only Gulf of Maine whales, individuals from other feeding areas have been identified in U.S. mid-Atlantic waters (Barco *et al.* 2002).

The stock structure of humpback whales in the Pacific is complex (Baker *et al.* 2008; Calambokidis *et al.* 2008) and differs from the western North Atlantic with respect to the "interbreed when mature" criteria. That is, humpback whales from different feeding grounds in the NW Atlantic have the opportunity to interbreed with each other in a single breeding area, while in the North Pacific not all animals have the opportunity to interbreed with each other because there are multiple breeding areas. There is some similarity between North Pacific humpbacks and those in the central and eastern North Atlantic, in that whales on the Norway and Iceland feeding areas may breed in different areas (Palsbøll *et al.* 1997; Stevick *et al.* 1998; Wenzel *et al.* 2009). Three humpback whale stocks are currently recognized in the North Pacific, based on three feeding areas (Allen and Angliss 2012; Carretta *et al.* 2013). The SAR for the Central North Pacific stock includes calculations of PBR for three different feeding areas (Allen and Angliss 2012), as is done for the PCFG in the current SAR (Carretta *et al*. 2013).

9. Review of Gray Whale Genetic Research on Population Structure

Lang provided a chronological summary of genetic research performed on North Pacific gray whales. Steeves *et al*. (2001) used mtDNA control region sequence data to compare 16 samples collected in summer in Clayoquot Sound, British Columbia, representing the PCFG, to 41 samples collected elsewhere in the ENP. Some haplotypes were shared between the two groups and no significant differentiation was found between them. Additional genetic analysis utilizing an extended set of samples (n=45) collected from whales within the seasonal range of the PCFG indicated that the genetic diversity and the number of mtDNA haplotypes identified among these samples were inconsistent with measures that would be expected (based on simulations) if recruitment into the group were exclusively internal (Ramakrishnan *et al*. 2001). Alternative scenarios, such as limited dispersal of whales from other areas into the PCFG, were not explored. LeDuc *et al*. (2002) examined mtDNA control region differences between ENP and WNP gray whales. The ENP sample consisted primarily of stranded animals along the migratory route with some samples from Chukotka, Russia (no distinctions between PCFG and non-PCFG whales were made). The WNP samples were collected off the northeastern coast of Sakhalin Island, Russia. Seven of the 36 identified haplotypes were shared between the two regions and significant genetic differentiation was found. In addition, haplotypic diversity of the WNP sample was lower than that seen for the ENP samples.

Within the ENP, Goerlitz *et al*. (2003) made comparisons between two wintering lagoons and between females sampled in wintering lagoons and those sampled outside the lagoons (in Clayoquot Sound and along the migration route- *i.e.,* "non-lagoon females"). They found small but significant differences in mtDNA data between Laguna San Ignacio cows (females with calves) and non-lagoon females and between Laguna Ojo de Libre cows and non-lagoon females but not when cows from the two lagoons were compared. Alter *et al*. (2009) compared both mitochondrial and nuclear microsatellite markers across three wintering lagoons and found small but significant differences between only one of the three pairwise comparisons using the microsatellite data set only. Similar to Goerlitz *et al.* (2003), they did not find significant differentiation between Laguna San Ignacio and Laguna Ojo de Libre at mitochondrial or nuclear DNA.

More recently, Frasier *et al*. (2011) examined mtDNA differences between whales sampled in Clayoquot Sound, British Columbia (representing the PCFG) and a more carefully constructed data set of ENP whales from LeDuc *et al.* (2002) in which known PCFG whales were specifically removed. They found significant genetic differentiation between the two sample sets and high levels of haplotype diversity in the PCFG sample, comparable to samples thought to represent the larger ENP population. Using this dataset, Frasier *et al.* (2011) also performed a likelihood ratio test using Theta (Θ) as a proxy for effective population size to examine whether the two sample sets come from the same population. The likelihood ratio test indicated that Θ for the PCFG did not equal Θ for the ENP and the authors concluded that the two groups were demographically independent.

D'Intino *et al*. (2012) made a comparison of whales sampled off Vancouver Island and representing the PCFG to whales sampled at the calving lagoon at San Ignacio. Using 15 microsatellite loci, they found no evidence for population differentiation between these two areas and concluded that the two sampled groups come from the same interbreeding population and that maternally-directed site fidelity to different feeding areas leads to genetic differentiation at mtDNA among feeding areas. Lang *et al*. (2011a) expanded on this result and compared whales sighted over two or more years within the PCFG seasonal range to animals sampled on the feeding ground(s) north of the Aleutians using both mtDNA and nuclear microsatellite markers. Significant differentiation was seen for the mtDNA data but not the microsatellite data, supporting the conclusion of Frasier *et al.* (2011) that structure is present among different feeding areas and this structure may be directed by matrilineal fidelity[5] to feeding grounds. Of note, when all samples collected on the PCFG seasonal range (including those collected from animals seen in only one year) were utilized in the mtDNA analyses, no significant differences were detected in the comparison to samples collected from whales off Chukotka. When all samples collected on the PCFG seasonal range were compared to all samples collected north of the Aleutians, the mtDNA F_{ST} comparison detected a significant difference although the χ^2 test did not.

Finally, Lang *et al.* (2011b) re-examined differences between ENP and WNP gray whales, expanding on the previous study of LeDuc *et al.* (2002) by using larger sample sizes, better characterized sampling and both mtDNA and nuclear microsatellite data. Comparisons of whales sampled off Sakhalin Island with whales feeding north of the Aleutians (i.e., ENP whales) and with the PCFG demonstrated significant differentiation at both nuclear and mtDNA markers. The extent of mtDNA differentiation between ENP strata (PCFG and whales feeding north of the Aleutians) and Sakhalin Island was higher than that observed in comparisons within ENP strata. As with previous studies, significant differentiation among ENP feeding areas was not seen in the microsatellite data. The Sakhalin stratum again displayed reduced haplotype diversity compared to the ENP strata. The authors conclude that the mtDNA data support demographic

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[5] Matrilineal fidelity as used here means the learned behavior of a calf (male or female) returning to the feeding ground of its mother.

independence for ENP and WNP gray whales. However, in examining the microsatellite genotypes, Lang *et al.* (2011b) found two individuals biopsied at the Sakhalin feeding ground and off the coast of southern California. These matches, in combination with recent photo-identification and telemetry data (Mate *et al.* 2011; Urbán *et al*. 2012; Weller *et al.* 2012), suggest that some animals summering off Sakhalin overwinter in the ENP in at least some years. Given that recent records document gray whales in the waters off Japan and China during winter and spring (see review in Weller and Brownell 2012) these results suggest that population structure in gray whales may be more complex than previously believed, such that not all of the animals that feed off Sakhalin share a common wintering ground, or that some animals may switch between wintering grounds.

In discussion, TF members suggested some further avenues for exploration including examining whether any microsatellite loci were out of Hardy-Weinberg equilibrium (HWE) for the Sakhalin samples, which might be an indication of mixing of multiple breeding populations on that feeding ground. It was noted that at the 2012 IWC Scientific Committee meeting a paper evaluating the use of HWE tests to look at mixing of stocks was presented and it might be worthwhile to see if the approaches in this paper could be applied to the Sakhalin dataset (IWC 2012b). There was also discussion regarding what proportion of mixing would have to take place before it would be detected by a relatively weak test like HWE.

9.1 Genetic modeling of immigration rates

Lang presented an overview of recent work utilizing a simulation-based approach to evaluate the plausible level of immigration (i.e., a permanent change of feeding ground fidelity, used interchangeably with external recruitment) that might be occurring into the PCFG. While the empirical studies summarized above have shown significant differences in mtDNA between the PCFG and other ENP gray whale feeding areas, suggesting that matrilineal fidelity is important in structuring feeding ground use, other evidence (some from genetics, mostly from photo-id) suggests that some immigration into the PCFG may be occurring. Lang and Martien (2012) used simulations to examine how much immigration into the PCFG could occur to produce results consistent with the empirical genetic (mtDNA) analyses. The results suggested that the plausible range of immigration is >1 and <10 animals/year on top of a two-year pulse of immigration (of 20 animals each year in 2000 and 2001). Annual immigration of 4 animals (with the 2 year pulse of immigration) produced simulated results that were most consistent with the empirical data. If the PCFG had been founded more recently or the abundance of the PCFG is greater than used in the simulations, it is plausible that no annual immigration could be occurring (still assuming the occurrence of a 2-year pulse of immigration).

In discussion of these results, the TF noted several important caveats to the approach used by Lang and Martien (2012), including: (1) the results may be overly precise because so many model parameters are set, and (2) the simulated abundance trajectories do not match well with the mark-recapture estimates (Calambokidis *et al*. 2012) when immigration is 4 immigrants/yr or more. The simulated population trajectories assumed that the PCFG split from the larger ENP population in 1930. Task Force members thought that the 1930 split might be unrealistic, as oceanographic conditions during the Little Ice Age (and earlier) would have limited access to the northern feeding ground(s) and thus may have caused some gray whales to utilize more southern waters for feeding. Lang commented that there were plans to model a split of the PCFG from the larger ENP in the Little Ice Age, but that this work is not yet complete. She also noted that there were many possible histories and it would be difficult to encompass all of them.

10. Discussion of Makah Documents Concerning the Pacific Coast Feeding Group

Weller introduced three documents drafted by or on behalf of the Makah Indian Tribe regarding the PCFG. These documents were provided to the TF in advance of the meeting for review and consideration. In combination, these three documents provided important summary information on the PCFG, including reviews of what is known about the history of the PCFG and summaries of the current status of the group.

The 2011 Makah document (Makah 2011) was drafted by the Tribe and their attorneys and provided to the Pacific and Alaska SRGs as a background paper to help inform their respective reviews of the draft 2012 gray whale SAR (NMFS 2012). This document provides the Makah perspective on whether the PCFG should be recognized as a stock and was therefore deemed important for the TF to review and consider. Information provided in Scordino *et al*. (2011) is largely the same as that presented in the Makah 2011 document.

The 2012 Makah document (Makah 2012) contains comments from the Makah Tribe and their attorneys on the 2012 draft gray whale SAR (NMFS 2012). This document was considered important for the TF to review. In response to the Tribe's request for government-to-government consultation, the SWFSC met with representatives from the Makah Tribe and their attorneys in person to review comments provided in the 2012 document. These comments, where appropriate, were incorporated as changes to the draft text of the SAR (NMFS 2012).

10.1 Discussion of genetics sections of Makah documents

In discussion of these documents, the TF agreed that it was most important to focus on the Makah comments and perspective regarding genetics research on the PCFG. Rosel agreed to lead the TF through the genetics sections of the Makah documents that called into question the strength of the genetic data presented with respect to demographic independence of the PCFG. These points were summarized as: (1) the samples used to represent the overall ENP stock may not be a random sample of the entire stock but could come from different and unknown feeding grounds. This calls into question what the PCFG is being compared to in the genetic analyses, (2) sample sizes from many locations are small relative to overall population size (i.e., relative to the size of the larger ENP population) and to the total level of genetic diversity and that this could cause misleading results, (3) many population comparisons of gray whales have yielded significant but low-level differences in haplotype frequencies; if this is considered sufficient evidence to classify the PCFG as a stock then every group of gray whales utilizing a particular feeding area should be considered a stock, and (4) the genetics results do not support reproductive isolation of the PCFG.

The first two points were related to sampling effects. In discussion, some members of the TF noted that it is not necessarily the sample size that is potentially problematic but rather if related animals are grouped together and multiple biopsies are taken from that "group" then the effective sample size is much smaller. It was further noted that small sample sizes may add variability, but it would only be a problem if there were additional (unrecognized) structure in the samples. From a genetic standpoint, many analyses rely on haplotype frequencies, but if a good sample relative to the genetic diversity of the group is not obtained then the genetic diversity may not be well characterized, especially if there are many rare haplotypes. Since haplotype frequency data also go into analyses for F_{ST} and Chi-square, then poor frequency estimates due to small sample size could affect the accuracy of the genetic differentiation results as well. Lang noted that there is some evidence from North Atlantic humpbacks that the migration to the West Indies is segregated according to feeding ground origin (Stevick *et al.* 2003).

The TF noted, however, that the recent PCFG genetic analyses show high diversity indicating that sampled animals have different haplotypes and are thus not related (maternally). The TF asked if the question at hand is whether gray whales have feeding aggregations or whether the group that migrates north of the Aleutians is different from the group that does not migrate north of the Aleutians. Lang noted that the original intent of the project was to compare samples collected from different feeding areas north of the Aleutians to the area used by the PCFG but in the end sample sizes were insufficient for areas other than Chukotka. Nevertheless, although there could be multiple feeding aggregations north of the Aleutians, one of the comparisons conducted by Lang *et al.* (2011a) used only samples collected off Chukotka to try to avoid including unrecognized structure.

The TF recognized the continuing need for additional data to be collected, but for the purposes of the workshop the focus was whether the lines of evidence from existing genetic analyses are strong enough to counter lines of evidence that put the demographic independence of the PCFG into question. The primary question in the short-term is what can be done with the information that is currently available.

The TF noted that Frasier *et al.* (2011) compared animals from the PCFG with a sample set primarily derived from stranded animals along the U.S. west coast during migration. They agreed that these samples might not be a random representation of the larger ENP, as was also pointed out in the Makah documents.

Overall, the TF felt it was important to recognize that the current research questions being addressed center around feeding-ground-based groups of animals. The genetics work has already shown that when the PCFG is compared to a sample set from northern feeding area (Chukotka) animals or to the Sakhalin animals (also a feeding area) differences have been found (Lang *et al.* 2011b). That is, the PCFG has been shown to be different from two other well-characterized feeding grounds.

While interpretation of the currently available genetic results as relevant to the PCFG has lead to debate amongst different groups, the TF concurred that it represents the best available science. In discussion, some members of the TF agreed that although more progress on this issue could be made over the next few years if resources were available for more intensive sampling, they did not think that the current interpretation of results would change much. That is, even if 1% of the 19,000 or so animals going through Unimak Pass were sampled, a mtDNA difference with the PCFG (as already observed) would remain. So far the PCFG has been compared to samples from feeding areas and from the migratory route and both comparisons detected a genetic difference. It was agreed that the critical issue for additional research to address was better determining the levels of internal versus external recruitment in the PCFG.

At this point the TF returned to discussing the remaining points raised by the Makah documents. The third point was that since multiple genetic comparisons have found low but significant differences, every group of gray whales should be considered a stock. The TF concurred and noted that there is nothing wrong with incrementally adding stocks as new evidence is uncovered, and that decisions have to be made based on the best available science.

The final point discussed was that the genetics results do not support reproductive isolation of the PCFG. The TF agreed in general that the pattern and timing of migration provide ample opportunity for breeding between PCFG whales and other ENP whales. Little is known about gray whale social and mating systems, however, and presently unrecognized mechanisms facilitating selective breeding could exist. If a form of selective breeding does exist, then it could be a long time before nDNA differences appear. A suggested approach to resolving this question is to look at the relatedness of animals in the PCFG. Despite this, the TF agreed that it is most likely that PCFG animals are interbreeding with animals coming from other areas.

11. Research Recommendations

The TF agreed that the following set of recommendations represent key research needs that could help provide additional insight regarding if the PCFG should be recognized as a population stock under the MMPA and GAMMS guidelines.

Given the limited photo-identification and biopsy effort north of 52°N but knowing that at least some observations of PCFG whales in northern feeding areas (e.g., Kodiak and Barrow, Alaska) have been recorded, the TF highlighted the importance of expanding the spatial and temporal coverage of the photo-identification and biopsy effort. In addition, the TF also recommended that further satellite tagging of known PCFG whales be conducted to better delineate habitat use and define the summer/fall feeding area boundaries.

The TF noted that PCFG animals might more regularly interact (compared to non-PCFG whales) with crab pots given their extended residency in coastal waters. Therefore, the TF recommended that the existing photo-identification time series be used to examine scarring patterns of PCFG whales to better understand the incidence of interactions with fishing gear.

Since much of the photo-identification sighting effort occurs in August and later, when many calves are likely to already be weaned and thereby more difficult to identify as a calf (versus a yearling), the TF recommended that the existing PCFG photo-identification time series be examined following a protocol developed by Bradford *et al*. (2011). This photo-based method uses barnacle and pigmentation characteristics on young gray whales to reliably distinguish calves of the year from yearlings.

Knowing that several lines of evidence demonstrate a relationship between minimum tenure and the probability of photographically capturing animals in the 42°N-52N° PCFG area, the TF recommended that the existing PCFG photo-identification time series be examined to see if moms/calves demonstrate higher degrees of fidelity than other whales.

Although photo-identification studies of the PCFG by Calambokidis and colleagues have been ongoing for over a decade, a relatively high number of "new" animals (not previously sighted in the area) are identified each year and subsequently show consistent return to the area (Calambokidis *et al*. 2012). These "new" animals could represent calves born into the group (i.e., internal recruitment) and not identified in their first year, or they could represent animals that traditionally feed in northern areas but now show fidelity to the seasonal range of the PCFG (i.e., external recruits). To better address this question, the TF recommended that relatedness analysis, in which microsatellite genotypes are used to identify animals that represent putative mother-offspring pairs, be used to assess the proportion of internal recruitment occurring within the PCFG. A sufficient understanding of recruitment to make a stock definition determination could potentially be achieved with a concerted effort to sample known mothers and recruits and determine their relatedness.

Related to the recommendation above, some TF members felt that it was plausible that the pulse of immigration into the PCFG could be larger than what the genetic simulations have modeled. If so, then the estimates of annual immigration into the PCFG could be lower than that estimated in the genetic simulations. With this in mind, the TF recommended that the genetic simulations should try pulses of 30 animals and see if that is consistent with the empirical genetic data.

12. Structured Decision-Making Process

At the request of the TF, Bettridge provided an overview of the FEMAT-style structured decision-making process[6]. In some NMFS status reviews, Biological Review Teams (BRTs) formed pursuant to the ESA have adopted formal methods to express plausibility for use in guiding its analysis of DPSs and in assessing the risks to the population(s). These formal methods are important in a setting where quantitative measures of uncertainty derived from the empirical data are unavailable. This point allocation method is often referred to as the "FEMAT" method because it is a variation of a method used by scientific teams evaluating options under the Northwest Forest Plan (Forest Ecosystem Management Assessment Team). In this approach, for example, each expert is asked to distribute plausibility points among the choices/scenarios for a given decision, reflecting his or her opinion of how likely that choice or option correctly reflected the population status. If the expert is certain of a particular option, or feels it is the only plausible scenario, he or she could assign all points to that option. An expert with less certainty about which option best reflected reality or best reflected the population's status could split the points among two or more options. This method has been used in all status review updates for anadromous Pacific salmonids since 1999, as well as in reviews of Southern Resident killer whales, West Coast rockfishes, Pacific herring (*Clupea pallasii*), Pacific groundfish, North American green sturgeon (*Acipenser medirostris*), black abalone (*Haliotis cracherodii*), Hawaii false killer whale (*Pseudorca crassidens*), and humpback whales.

In the humpback whale status review, BRT members distributed 100 likelihood points among the defined scenarios or options, reflecting their expert opinion of the relative likelihood that the status of a specific DPS falls into each of three risk categories. Then the team discussed how they had allocated points and subsequently had a chance to revise their scores. Scorer identity was known.

In the Hawaii false killer whale status review, BRT members distributed 10 points between the arguments for and against each factor. Team members agreed to view resulting scores with names associated to facilitate discussion and assure that linguistic uncertainty was not responsible for any disparate votes. The BRT discussed the scores and, in some cases, adjusted scores when prior articulation of the arguments had been unclear.

After presentation of the structured decision-making approach, Bettridge asked the TF the following questions: (1) Does the TF want to use this approach? (2) If so, how many points will each member allocate among scenarios? (3) Does the TF wish to disclose names, or keep scores anonymous? (4) Does the TF wish to allow for rescoring after discussion? The TF members agreed to employ the structured decision-making approach, allocating 100 points per person. The

[6] The TF agreed that Bettridge, as leader of the decision-making process, should refrain from allocating points on the decision questions.

group agreed to disclose names with scores for the purposes of internal discussion and possible rescoring but to retain anonymity in the final report.

The TF further agreed that they needed to carefully formulate the questions to be addressed and clearly understand what it means to put likelihood points in one category or another so as to provide the necessary advice for management-related issues such as: (1) how future NMFS stock assessment reports will be drafted with regard to gray whale stock structure in the North Pacific and (2) how to interpret any new information in the context of the Makah Indian Tribe MMPA waiver request to resume hunting gray whales off Washington State, USA.

Some TF members with experience using this approach in other situations found that when one or a few members allocated points very differently it was often due to misunderstanding of the question or what the answers implied. Therefore, it was agreed that the questions and the categories of answers should be as clear as possible to make the process both efficient and transparent.

12.1 Question formulation

In keeping with the objectives stated above for developing questions, the TF dedicated significant time during day 2 of the workshop agreeing on questions to be considered during the decision-making process. A key objective of this exercise was to focus on existing lines of evidence to help create the questions while at the same time being mindful of the existing definitions of the terms (e.g., demographic independence, interbreed when mature, functioning element of the ecosystem) contained in the MMPA and GAMMS guidelines. For instance, a simple example of this might be; "*evidence of demographic independence is when the number of internal recruits is greater than the number of external recruits*". In general, this philosophy of creating questions was adopted by the TF and maintained during its deliberations.

After considerable work, the TF agreed to 11 questions. Overnight, TF members privately completed their point allocations for each of the questions. Point allocations were tallied and ready for discussion on the final day of the workshop. Allocating points in this manner allowed individual TF members to express their level of certainty on each of the questions, such that placement of all points in a single category indicated relative certainty in the lines of evidence discussed during the workshop. The TF agreed to view resulting scores with names associated to facilitate discussion and assure that linguistic uncertainty was not responsible for any disparate votes. The TF discussed the scores and, in some cases, members adjusted them when prior articulation of the lines of evidence had been unclear. The final 11 questions and likelihood point allocations for each of the TF members (anonymous, labeled A – G), as well as the proportional distribution of points overall, are provided below.

Question 1.	Overall	A	B	C	D	E	F	G
	Does the ecosystem occupied by the PCFG when they are feeding differ from the ecosystems occupied by other ENP gray whales?							
Strongly Agree	53	100	0	80	100	90	0	0
Somewhat Agree	47	0	100	20	0	10	100	100
Neutral	0	0	0	0	0	0	0	0
Somewhat Disagree	0	0	0	0	0	0	0	0
Strongly Disagree	0	0	0	0	0	0	0	0

Question 2.	Overall	A	B	C	D	E	F	G
	If gray whales in the ENP continued to be managed as a single stock, would the future abundance of PCFG gray whales be maintained above 60% of their current abundance if annual HCM in the PCFG was 5?							
Strongly Agree	38	0	95	0	0	20	50	100
Somewhat Agree	23	20	5	5	0	80	50	0
Neutral	25	50	0	25	100	0	0	0
Somewhat Disagree	14	30	0	70	0	0	0	0
Strongly Disagree	0	0	0	0	0	0	0	0

Question 3.	Overall	A	B	C	D	E	F	G
	If gray whales in the ENP continued to be managed as a single stock, would the future abundance of PCFG gray whales be maintained above 60% of their current abundance if annual HCM in the PCFG was 10?							
Strongly Agree	10	0	50	0	0	0	0	20
Somewhat Agree	24	10	50	0	0	25	30	50
Neutral	21	40	0	0	0	25	50	30
Somewhat Disagree	17	40	0	10	0	50	20	0
Strongly Disagree	29	10	0	90	100	0	0	0

Question 4.	Overall	A	B	C	D	E	F	G
	If gray whales in the ENP continued to be managed as a single stock, would the future abundance of PCFG gray whales be maintained above 60% of their current abundance if annual HCM in the PCFG was 20?							
Strongly Agree	0	0	0	0	0	0	0	0
Somewhat Agree	4	0	25	0	0	0	0	0
Neutral	7	0	50	0	0	0	0	0
Somewhat Disagree	22	10	25	0	0	50	50	20
Strongly Disagree	67	90	0	100	100	50	50	80

Question 5.	Overall	A	B	C	D	E	F	G
	Given the lack of significant differences found in nuclear markers between PCFG whales and other eastern Pacific whales, how would you allot points to:							
There is complete random mating within the eastern NP	63	70	70	70	50	80	60	40
There could be some non-random mating within PCFG whales that is either too recent or at too low a level to be detected given current sample sizes and marker numbers	37	30	30	30	50	20	40	60
PCFG whales breed primarily with each other	0	0	0	0	0	0	0	0

Question 6.	Overall	A	B	C	D	E	F	G
	Based on the genetic data and simulations, how would you allot points to:							
Nearly all recruitment into the PCFG area results from external recruitment (immigration)	0	0	0	0	0	0	0	NA
Most recruitment into the PCFG area results from external recruitment	21	20	30	20	0	20	33	NA
Recruitment is about equal between internal (births) and external (immigration) recruitment	56	60	50	60	100	30	34	NA
Most recruitment into the PCFG area results from internal recruitment	24	20	20	20	0	50	33	NA

Question 7.	Overall	A	B	C	D	E	F	G
	Based on the photo-identification data, how would you allot points to:							
Nearly all recruitment into the PCFG area results from external recruitment (immigration)	0	0	0	0	0	0	0	0
Most recruitment into the PCFG area results from external recruitment	38	30	55	50	0	30	50	50
Recruitment is about equal between internal (births) and external (immigration) recruitment	48	40	35	35	100	50	35	40
Most recruitment into the PCFG area results from internal recruitment	14	30	10	15	0	20	15	10
Nearly all recruitment into the PCFG area results from internal recruitment	0	0	0	0	0	0	0	0

Question 8.	Overall	A	B	C	D	E	F	G
	Do the genetic and photo-identification data indicate that the PCFG is a demographically independent population?							
Strongly Agree	0	0	0	0	0	0	0	0
Somewhat Agree	35	25	10	80	100	30	0	0
Neutral	21	50	30	10	0	40	20	0
Somewhat Disagree	25	25	50	10	0	30	40	20
Strongly Disagree	19	0	10	0	0	0	40	80

Question 9.	Overall	A	B	C	D	E	F	G
	Given all lines of evidence, is the PCFG a "population stock" under the agency's interpretation of the MMPA?							
Strongly Agree	14	0	0	0	100	0	0	0
Somewhat Agree	22	25	10	80	0	30	10	0
Neutral	21	50	30	10	0	40	20	0
Somewhat Disagree	24	25	50	10	0	30	35	20
Strongly Disagree	18	0	10	0	0	0	35	80

Question 10.	Overall	A	B	C	D	E	F	G
	Given that some whales identified in the WNP migrate through U.S. waters to Mexico, should a separate SAR be developed for the WNP?							
Yes	79	100	70	100	100	50	80	50
No	21	0	30	0	0	50	20	50

Question 11.	Overall	A	B	C	D	E	F	G
	Given the differences found in mtDNA and nDNA between Sakhalin Island (WNP) and ENP gray whales, is there a "population stock" within the WNP under the agency's interpretation of the MMPA?							
Strongly Agree	100	100	100	100	100	100	100	100
Somewhat Agree	0	0	0	0	0	0	0	0
Neutral	0	0	0	0	0	0	0	0
Somewhat Disagree	0	0	0	0	0	0	0	0
Strongly Disagree	0	0	0	0	0	0	0	0

12.2 Question outcomes and discussion

The outcomes of each question above are discussed below and follow the convention of using "percentage of total points" to describe the results. For example, in Question 1 the "strongly agree" category was allotted 53% of the total available TF points (370 points allotted/700 total points = 53%).

Question 1

The TF expressed general agreement, by allocating 100% of the their combined points to the categories "somewhat agree" (47%) and "strongly agree" (53%) that PCFG whales seasonally feed in a unique ecosystem that differs from other gray whale feeding areas in the Pacific. Therefore, the TF concurred that it is reasonable to consider that if the PCFG no longer existed and the region was not reoccupied via immigration, summer feeding gray whales would no longer be a functioning element of the coastal Pacific Northwest ecosystem. Although such a circumstance is plausible, keeping all other things equal (e.g., habitat, prey availability), the current lines of evidence from photo-identification studies suggest it is unlikely that the level of annual immigration into the PCFG in the past decade would cease. Thus, the likelihood of gray whales not being found in the PCFG area seems low. However, the time it might take for "recolonization" of the PCFG via immigration is undetermined and thereby puts into question whether this scenario would meet the MMPA objectives of maintaining stocks not only for ecological purposes but also for aesthetic, recreational and economic reasons.

Questions 2, 3 and 4
These three questions were meant to address the MMPA objective of maintaining population stocks as significant functioning elements in the ecosystem of which they are part, and that population stocks should not be permitted to decline below OSP. GAMMS II state that where mortality is greater than a PBR level calculated from the abundance for the region where human caused mortality (HCM) occurs, serious consideration should be given to identifying an appropriate management unit in the region. While estimates of PBR and HCM for a putative PCFG stock have been generated (Carretta *et al*. 2013), there is uncertainty about both estimates, especially with respect to: (1) whether HCM (e.g., ship strikes and fisheries bycatch) for whales in the PCFG area is indeed higher than for whales that migrate through the area, and (2) where HCM actually occurs. In response to these questions, the TF expressed increasing concern about the ability of the PCFG to be maintained above 60%[7] of its current abundance once HCM exceeded 5 whales per year.

The point allocation in Question 2 indicates that the TF overall tended to agree that the future abundance of PCFG gray whales would be maintained above 60% of their current abundance if annual HCM in the PCFG was 5. However, the relatively equal distribution of likelihood points in all categories except "strongly agree" indicates a high level of uncertainty among the TF.

For Question 3, points were allocated more broadly across categories, indicating a higher level of uncertainty among TF members as to whether the PCFG could sustain levels of HCM at 10 whales per year.

There was increased consensus among the TF for Question 4 in that none of them responded "strongly agree". Overall, the TF concurred that it somewhat (22%) or strongly disagreed (67%) that the future abundance of PCFG gray whales would be maintained above 60% of their current abundance if annual HCM in the PCFG was 20.

Question 5
The TF found no evidence to suggest that PCFG whales breed primarily with each other. While there was general agreement (63%) that the lack of significant differences found in nuclear DNA markers between PCFG whales and other ENP whales suggests random interbreeding among all ENP whales, the allotment of 37% of the total points to the intermediate category suggests TF members thought it was possible that some breeding segregation may exist based on migratory timing (see Lang *et al*. 2011) but there is no direct evidence presently available to support or further test this theory.

Question 6
The TF found no evidence in the results from genetics studies to suggest that nearly all recruitment into the PCFG area results from external recruitment (immigration). Based on the genetic data and simulations discussed during the workshop, the highest average TF response (56%) indicates that TF members believe recruitment is most likely about equal between internal (births) and external (immigration) recruitment. That being said, the remaining 45% of the total points were split between most recruitment into the PCFG area resulting from either internal or

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[7] The management goal of the MMPA is to prevent populations from "depletion". NMFS considers a population depleted if it fall below its Maximum Net Productivity Level (MNPL). For marine mammals, this level is thought to be between 50% and 85% of carrying capacity and is more likely to be in the lower portion of that range (Taylor and DeMaster 1993). Therefore, populations are considered depleted by the U.S. government if they are directly estimated to be below their MNPL, or if they are estimated to be below 50%-70% of a historic population size which it thought to represent carrying capacity (Gerrodette and DeMaster 1990).

external recruitment, indicating some overall uncertainty among members regarding the presently available lines of evidence about recruitment in the PCFG. It should be noted that one member of the TF refrained from assigning any points to this question, so these results represent 6 of 7 TF members actively involved in the point assignment process.

Question 7

Based on the photo-identification data, the TF found no evidence to suggest that nearly all recruitment was either external or internal, but rather some combination of the two. As with the genetics evidence, the highest average TF response (48%) indicates that the TF felt recruitment from internal (births) and external (immigration) sources are comparable. That being said, 38% of the total points were allocated to most recruitment into the PCFG area resulting from external recruitment. Therefore, a majority of the total points were allocated to either recruitment being about equal between internal (births) and external (immigration) recruitment (48%) or most recruitment into the PCFG area results from external recruitment (38%). As was also true with the genetic lines of evidence, these results from the TF suggest a fairly high level of uncertainty regarding recruitment into the PCFG.

Question 8

Based on the genetic and photo-identification data, the TF did not strongly agree that the PCFG is a demographically independent population. Although the highest average TF response (35%) was “somewhat agree” that the PCFG is a demographically independent population, the combined categories of “somewhat disagree” and “strongly disagree” elicited 44% of the total points allocated. Overall, these results from the TF suggest a high level of uncertainty regarding recruitment in the PCFG.

Question 9

Given all lines of evidence, the point allocation of the TF reflects broad uncertainty as to whether the PCFG should be regarded as a population stock under the MMPA and GAMMS guidelines. Perhaps more than all of the other questions considered, Question 9 reflects the highest degree of uncertainty. For instance, the “strongly agree” (14%) and somewhat agree (22%) categories are almost perfectly counter-balanced by the “somewhat disagree”(24%) and “strongly disagree” (18%) categories. An additional level of uncertainty is indicated by the “neutral” category (21%). Given these results, it seems clear that TF was unable to reach a definitive response with respect to the PCFG being a population stock. That is, members of the TF ranged in their opinions from strongly agree to strongly disagree as to whether the PCFG should be considered a separate stock.

Given that this question represents the primary purpose of the workshop, the following two sections provide insight into the deliberations of the TF with regard to arguments for and against the PCFG being a demographically independent unit.

❖ *Arguments for the PCFG being a demographically independent unit*

The return of individual whales to specific feeding areas for as long as the PCFG has been studied (30+ years) strongly suggests that site fidelity is key to maintaining gray whales as a functioning element of this ecosystem. There was agreement that this ecosystem differs from other feeding ecosystems occupied by gray whales. Gray whales are unique among the great whales in being found in only a single ocean basin. Within this ocean basin the PCFG is the only feeding group that does not rely on the dynamics of a sub-arctic ecosystem. As such, the PCFG deserves the protections afforded by being an MMPA stock because the ecosystem role of these animals is unique and also because it provides gray whales, as a species, the flexibility they may need given potential challenges in a changing sub-arctic ecosystem.

Although there is evidence of recruitment from other feeding aggregations, there is also evidence of direct internal recruitment because calves have been shown to return to the PCFG area and reside there. Furthermore, because photographic efforts take place after most claves would be weaned, the recruits into the population not first seen as calves are actually of unknown origin and cannot be definitively assigned as external recruits.

PCFG whales show a low but significant level of genetic differentiation at the mtDNA control region when compared to samples collected in Chukotka [representative of the ENP population and sampled at a single feeding location in the Bering Sea], and when compared to a set of samples collected primarily from animals that stranded along the west coast of the U.S. [representative of a broader sampling of the ENP population]. The significant differences found when the mtDNA haplotype data from the PCFG is compared with that of groups representing the larger ENP population provide indirect evidence of internal recruitment and matrilineally-directed site fidelity to feeding grounds. The level of differentiation is on par with levels identified among humpback whales feeding in different areas of the western North Atlantic (Palsbøll *et al*. 2001) as well as humpback whales using different breeding grounds in the Southern Hemisphere (Rosenbaum *et al*. 2009), suggesting that the PCFG exhibits demographic independence similar to what has been inferred for other large whales. Within the western North Atlantic, humpback whales feeding in the Gulf of Maine are managed as a separate stock despite the fact that they share a common breeding ground with humpbacks feeding in other areas. Although evidence for nuclear DNA differentiation between PCFG whales and other areas has not been found, nuclear genetic differentiation has not always been required for stock delimitation. Pacific harbor seal stocks were delimited on mtDNA differentiation alone (nuclear data were not available at the time), while the Gulf of Maine/Bay of Fundy stock of harbor porpoises was delimited based on significant differentiation at mtDNA, contaminant loads, and life history differences, and despite a lack of differentiation at nuclear markers.

❖ ***Arguments against the PCFG being a demographically independent unit***

The evidence that external recruitment is not a rare event is quite strong. The genetic data have numerous rare haplotypes that are not consistent with a small, closed population. Indeed, simulations are not consistent with a closed population. A sizable number of individuals seen in the main feeding season are identified as transients, which is consistent with an on-going level of the main ENP population investigating this new habitat but then moving on. Further, when all samples collected in summer in the PCFG area are used there is not a significant difference found in mtDNA frequencies compared to all samples collected north of the Aleutian Islands. The number of recruits into the PCFG has been estimated, through genetic data, to be 4 to as high as 8 individuals per year. Photo-identification data suggest similarly high numbers of non-calf recruits per year (8-11). These numbers exceed the estimated number of internal recruits and, given that PCFG numbers appear to be relatively stable, an addition of 4 or more external recruits per year cannot be considered trivial. These external recruitment rates suggest the PCFG is not demographically independent from the larger ENP population.

Furthermore, unlike other large whale populations, the annual coastal migration of the vast majority of ENP gray whales brings most individuals into contact with the habitat used by the PCFG. Should there be increased removals from this area, the continual visitation to this area by a large number of gray whales would make it likely that external recruitment would increase to fill any voids. The apparent pulse recruitment in 1999-2000 when conditions in the sub-arctic feeding areas resulted in a large mortality event shows that gray whales can adapt to a new habitat when conditions dictate. Using data collected since 2002 (post-pulse recruitment event), an average of 29.3 new whales have been identified in summer in the area used by the PCFG, with 18.5 animals that are not seen in later years and 10.8 whales that are seen in later years. Given that an average of 18.5 new whales (at least, as this does not account for new whales not photographed) visit the PCFG area each summer but do not return, this suggests that something on the order of 10% of the whales that occur in the PCFG area each summer are transients that otherwise feed north of the Aleutians, and serve as a substantial and continuous source of potential recruitment into the PCFG.

To date, there is no evidence for nDNA differentiation between Chukotka and PCFG whales based on 8 microsatellite loci or between the PCFG and one Mexican calving lagoon based on 15 loci. These results may be interpreted as female directed site fidelity to the PCFG area coupled with random mating between PCFG and ENP whales on the breeding ground. Lack of nuclear differentiation diminishes support for demographic independence.

All lines of evidence (photo-identification and genetics) are consistent with ongoing external recruitment that could be at a magnitude that is not trivial to the persistence of the feeding aggregation (more than a percent or two per year). Uncertainty in the number of recruits per year and exactly who those recruits are (PCFG calves misidentified as recruits, true recruits of adults, temporary immigrants who do not stay more than a few years and may not even be contributing to the gene pool) creates significant uncertainty as to whether internal recruitment exceeds external recruitment. Given the high level of mtDNA haplotypic diversity, the precision of F_{ST} estimates is also uncertain. Taken together, the available evidence is weak for concluding the PCFG is demographically independent.

Question 10
Given that some whales identified in the WNP have been observed to migrate through U.S. waters to Mexico, in combination with the 1994 amendments to the MMPA requiring that SARs be published for all stocks of marine mammals in U.S. waters, the TF agreed to a high degree (79%) that a separate SAR should be developed in the future for the WNP stock of gray whales.

Question 11
Based on the differences found in mtDNA and nDNA between Sakhalin Island (WNP) and ENP gray whales, the TF unanimously (100%) agreed that it qualifies as a population stock under the MMPA and GAMMS guidelines.

13. Concluding Remarks

The implications of new data pertinent to stock structure, including considerable information related to the PCFG and WNP gray whales, were thoroughly reviewed during the workshop. Evaluating the new findings relevant to the status of the PCFG proved particularly complex. After review of results from photo-identification, genetics, tagging, and other studies within the context of the GAMMS guidelines there remains a substantial level of uncertainty in the strength of the lines of evidence supporting demographic independence of the PCFG. Consequently, the TF was unable to provide definitive advice as to whether the PCFG is a population stock under the MMPA and the GAMMS guidelines. Members of the TF ranged in their opinions from strongly agreeing to strongly disagreeing about whether the PCFG should be recognized as a separate stock.

In the case of WNP gray whales, the work of the TF was more straightforward. The mitochondrial DNA and nuclear DNA genetic differentiation found between the WNP and ENP stocks provided convincing evidence that resulted in the TF providing unambiguous advice that the WNP stock should be recognized as a population stock pursuant to the GAMMS guidelines and the MMPA.

Additional research may narrow the uncertainty associated with the question of whether the PCFG should be recognized as a population stock. To work towards this objective, the TF recommended further investigation of recruitment into the PCFG. Presently, both the photo-identification and genetics data indicate that the levels of internal versus external recruitment are comparable, but these are not quantified well enough to determine if the population dynamics of the PCFG are more a consequence of births and deaths within the group (internal dynamics) rather than related to immigration and/or emigration (external dynamics). The TF offered a number of research recommendations, using the existing photo-identification and genetics datasets, that could provide increased resolution on the issue of recruitment and, in turn, the question of stock identification.

While the need for additional data collection was apparent, especially with regard to recruitment into the PCFG, the purpose of the workshop was for the TF to determine whether the *existing* best available science was sufficient to advise that the PCFG be recognized as a population stock under the language of the MMPA and GAMMS guidelines. Therefore, the advice of the TF offered in this report should be viewed as a contemporary "snapshot" taken from an emerging and ever-changing body of knowledge regarding the PCFG.

The TF emphasizes that the PCFG is relatively small in number and utilizes a largely different ecosystem from that of the main ENP stock. While the status of the PCFG as a population stock has yet to be resolved, continued research on these whales should be undertaken with particular attention dedicated to collecting data relevant to the question of stock identification.

14. Acknowledgements

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16. Appendix 1 – Workshop Agenda

GRAY WHALE STOCK IDENTIFICATION WORKSHOP AGENDA

Southwest Fisheries Science Center
La Jolla, California
31 July-2 August 2012

Day 1 (31 July 2012)

8:30-8:45
1. Introductory Items
1.1 Convenor's opening remarks (Ballance)
1.2 Arrangements for the meeting (Henry)
1.3 Appointment of chair, task force and rapporteurs
1.4 Adoption of agenda
1.5 Documents available

8:45-9:15
2. Workshop Objectives
2.1 Provide scientific advice on gray whale stock structure (Weller)
2.2 Workshop relationship to stock assessment reports (Carretta/Bettridge)
2.2.1 Confirm current stock structure
2.2.2 Assess new information on putative or prospective stocks
2.2.3 Provide advice on necessary changes to stock structure
2.3 Workshop relationship to Makah waiver request (Darm/Stone)
2.3.1 History
2.3.2 Key considerations
2.3.3 Current status of waiver request
2.3.4 Need to know information

9:15-10:30
3. Working Group on Stock Identification (Bettridge and Moore)
3.1 Overview of MMPA language and GAMMS guidelines pertaining to stock definition (Moore)
3.1.1 Existing GAMMS language
3.1.2 Proposed GAMMS revisions from the GAMMS III workshop
3.2 Overview of recent history pertaining to NMFS interpretation of "interbreed when mature" (Bettridge/Beale)
3.2.1 Draft GAMMS II language pertaining to "interbreed when mature"
3.2.2 Status of current legal analysis of NMFS proposed definition
3.3 Additional relevant history concerning definition of "population" for marine mammals (e.g., Taylor 1997, excerpts from Eagle *et al.* 2008) (Moore/ Taylor)

BREAK 10:30-10:45

10:45-12:00
3.4 Current status of gray whale SAR development (Bettridge)
3.5 Discuss key concepts: interbreed when mature, population, demographic independence, functioning element of ecosystem
3.6 Proposed TF voting protocol and process: examples from FEMAT and the ESA (humpback whale BRT, false killer whale BRT) (Bettridge)

3.7. Proposed questions to be voted on by the Task Force

12:00-12:45
4. Working Group on Other Information (Weller and Brownell)
4.1 Overview of gray whale "population stocks" (Lang)
4.1.1 Eastern North Pacific Stock
4.1.2 Western North Pacific Stock
4.1.2.1 Genetic lines of evidence as being a stock
4.1.2.2 Movements of whales between the WNP and ENP
4.2 Brief overview of the Pacific Coast Feeding Group (PCFG) putative stock (Lang)
4.2.1 History
4.2.2 Range
4.2.3 Abundance
4.2.4 Diet
4.2.5 Movements (tagging, photo-ID)
4.2.6 Incidental Take (Carretta)
4.2.7 Emerging issues and areas of uncertainty
4.2.7.1 Probability of a WNP Being Taken by the Makah (Moore)
4.3 Status of the ENP, WNP and PCFG as stocks (NMFS/MMPA/ESA/IWC) (Stone)
4.4 Proposed questions to be voted on by the Task Force

LUNCH 12:45-1:30

13:30-14:15
5. Working Group on Genetic Population Structure (Taylor and Rosel)
5.1 Broad overview of evidence used in recently defined stocks (Stone)
5.2 Review of stock definition cases relevant to the PCFG case
5.2.1 Atlantic harbor porpoises (Rosel)
5.2.2 Alaska harbor seals (Taylor)
5.2.3 Humpback whales (Lang)

14:15-15:00
5.3 Review of gray whale genetic research relating to population structure (Lang)
5.3.1 Summary of early work (LeDuc, Ramakrishnan, Alter breeding lagoon)
5.3.2 Summary of recent work
5.3.2.1 Frasier and D'Intino
5.3.2.2 Lang – empirical genetics
5.3.2.3 Lang – modeling genetics
5.4 Proposed questions to be voted on by the Task Force

BREAK 15:00-15:30

15:30-17:00

6. Discussion of Documents Drafted by the Makah Tribe and Other General Matters (Task Force)
6.1 Makah Tribe documents (Weller)
6.1.1 Introduce GWLJ33: "Is the Pacific feeding group of gray whales a "population stock" within the meaning of the Marine Mammal Protection Act?"
6.1.2 Introduce GWLJ32: "Comments on Draft 2012 Stock Assessment Report for eastern North Pacific stock of gray whales"
6.1.3 Introduce GWLJ34: "What is the PCFG? A review of available information"
6.1.4 Discuss genetics sections of Makah Tribe document GWLJ33 (Taylor/Rosel)
6.2 General discussion of Day 1 information

Day 2 (1 August 2012)

9:00-10:30
7. Working Group on Population Abundance and Trends (Laake and Wade)
7.1 Photo-identification and population dynamics of the PCFG (Laake)
- 7.1.1 Definition of PCFG whales based on timing/area
- 7.1.2 Movements of know PCFG whales (photo-identification and telemetry)
- 7.1.3 Abundance/survival estimates
- 7.1.4 Trends (Wade)
- 7.1.5 Recruitment
- 7.1.6 PCFG Trend/OSP (Moore)
- 7.1.7 Discuss photo-identification and telemetry sections of Makah Tribe document GWLJ33 (Laake/Wade)

7.2 Proposed questions to be voted on by the Task Force

BREAK 10:30-11:00

11:00-12:30
8. Review and Agree on Workshop Questions for Voting

LUNCH 12:30-13:30

13:30-15:30
9. Description of Vote Procedure (Bettridge)
10. TF Voting on Workshop Questions (TF Only)

Overnight
11. Compile and Tally Votes (Lang/Henry)

Day 3 (2 August 2012)

9:00-12:00
12. Review of Vote Outcomes (Lang/Henry)
13. Discussion of Vote Outcomes
14. Revision of Questions for voting if Necessary
15. Revote if Necessary

LUNCH 12:00-13:30

13:30-16:30
16. Review of Revote Results if Necessary (Lang/Henry)
17. Other Business
18. Workplan for Workshop Report Completion
19. Adjourn

17. Appendix 2 - Workshop Document List

GWLJ01

Moore, J. E., and Merrick, R., eds. *Guidelines for Assessing Marine Mammal Stocks: Report of the GAMMS III Workshop, February 15 – 18, 2011, La Jolla, California*. Dept. of Commerce, NOAA Technical Memorandum NMFS-OPR-47.

GWLJ02

Andrews, K. R., Karczmarski, L., AU, W. W. L., Rickards, S. H., Vanderlip, C. A., Bowen, B. W., Grau, E. G., and Toonen, R. J. (2010), Rolling stones and stable homes: social structure, habitat diversity and population genetics of the Hawaiian spinner dolphin (*Stenella longirostris*). Molecular Ecology **19**: 732–748.

GWLJ03

Chivers, S. J., Dizon, A. E., Gearin, P. J., and Robertson, K. M. 2002. Small-scale population structure of eastern North Pacific harbour porpoises (*Phocoena phocoena*) indicated by molecular genetic analyses. Journal of Cetacean Research and Management **4**: 111–122.

GWLJ04

Courbis, S. S. 2011. Population Structure of Island-Associated Pantropical Spotted Dolphins (*Stenella attenuata*) in Hawaiian Waters. PhD Thesis, Portland State University, Oregon.

GWLJ05

Taylor, B. L. 2005. Identifying Units to Conserve. In: J. E. Reynolds III, W. F. Perrin, R. R. Reeves, S. Montgomery, and T. J. Ragen, eds. *Marine Mammal Research: Conservation beyond Crisis*. The John Hopkins University Press, Baltimore, MD.

GWLJ06

Carretta, J. V., Oleson, E., Weller, D. W., Lang, A. R., Forney, K. A., Baker, J., Hanson, B., Martien, K. Muto, M. M., Lowry, M. S., Barlow, J., Lynch, D., Carswell, L., Brownell Jr., R. L., Mattila, D. K., and Hill, M. C. *In press*. DRAFT: Gray whale (*Eschrichtius robustus*): Eastern North Pacific Stock and Pacific Coast Feeding Group. In: U.S. Pacific Marine Mammal Stock Assessments: 2012. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-SWFSC-XXX.

GWLJ07

Lang, A. R. 2010. The population genetics of gray whales (*Eschrichtius robustus*) in the North Pacific. PhD Thesis, University of California, San Diego, California.

GWLJ08

N/A

GWLJ09

Pyenson N. D., and Lindberg, D. R. 2011. What Happened to Gray Whales during the Pleistocene? The Ecological Impact of Sea-Level Change on Benthic Feeding Areas in the North Pacific Ocean. PLoS ONE **6**: e21295. doi:10.1371/journal.pone.0021295.

GWLJ10

Spalding, M. D., Fox, H. E., Allen, G. R., Davidson, N., Ferdana, Z. A., Finlayson, M. A. X., Halpern, B. S., Jorge, M. A., Lombana, A., Lourie, S. A., Martin, K. D., McManus, E., Molnar, J., Recchia, C. A., and Robertson, J. 2007. Marine ecoregions of the world: a bioregionalization of coastal and shelf areas. BioScience **57**: 573-583.

GWLJ11

Calambokidis, J., Laake, J. L., and Klimek, A. 2010. Abundance and population structure of seasonal gray whales in the Pacific Northwest, 1998-2008. Paper SC/62/BRG32 presented to the IWC Scientific Committee.

GWLJ12

N/A

GWLJ13

Oleson, E. M., Boggs, C. H., Forney, K. A., Hanson, M. B., Kobayashi, D. R., Taylor, B. L., Wade, P. M. and Ylitalo, G. M. 2010. Status review of Hawaiian insular false killer whales (*Pseudorca crassidens*) under the Endangered Species Act. U. S. Dept Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-22.

GWLJ14

NMFS. 2005. Revisions to Guidelines for Assessing Marine Mammal Stocks. 24 pp. Available at: http://www.nmfs.noaa.gov/pr/pdfs/sars/gamms2005.pdf.

GWLJ15

Eagle, T. C., Cadrin, S. X., Caldwell, M. E., Methot, R. D., Nammack, M. F. 2008. Conservation Units of Managed Fish, Threatened or Endangered Species, and Marine Mammals Report of a Workshop: February 14-16, 2006 Silver Spring, Maryland. U. S. Dept of Commerce, NOAA Technical Memorandum NMFS-OPR-37.

GWLJ 16

Taylor, B. L. 1997. Defining "Population" to Meet Management Objectives for Marine Mammals. Molecular Genetics of Marine Mammals **3:** 49-65.

GWLJ17

DRAFT Status Review of the Humpback Whale under the Endangered Species Act (confidential)

GWLJ18

Lang, A. R., Weller, D. W., LeDuc, R., Burdin, A. M., Pease, V. L., Litovka, D., Burkanov, V., and Brownell Jr., R. L. 2011. Genetic analysis of stock structure and movements of gray whales in the eastern and western North Pacific. Paper SC/63/BRG32 presented to the IWC Scientific Committee.

GWLJ19

Lang, A. R., Taylor, B. L., Calambokidis, J. C., Pease, V. L., Klimek, A., Scordino, J. Robertson, K. M., Litovka, D., Burkanov, V., Gearin, P., George, J. C., and Mate, B. 2011. Assessment of stock structure among gray whales utilizing feeding grounds in the Eastern North Pacific. Paper SC/M11/AWMP4 presented to IWC Scientific Committee.

GWLJ20

Lang, A. R. and Martien, K. K. 2012. Update on the use of a simulation-based approach to evaluate plausible levels of recruitment into the Pacific Coast Feeding Group of gray whales. Paper SC/64/AWMP4 presented to IWC Scientific Committee.

GWLJ 21

Alter, S. E., Rynes, E., and Palumbi, S. R. 2007. DNA evidence for historic population size and past ecosystem impacts of gray whales. Proceedings of the National Academy of Sciences **104**: 15162-15167.

GWLJ22

Alter, S. E., Ramirez, S. F., Nigenda, S., Ramirez, J. U., Bracho, L. R., and Palumbi, S. R. 2009. Mitochondrial and nuclear genetic variation across calving lagoons in eastern North Pacific gray whales (*Eschrichtius robustus*). Journal of Heredity **100**: 34-46.

GWLJ23

Alter, S. E., Newsome, S. D., and Palumbi, S. R. 2012. Pre-whaling genetic diversity and population ecology in eastern Pacific gray whales: insights from ancient DNA and stable isotopes. PLoS ONE **7**:e35039. doi: 10.1371/journal.pone.0035039.

GWLJ24

D'Intino, A. M., Darling, J. D., Urbán-Raminez, J., and Frasier, T. R. 2012. Substructuring of mitochondrial, but not nuclear, markers in the "southern feeding group" of eastern North Pacific gray whales. Paper SC/64/AWMP2 presented to IWC Scientific Committee.

GWLJ25

Frasier, T. R., Koroscil, S. M., White, B. N., & Darling, J. D. 2011. Assessment of population substructure in relation to summer feeding ground use in the eastern North Pacific gray whale. Endangered Species Research **14**: 39-48.

GWLJ 26

Goerlitz, D. S., Urbán, J., Rojas-Bracho, L., Belson, M., and Schaeff, C. M. 2003. Mitochondrial DNA variation among Eastern North Pacific gray whales (*Eschrichtius robustus*) on winter breeding grounds in Baja California. Canadian Journal of Zoology, 81: 1965-1972.

GWLJ27

Lang, A. R., Weller, D. W., LeDuc, R. G., and Burdin, A M. 2010. Delineating Patterns of Male Reproductive Success in the Western Gray Whale (*Eschrichtius robustus*) Population. Paper SC/62/BRG10 presented to IWC Scientific Committee.

GWLJ28

LeDuc, R. G., Weller, D. W., Hyde, J., Burdin, A. M., Rosel, P. E., Brownell Jr., R. L., Würsig, B., and Dizon, A. E. 2002. Genetic differences between western and eastern North Pacific gray whales (*Eschrichtius robustus*). Journal of Cetacean Research and Management **4**: 1-6.

GWLJ29

Ramakrishnan, U., & Taylor, B. L. (2001). Can gray whale management units be assessed using mitochondrial DNA? Journal of Cetacean Research and Management **3:** 13-18.

GWLJ30

Ramakrishnan, U., LeDuc, R. G., Darling, J., Taylor, B. L., Gearin, P., Gosho, M., Calambokidis, J., Brownell Jr., R. L., Hyde, J., and Steeves, T. E. 2001. Are the southern feeding group of Eastern Pacific gray whales a maternal genetic isolate? Report of the International Whaling Commission SC53/SD8.

GWLJ31

Steeves, T. E., Darling, J. D., Rosel, P. E., Schaeff, C. M., and Fleischer, R. C. 2001. Preliminary analysis of mitochondrial DNA variation in a southern feeding group of eastern North Pacific gray whales. Conservation Genetics **2**: 379-384.

GWLJ32

Makah 2012. Comments on Draft 2012 Stock Assessment Report for the Eastern North Pacific Stock of Gray Whales (Revised 11/1/2011) - Submitted by the Makah Indian Tribe on January 17, 2012

GWLJ33

Makah 2011. Is the Pacific Coast Feeding Group of Gray Whales a "Population Stock" within the Meaning of the Marine Mammal Protection Act? A Preliminary Analysis by the Makah Indian Tribe, October 5, 2011. PCFG Stock Status Memo from Makah Indian Tribe 10-5-2011; PSRG-2011-B13.

GWLJ34

Scordino, J., Bickham, J., Brandon, J., and Ammajian, A. 2011. What is the PCFG? A review of available information. Paper SC/63/AWMP1 presented to IWC Scientific Committee.

GWLJ 35

Brandon, J. R., Scordino, J., Butterworth, D. S., Donovan, G. P., and Punt, A. E. 2012. Towards the Selection of a Final Set of Trials for the 2012 ENP Gray Whale Implementation Review. Paper SC/64/AWMP11 presented to IWC Scientific Committee.

GWLJ 36

Ford, J. K., Durban, J. W., Ellis, G. M., Towers, J. R., Pilkington, J. F., Barrett-Lennard, L. G., and Andrews, R. D. 2012. New insights into the northward migration route of gray whales between Vancouver Island, British Columbia, and southeastern Alaska. Marine Mammal Science. doi: 10.1111/j.1748-7692.2012.00572.x

GWLJ37

Gosho, M., Gearin, P., Jenkinson, R., Laake, J., Mazzuca, L., Kubiak, D., Calambokidis, J., Megill, W., Gisborne, B., Goley, D., Tombach, C., Darling, J., and Deecke, V. 2011. Movements and diet of gray whales (*Eschrichtius robustus*) off Kodiak Island, Alaska, 2002-2005. Paper SC/M11/AWMP2 presented to IWC Scientific Committee.

GWLJ38

Mate, B., Bradford, A., Tsidulko, G., Vertyankin, V., and Ilyashenko, V. 2011. Late-Feeding Season Movements of a Western North Pacific Gray Whale off Sakhalin Island, Russia and Subsequent Migration into the Eastern North Pacific. Paper SC/63/BRG23 presented to IWC Scientific Committee.

GWLJ39

Punt, A. E. 2012. Revised ENP Gray Whale Trials and Initial Conditioning Results. Paper SC/63/AWMP presented to IWC Scientific Committee.

GWLJ40

Baird, R. W., Stacey, P. J., Duffus, D. A., and Langelier, K. M. 2002. An evaluation of gray whale (*Eschrichtius robustus*) mortality incidental to fishing operations in British Columbia, Canada. Journal of Cetacean Research Management **4**: 289–296.

GWLJ41

Conner, L., Stelle, L. L., Najera-Hillman, E., Megill, W., Calambokidis, J., and Klimek, A. 2011. Using Photo ID to Examine Injuries in Eastern Pacific Gray Whales (*Eschrichtius robustus*). Poster presentation, 20th Biennial Conference on the Biology of Marine Mammals, Tampa, Florida.

GWLJ42

International Whaling Commission. 2011. Report of the 2011 AWMP Workshop with a focus on eastern gray whales. Paper SC/63/Report 2 presented to the IWC Scientific Committee.

GWLJ43

International Whaling Commission. 2012. Report of the AWMP Workshop focussing on the PCFG gray whale Implementation Review. Paper SC/64/Report 3 presented to the IWC Scientific Committee.

GWLJ44

International Whaling Commission. 2012. Report of the Scientific Committee, Panama City, Panama, 11-23 June 2012. Paper IWC/64/Report 1, Revision 1.

GWLJ45

International Whaling Commission. 2012. Annex E: Report of the Scientific Committee: International Whaling Commission, Panama City, 2012. Paper IWC/64/Report 1 Annex E.

GWLJ46

O'Corry-Crowe, G. M., Martien, K. K., and Taylor, B. L. 2003. The analysis of population genetic structure in Alaskan harbor seals, *Phoca vitulina*, as a framework for the identification of management stocks. Southwest Fisheries Science Center Administrative Report LJ-03-08.

GWLJ47

Mate, B., Lagerquist, B., and Irvine, L. 2010. Feeding habitats, migration, and winter reproductive range movements derived from satellite-monitored radio tags on eastern North Pacific gray whales. Paper SC/62/BRG21 presented to IWC Scientific Committee.

GWLJ48

Weinrich, M. T., and Clapham, P. J. 2002. Population identity of humpback whales (*Megaptera novaeangliae*) in the waters of the US mid-Atlantic states. Journal of Cetacean Research and Management, **4**: 135-141.

GWLJ49

Palsboll, P. J., Clapham, P. J., Mattila, D. K., Larsen, F., Sears, R., Siegismund, H. R., Sigurjónsson, J. Vasquez, O., and Arctander, P. 1995. Distribution of mtDNA haplotypes in North Atlantic humpback whales: the influence of behaviour on population structure. Marine Ecology Progress Series **116**: 1-10.

GWLJ50

Palsboll, P. J., Allen, J. , Andersen, T. H. , Berube, M., Clapham, P. J., Federsen, T. P., Friday, N., Hammond, P.S., Jorgensen, H., Katona, S., Larsen, A. H., Larsen, F., Lien, J., Mattila, D. K., Nygaard, F. B., Robbins, J., Sears, R., Sigurjónsson, J., Smith, T., Sponer, R., Stevick, P., Oien, N., and Vikingsson, G. 2001. Stock structure and composition of the North Atlantic humpback whale, *Megaptera novaeangliae*. Paper SC/53/NAH11presented to IWC Scientific Committee.

GWLJ51

Waring, G. T., Josephson, E., Maze-Foley, K., Rosel, P. E., eds. 2012. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2011. NOAA Technical Memorandum NMFS-NE-221.

GWLJ52

Calambokidis, J., Falcone, E. A., Quinn, T. J., Burdin, A. M. Clapham, P. J., Ford, J. K. B., Gabriele, C. M., LeDuc, R., Mattila, D., Rojas-Bracho, L. Straley, J. M., Taylor, B. L., Urbán-R, J. Weller, D. Witteveen, B. H., Yamaguchi, M., Bendlin, A., Camacho, D., Flynn, K., Havron, A., Huggins, J., and Maloney, N. 2008. SPLASH: Structure of populations, levels of abundance and status of humpback whales in the North Pacific. Final report for Contract

AB133F-03-RP-00078 prepared by Cascadia Research for the U.S. Department of Commerce.

GWLJ53

Baker, C. S., Steel, D., Calambokidis, J., Barlow, J., Burdin, A. M., Clapham, P. J., Falcone, E., Ford, J. K. B., Gabriele, C. M., Gozález-Peral, U., LeDuc, R., Mattila, D., Quinn, T. J., Rojas-Bracho, L., Straley, J. M., Taylor, B. L., Urbán-R, J., Vant, M., Wade, P. R., Weller, D., Witteveen, B. H., Wynne, K., and Yamaguchi, M. 2008. geneSPLASH: An initial, ocean-wide survey of mitochondrial (mt) DNA diversity and population structure among humpback whales in the North Pacific. Final report for Contract 2006-0093-008 to the National Fish and Wildlife Foundation.

GWLJ54

Calambokidis, J. (complier). 2010. Symposium on the results of the SPLASH humpback whale study: Final Report and Recommendations, 11 October 2009, Quebec City, Canada.

GWLJ55

Weller, D. W., Klimek, A., Bradford, A. L., Calambokidis, J., Lang, A. R., Gisborne, B., Burdin, A. M., Szaniszlo, W., Urbán, J., Gómez-Gallardo Unzueta, A., Swartz, S., and Brownell Jr., R. L. 2012. Movements of gray whales between the western and eastern North Pacific. Endangered Species Research **18**: 193–199.

GWLJ56

Weller, D. W. and Brownell Jr., R. L. 2012. A re-evaluation of gray whale records in the western North Pacific. Paper SC/64/BRG1 presented to the IWC Scientific Committee.

GWLJ57

Table by Stone on MMP, ESA, IUCN listing status

GWLJ58

Table by Stone on SAR stock listings